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Trade, migration and regional unemployment

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Abstract

A by now large literature in regional economics has greatly improved our understanding of the determinants of the observed spatial disparities in productivity. However, this literature neglects what seems to be a robust and persistent fact accompanying regional productivity differences: high productivity regions also have lower unemployment than low productivity regions. In this paper, we set out a model in the New Economic Geography (NEG)/job search tradition to explore the theoretical determinants of this fact. We find that the same forces producing regional agglomeration and productivity differences also generate persistent unemployment disparities. Moreover, we highlight a contrast between the short-run and long-run effects of migration on regional unemployment. In particular, migration from the periphery to the core may reduce unemployment disparities in the short-run, but exacerbates them in the long-run.

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1. Introduction

A large literature in regional economics has greatly improved our understanding of the determinants of the wide and persistent disparities in productivity observed within

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all countries.[1] However, this literature neglects what seems to be a robust stylized fact: high productivity regions also have lower unemployment than low productivity regions. For instance, a cross-section of the log rate of unemployment on the log real GDP per worker shows that a doubling of productivity in the typical European region is associated with a 76% fall in the rate of unemployment.[2] Further, the correlation between regional unemployment and real GDP per worker is negative within all European countries, except Portugal. Spatial disparities in productivity have been linked empirically to agglomeration economies: Ciccone and Hall (1996) and Ciccone (2002) find, for instance, that more than half of the variance of regional productivity can be accounted for by regional differences in the density of economic activity. This immediately suggests that the same forces producing regional agglomeration and productivity differences may also generate unemployment disparities. It also suggests that labor mobility, by fuelling agglomeration economies, may create regional unemployment disparities instead of alleviating them.

To explore this possibility, we set out a model combining agglomeration forces, as described in the New Economic Geography (NEG) literature, with job search frictions. In particular, we build a dynamic core-periphery model where transport costs generate agglomeration economies, workers can move costlessly between regions and frictions in the job matching process lead to equilibrium unemployment. We introduce a congestion effect in utility to ensure that, even in the absence of migration costs, some workers do not leave the backward region, so that peripheral unemployment never disappears.[3] We then use our model to show how regional unemployment, income and migration respond to a reduction of transport costs. Our focus on transport costs is motivated by the fact that they are the key "geographic" element of the model, governing the strength of agglomeration economies. It should also be noted that transport costs are intended to broadly measure (inversely) the degree of regional trade integration. Historical improvements in communication networks, due to technical progress and investment in infrastructure, together with the fact that regional economies are becoming increasingly "weightless" (Quah, 1997), suggest that these costs fell substantially over time and may be lowered in the future.[4]

[1] Ciccone and Hall (1996) show that labor productivity in the 10 most productive US states is one-third larger than in the 10 least productive states. Regional productivity differences are even more striking within European countries: for instance, Ciccone (2002) shows that labor productivity in the five most productive German regions is 140% higher than in the five least productive regions. Theoretical determinants of regional productivity differences have been investigated, in particular, by the New Economic Geography literature. See, among others, Fujita et al. (1999).

[2] The data used to calculate these figures come from the Eurostat Regio Database and refer to 106 *Nuts* 2-regions of 9 countries in year 1990.

[3] A pattern of spatial allocation where in spite of negligible migration costs workers do not leave low productivity regions because, e.g., of higher costs of housing, seems to accord well with empirics, as discussed, among others, by Ciccone and Hall (1996).

[4] The surge of the "weightless" economy refers to the fact that a growing share of value added is represented by intangible goods (like software). These goods are not embodied in physical objects and hence are not subject to transport costs.

Our main results can be summarized as follows. First, we show that the agglomeration of economic activity causes core regions to enjoy lower unemployment than the periphery. Therefore, variables affecting the spatial distribution of production, such as transport costs, also affect regional disparities in unemployment. In particular, starting from a symmetric equilibrium for high transport costs, we find that a fall of these costs triggers a wave of migration, which leads to the emergence of a core-periphery equilibrium, with strong and persistent disparities both in terms of per capita income and unemployment. The intuition behind this result is that, when the symmetric equilibrium breaks down, agglomeration economies increase profits in the core and induce the opening of new vacancies, thereby lowering unemployment. The opposite happens in the periphery, where the fall in profits deteriorates the labor market conditions. This translates into a core-periphery unemployment gap.

Second, by studying the transitional dynamics, we show that immigration lowers the unemployment rate of the host region in the long-run, but raises it in the short-run. The reason is that the immediate effect of in-migration is to increase the pool of job seekers, while out-migration lowers it. However, as soon as migrants are gradually absorbed by the labor market of the host region, agglomeration forces kick in and lower local unemployment, the opposite happening in the other region. Therefore, migration from the periphery to the core may reduce unemployment disparities at first, but amplifies them in the long-run.

The two basic ingredients of our model are agglomeration economies and search frictions. In particular, our model is related to the NEG literature (Fujita et al., 1999; Baldwin et al., 2003) and the equilibrium unemployment theory (Pissarides, 1990). Our picture of regional unemployment disparities in the long-run mirrors that of regional income disparities provided by NEG models. It should be noted, however, that our main insight, namely, that agglomeration forces can account not only for income inequality, but also for the uneven distribution of unemployment, is not intrinsically linked to the NEG way of producing agglomeration economies: even "Marshallian" externalities would produce similar results. Moreover, compared to more traditional NEG models, our framework has the interesting feature of having well-defined transitional dynamics even in the absence of migration costs.

We are not aware of other papers combining the NEG and search literature to study regional unemployment differentials. Other contributions, however, use search in NEG models to understand other issues. In particular, Monfort and Ottaviano (2002) introduce search frictions in a NEG model to analyze the relation between agglomeration and investment in human capital. Ortega (2000) builds a model with search frictions in the job market to show that immigration may reduce the rate of unemployment of the host region in the long-run. Ortega's result, which, like ours, is rather uncommon in the theoretical literature on migration, is generated by the assumptions that immigrants have a higher search cost than the natives and that the two countries' labor markets are structurally different. Because of these asymmetries, Ortega's analysis is appropriate for analyzing international migration. Our approach, instead, is more appropriate for analyzing internal migration and regional unemployment in developed countries as we assume that regional labor markets do not differ structurally, that all workers are identical, and that workers are perfectly mobile across regions.

The paper is organized as follows. Section 2 sets out the formal model. Section 3 analyzes the steady-state of the model, whereas Section 4 discusses its dynamic properties. Section 5 concludes.

2. The model

In this section, we describe a core-periphery model along the lines of Krugman (1991) and Helpman (1998). Our main innovation is to allow for equilibrium unemployment stemming from frictions in the job matching process. We consider an economy in which there are two regions, north and south (indexed by $i = N, S$), two factors, farmers and workers, and two sectors, agriculture and manufacturing. The two regions share the same preferences, technology and original endowments. We assume that it is costly to transport manufactured goods between regions, while the costs of transporting agricultural goods are negligible. Firms in manufacturing use workers to produce a variety of manufactured goods. Workers are mobile between the two regions and their final location is endogenous. The agricultural sector employs farmers to produce an homogeneous good. Farmers account for a fraction $(1-\mu)\in(0,1)$ of the total population, which is normalized to unity. As in Krugman (1991), farmers are immobile and divided evenly between the two regions.[5] Finally, similar to Helpman (1998), we introduce a congestion effect in utility linked to the regional density of population. We think of this effect as capturing mainly that non-traded services—most importantly housing—become more expensive as regional population densities increase. But the congestion effect in utility can also be thought of as capturing other disamenities (e.g., traffic congestion, noise or air pollution) associated with population density. We lay out the model in discrete time[6]; however, in order to save on notation, we omit the time index from all the static equations.

2.1. Households

Individuals are risk-neutral, have time separable preferences and discount future utility at the rate $(1+r)^{-1}$. Utility of any agent in region i is given by:

$$V_{i,t=0} = \sum_{t=0}^{\infty} (1+r)^{-t}\left[(1-\epsilon)c_{i,t} + \epsilon a_{i,t}\right], \tag{1}$$

where instantaneous utility comes from consumption of regional output, c_i, and from the availability of nontraded local "amenities", a_i. The parameter ϵ captures the importance of a_i relative to c_i in utility. Amenities are rival and available in fixed supply A_i, so that each

[5] Immobile farmers provide the centrifugal force that sustains the symmetric equilibrium for high levels of trade barriers. This assumption is formally equivalent to assume a region-specific component in the demand for manufactured goods (including, for example, demand from immobile consumers outside the labor force, but also demand for construction and maintenance of local public infrastructure). Without the agricultural sector (or with farmer mobility), the symmetric equilibrium for high trade barriers would always be unstable, but most of our results would be unchanged.

[6] Discrete time allows us to use numerical methods to solve for transitional dynamics of the model.

consumer enjoys only a fraction $a_i = A_i/L_i$, where L_i is the manufacturing workforce of region i.[7] To preserve symmetry, we assume that the two regions offer the same total amount of amenities, which is normalized to unity: $A_i = A_j = 1$.

2.2. Production

Regional output, Y_i, is a nontraded Cobb–Douglas aggregate of an agricultural input, X_i, and a bundle of differentiated manufactured inputs, M_i[8]:

$$Y_i = \left(\frac{M_i}{\mu}\right)^{\mu}\left(\frac{X_i}{1-\mu}\right)^{1-\mu}$$

The agricultural good is homogeneous and produced in each region by $(1 - \mu)/2$ immobile farmers under constant returns to scale and perfect competition. It is freely traded and taken as the numeraire. Productivity in agriculture is set equal to one. The role of this sector is only to sustain demand in the peripheral region that retains a small share of manufacturing workers. For this reason, we interpret it in a broad sense that includes traditional activities that cannot be easily relocated. For simplicity, we do not study farmers' unemployment.

The manufacturing bundle M_i is defined as a CES function over a continuum of measure n of varieties produced by firms in the whole economy:

$$M_i = \left[\int_0^n \left(m_{i,\omega}\right)^{\frac{\sigma-1}{\sigma}} \mathrm{d}\omega\right]^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where $\sigma > 1$ is the elasticity of substitution between any two varieties and $m_{i,\omega}$ is aggregate demand for variety ω in region i. By minimizing the cost of obtaining one unit of M_i, we find the price index for the bundle M_i:

$$q_i = \left[\int_0^n \left(p_{i,\omega}\right)^{1-\sigma} \mathrm{d}\omega\right]^{1/(1-\sigma)}, \tag{3}$$

where $p_{i,\omega}$ is the final price of variety ω. Aggregate demand for each variety is obtained by using Shephard's lemma on the expenditure function q_iM_i:

$$m_{i,\omega} = \frac{\left(p_{i,\omega}\right)^{-\sigma}}{q_i^{1-\sigma}} \mu P_i Y_i, \tag{4}$$

[7] For simplicity, we do not include farmers (which are equally distributed between the two regions) in the definition of the congestion term a_i. A justification may be that farmers do not contribute much to over-urbanization and pollution compared to manufacturing workers. Given that in our simulations the parameter ϵ, capturing the strength of the congestion effect, is calibrated to yield that a certain fraction of workers stays in the periphery, including farmers in the congestion term would only affect our calibration of ϵ and leave the results unchanged.

[8] The assumption of non-tradeability of aggregate output Y is made for simplicity. Under plausible assumptions, it can be shown that non-tradeability of Y arises endogenously in our model.

where P_i is the price index in region i (and $P_i = q_i^{\mu}$), $P_i Y_i$ is nominal income and μ is the share of income devoted to manufacturing goods implied by the Cobb–Douglas aggregator, so that $q_i M_i = \mu P_i Y_i$.

Manufacturing firms are monopolistically competitive, symmetric and need one worker each; firms and workers are matched in the labor market through a process that requires time. This assumption captures the idea that heterogeneities in skills and jobs make it costly for a firm and a worker to find a suitable partner. Once employed, a worker produces one unit of a single variety which coincides with the final output of the firm, $m_{\omega} = 1$. Since the price of any variety is decreasing in the quantity supplied, no two firms will find it convenient to produce the same variety. Furthermore, as differentiated goods can be traded, each region will specialize in a different range of varieties, so that $n_{\mathrm{N}} + n_{\mathrm{S}} = n$. Given symmetry in production and demand, every variety from each region will have the same production price p_i. Production prices can differ from final prices because of an "iceberg" trade cost: of $\tau > 1$ units shipped to the other region, only one unit arrives at the destination. This implies that the final price in region i of a variety produced in region j is $p_j \tau$ and the price index (3) reduces to:

$$q_i = \left[n_i p_i^{1-\sigma} + n_j (p_j \tau)^{1-\sigma} \right]^{1/(1-\sigma)}, \tag{5}$$

for i,j = N,S and $i \neq j$.

2.3. The labor market

We assume that for workers to search for a job in a region they have to live in it. As a firm decides to enter the market, it has to post a vacancy and incurs a search cost of c units of Y_i in every period until a suitable worker has been found. The search cost is financed by borrowing from households at the real interest rate $(1 + r)$, so that aggregate output Y_i is allocated between consumption and investment in vacancies. Following Pissarides (1990), the frictions generated by heterogeneity in the labor market are summarized by a function that gives the measure of successful matches per period. In the simplest approach, this function depends positively on the number of job seekers and the number of vacant jobs. For tractability, we assume that it takes the form $u_i v_i / (u_i + v_i)$, where u_i represents the unemployment rate and v_i is the number of searching firms as a fraction of the labor force.[9] Defining $\theta_i = v_i / u_i$ as the "tightness" of the labor market, we can write the probability (Θ_i) that an unemployed worker will be matched as a monotonically increasing function of θ_i:

$$\Theta_i = \frac{v_i}{u_i + u_i} = \frac{\theta_i}{1 + \theta_i}.$$

[9] The chosen formulation for the matching function ensures a proper discrete time matching, i.e., that the matching probabilities for workers and firms posting a vacancy are each less than one. This property would be lost in discrete time with a Cobb–Douglas specification (which is instead commonly used in continuous time models). Note also that the chosen matching function exhibits constant returns to scale, in line with most empirical estimates. See Petrongolo and Pissarides (2001) on this point.

Similarly, the probability that a firm will fill a vacancy is $u_i/(u_i+v_i)=1/(1+\theta_i)=(1-\Theta_i)$. Matches are destroyed at the exogenous rate s. Upon separation, both the firm and the worker must reenter the labor market.

The asset value at time t of a firm with a filled job, $V^{\mathrm{f}}_{i,t}$, can be expressed, in units of final output, as the sum of its real profits at time t, $(p_{i,t}-w_{i,t})/P_{i,t}$ (where $w_{i,t}$ denotes the wage rate), plus the expected discounted value of the firm at time $t+1$:

$$V^{\mathrm{f}}_{i,t}=\frac{p_{i,t}-w_{i,t}}{P_{i,t}}+\frac{(1-s)V^{\mathrm{f}}_{i,t+1}+sV^{\mathrm{v}}_{i,t+1}}{1+r}. \tag{6}$$

Note that with probability s the match is destroyed, and hence the value of the firm falls to $V^{\mathrm{v}}_{i,t+1}$, which represents the value at time $t+1$ of a searching firm. Next period income is discounted by the rate of interest, which is equal to the rate of time preference because consumers are risk-neutral.

Similarly, the value at time t of a firm posting a vacancy, $V^{\mathrm{v}}_{i,t}$, equals the expected discounted value of the firm in the next period, minus the search cost c:

$$V^{\mathrm{v}}_{i,t}=-c+\frac{\Theta_{i,t}V^{\mathrm{v}}_{i,t+1}+\left(1-\Theta_{i,t}\right)V^{\mathrm{f}}_{i,t+1}}{1+r}. \tag{7}$$

Note that the value of the firm rises to $V^{\mathrm{f}}_{i,t+1}$ in case of a successful match, i.e., with probability $(1-\Theta_{i,t})$.

We assume free entry of firms, hence, the value of posting a vacancy must be zero. Imposing $V^{\mathrm{v}}_i=0$ in Eq. (7) yields:

$$V^{\mathrm{f}}_{i,t+1}=\frac{(1+r)}{1-\Theta_{i,t}}c. \tag{8}$$

Using Eq. (8) into Eq. (6) and imposing $V^{\mathrm{v}}_i=0$, we obtain:

$$V^{\mathrm{f}}_{i,t}=\frac{p_{i,t}-w_{i,t}}{P_{i,t}}+\frac{(1-s)}{1-\Theta_{i,t}}c. \tag{9}$$

To avoid some uninteresting complications, we assume that employed workers cannot quit their job.[10] The value for an employed worker at time t in terms of utility, $V^{\mathrm{e}}_{i,t}$, equals current period utility, $(1-\epsilon)w_{i,t}+\epsilon/L_{i,t}$, plus the expected discounted value at time $t+1$:

$$V^{\mathrm{e}}_{i,t}=(1-\epsilon)w_{i,t}+\frac{\epsilon}{L_{i,t}}+\frac{s\max\left\{V^{\mathrm{u}}_{i,t+1},V^{\mathrm{u}}_{j,t+1}\right\}+(1-s)V^{\mathrm{e}}_{i,t+1}}{1+r}, \tag{10}$$

for $i,j=\mathrm{N,S}$ and $i\neq j$. Note that with probability s the match is destroyed and the worker becomes unemployed in the next period. In that case, the value falls automatically to the highest value of being unemployed in the two regions, $\max\{V^{\mathrm{u}}_{i,t+1},V^{\mathrm{u}}_{j,t+1}\}$, as the worker can move freely to the location offering the best prospects.

[10] This assumption has no bearings on long-run equilibria. Further, it can be shown that unemployed workers have a stronger incentive to move than those who have a job. Therefore, along a transition, our constraint on mobility of employed workers would be binding only in the extreme case when all the unemployed workers have left a region. Since this never happens for sufficiently small shocks, it follows that our simplifying assumption does not affect local dynamics either.

By the same reasoning, the value for a job seeker in region i equals:

$$V_{i,t}^{\mathrm{u}} = \frac{\epsilon}{L_{i,t}} + \frac{\Theta_{i,t} V_{i,t+1}^{\mathrm{e}} + \left(1 - \Theta_{i,t}\right) \max\left\{ V_{i,t+1}^{\mathrm{u}}, V_{j,t+1}^{\mathrm{u}} \right\}}{1+r}, \tag{11}$$

for i,j = N,S and $i \neq j$. Wages are flexible, i.e., there is renegotiation in each period (see Pissarides, 1990).[11] They are determined as the solution to a Nash bargaining problem, implying that the worker surplus is a constant fraction β of the total surplus generated by the match. To calculate this, we express the worker surplus as the amount of consumption goods that leaves a worker indifferent between staying in the job and becoming unemployed. Then, wages must satisfy the sharing condition:

$$\frac{V_i^{\mathrm{e}} - \max\left\{ V_i^{\mathrm{u}}, V_j^{\mathrm{u}} \right\}}{1-\epsilon} = \beta \left(\frac{V_i^{\mathrm{e}} - \max\left\{ V_i^{\mathrm{u}}, V_j^{\mathrm{u}} \right\}}{1-\epsilon} + V_i^{\mathrm{f}} \right), \tag{12}$$

where the left hand side represents the worker surplus (in terms of Y) and the right hand side is β times the total surplus.

Unemployed workers can move costlessly between regions. An unemployed worker of region j will migrate to region i if and only if $V_i^{\mathrm{u}} > V_j^{\mathrm{u}}$. Hence, the equilibrium distribution of the workforce (L_i and L_j with $L_i + L_j = \mu$) is characterized by the following conditions:

$$\begin{cases} V_i^{\mathrm{u}} = V_j^{\mathrm{u}} & \text{if } \min\{\mathrm{u_i}, \mathrm{u_j}\} > 0; \\ u_j = 0 & \text{if } V_i^{\mathrm{u}} > V_j^{\mathrm{u}}. \end{cases} \tag{13}$$

In the first case, we are at an interior solution: only a fraction of the unemployed workers move and the distribution of labor is determined by the indifference condition $V_i^{\mathrm{u}} = V_j^{\mathrm{u}}$. In the second case, all the unemployed workers prefer to leave region j so that $L_j = n_j$.

Finally, in each period t, a measure $sn_{i,t}$ of jobs are exogenously destroyed, whereas a measure $\Theta_{i,t} u_{i,t} L_{i,t}$ of new jobs are created. Hence, the measure of producing firms, which is identically equal to the measure of employed workers, evolves according to the following law of motion:

$$n_{i,t+1} = (1-s) n_{i,t} + \Theta_{i,t} u_{i,t} L_{i,t}. \tag{14}$$

2.4. General equilibrium

In order to close the model, we impose the following general equilibrium conditions. First, regional nominal income equals the value of agricultural production plus manufacturing:

$$P_i Y_i = \frac{1-\mu}{2} + p_i n_i. \tag{15}$$

[11] The assumption of flexible wages is commonly made in search models for tractability. In this context, it rules out the possibility that regional unemployment disparities are affected by institutional rigidities in the regional wage-setting process, as suggested instead by some authors (see Jimeno and Bentolila, 1998 for the Spanish case). Our assumption of flexible wages allows us to isolate a different mechanism.

Further, since we allow for equilibrium unemployment, the labor market clearing condition is replaced by the requirement that the number of employed workers be equal to the number of active firms:

$$n_i = L_i(1 - u_i). \tag{16}$$

Finally, given regional income, market clearing for manufacturing goods requires the total supply of each variety (one unit) to equal total demand from both regions. Using Eq. (4), we obtain:

$$1 = \frac{p_i^{-\sigma}}{q_i^{1-\sigma}} \mu P_i Y_i + \frac{p_i^{-\sigma} \tau^{1-\sigma}}{q_j^{1-\sigma}} \mu P_j Y_j, \tag{17}$$

for i,j = N,S and $i \neq j$.

Using Eqs. (15) and (16) into Eq. (17), we finally obtain:

$$p_i^{\sigma} = \mu \left[q_i^{\sigma-1} \left(\frac{1-\mu}{2} + p_i L_i (1 - u_i) \right) + \left(\frac{q_j}{\tau} \right)^{\sigma-1} \left(\frac{1-\mu}{2} + p_j L_j (1 - u_j) \right) \right]. \tag{18}$$

Eq. (18) shows that total demand faced by manufacturing firms located in region i is higher the higher is income in regions i and j, the lower is competition in these markets (i.e., the lower are q_i and q_j, which are decreasing in the number of firms selling in markets i and j) and the lower are transport costs.[12] Note that, ceteris paribus, transport costs reduce the share of market j in the total sales of firms located in region i. Hence, local income has a disproportionate effect on local firms' demand relative to income from the other region (the so-called home market effect). This implies that a reshuffling of unemployment from region i to region j (and hence a reshuffling of income from region j to region i) has the effect of increasing (reducing) total demand faced by manufacturing firms located in region i (j).

3. Steady-state analysis

A steady-state is defined as an equilibrium where all variables are constant and there is no migration.[13] This immediately implies $V_{i,t}^{e} = V_{i,t+1}^{e}$, $V_{i,t}^{u} = V_{i,t+1}^{u}$ and $V_{i,t}^{u} = V_{j,t}^{u}$. Under these conditions, Eqs. (10) and (11) yield:

$$V_i^{e} = \frac{r+1}{r} \left[\frac{(r+\Theta_i)(1-\epsilon)}{(r+s+\Theta_i)} \frac{w_i}{P_i} + \frac{\epsilon}{L_i} \right], \tag{19}$$

$$V_i^{u} = \frac{r+1}{r} \left[\frac{\Theta_i(1-\epsilon)}{(r+s+\Theta_i)} \frac{w_i}{P_i} + \frac{\epsilon}{L_i} \right]. \tag{20}$$

[12] Eq. (18) is the equivalent of the so-called wage equation of NEG models. See, for instance, Fujita et al. (1999, pp. 42–43).

[13] The absence of migration in a steady-state is rational in the presence of a positive, but arbitrarily small, migration cost.

Similarly, imposing steady-state on Eqs. (8) and (9), we can obtain the following price equation:

$$p_i = w_i + \frac{cP_i(r+s)}{1-\Theta_i}. \tag{21}$$

Using Eqs. (9), (12), (19), (20) and (21), we can express the equilibrium real wage and real price of a variety produced in region i, p_i/P_i, as functions of the job finding rate (Θ_i) and parameters:

$$\frac{w_i}{P_i} = \frac{\beta c(\Theta_i + r + s)}{(1-\beta)(1-\Theta_i)}, \tag{22}$$

$$\frac{p_i}{P_i} = \frac{\beta c[\Theta_i + (r+s)/\beta]}{(1-\beta)(1-\Theta_i)}. \tag{23}$$

As a final requirement, in steady-state, the number of unemployed workers is constant. From Eq. (14), this implies that the flow of laid off workers offsets exactly the flow of job seekers who are hired. Hence, from Eqs. (14) and (16), the steady-state rate of unemployment is given by:

$$u_i = \frac{s}{s+\Theta_i}. \tag{24}$$

Summarizing, the steady-state of the system is described by Eqs. (5), (8), (13), (15–17), (19), (20) and (22–24), and by the equivalent equations for region j.

We can now explore the steady-state properties of the model. Since the system is non-linear and has no analytical solution, we proceed by numerical simulations. We consider first the effects of decreasing transport costs, τ, on the geographic distribution of production, people and unemployment; then, we mention the effects of the other parameters in the model.

3.1. Trade, migration and regional unemployment

Before turning to numerical examples, we briefly summarize the forces that affect the geographical structure of the economy. Since the two regions are originally identical, the model will always exhibit a symmetric equilibrium in which manufacturing production is evenly distributed. However, labor mobility implies that a geographically differentiated production structure may arise. The specific outcome depends on the migration choice, which is in turn determined by a tension between centripetal and centrifugal forces. Transport costs in manufacturing generate agglomeration forces that tend to attract firms and workers toward the region with the larger market to save on transport costs. Centrifugal forces arise because competition for local farmers' demand is lower in the smaller region and this tends to increase, ceteris paribus, wages and profits in the peripheral region. Congestion effects in utility further reduce the incentive for agglomeration. Consistent with a well-established result from the new economic geography literature (e.g., Baldwin et al., 2003; Fujita et al., 1999), we find that for

Table 1
Baseline parameter values

Interest rate	r = 0.02 per quarter
Elasticity of substitution among manufactures	$\sigma = 5$
Share of mobile sector	$\mu = 0.75$
Separation rate	s = 0.045 per quarter
Worker's bargaining power	$\beta = 0.5$
Search costs	$c = 0.9$
Weight of amenities in preferences	$\epsilon = 0.015$

very high or very low transport costs centrifugal forces prevail, so that the symmetric equilibrium is unique. Conversely, agglomeration forces prevail for intermediate levels of transport costs. In this case, the symmetric equilibrium becomes unstable and a stable core-periphery pattern emerges: workers and firms leave the peripheral region (the south) and manufacturing production becomes partially agglomerated in the core region (the north).[14]

3.1.1. Parametrization

The baseline parameter values used in our simulations are reported in Table 1. The length of the period is one quarter. Accordingly, the interest rate is set to $r = 0.02$, equivalent to an annual discount factor of 0.923. The job separation rate is $s = 0.045$ to yield an average job duration of about 5.5 years, consistent with the recent European experience (Pissarides, 1998). The worker's rent share, β, is one half, as implied by the common assumption of symmetric Nash bargaining. The recruitment cost, c, is chosen to give reasonable values for the unemployment rate. The weight of amenities in utility, ϵ, is set to yield a share of manufacturing workers left in the periphery roughly equal to 20% of the original manufacturing workforce. As for the elasticity of substitution between manufactures, σ, we refer to some recent empirical estimates of this parameter which suggest an average value around $\sigma = 5$.[15] Finally, the share of the manufacturing sector, μ, is set to 0.75, implying that one-fourth of national expenditure is region-specific. Since, however, the quantitative implications of the model are sensitive to the choice of σ and μ, in the next section, we report how the main results change using alternative values.

3.1.2. Results

Fig. 1 summarizes the steady-state evolution of regional variables as a function of transport costs.[16] Only (locally) stable equilibria are displayed. In all graphs, the solid line

[14] As in other core-periphery models, we also find that, before the symmetric equilibrium breaks down, there is a range of transport costs where both types of equilibria are stable. Unfortunately, we cannot characterize the break-point of the model and the stability of equilibria analytically. To study local stability properties of equilibria, we have linearized the system in a neighborhood of the steady-state. Details on the transitional dynamics are discussed in Section 4.

[15] See, in particular, the empirical studies surveyed in Head and Mayer (2003) on this point.

[16] Available estimates of trade costs within countries suggest that they rise very quickly with distance. For instance, Crozet's (2003) estimates of the elasticity of trade costs with respect to distance vary between 0.5 and 3 within European countries.

Fig. 1. Steady-states as function of transport costs.

represents northern variables whereas the dashed line refers to the south. The fall of transport costs is represented by a movement to the left on the x-axis.

Panel (a) reports the share of manufacturing workers in the two regions. For very high τ, there is only one equilibrium in which workers are evenly divided between the two regions (the solid and dashed lines are overlapped). When transport costs are reduced below a threshold level, the symmetric equilibrium breaks down: employment and production agglomerate discontinuously in the core, although the periphery keeps a positive share of manufacturing. The reason for partial agglomeration is that in this model, contrary to Krugman (1991), agglomeration forces are bounded by the congestion effect in utility.[17] The graph also shows that, before the symmetric equilibrium loses stability, there is a small range of transport costs where both the symmetric and the partially agglomerated equilibria are stable.[18] In this range, a sufficiently large shock may move the economy from one equilibrium to the other. The breakdown of the symmetric equilibrium is

[17] Partial agglomeration is also a feature of Puga's (1999) model, under the assumptions of interregional immobility of labor and decreasing marginal productivity of labor in the residual sector. Recently, Tabuchi and Thisse (2002) have shown that partial agglomeration can also be generated by heterogeneity in workers' valuation of local amenities.

[18] This is a common feature of core-periphery models (e.g., Krugman, 1991; Fujita et al., 1999; Baldwin et al., 2003). We are not interested in this multiplicity, which is not always robust to alternative specifications of the congestion effect.

followed by a substantial range of transport costs where lower transport costs are associated with small changes in the geographic distribution of workers and production. Finally, for low transport costs, agglomeration forces are weakened and can no longer offset the disutility induced by congestion in the north. This triggers a wave of in-migration to the south until the symmetric equilibrium is restored.

Panel (b) reports the price index of manufacturing, which can be thought of as an inverse index of regional productivity in manufacturing. When symmetry breaks down, a large mass of workers and firms leave the south, and hence this region has to import most manufacturing goods from the north. As a consequence, transport costs become a relevant component of the price index, which explains its dramatic increase in the south. The opposite happens in the north, where agglomeration induces a fall in the volume of imports and in the price index. Note, also, that further falls in transport costs imply a different response by the two regions' price indexes. Since northern imports from the south are small, the price index is fairly stable in this region. Conversely, since the south imports most manufacturing goods from the north, the fall of its price index closely mirrors the fall of transport costs.

Panel (c) illustrates the evolution of regional rates of unemployment. To gain some intuition, it is useful to rewrite Eq. (21) as follows:

$$\Theta_i = 1 - \left(\frac{p_i - w_i}{P_i}\right)^{-1} c(r+s). \tag{25}$$

When the symmetric equilibrium breaks down, agglomeration economies cause a sharp increase in the real value of profits in the north and induce the opening of new vacancies, thereby raising the labor market tightness in the north. The opposite happens in the south, where the fall in the real value of profits deteriorates the labor market conditions. This translates into a core-periphery unemployment gap. Note, from Eq. (18), that there is also an indirect effect at work. The fall of unemployment in the north and the rise in the south raise demand for northern firms and reduce demand for southern firms, thereby giving an extra push to agglomeration forces. Further reductions in transport costs reinforce at first agglomeration economies in the north and thus amplify the core-periphery unemployment gap. However, panel (c) also shows that, when transport costs are low enough, the geographic advantage of the core vanishes, so that the periphery experiences a wave of in-migration which reduces the steady-state rate of unemployment (partly at the expense of the north). Hence, as out-migration from the periphery generated the emergence of regional disparities, in-migration to the periphery speeds up the process of convergence. Finally, once the symmetric equilibrium is restored, further falls of transport costs reduce unemployment in both regions because they lower the price index of manufacturing.

Panel (d) shows the evolution of regional real consumption wages. Note, from Eq. (22), that real wages are monotonically related to the job finding rate, which also determines the unemployment rate. Hence, regional real wages mirror inversely the behavior of unemployment rates. As a consequence, agglomeration of labor force in the north deteriorates labor market conditions in the periphery both by increasing the unemployment rate and by reducing real consumption wages. By the same reasoning, when transport costs become very low, in-migration to the periphery speeds up convergence of both unemployment rates and real consumption wages.

Fig. 1 is a collection of steady-state equilibria. Overall, it provides a picture of the relation between transport costs and the geography of production, workers and unemployment in the long-run. Its main message is that geographic variables matter for unemployment, since the geography of unemployment strictly follows (inversely) the geography of production. This means that variables, such as transport costs, that influence the spatial distribution of economic activities also determine unemployment. Note, however, that there is a substantial range of intermediate transport costs in which a fall in these costs is associated with an almost unchanged geography of production. Interestingly, in this range, the model mimics the recent experience of regional inequality within European countries, characterized by low and falling migration rates despite persistent disparities both in terms of unemployment and per capita income, just as illustrated in Fig. 1.[19]

Finally, the model suggests that, contrary to conventional wisdom, the unemployment gap is triggered by migration flows. In particular, in-migration, by fuelling agglomeration forces, reduces unemployment and raises real wages in the host region, whereas out-migration raises unemployment and lowers real wages for those left behind.

3.1.3. Alternative parametrizations

The general pattern displayed in Fig. 1 is fairly robust to alternative parametrizations. The most notable changes take place when the strength of agglomeration forces varies. This, in turn, is determined by σ, μ and ϵ. As it is well known from the new economic geography literature, a higher share of manufactured goods in production, μ, or a lower elasticity of substitution among varieties, σ, imply stronger agglomeration forces. In terms of Fig. 1, this translates into wider core-periphery disparities and a higher critical value of τ under which symmetry is broken. Consistent with other core-periphery models, we find that the symmetric equilibrium is unstable for high values of τ if agglomeration forces are too strong.[20] Similarly, a lower weight of local amenities in utility, ϵ, implies a lower disutility from congestion and a stronger incentive to agglomerate production in one region, thereby inducing greater regional disparities and a lower share of workers left in the periphery.

Given that there is some disagreement on values of σ and μ, we want to have a sense of how the quantitative predictions of our model depend on them. Further, we want to assess the ability of the model to generate quantitatively significant north–south inequalities. To this end, Table 2 shows, for an intermediate level of transport costs ($\tau = 2$), the rate of unemployment in the periphery relative to that

[19] See, among others, Faini et al. (1997), Bentolila (1997), Mauro et al. (1999) and Overman and Puga (2002).

[20] Our simulations confirm that the symmetric equilibrium is stable for high trade costs when $(\sigma-1)/\sigma>\mu$, i.e., when the so-called no-black-hole condition is satisfied (see Fujita et al., 1999, pp. 58–59).

Table 2
Relative unemployment

	μ = 0.75	μ = 0.9
σ = 3	1.35	1.81
σ = 5	1.17	1.34
σ = 7	1	1.2

in the core predicted by the model under alternative values of σ and μ found in the literature.

Note that, with strong agglomeration economies (σ = 3 and μ = 0.9), the model yields a peripheral unemployment rate that is 81% higher than that in the core, a value not far from the one observed in some European countries, such as Spain and Italy; for intermediate cases, the model generates a north–south unemployment gap in the range of 20%–30%, perhaps too small to match the regional unemployment disparities in these countries, but still remarkable given that it comes from a model with no structural asymmetries between regions, no migration costs and no regional wage stickiness.

To better understand these numbers, Fig. 2 shows the evolution of the unemployment rate in the two regions for the most extreme cases considered. As already mentioned, with weak agglomeration forces, regional disparities are small and emerge at low levels of transport costs, as in panel (a). On the contrary, when agglomeration forces are very strong, the symmetric equilibrium is always unstable for high τ and regional disparities may become very large, as in panel (b).

Finally, regional disparities are not very sensitive to the labor market parameters, namely, the rate of job destruction, s, the share of the match surplus that goes to workers, β, and the search cost, c. Variation in these parameters generally induces changes in the regional rates of unemployment in the direction predicted by the equilibrium unemployment theory. For instance, a rise of s, c or β increases unemployment in both regions. Extensive simulations suggest, however, that varying these parameters within any plausible range has only minor effects on regional inequalities.

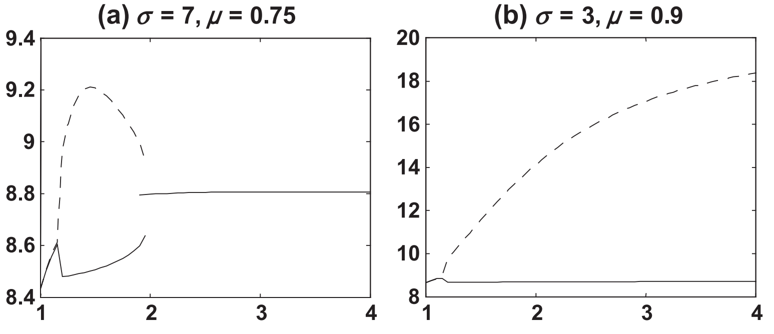

Fig. 2. Unemployment disparities, alternative parametrizations.

4. Dynamics

In this section, we study the adjustment path which leads the system from one steady-state to another after an unanticipated, permanent shock. Although the assumption of no mobility costs makes the model more suited to address long-run issues, the steady-state analysis alone would be incomplete, as the short-run dynamics govern the stability of equilibria. Moreover, by solving for the transitional dynamics, we will see that migration may have a different impact on regional unemployment in the short-run and long-run.

To select the (locally) stable equilibria, we have linearized the equilibrium conditions in a neighborhood of each steady-state and computed the eigenvalues of the dynamic system. We followed this procedure for every equilibrium point in Figs. 1 and 2, and we displayed only those that are saddle-path stable (see Appendix A for more details). Now, we use the computed eigenvalues, together with the linearized system, to show the transitional dynamics implied by the model after a reduction of transport costs starting from an equilibrium in which manufacturing is already partially agglomerated in the north. This exercise naturally complements our previous analysis, as it gives a picture of the short-run adjustment between the steady-states displayed in Figs. 1 and 2. At time $t = 0$, the economy

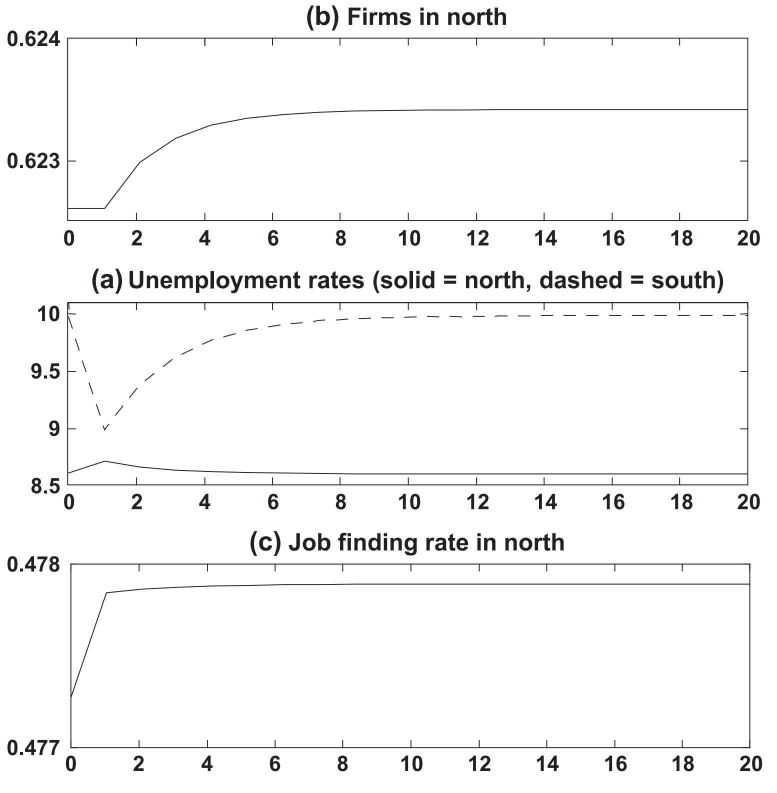

Fig. 3. Dynamics.

is in steady-state and at $t = 1$ there is a one and for all unanticipated fall in transport costs, from $\tau = 2$ to $\tau = 1.9$ (all the other parameters are the same as in Table 1).

Results are depicted in Fig. 3. Panel (a) plots the time path of total manufacturing employment in the north. In this exercise, the reduction of transport costs reinforces the geographical advantage of the north, which makes the core region more attractive for locating manufacturing workers. The outcome is a wave of migration from the periphery. The reaction of employment is gradual: it rises smoothly in the north, where the higher number of job seekers increases the likelihood of a match. Similarly, it falls gradually in the south, because the rate of job destruction is not compensated any more by new matches. The eventual increase in employment in the north and the fall in the south strengthen even more agglomeration forces in the core region, until the new steady state is reached.[21]

Panel (b) shows the evolution of regional unemployment rates. As unemployed workers move from the south to the north, the instantaneous effect of a fall in transport costs is a temporary discrete fall in the unemployment rate of the south and a rise in the north. As manufacturing production agglomerates in the core, the unemployed workers are gradually absorbed. The opposite happens in the south. The short-run increase in the unemployment rate of the region experiencing an inflow of immigrants should not be interpreted as a deterioration of labor market conditions: the prospect of higher real profits due to agglomeration economies increases immediately the value of creating vacancies for northern firms and the job-finding rate (Θ_i) grows monotonically to the new, higher, steady-state level, as shown in panel (c).

These transitional dynamics highlight a contrast between the short-run and long-run effects of migration flows on the core-periphery unemployment gap. Migration may cause a temporary convergence in the regional rates of unemployment, but once the southern immigrants are absorbed by the northern labor market, the unemployment gap is permanently higher than before the shock. Therefore, our model suggests that the short-run impact of immigration on unemployment can be different from its long-run effect.

5. Conclusions

In this paper, we have formulated a dynamic two-region model with search frictions in the job market, where the spatial allocation of production, workers and unemployment stems from a tension between agglomeration economies in production and congestion effects in utility. We have shown that the same factors producing agglomeration and regional productivity differences also induce persistent unemployment disparities. The reason is that agglomeration economies increase profits in the core and induce the opening of new vacancies, thereby lowering unemployment. Despite negligible migration costs, lower wages and higher unemployment in the periphery, some workers do not move to the more productive region because of congestion effects (which we interpret as capturing

[21] Another result of our simulations (not reported to save space) is that, despite perfect labor mobility, migration during the transition tends to be gradual: as incoming migrants are gradually employed, the geographic advantage of the north is reinforced and this attracts even more workers from the south.

more expensive non-traded services—most importantly housing—as well as agglomeration diseconomies like pollution). This translates into a stable core-periphery unemployment gap. By studying explicitly the transitional dynamics, we have shown a contrast between the short-run and long-run effects of migration on regional unemployment. In the short-run, migration from the periphery to the core may lower unemployment disparities but in the long-run unemployment disparities will be amplified. We have also argued that our main assumptions and conclusions seem to accord well with the existing evidence on spatial dynamics.

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Appendix A. Notes on simulations

Overall, the model has 24 unknowns: Y_i, P_i, q_i, p_i, n_i, Θ_i, w_i, u_i, V_i^{f}, V_i^{e}, V_i^{u}, L_i, for $i=\mathrm{N}$, S. By substituting out the price index P_i and L_j from the population constraint, we can characterize the equilibrium as the solution of a system of 21 equations, including eight inter-temporal equations for the two state variables, n_i, and the value functions: V_i^{f}, V_i^{e}, V_i^{u} for $i=\mathrm{N}$, S. Price indexes and the market clearing conditions for manufacturing are the only non-linear equations, with no analytical solution. As for the rest, the system is linear.

Steady-states are found using a non-linear equation solver on the system given by Eqs. (5), (8), (13), (15–17), (19), (20) and (22–24). In order to find all the equilibria for any given t, we have solved the system without the mobility condition (13) for all possible values of $L_i \in (0, \mu)$. Equilibria are then identified as the points where the function $V_i^{\mathrm{u}}/V_j^{\mathrm{u}}$ takes value one. Local stability of equilibria is examined by studying explicitly the transitional dynamic in a neighborhood of each steady-state. Fig. 1 reports only the saddle-path stable equilibria.

Transitional dynamics are solved by linearization around the steady-state. We proceed as follows. Let x_t denote the vector of variables in the system at time t. From Eqs. (8), (10), (11) and (14), we can solve the inter-temporal equations to get each variable at $t+1$ (n_i, V_i^{f}, V_i^{e}, V_i^{u}) as a function of time t variables only. Then, the system is rewritten in the form:

$$Ax_{t+1} = Bx_t$$

where A and B are the coefficient matrices resulting from the linearization. Further, x_t is arranged so that the state variables come first, then come the other inter-temporal equations and finally the intra-temporal equations follow. Given the presence of intra-temporal equations, A is singular and non-invertible and hence standard diagonalization methods do not work. To circumvent the problem, we have used a solution method based on the generalized Schur decomposition that can handle intra-temporal equations. See Klein (2000) for details on this solution method.

The choice of a local solution method is dictated by computational convenience, as our model is multi-dimensional, with two state variables (n_i and n_j), and non-linear. Our approximation is reliable because we study the dynamic adjustment between steady-states that are fairly close to each other and because most of the equations of the original system (including all the dynamic equations) are linear. To check the accuracy of the simulation reported in Fig. 3, we fed the original dynamic system with the simulated path and verified that errors from linearization are negligible.

In the dynamic simulation, the timing of events is the following. At $t = 0$ the economy is in the old steady-state. At $t = 1$, the system is hit by the shock: the pre-determined state variables cannot change, but the remaining jump variables are now determined by the decision rules corresponding to the new steady-state. At $t = 2$, the state variables start to move, according to Eq. (14).

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