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Regional unemployment and productivity in Europe*

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Abstract. We analyse the relationship between regional unemployment and labour productivity in Europe, basing our empirical analysis on the predictions of a Neary-type General Oligopolistic Equilibrium trade model with efficiency-wages. Using semiparametric and dynamic panel data estimators and controlling for other factors, we give evidence of a nonlinear relationship between productivity and regional unemployment in Europe: with a level of productivity smaller than a certain threshold, this relationship is negative, while no relation occurs in the case of higher productivity regions. This evidence proves an important role of a wage-floor (induced by efficiency wages and exacerbated by institutional factors) under which the productivity gap cannot be compensated by a wage gap.

JEL classification: C14, D50, F12, J41, R23

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1 Introduction

The existence and persistence of large spatial disparities in unemployment within national economies has become a central issue in regional economics.[1] It has rapidly expanded beyond

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[1] Until the mid-nineties the regional dimension of European unemployment was highly disregarded (Bean 1994) and most of the studies were carried out on UK and US data. In the second half of the nineties, many contributions set up the basis for the analysis of regional unemployment in Europe. Among the many, see Taylor and Bradley (1997), Martin (1997), Pench et al. (1999), Overman and Puga (2002), Decressin and Fatàs (1995), Fatàs (2000), Kostoris Padoa Schioppa and Basile (2002) and Niebuhr (2002).

the boundaries of the research field[2] and has entered the policy agenda especially in European countries.

As it has been reported by the European Commission (EC 2002), regional unemployment rates in the European Union reveal a pronounced and persistent core-periphery structure, with very high unemployment rates concentrated in peripheral regions. Regional unemployment differentials are wide and persistent, regional wages are relatively insensitive to local economic conditions and labour mobility from the periphery to the economic core is insufficient in reducing regional disparities. Such characteristics contributed to the classification of Europe as a case study of labour market rigidity. Especially in comparison with the US case (Blanchard and Katz 1999), where unemployment rates are lower, much more equally spread across regions and less persistent over time, the causes of European unemployment, at the national and the regional level, have been generally attributed to the role of labour market institutions in prolonging the otherwise temporary effect of aggregate demand shocks (Bentolila and Bertola 1990) and to the limited labour mobility and the downward rigidity of nominal wages (Blanchard and Portugal 2001). In addition to this general and widely shared class of explanations, the empirical analyses on regional unemployment have proposed a large set of explanatory variables, capturing labour supply, labour demand and wage-setting factors. Elhorst (2003a), in his review of the literature on regional unemployment differentials, gives a comprehensive description of the many variables included in recent empirical analyses. They go from variables positively correlated with unemployment, such as the weight of young people on the population or the presence of amenities in the region, to variables negatively correlated with it, such as the participation rate, GDP per capita, and industry concentration. Surprisingly enough, among the many variables included in regressions, labour productivity has never been explicitly considered as a relevant explanatory factor of regional unemployment. However, we claim that one cannot explain wide and persistent unemployment disparities in Europe without taking into account the role of fundamentals. Unemployment is undeniably driven by labour productivity and real wages and, because of the centralisation of the national wage-setting process, labour productivity differentials appear as one of the main determinants of regional unemployment disparities.

The task of this article is therefore to analyse the relationship between regional unemployment, wages and productivity differentials in Europe. We built our analysis on the insights coming from the merge of a General Oligopolistic Equilibrium (GOLE) model proposed by Neary (2002, 2003) with the Shapiro and Stiglitz (1984) efficiency wage model. The main prediction of the model is that the relationship between productivity and unemployment is nonlinear and asymmetric. A negative relationship does exit in the case of low-productivity regions (say the ‘periphery’), while no or very limited negative relationship exists in the case of high productivity regions (say the ‘core’). The reason behind such asymmetric effect is the constraint imposed by the no-shirking condition on the possibility for regional productivity gaps to be fully matched by regional wage gaps.

Subsequently, we carry out an empirical analysis to verify these predictions. Using semi-parametric and dynamic panel data methods, controlling for wages, labour force participation, market potential, labour market regulation and spatial correlation, we give evidence of the nonlinear negative relationship between labour productivity and regional unemployment as predicted by the model. The implication is noteworthy: a change in productivity has a regional asymmetric effect on the labour market, affecting unemployment much more in the periphery than in the core.

[2] The issue is now largely recognised as relevant by macroeconomists. As it has been noticed by Blanchard and Katz (1999), since Blanchflower and Oswald (1994) the understanding of the regional dimension of unemployment is considered as “. . . a more appropriate testing ground for comparing Phillips curve and wage curve specifications” (Blanchard and Katz 1999, p.72).

The rest of the article is organised as follows. Section 2 sketches the model, section 3 bridges theory and data and section 4 presents the empirical evidence in support of the predictions of the theoretical model. Section 5 stresses the implications in terms of employment policies and concludes.

2 A general oligopolistic equilibrium efficiency-wage model

In this section, we develop a two-country (three-region) model linking productivity, wages and unemployment, allowing for regional productivity and unemployment differentials. The Home country has a Core-Periphery structure, while the Foreign country has a unique region. To stress the resulting effects of the interactions between the good's market and the labour market in an internationally integrated environment, we opted for a general equilibrium trade model. Given that empirical evidence indicates different productivity levels across regions and low inter-regional labour mobility, we need a framework where the labour force is immobile, goods can be traded nationally and internationally and firms producing substitute goods can have different productivity levels in an involuntary unemployment equilibrium. So, we abandon the traditional competitive general equilibrium trade model and follow Neary (2002) and Shapiro and Stiglitz (1984) in building up a General OLigopolistic Equilibrium (GOLE) model, where firms imperfectly monitor workers' on-the-job effort.[3]

As in Neary (2002), firms are assumed to have sectoral market power, so that they act strategically only with respect to their direct rivals, but they take macro variables such as wages, unemployment or GDP as given. In Neary's terminology, they are 'large' in their own sector, but 'small' in the economy as a whole. As in Shapiro and Stiglitz (1984), each firm uses wages as incentives to induce workers to a self-discipline in their effort production.

2.1 *Preferences and effort*

In every region of our 'Shapiro-Stiglitz economy' there is a fixed number of identical infinitely living individuals, $\bar{N}$. Each individual offers labour inelastically with a disutility from working's effort, $e_t \geq 0$, and receives utility from the consumption of a continuum of goods $x_t(z)$, (produced by each sector z in the unit interval [0,1]), that the wage income, $w_t \geq 0$, allows to sustain. Where $\int_0^1 q(z)\cdot x(z)dz = w$, and $q(z)$ is the price of $x(z)$ in every instant t.[4] Goods are imperfect substitutes produced in the core region (c), in the peripheral region (p) and abroad (*).

We assume that the period-by-period utility function is quadratic in consumption (Neary 2002) and linearly decreasing in effort. Therefore, all these risk-averse individuals pursue the same goal:

$$\arg\max E\int_0^\infty \int_0^1 \left[\left(ax_t(z) - 1/2\, bx_t(z)^2\right)dz - e_t\right]\exp(-\rho t)\, dt \tag{1}$$

where a and b are linear demand's parameters and ρ is the discount rate. For each worker, there is a positive per-unit-time probability, ξ, of loosing her job independently of her on-the-job

[3] Previous merges of trade models with an efficiency-wage labour market setup are in Copeland (1989) and Hoon (2001). As in Copeland (1989), our model is Ricardian in its essence. As in Hoon (2001), firms interact in an imperfectly competitive setting. None of the two models, however, deals with productivity and unemployment at a regional level.

[4] We assume for simplicity that individuals cannot borrow or lend.

behaviour (the exogenous 'quit rate') and a positive per-unit-time probability, ζ, of being identified while shirking and fired. Hence, each individual will select e_t according to equation (1).

If V_E^S is the expected lifetime utility of an employed shirker, V_E^N is the expected lifetime utility of an employed no-shirker and V_U is the expected lifetime utility of an unemployed individual, using Bellman's principle of dynamic programming, we obtain the following equation in case of shirking:

$$\rho V_E^S = \int_0^1 \left(ax(z) - 1/2\, bx(z)^2\right) dz + (\xi + \zeta)\left(V_U - V_E^S\right) \tag{2}$$

and in the no-shirking case:

$$\rho V_E^N = \int_0^1 \left(ax(z) - 1/2\, bx(z)^2\right) dz - e + \xi\left(V_U - V_E^N\right) \tag{3}$$

Following Neary (2002), the constrained maximisation of the indirect utility allows to derive an expression for the utility from consumption in terms of the wage income w from which we obtain:[5]

$$V_E^S = \left[\left(a^2 - \lambda^2 \sigma_q^2\right)\big/ 2b + (\xi + \zeta) V_U\right]\big/(\rho + \xi + \zeta)$$

$$V_E^N = \left[\left(a^2 - \lambda^2 \sigma_q^2\right)\big/ 2b - e + \xi V_U\right]\big/(\rho + \xi)$$

where $\lambda = \left(a \ {}_q - bw\right)\big/\sigma_q^2$ is the marginal utility of income, μ_q is the mean value of prices and $\sigma_q^2 = \int_0^1 q^2(z)\, dz$ is their uncentered variance. The equilibrium 'no-shirking condition', derived from the choice of each worker, if $V_E^N \geq V_E^S$, is

$$\left(a^2 \sigma_q^2 - \left(a \ {}_q - bw\right)^2\right)\Big/ 2b\, \sigma_q^2 = \rho V_U + e(\rho + \xi + \zeta)/\zeta \tag{4}$$

where ρV_U is

$$\rho V_U = (\xi L/U)\left(V_E^N - V_U\right) \tag{5}$$

with L indicating the number of working individuals, U the number of unemployed individuals and $\xi L/U$ the probability of job finding among unemployed individuals. The income received when unemployed is assumed to be null.

Given the definition of the unemployment rate, $u = [1 - L/(L + U)]$, and using equations (4) and (5), we finally obtain the 'aggregate no-shirking condition':

$$\left(a^2 \sigma_q^2 - \left(a \ {}_q - bw\right)^2\right)\Big/ 2b\, \sigma_q^2 = (1 + \rho/\zeta + \xi/\zeta u)\, e \tag{6}$$

that identifies the minimum wage that guarantees that workers will not shirk. The efficiency wage (that is the positive root of the quadratic function in equation 6) is positively related with effort (e), the 'quit rate' (ξ), and the discount rate (ρ); and negatively related with the probability

[5] The full derivation of the expression for $ax(z) - 1/2bx(z)^2$ in terms of w is contained in the Appendix. We are grateful to an anonimous referee for pointing out that in the Neary-type GOLE the marginal utility of revenue is a decrasing function of the wage income.

of being detected shirking (ζ), with the shifter of the demand curve (a) and with the unemployment rate (u). Since we do not further explore the role of effort in determining the equilibrium in the labour market, we normalise e to 1.

The 'no-shirking condition' states that the lower the rate of unemployment, the shorter is the expected time of searching for a job when unemployed, to be fired is therefore less costly and shirking becomes a better option. Firms should therefore offer higher wages to counterbalance the more convenient shirking option.

As far as we are concerned, the 'aggregate no-shirking condition' can be reduced to the equilateral hyperbola

$$w = a \cdot \ {}_{q} / b - (\theta_1 - \theta_2 / u)^{1/2} \tag{7}$$

that goes to $+\infty$ when $u \to 0$ and has a horizontal asymptote at $a \cdot \ {}_{q} / b - (\theta_1 - \theta_2)^{1/2}$ when $u \to 1$, where $\theta_1 = \sigma_q^2 \cdot [\zeta \cdot a^2 - 2b(\zeta - \rho)] / \zeta \cdot b^2$ and $\theta_2 = 2 \cdot \sigma_q^2 \cdot \xi / b\zeta$.

2.2 Production in an international oligopoly

In the Home country, the N^c (N^p) individuals living in the core (peripheral) region can be employed in one of the n^c (n^p) immobile firms or be unemployed, so that $N^c \equiv L^c + U^c$ ($N^p \equiv L^p + U^p$), receiving a positive efficiency wage, or no wage income if unemployed. Since all individuals have a utility function that is quadratic in consumption, the resulting inverse demand for each good[6] is

$$q = a - bx \tag{8}$$

(for convenience, we suppressed the sectoral index z). Assuming a fixed number of firms, each firm (in the core, in the periphery and abroad), produces using only labour as a factor of production, so that production functions are

$$x^c = \phi^c e l^c = \phi^c l^c \tag{9}$$

$$x^p = \phi^p e l^p = \phi^p l^p \tag{10}$$

where ϕs are the marginal physical productivity of labour, ls are the amount of labour employed by firms (fixed costs are ignored for simplicity) and $e = 1$ is the normalised no-shirking effort.[7] In each region the employment-unemployment identity is $nl \equiv (1 - u)N$, so that $u = [1 - nl/N]$ is the unemployment rate, being nl the total number of workers and N the total number of individuals.

The first-order condition for a maximizing firm that in the core (periphery) region follows a Cournot-Nash strategy, taking its rivals' output as given, is

$$p - w^c / \phi^c = x^c b \tag{11}$$

$$p - w^p / \phi^p = x^p b \tag{12}$$

[6] See Neary (2002) for a detailed discussion on the difference between the true and the perceived inverse demand and the role of the marginal utility of income.

[7] In principle, e would be zero in case of shirking and a positive value otherwise, but, since in equilibrium all firms use wages as a worker-discipline device, e always takes a positive value.

Foreign firms exporting in the Home market would have an analogous expression

$$p - w^*/\phi^* = x^* \tau b \tag{13}$$

where $0 \leq \tau \leq 1$ is an 'iceberg' trade cost. When $\tau = 1$, no trade costs are present and Home and Foreign firms are competing on an equal basis in the Home market. When $\tau = 0$, trade costs are prohibitive and no Foreign firms are competing in the Home market. We assume that trade costs are bi-directional, so that $\tau = \tau^*$, and that they are binary, $\tau = \tau^* = [0 \vee 1]$. The world economy is therefore in either of the two extreme conditions of full integration (free trade) or perfect segmentation (autarky).

2.3 General equilibrium

If trade costs are prohibitive, using equations (8), (11) and (12), we can obtain the best response functions for the core and periphery firms operating in the Home market, that can be solved in order to obtain the Nash equilibrium for x^c and x^p:

$$x^c = [a - (1 + n^p)(w^c/\phi^c) + n^p(w^p/\phi^p)]/[b(1 + n^c + n^p)] \tag{14}$$

$$x^p = [a - (1 + n^c)(w^p/\phi^p) + n^c(w^c/\phi^c)]/[b(1 + n^c + n^p)] \tag{15}$$

Assuming that the core has a higher level of productivity, then in equilibrium $w^c/\phi^c \leq w^p/\phi^p$, if the wage differential does not counterbalance the productivity gap.[8] In that case, firms in the core region have a larger market share than firms located in the periphery: $x^c \geq x^p \Leftrightarrow w^c/\phi^c \leq w^p/\phi^p$. Using (9) and (10), we can easily find the equilibrium level of unemployment in both regions:

$$N^c(1 - u^c) = (n^c/\phi^c)[a - (1 + n^p)(w^c/\phi^c) + n^p(w^p/\phi^p)]/[b(1 + n^c + n^p)] \tag{16}$$

$$N^p(1 - u^p) = (n^p/\phi^p)[a - (1 + n^c)(w^p/\phi^p) + n^c(w^c/\phi^c)]/[b(1 + n^c + n^p)] \tag{17}$$

Finally, the autarkic system is closed using a regional specification of equation (7):

$$w^c = a \cdot \quad {}_q/b - (\theta_1 - \theta_2/u^c)^{1/2} \tag{18}$$

$$w^p = a \cdot \quad {}_q/b - (\theta_1 - \theta_2/u^p)^{1/2} \tag{19}$$

$$w^c = [a - (N^c b\phi^c)(1 + n^c)/n^c - (N^p b)(\phi^p - u^p)]\phi^c + [(N^c b\phi^c)(1 + n^c)/n^c]\phi^c u^c \tag{20}$$

$$w^p = [a - (N^p b\phi^p)(1 + n^p)/n^p - (N^c b)(\phi^c - u^c)]\phi^p + [(N^p b\phi^p)(1 + n^p)/n^p]\phi^p u^p \tag{21}$$

where the first two equations are the regional no-shirking conditions and the second two equations are the regional good-market schedules. It is worth noticing that the regional equilibria cannot be solved independently in the two regions (the system is not block-independent) and

[8] As in Neary (2003), firms in the core make non-negative profit only if $w^c/\phi^c \leq a/(1 + n^p)$, while firms in the periphery make non-negative profits if $w^p/\phi^p \leq a/(1 + n^c)$.

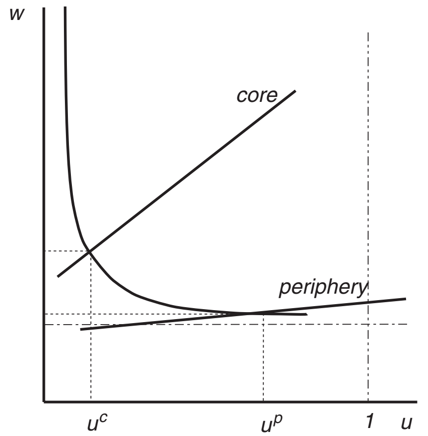

Fig. 1. The two regions equilibria

that only the last two equations depend on productivity. Combining the above equations allows us to illustrate the possible equilibria for the core region and the peripheral region in a *w-u* space, as in Figure 1.

In Figure 1, the two regional no-shirking conditions are represented by the two perfectly overlapping equilateral hyperbola (equations 18 and 19) and the two positively sloped straight lines are the regional good-market schedules (equations 20 and 21). Since we have characterised the core region by higher productivity, in equilibrium the core would realise higher production, higher wages and lower unemployment, with respect to the peripheral region.

2.4 Comparative statics: Productivity and trade

Given the setup represented in Figure 1, it is now possible to do some comparative statics, allowing for changes in productivity and foreign trade.

2.4.1 Productivity

If we shock the system of equations 18–21 through an increase in productivity in the core region, the result is that an increase in ϕ^c increases the regional wage and unemployment gap. This is visualised in Figure 1 by a shift of both good market schedules: in the core, as shown in equation (22), at high levels of u^c, the schedule shifts upward and the equilibrium is reached at a higher level of wages and a lower unemployment rate; in the periphery, as shown in equation (23), the schedule shifts downward and a new equilibrium is reached at a lower level of wages and a higher unemployment rate:

$$\partial w^c / \partial \phi^c = -\phi^c (1-u^c)\left[N^c b\left(1+n^c+n^p\right)\right] / \left[n^c\left(1+n^p\right)\right] + w^c / \phi^c \geq 0 \tag{22}$$

$$\partial w^p / \partial \phi^c = -\left[N^c b \phi^p\right] \leq 0 \tag{23}$$

To summarise: an increase in ϕ^c has a positive impact on l^c, w^c and u^c (that decreases) and a negative impact on l^p, w^p and u^p (that increases).

The relative size of the effect on wages and unemployment depends on where the regional good-market schedules cross the regional no-shirking conditions. If productivity in both regions is sufficiently high (the Home country is a 'high-productivity country'), both regional good-market schedules cross the regional no-shirking conditions along the vertical section of the hyperbola. In this case, a productivity shock in the core has a positive effect on wages in the core and a negative effect on wages in the periphery, leaving the regional unemployment level almost unchanged. The opposite happens if the country is a 'low-productivity country', both regional good-market, schedules cross the regional no-shirking conditions along the horizontal section of the hyperbola. In that case, wages do not change, while unemployment varies. The argument is that the efficiency wage, induced by the necessity of firms to anticipate workers' shirking behaviour, generates an implicit 'wage floor' under which the regional productivity gap cannot be fully compensated by a regional wage gap.

2.4.2 Trade

If trade costs are not prohibitive and Foreign firms sell in the Home market, the Nash equilibrium for x^c, x^p and x^* becomes

$$x^c = \left[a - (1 + n^p + n^*)(w^c/\phi^c) + n^p(w^p/\phi^p) + n^*(w^*/\phi^*)\right]/\left[b(1 + n^c + n^p + n^*)\right] \tag{24}$$

$$x^p = \left[a - (1 + n^c + n^*)(w^p/\phi^p) + n^c(w^c/\phi^c) + n^*(w^*/\phi^*)\right]/\left[b(1 + n^c + n^p + n^*)\right] \tag{25}$$

$$x^* = \left[a - (1 + n^c + n^p)(w^*/\phi^*) + n^c(w^c/\phi^c) + n^p(w^p/\phi^p)\right]/\left[b(1 + n^c + n^p + n^*)\right] \tag{26}$$

The opening of the Home market to international trade has the immediate effect of increasing competition and reducing the market power of all Home firms regardless of their location. The entrance of Foreign firms shifts downward the best response function of firms in the core region and in the periphery and the symmetry of the shift depends only on the level of competition in the two regions (that is the number of firms n^c and n^p). The drop in x^c and x^p is higher the lower is w^*/ϕ^* with respect to w^c/ϕ^c and w^p/ϕ^p. In any case, the increase in x^* reduces x^c and x^p, causing an increase in u^p and u^c and a drop in w^c and w^p, even if $w^*/\phi^* \geq w^p/\phi^p \geq w^c/\phi^c$. As before, the relative effect on unemployment and on wages depends on if the Home country is a 'high-productivity country' or a 'low-productivity country'. In a 'low-productivity country', if the core region and the peripheral region are hit by the same trade shock, the effect on unemployment would be however asymmetric. In the core the shock is absorbed mainly by a drop in wages, while in the periphery the shock would affect the unemployment rate more severely. In general, in a country with high average regional productivity changes in trade integration or the variability in openness do not affect the unemployment rate.

In the setup we defined so far, the prevalent effect of trade integration is an increase in competition in the Home market. The reduction in trade costs allows Foreign firms to export more to the Home country and that makes the Home production sold at Home shrinking, Home wages dropping and Home unemployment rising. Referring again to Figure 1, both regional good-market schedules shift downward.

However, that is not the only effect brought about by trade integration. A second and opposite effect comes from the ability to catch the opportunity of a larger market, since also the Home firms could sell abroad if the Home country has a relevant export potential. In other words, if $w^*/\phi^* \geq w^p/\phi^p \geq w^c/\phi^c$, the negative effect of a trade shock can be reversed. In fact, the reduction in trade costs gives the Home country an advantage in terms of export opportunities that can outweigh the negative effect of an increase in imports from the Foreign country. If the country has a relevant export potential, x would rise in both regions, as would w and the regional and the national equilibrium rates of unemployment would decrease.

Finally, an interesting case is when $w^c/\phi^c \leq w^*/\phi^* \leq w^p/\phi^p$. In this particular case, the core is advantaged by the process of trade integration and the periphery is disadvantaged. The effect on regional unemployment is again not symmetric: u^c remains unchanged, while u^p increases.

2.4.3 Productivity and trade

Let's now examine the effects of an increase in ϕ^c when the Home country is open to trade. The opportunity offered by international trade can in fact partially modify the negative effect in the periphery of a productivity shock in the core. There would be four distinct effects. The first one comes from international competition. Since the number of firms is fixed at n and n^*, an increase in ϕ^c affects the quantity of x^* exported by Foreign firms in the Home market. Domestic production substitutes Foreign exports. The second effect comes from national competition. As it has been shown, an increase in ϕ^c increases x^c and reduces x^p. The regional composition of domestic production does not remain unchanged. Production in the core substitutes production in the periphery. The third effect comes from general equilibrium and it is quite relevant since it can reverse the previous negative effect hitting the periphery. An increase in ϕ^c reduces x^p, generating an increase in u^p and a reduction in w^p. The periphery loses in the domestic game, but the reduction in w^p increases its advantage in the trade contest. Export from the periphery substitutes production in the Foreign country. The effect would be larger the larger is the export potential of the periphery. The fourth effect (Neary 2002) comes from the demand for labour in the Foreign market and it is in contrast to the previous one: the fall in x^* reduces the demand for labour in the Foreign country and w^* falls. Foreign exports substitute domestic production.

As in autarky, the total effect depends on if the Home and the Foreign country are more similar to the 'low-productivity country' or to the 'high-productivity country'. Some of the effects would be null or fully active depending on where the two regional good-market schedules cross the regional no-shirking condition. For example, if the productivity of the peripheral region is so low that the good-market schedules crosses the regional no-shirking condition in its horizontal section, the third effect would be null, since the shift of the good-market schedule would only affect the unemployment rate in the periphery, living w^p unchanged. Ricardian comparative advantages remain as well unchanged leaving the periphery in a no-export potential lock-in.

3 From theory to empirics

Let's now summarise the main findings of the theoretical model that can be subjected to empirical validation, using EU regional data. The first one is the existence of a negative relationship between productivity and unemployment in the periphery, while no relationship should exist in core regions. The second one is the existence of a nonlinear relationship between wages and unemployment. Once controlling for productivity differentials, the relationship should be weakened, since wage differentials partially compensate productivity gaps. The third one is a negative effect of market potential on unemployment *via* international trade.

It is possible to test those predictions using a reduced form of the system derived from the no-shirking conditions, the production functions and the market share equations (24), (25) and (26). Taking the foreign variables w^*, u^* and ϕ^* as given, the solution of the system yields to an equation of the form

$$E(u|\mathrm{C}, \phi, w) = \sum_{j=1}^{J} \mathrm{C}_j + g_1(w) + g_2(\phi) \tag{27}$$

where $\boldsymbol{C}$ is a matrix of dimension J of control variables depending on regional, national and international characteristics, such as N, n, a, b, μ_q, θ_1 and θ_2, as well as foreign parameters. The effect of productivity and wages on unemployment is nonlinear, since ϕ enters as a polynomial and the coefficients depend on the interaction of regional parameters, such as n and N. But, since the form of nonlinearity of $g_1(w)$ and $g_2(\phi)$ depends on regional specificities, we leave it in a general form to be tested empirically.

The theoretical relationship between productivity and unemployment is therefore nonlinear, as it is the one between wages and unemployment coming from the no-shirking condition and this is the first theoretical point that we bring to the data.

4 Empirical evidence for European regions

In this section we perform an econometric analysis to test the effect of labour productivity, wages and market potential on regional unemployment rates in Europe. After having presented the dataset used (section 4.1), we perform a semiparametric analysis to test the existence of a nonlinear relationship between unemployment rates, labour productivity and wages (section 4.2). Then, we use the information from this analysis to identify the functional form of a parametric model and, thus, to apply the System-GMM methodology in order to control for all potential endogeneity sources: simultaneity and measurement-error problems (section 4.3). The presence of spatial autocorrelation is also taken into account by using spatially-filtered data.

4.1 Data

All regional data are extracted from the Eurostat-Regio data system at the NUTS-2 spatial level, except for Germany and United Kingdom that provide complete information only at the NUTS-1 level.[9] The unemployment rate is defined as the ratio between unemployed people and total labour force, labour productivity is the ratio between gross value added (VA) and total employment, while wages are measured in terms of labour compensation per employee.

The market potential that we calculate to take into account the regional international trade linkages is a gravity-adjusted measure: it accounts for both the size of the regional market and its position relative to other regional markets. The variable for a region i is created by taking the sum of the regional VA and the VA of all other regions (k), weighted by the square of the Euclidean distance (d_{ik}) from region i to region k:

$$MARKET_i = VA_i + \sum_k \left(VA_k / d_{ik}^2\right)$$

In 1993 Eurostat introduced some important changes in the definition of unemployment and in the construction of the labour force survey. Moreover, data on gross value added and standard employment, used to calculate regional labour productivity, compiled according to the last

[9] NUTS is an acronym for 'Nomenclature of Territorial Units for Statistics'. In this classification, NUTS-1 means aggregation of regions, while NUTS-2 means Basic Administrative Units (regions) and NUTS-3 corresponds to sub-regions (for example, provinces).

European economic account review (ESA95), are available only for the period 1995–2001. Thus, the data used in the econometric analysis cover this time span.

As in many other empirical studies on regional unemployment (Elhorst 2003a), we also include the participation rate (that is the ratio between labour force and working population) as a covariate to capture labour supply side effects on unemployment.

Finally, we take account of the possible effect of labour market institutions by introducing a country-wide variable ('labour market regulation') taken from the IMD's World Competitiveness Yearbook. This variable measures the extent to which labour regulations (hiring and firing practices, minimum wages and so on) hinder business activity. In other words, it measures the tightness of the employment protection legislation. It is worthwhile to mention that IMD data are normalised and range from 0 to 10. Higher values denote less restrictive legislations. Thus, we expect a negative effect of this variable on regional unemployment. We also include a set of country dummies to take account of other unobserved (time invariant) national specificities. These dummies are eliminated subtracting the means of each variable calculated for each country.

All variables are also normalised with respect to the EU yearly average. Working with relative values helps removing co-movements due to the European wide business cycle and trends in the average values. The number of regions included in the sample is 129: Belgium (10 regions), Germany (16), Spain (15), France (22), Italy (20), The Netherlands (11), Austria (9), Finland (6), Sweden (8) and The United Kingdom (12).[10] So, we have a panel dataset of 129 regions and 7 years.

4.2 A semiparametric analysis

As we mentioned above, in order to identify the presence of nonlinearities in the behaviour of the 'fundamental' variables, that is wages (w) and labour productivity (ϕ), we apply a semiparametric methodology. Specifically, by using a particular version of the semiparametric model that allows for additive components, we are able to obtain graphical representation of the relationship between unemployment, labour productivity and wages. Indeed, additivity ensures that the effect of each of the model predictors can be interpreted net of the effect of the other predictors, just as in linear multiple regression. The semiparametric model can be written as

$$u_{it} = \alpha + \mathbf{C}'_{it}\boldsymbol{\beta} + g_1(w_{it}) + g_2(\phi_{it}) + \varepsilon_{it} \quad i = 1, \ldots, N \quad t = 1, \ldots, T \tag{28}$$

where i stands for region, t for period, ε_{it} is an i.i.d. stochastic term and $g_s(\ldots)$, ($s = 1, 2$), are unknown functions. We take the participation rate, the market potential and the labour market regulation as controls (***C***) entering the model linearly, whereas we allow the wage and the labour productivity variables to make up the nonlinear components of the model. We use a penalised cubic regression spline to estimate $\hat{g}_s(\ldots)$. In particular, we apply the method described in Wood (2000) and Wood and Augustin (2002) that allows integrated smoothing parameter selection via GCV (Generalised Cross Validation).[11]

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[10] We excluded Luxemburg, Ireland and Denmark from our dataset as for these countries there is no regional information (they are considered as NUTS-2 regions according to Eurostat). Previous studies by Blanchard and Portugal (2001) and Puga (2002) reported and discussed the anomalies of Portuguese and Greek data on unemployment. Thus, we also eliminated these two countries. Moreover, as it is usual, we excluded ultra-peripheral regions of Spain (Baleares, Canaries and Ceuta y Melilla) and France (Guadeloupe, Martinique and Reunion). Finally, two other regions (Luxemburg in Belgium and Flevoland in The Netherlands) have been rejected, since they appeared as outliers in a preliminary econometric test.

[11] A methodological note on additive models based on penalised regression splines is available upon request. This method (implemented in the R package 'mgcv') helps overcome the difficulties of model selection typical of the additive model framework based on back-fitting developed by Hastie and Tibshirani (1990).

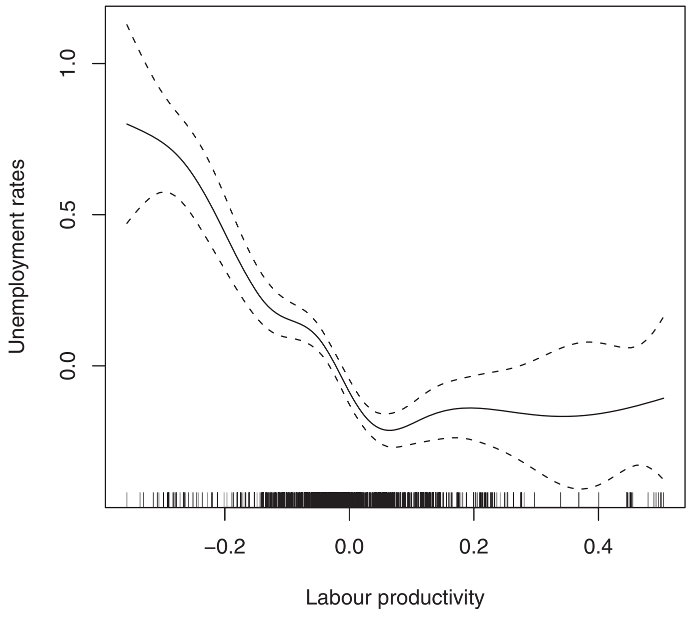

Fig. 2. European regions. Spline for labour productivity

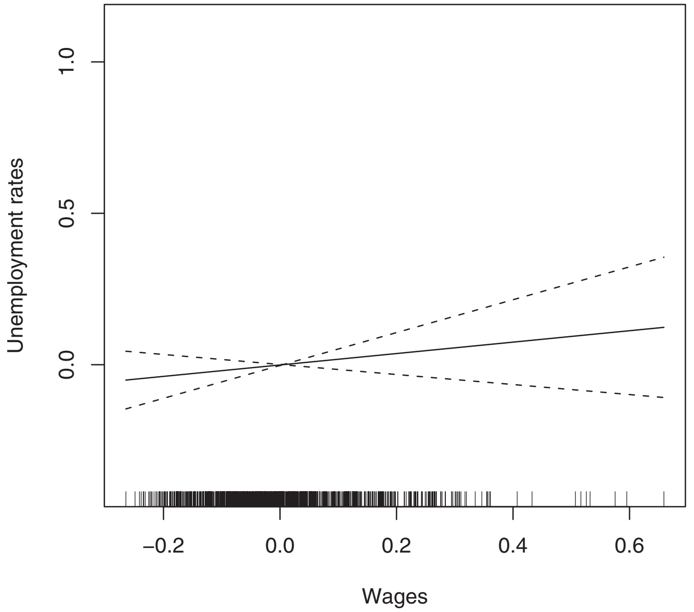

Fig. 3. European regions. Spline for wages

Figures 2 and 3 show the fitted smooth functions $\hat{g}_2(\phi_{it})$ and $\hat{g}_1(w_{it})$ alongside Bayesian confidence intervals (Wood 2004). In each plot, the vertical axis reports the scale of the expected values of relative regional unemployment rate; the horizontal axes report the scale of relative regional wages and relative regional labour productivity, respectively. A simple F test suggests a significant effect of labour productivity (the F statistic is 18.3 with a p-value of 0.000), while wages do not affect significantly unemployment rates (the F statistic is 1.1 with a p-value of 0.284). Moreover, the result of the specification test for the null hypothesis of a linear model against the semiparametric alternative suggests that the null hypothesis can be rejected at the 1% level ($F = 8.1$ with a p-value of 0.000) in the case of labour productivity, while it cannot be rejected in the case of wages ($F = 1.8$ with a p-value $= 0.081$).

In the interpretation of the results shown in Figure 2, it is useful to partition the graph into two parts, one located on the left side of the value of 0.045 on the horizontal axis (low-productivity regions or 'peripheral regions') and the other on the right side of that value on the same axis (high-productivity regions or 'core regions'). In the left part, there is a negative relationship between unemployment and labour productivity (the unemployment rate declines steeply with increasing labour productivity). Beyond the threshold, however, there is no significant relationship, since the line is parallel to the horizontal axis and the confidence interval is quite large. This result strongly corroborates the prediction of our theoretical model of a nonlinear relationship between unemployment and productivity. In the case of core regions, productivity gaps are compensated by wage gaps and they are not reflected in unemployment differentials. In the case of peripheral regions, instead, a wage-floor (induced by efficiency wages and, eventually, exacerbated by institutional factors) prevents the compensation of lower productivity levels with lower wage levels. Thus, only in the case of peripheral regions, productivity gaps determine unemployment differentials.

Traditionally, higher wages are believed to have a positive effect on labour supply and a negative effect on labour demand, hence unemployment will increase if wages go up. However, models of unemployment based on efficiency wages, as well as matching models or bargaining models, all generate a negative relationship between the level of real wages and unemployment rates. In our case, as we mentioned above, wages do not have any significant effect on regional unemployment, even if Figure 3 shows the presence of a slightly increasing effect of wages on unemployment rates. However, if we remove the labour productivity variable from the specification of our econometric model, it turns out that the wage variable affects significantly and nonlinearly regional unemployment rates (see Figure 4),[12] thus confirming the prediction of the efficiency wage model. It is also important to remark that the same results are obtained by using natural log transformations of the variables.[13]

Table 1 shows the regression results of the semiparametric formulation, where wages and labour productivity are treated as nonlinear nonparametric components (column 2) and where labour productivity is excluded from the model specification (column 3). The coefficient on participation rate and on labour market regulation are always significant at 1% level and have the expected sign, whereas the one on market potential is significant and has the expected negative sign only when labour productivity is excluded from the specification of the model.

The evidence of a negative effect of the participation rate is perfectly coherent with the results of previous analyses on regional unemployment (Elhorst 2003a). This effect is usually interpreted as follows: factors determining low participation rates in a particular region also reflect relatively low investments in human capital and low commitment to working life, resulting in higher risk for people with these characteristics to become unemployed.

The evidence of a negative effect on regional unemployment of the level of market potential in column 3 corroborates the prediction of our theoretical model and is also in line with the literature on regional unemployment. Elhorst (2003a), for example, cites three studies (Elhorst 1995; Molho 1995a, 1995b) that include the market potential as explanatory variable in an

[12] The two nested models reported in Table 2 (columns 2 and 3) have been compared through a F test. The estimated F is 12.06 with a p-value of 0.000; therefore, they can be considered as statistically different.

[13] It is worth noting indeed that the wage-curve literature (which does not consider labour productivity) has found a negative relationship between the log of the wage rate and the log of the unemployment rate. The results obtained using log transofrmations of the variable are available upon request.

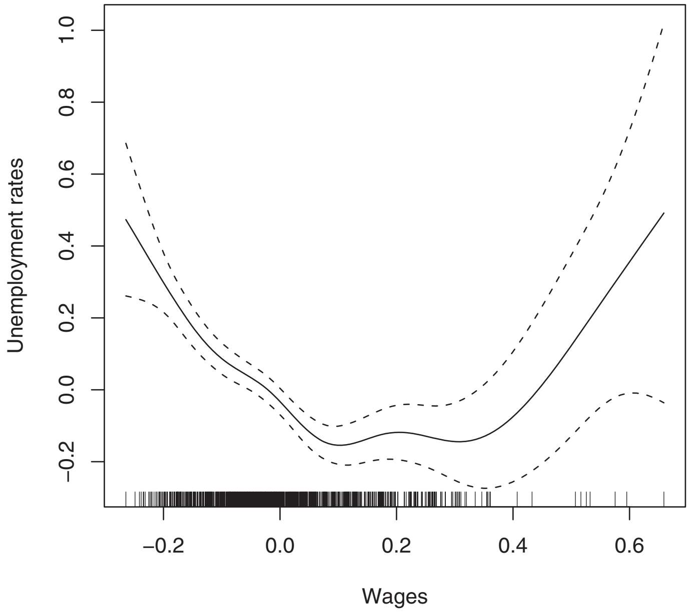

Fig. 4. European regions. Spline for wages (excluding labour productivity from the model specification)

Table 1. Regression results

Variable	Semi-parametric model 1	Semi-parametric model 2	Core-Periphery model
Constant	–0.001	–0.001	–0.204
	(0.012)	(0.012)	(0.037)
Wages	See fig. 2	See fig. 4	0.207
			(0.170)
Labour productivity	See fig. 3		
Labour productivity (peripheral regions)			–2.813
			(0.282)
Labour productivity (core regions)			0.198
			(0.231)
Market potential	0.008	–0.065	–0.001
	(0.024)	(0.025)	(0.023)
Participation rate	–2.391	–2.182	–2.380
	(0.223)	(0.224)	(0.217)
Labour regulation	–0.273	–0.203	–0.279
	(0.075)	(0.079)	(0.075)
Dummy periphery			0.124
			(0.043)
N	903	903	903
R^2	0.33	0.26	0.33
Deviance explained	34.3%	26.6%	33.4%

Notes: Dependent variable: regional unemployment rate. Standard errors are in brackets.

unemployment equation. All these studies find the market potential to have a significant downward effect on the unemployment rate. Not surprisingly, this effect vanishes when the level of labour productivity is controlled for (column 2), given the high correlation between labour productivity and market potential.

The significant result of the variable 'labour market regulation' is also in line with some recent contributions to the literature on regional unemployment in Europe. Caroleo and Coppola (2005), for example, suggest that the regional unemployment disparities in Europe are affected by differences among the institutional arrangements that regulate labour markets.[14]

4.3 Robustness: Heterogeneity, spatial dependence, dynamics and endogeneity

In this section, we perform a number of robustness checks of the econometric results discussed above. First, we consider the possibility that regional unemployment rates are highly correlated in time and in space. It is widely recognised, indeed, that unemployment rates usually change by small amounts over time and across regions (see, for example, Elhorst 2003a and Niebuhr 2002). Thus, if we ignore spatial and serial dynamic effects, our regional unemployment rate equation may be seriously mis-specified. Second, we take account of regional heterogeneity in unemployment. In the previous section, we used deviations from the country mean to control for the presence of national unemployment heterogeneity. Here, we consider a finer level of spatial heterogeneity, that is regional heterogeneity. Third, we consider the possible endogeneity of the explanatory variables. In the case of the unemployment equation, indeed, wages, labour productivity, market potential, participation rate and labour market institutions cannot be considered as strictly exogenous; rather, these variables may be assumed to be predetermined or even endogenous.

First of all, we parameterise the nonlinearity in the labour productivity term by including a dummy variable for the group of low-productivity regions (or 'peripheral regions'), that is the regions with a level of labour productivity lower than the threshold 0.045, and an interaction between this dummy variable and the labour productivity variable. The results of this 'core-periphery' model are reported in the last column of Table 1. An *F* test suggests that the two models are not statistically different (the *F* statistic is equal to 1.1 with a *p*-value of 0.337). Having found a reliable parametric formulation of the nonlinear model, we start exploiting the panel structure of the dataset by System-GMM (Generalised Method of Moments) estimation of a dynamic version of this 'core-periphery' model (Blundell and Bond 1998):[15]

$$u_{it} = \alpha_i + \rho u_{i,t-1} + \mathbf{C}'_{it}\boldsymbol{\beta} + \chi w_{it} + \gamma_{core}\phi_{it} + \gamma_{perypheryy}\phi_{it} + d_{perypheryy} + \varepsilon_{it}. \quad (29)$$

The regional fixed effects are captured by the term α_i. Serial correlation is controlled for by the lagged term $u_{i,t-1}$. Results from the two-step System-GMM estimation of equation (29) are shown in Table 2 (columns 2). All variables are treated as endogenous (all instruments are lagged at least two periods). The test statistics of serial correlation (m_1 and m_2) and over-identifying restrictions ('Sargan/Hansen') do not indicate misspecification.[16]

[14] As we described above, our institutional variable measures the tightness of the employment protection legislation. Obviously, many other national policies and institutions may influence the functioning of the labour market: one may consider, for example, the role of collective bargaining mechanisms or that of the level of the tax wedge on labour. We tried to include some more variables in order to capture the effect of these other national institutional dimensions, but we found that only 'labour market regulation', as defined above, had a robust significant effect on regional unemployment rates. Of course, this result is affected by the inclusion of country dummies in the model.

[15] A methodological note on the System GMM estimator is available upon request.

[16] The statistics m_1 and m_2 test for presence of serial correlation in the first differenced residuals of first and second order, respectively; they are asymptotically normally distributed under the null of no serial correlation (see Arellano and Bond 1991). The results show that there is no significant second order autocorrelation which is the crucial point with respect to the validity of the instruments. The Sargan test statistic of overidentifying restrictions is χ^2-distributed with degrees of freedom equal to the number of instruments minus the number of estimated parameters. This misspecification test does not indicate correlation between the instruments and the error term.

Table 2. Two-step system GMM results

Variable	Dynamic model	Dynamic model controlling for spatial dependence
Lag of the dependent variable	0.841	0.865
	(0.050)	(0.051)
Wages	0.059	0.092
	(0.095)	(0.083)
Labour Productivity (peripheral regions)	−1.144	−0.948
	(0.467)	(0.428)
Labour Productivity (core regions)	−0.143	−0.171
	(0.236)	(0.152)
Market Potential	0.019	0.036
	(0.030)	(0.028)
Participation rate	−0.655	−0.606
	(0.278)	(0.251)
Labour Regulation	−0.120	−0.084
	(0.024)	(0.025)
Dummy Periphery	0.001	0.011
	(0.057)	(0.028)
N	774	774
Sargan/Hansen test	75.91	74.17
	[0.167]	[0.204]
m_1	−5.06	−4.92
	[0.000]	[0.000]
m_2	0.61	1.37
	[0.543]	[0.170]
Long run parameters		
Wages	0.371	0.688
Labour Productivity (peripheral regions)	−7.176	−7.052
Labour Productivity (core regions)	−0.903	−1.275
Market Potential	0.122	0.268
Participation rate	−4.111	−4.513
Labour Regulation	−0.754	−0.623
Dummy Periphery	0.006	0.083

Notes: Dependent variable: regional unemployment rate. The null hypothesis that each coefficient is equal to zero is tested using two-step robust standard errors. $m_1(m_2)$ is a test of the null hypothesis of no first (second) order serial correlation in the first-differenced residuals. It is asymptotically normally $N(0,1)$ distributed under the null of no serial correlation (see Arellano and Bond 1991). The Sargan/Hansen test statistic of over-identifying restrictions is χ^2-distributed with degrees of freedom equal to the number of instruments minus the number of estimated parameters. Standard errors are in round brackets. P-values are in square brackets.

The results of the GMM estimation confirm the findings reported in the last column of Table 1. The magnitude of the coefficient of the lagged term of the dependent variable is very high (0.84), denoting the presence of strong serial correlation. In line with the results reported in Table 1, labour productivity has a negative effect on the unemployment rate only for the peripheral regions: for a standard deviation increase in labour productivity, the unemployment rate is expected to decrease by 0.21 standard deviations in the short run and by 1.3 standard deviations in the long run, holding all other variables constant.[17] Market potential and wages are not significant. Again, the coefficient on labour market regulation has the expected negative sign (the short-run fully standardised coefficient is equal to −0.04; the long-run fully standardised

[17] Being β_k the estimated coefficient of a variable x, a fully standardised coefficient is defined as $\sigma_k\beta_k/\sigma_y$, where σ_k is the standard deviation of the variable x and σ_y is the standard deviation of the dependent variable.

coefficient is equal to –0.92). Finally, the participation rate exerts a negative effect on the unemployment rate (the short-run standardised coefficient is –0.09, while the long-run standardised coefficient is –0.58).

Finally, we take into account the presence of spatial dependence. The literature on spatial econometrics offers a number of estimators for models that treat spatial dependence explicitly (Anselin and Bera, 1998), but techniques for handling spatial dependence appear to be mostly confined to cross-sectional studies. Within the panel data approach, static and dynamic fixed-effect spatial autoregressive and spatial error models have been recently proposed (Elhorst 2003b, 2004, 2005). In these models, however, explanatory variables are treated as exogenous. In the absence of a direct estimator for spatial panel data models with endogenous variables, we use a two-step procedure (already proposed by Badinger et al. 2004), in which a system-GMM is used after having filtered the variables in order to remove spatial correlation. Spatial filtering is performed using spatial dependence coefficients estimated on single cross-sections for each time period.[18]

The results reported in the last column of Table 2 confirm those discussed above. In particular, they confirm that the negative effect of labour productivity on unemployment rates in the peripheral regions is the most important effect: for a standard deviation increase in labour productivity, the unemployment rate is expected to decrease by 0.17 standard deviations in the short run and by 1.28 standard deviations in the long run, holding all other variables constant. The fully short-run (long-run) standardised coefficients on the participation rate and on labour market regulation are, respectively, equal to –0.09 (–0.64) and –0.03 (–0.76).

5 Concluding remarks

In this article, we explore the link between labour productivity and regional unemployment differentials. The many empirical analyses on regional unemployment that preceded our contribution have proposed a large set of explanatory variables while never explicitly considering labour productivity as a relevant explanatory factor of regional unemployment (Elhorst 2003a). In this article, we have shown how this covariate largely explains wide regional unemployment disparities in Europe.

The predictions of a General Oligopolistic Equilibrium efficiency wage model of a nonlinearity between labour productivity and unemployment is confirmed by the European regional data. A negative relationship does exist in the case of low-productivity regions (the periphery), while no relationship occurs in the case of high-productivity regions (the core). The argument is that the efficiency wage, induced by the necessity of firms to anticipate workers' shirking behaviour, generates a wage-floor under which the productivity gap cannot be compensated by a wage gap.

Some economic policy implications can be associated to our results. The most relevant one is that unemployment policies should be set at the regional level. The same policy has in fact different implications according to the level of regional labour productivity and export potential.

[18] We estimated both the spatial autoregressive model (SAR) – where a spatial lag of the dependent variable is included on the right hand side of the statistical model – and the spatial error model (SEM) – where the error term is modelled as a spatial autoregressive random field and found evidence in favour of the SAR model (see, for example, Anselin and Bera 1998, for a comphensive description of these two models). In other words, having used deviations from the national average, the simple SAR model was sufficient to remove spatial autocorrelation from the error term. In order to make these estimations, we used a 15-nearest neighbours spatial weights matrix. We also tried with 5- and 10-nearest neighbours spatial weights matrices and found very similar results. The spatial autoregressive coefficients estimated and used to spatially filter the unemployment rates vary between 0.42 (calculated for the cross-section of 1995) and 0.60 (calculated for the cross-section of 2001). There is not enough space in this article to report all the performed spatial econometric tests. These, however, are available upon request.

The most common proposal is the regional de-centralisation of the wage-setting process (Pench et al. 1999). If wages followed productivity more quickly, the competitiveness of peripheral regions would be less penalised and the employment and unemployment conditions within these regions would improve. However, if the downward wage rigidity does not entirely reflect the institutional mechanism, but can be also attributed to efficiency wages, then the adjustment process discussed above cannot properly work.

The asymmetry in the relationship between unemployment and productivity makes evident that the reduction in the regional unemployment gap can be pursued through policies that increase labour productivity at the periphery level (such as Structural and Cohesion funds) and the periphery export potential.

A possible extension of our analysis is to consider inter-regional labour mobility in both the theoretical and the empirical analysis. With labour immobility, regional wage and unemployment disparities could persist along time, with the periphery steadily lagging behind; with labour mobility regional disparities can be reduced via migration. In fact, Blanchard and Katz (1992), Decressin and Fatàs (1995) and Fatàs (2000) point out that the degree of labour mobility modifies the channels through which shocks hit labour market equilibrium in the 'low-productivity country' differently from the 'high-productivity country'. Referring to Figure 1, the change in regional labour endowment induces a convergence in regional wages due to the simultaneous shift of the core good-market schedule downward and of the periphery good-market schedule upward. Thus, migration may induce convergence in regional wages and unemployment rates in countries with high inter-regional mobility of labour. In any case, the role of labour productivity in shaping the condition of regional labour market would remain undeniable.

Appendix: Utility, marginal utility of income and wages

In every period t the indirect utility function derived from consumption is obtained maximizing

$$\int_0^1 \left(ax(z) - (b/2)\,x(z)^2\right) dz \tag{A1}$$

subject to the budget constraint

$$\int_0^1 (q(z)\,x(z))\,dz = w \tag{A2}$$

Following Neary (2002), one can derive the following f.o.c. $a - bx(z) - \lambda q(z) = 0$, where λ is the marginal utility of income. Multiplying by $q(z)$ and integrating over goods, one obtains:

$$\lambda = \left(a\ {}_{q} - bw\right)/\sigma_q^2 \tag{A3}$$

where μ_q is the mean value of prices and $\sigma_q^2 = \int_0^1 q^2(z)\,dz$ is the uncentered variance. The marginal utility of income is a decreasing function of w.[19]

[19] We are very grateful to a referee for pointing out this characteristic of the utility function and for indicating the correct relationship between wage income and utility.

Using the f.o.c. to derive $x(z)$, and using (A1) and (A3), it is possible to obtain an expression of the indirect utility in terms of the marginal utility of income:

$$\begin{aligned}&\int_0^1 \left(a(a-\lambda\cdot q(z))/b - b/2((a-\lambda\cdot q(z))/b)^2\right)dz = \\ &\int_0^1 ((a^2-\lambda^2\cdot q^2(z))/2b)\,dz = \left(a^2\sigma_q^2 - \left(a\ \ _q - bw\right)^2\right)\Big/2b\,\sigma_q^2\end{aligned} \tag{A4}$$

Hence,

$$\int_0^1 \left(ax(z) - (b/2)\,x(z)^2\right)dz = \left(a^2\sigma_q^2 - \left(a\ \ _q - bw\right)^2\right)\Big/2b\,\sigma_q^2 \geq 0 \tag{A5}$$

This is the expression that we have substituted in equation (4).

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