CAEPR CENTER FOR APPLIED ECONOMICS AND POLICY RESEARCH
INDIANA UNIVERSITY

CAEPR Working Paper
#2007-002

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January 31, 2007

This paper can be downloaded without charge from the Social Science Research Network electronic library at: http://ssrn.com/abstract=960475.

Growth Effects of Spatial Redistribution Policies[*]

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August 2005, this version December 2006

Abstract

We develop a two-region, two sector model with migration and public investment in infrastructure and education. In a numerical example calibrated to Portugal, we find that the structural funds can improve the growth rate of the lagging region and slightly reduce the regional inequality, without necessarily producing convergence. When the mix of national public investment departs from optimum, the allocation of supra-national funds across infrastructure and public education can partially offset this national suboptimality. We also find that the short run growth-maximizing composition of structural funds is different from the long rung optimal mix. Moreover, the rich region has an incentive to bias the allocation of structural funds towards human capital formation.

JEL Codes: H7, R58, R12.

Keywords: endogenous growth, spatial redistribution, regional policy, European Union.

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1 Introduction

In most developed countries balanced regional growth is a major goal for policy makers at all administrative levels. However, two things distinguish the case of the European Union (EU). First, policies are designed and applied by a multi-layered governance structure with both national and European institutions being concerned with various measures of regional growth and inter-regional inequality. Second, the regional development policies have increased in importance as the EU continued to enlarge towards countries with large differences in terms of output per capita. The view of the European Commission is that "Imbalances do not just imply a poorer quality of life for the most disadvantaged regions and the lack of life-chances open to their citizens, but indicate an under-utilization of human potential and the failure to take advantage of economic opportunities which could benefit the Union as a whole[1]." Thus, given the last wave of EU enlargement, regional development policies[2] are called for to fulfill an even bigger role. This brings into sharper focus the question of how effective these funds have been in reducing the inter-regional inequality and other imbalances, like long-term unemployment and a presumed lack of innovation. However, the existing economic literature (see for example Crozet and Koenig (2005), Brauninger and Niebuhr (2005), Martin and Ottaviano (2001) and Boldrin and Canova (2001), among many others) suggests that there might be a trade-off between aggregate growth and regional equality if agglomeration forces play an important role and resources are mobile.

Table 1 summarizes the markedly different evolutions of regional disparities across European countries, from some degree of convergence (Italy) or stability (UK, Spain) to significant divergence (Portugal, Belgium). In this paper, we provide a two-region endogenous growth framework suitable for the study of spatial redistribution policies, similar to those employed in the EU. To this end, we incorporate investment in infrastructure and human

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[1]First Report on Economic and Social Cohesion, European Commission (1996)

[2]These policies include the Structural Funds – ERDF, EAGGF Guidance Section, ESF, and FIFG – as well as the Cohesion Fund. In this paper we shall reffer generically to structural funds.

capital development as the two main outlays of public spending and allow for inter-regional migration. The model is used to provide quantitative and qualitative assessments of these policies. Specifically, we go beyond analyzing the size of inter-regional transfers to consider the shares of such transfers allocated to infrastructure and skills improvement (education), respectively.

Table 1: GDP ratio of richest to poorest region

Year	1977	2002
Spain	2.00	2.057
Portugal	1.621	1.818
Greece	1.860	1.867
Italy	2.373	2.095
Belgium	1.795	2.782
Germany	1.805	1.952
France	1.869	2.033
UK	1.465	1.419

Source: Regio Dataset/ Eurostat

The structure of the paper is the following. Section 2 gives a literature overview, sections 3 and 4 present and solve the model in the case of one region while section 5 extends it to incorporate a second region and migration. In section 6, we calibrate the model to Portugal. Section 7 includes policy experiments. The final section concludes and the appendix contains sensitivity analysis of the policy experiments.

2 Literature

A better understanding of the geographical disparities within a certain area (a federation, a state, region or county) is key for efficient regional policy making. Two main strands of economic literature have dealt with this issue: rural-urban migration literature and new economic geography models that stress agglomeration effects. Rural-urban migration theory makes consistent use of inter-temporal optimization to explain the steady shift of

employment from traditional crafts (such as agriculture) towards modern technologies, like manufacturing. In the new economic geography literature, agglomeration models generally focus on static optimization with ad-hoc dynamics used to describe short run and long run equilibria. A comprehensive overview of this type of models is given in Robert-Nicoud (2002).

Agglomeration papers, following Krugman (1991), show that in a two-region economy, the inputs' localization pattern is a function of their relative mobility and depends essentially on the cost of trade. When the cost of trading goods across regions is sufficiently high, the model yields a dispersed equilibrium where both regions remain populated. When the cost of trade decreases under a certain threshold, an agglomerated equilibrium obtains, where mobile factors concentrate in one region. Using this type of model, Baldwin and Krugman (2004) analyze the effects of tax harmonization and prove that agglomeration effects reverse the "race to the bottom" characteristic of the international tax competition. Brakman et al. (2002) build a more elaborate model of government to show the effects of government spending. Suedekum (2005), Pflueger and Suedekum (2004), Pflueger (2003), Forslid and Ottaviano (2003) and Ottaviano and Thisse (2002) proceed along similar lines to analyze the effects of regional policies on agglomeration. They find that regional policies which are aimed at fostering dispersion in general, are counterproductive when trade integration is deep enough. Martin (1999) studies the effect of a variety of infrastructure policies on regional inequalities and economic growth. He emphasizes the trade-offs between growth and inequality that characterize current redistribution policies. He abstracts from public education spending.

On the other side, migration models, like Glomm (1992) or Lucas (2004), take the long run view on the drivers of the urbanization process that leads to divergent evolutions of the "traditional" (agricultural) country-side compared to the "modern" (industrialized) city. Complete specialization is assumed and while the factors of production enjoy mobility, trade issues do not play an important role. Learning dynamics however introduces "transition" costs as migration entails a human capital loss because of region or activity-specific technologies. The models predict sustained migration from country

side to city and steady wage differentials. Tamura (2002) shows that switching from agriculture to industry generates higher growth rates in population and income. A somewhat different angle is adopted by Tamura (2001) who studies the forces that generate increasing returns to regional integration, such as reduced coordination costs and specialized human capital.

In this paper we introduce development policies in a dynamic framework that also allows for factor mobility. The setup we present conveniently incorporates two types of public policies in an endogenous growth type model. The presence of two outlays - public capital investments and human capital formation - replicates the main usages of structural funds and allows for comparative dynamics exercises with regard to changes in both their size and composition. Moreover, when expanding the analysis to the two-region case, we are able to remove some of the strong mobility assumptions present in new economic geography models, by allowing the population size of each region to be endogenously determined. The model links the regional income differences to empirical differences in the industrial structure of each economy and generates optimal patterns of public expenditures that can be used as a benchmark when assessing the performance of actual policies. Our paper complements de la Fuente et al. (1995) who use an econometric approach to assess the success of infrastructure and education policies in promoting regional convergence. They find the actual impact of these policies to be small. This is comparable to a claim in Boldrin and Canova (2001) that, even in the presence of structural funds policies, convergence among European regions has been limited.

3   The Model

In order to study the effect of supra-national development policies on the growth rate differential between different parts of the union, we use a two-region overlapping generation model with migration and monopolistic competition. We model the two regions as small open economies in the sense

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that they take the interest rate (r) as given. First, we assume identical regions for description simplicity. Later on, we specify exactly how they differ and interact. Each region is characterized by a certain area L.

3.1 Households

In each region there is initially a large number of residents, N. Individuals live for two periods, derive utility from consumption in both periods and dislike congestion when young. Whether congestion costs are incurred when young or when old is immaterial for our results. Similar to Casella (2005) and Ciccone and Hall (1996), this congestion depends on population density in the region in which they reside. One can think of this disutility from congestion as deriving from increased housing costs or longer commuting time. Individuals earn wages and save when young, get the return on their savings when old, and consume in both periods. While young, consumers also decide to move to the other region if that increases their life-time utility. The utility of a typical agent from generation t is

$$U(c_t, c_{t+1}, a_t) = \log c_t + \beta \log c_{t+1} - a_t, \tag{1}$$

where c_s is consumption in periods s; $s = t, t+1$ and a_t is a congestion cost that kicks in once the density $\frac{N_t}{L}$ in that region exceeds a certain level $\frac{\widetilde{N}}{L}$. For simplicity, the congestion cost accrues in the first period of life, but results do not depend on this assumption. Notice that once migration is allowed, the population size in each region is no longer constant, hence the time subscripts. Formally, congestion costs are given by

$$a_t = \omega \max(0, \frac{N_t - \widetilde{N}}{L})^\eta. \tag{2}$$

We assume $\omega > 0$ and $\eta > 1$, so that congestion costs are increasing and convex in population density.

3.2 Production

Output is produced using physical capital K_t, a fraction ϕ_t of the raw labor available in the region, N_t, a continuum of differentiated intermediate goods h_{it} and services flowing from a publicly provided good, $\widehat{X}_{G,t}$. The production function is given by

$$Y_t = \widehat{X}_{G,t}^{\epsilon} \; K_t^{\alpha_1} \; (\phi_t N_t)^{\alpha_2} \int_0^{A_t} h_{it}^{\alpha_3} di. \tag{3}$$

Constant returns to scale in hired factors implies $\alpha_1 + \alpha_2 + \alpha_3 = 1$. The term $\widehat{X}_{G,t}^{\epsilon}$ denotes services of the aggregate stock of public good (subject to congestion). The public good can be thought of as infrastructure such as roads, utilities, contracts enforcement, etc. It is made available to all firms at a zero price. We model congestion as in Eicher and Turnovsky (2000) and Glomm and Ravikumar (1994):

$$\widehat{X}_{G,t} = \frac{X_{G,t}}{K_t^{\rho}}, \tag{4}$$

where $X_{G,t}$ and K_t are the aggregate stocks of infrastructure and private capital, respectively and $\rho > 0$. The above specification of congestion implies that a higher use of private capital leads to a lower contribution of the public input to each firm's productivity. When ρ is equal to zero, then infrastructure becomes a pure public good.

As each region is a small open economy, the capital is available at an exogenous and fixed interest rate r. Capital depreciates at a constant rate, δ_k. This also implies that the stock of physical capital is composed of local (S_t) and out-of-region (S_t^f) aggregate savings, such that:

$$K_t = S_{t-1} + S_{t-1}^f. \tag{5}$$

Production of intermediate goods is similar to Romer (1987) and Romer (1990). A fraction $1 - \phi_t$ of the workforce decides to specialize in producing new differentiated goods for which they have monopoly power so they can sell at a markup over marginal cost. The intermediate good is produced

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from consumption good at a constant marginal cost of e. The price of the ith variety of h is p_{it}.

One interpretation for these differentiated goods is new skills formation. This usually involves (public) education or on-the-job training. Publicly financed education has been extensively used in models of human capital accumulation such as Loury (1981), Glomm and Ravikumar (1992), Fernandez and Rogerson (1998) or Blankenau and Simpson (2004). In addition, we simultaneously model on-the-job training as a significant source of new skills. This is done by incorporating existing skills into the production of new ones. The range of intermediate goods then follows the law of motion

$$A_{t+1} = A_t(1-\delta) + B(1-\phi_t) \; N_t \; A_t^\gamma \; X_{E,t}^\theta \; , \qquad (6)$$

where $0 < \delta < 1$, $0 < \theta < 1$, $B > 0$. Here $X_{E,t}$ is public education expenditures and public R&D expenditures and $1 - \phi_t$ is the fraction of labor force producing the intermediate goods. The constant γ captures the "standing on shoulders effect" as in Jones (2004) and Romer (1990). In other words, the range of new skills produced over a given interval of time is an increasing function of the existing stock of skills.

3.3 Government

Each region has its own government that taxes income uniformly at rate τ which is assumed constant over time and uses the proceeds to finance the public goods described above such that a balanced budget is maintained each period. The government budget constraint is

$$X_{E,t} + X_{G,t} = R_t = (w_t N_t + r_t S_{t-1} + r_t S_{t-1}^f)\tau, \qquad (7)$$

where $X_{E,t}$, $X_{G,t}$ are the two expenditure outlays, public education and infrastructure respectively. Since we have assumed each region is a small open economy, the stock of capital used each period will not generally be equal to the savings from that region. For simplicity, we assume that both

local and out-of-region savings are taxed in the region where the capital was used. In later sections we will specify another layer of government, the supra-national (or European Union) level, that will use a fraction of the tax proceeds to finance redistribution programs between regions.

4 One region case

4.1 The household problem

Since the congestion disutility is irrelevant in the one region case, the household's problem is

$$\max_{c_t, c_{t+1}, s_t} \log c_t + \beta \log c_{t+1} \tag{8a}$$

$$\text{s.t. } c_t + s_t \leqslant w_t(1 - \tau) \tag{8b}$$

$$c_{t+1} \leqslant (1 + (1 - \tau)r_{t+1})s_t. \tag{8c}$$

$$\text{given } \{w_t, r_{t+1}, \tau\}.$$

4.1.1 Firm's problem in consumption good sector

Production of the consumption good is standard. Firms take prices and the level of public good as given and maximize profits. Their problem is:

$$\max_{\phi_t, h_{it}, K_t} Y_t - w_t \ \phi_t N_t - p_{it} \int_0^{A_t} h_{it} di - q_t K_t \tag{9}$$

$$\text{s.t. } Y_t \ = \ \widehat{X}_{G,t}^{\epsilon} \ K_t^{\alpha_1} \ (\phi_t N_t)^{\alpha_2} \int_0^{A_t} h_{it}^{\alpha_3} di.$$

$$\text{given } \{\widehat{X}_{G,t}, w_t, p_{it}, q_t\}.$$

In equilibrium, due to symmetry of the intermediate goods, their prices are the same. Hence,

$$p_t = p_{it} = \frac{\partial Y_t}{\partial h_{it}} = \alpha_3 \ \widehat{X}_{G,t}^{\epsilon} \ K_t^{\alpha_1} \ (\phi_t N_t)^{\alpha_2} \ h_t^{\alpha_3 - 1}. \tag{10}$$

All intermediate goods are produced in the same quantity, so that $h_{it} = h_t$. Therefore (3) becomes

$$Y_t = \widehat{X}_{G,t}^{\epsilon} \ K_t^{\alpha_1} \ (\phi_t N_t)^{\alpha_2} A_t h_t^{\alpha_3}.$$

Labor and capital are paid competitive prices, i.e.

$$w_t = \alpha_2 \frac{Y_t}{\phi_t N_t}, \tag{11}$$

$$q_t = q = \alpha_1 \frac{Y_t}{K_t}. \tag{12}$$

Since r is exogenous and fixed, firm's choice for K will also be fixed so that capital is paid its marginal value. Factoring in the depreciation, we get $q_t = q = r + \delta_k$.

4.1.2 Firm's problem in skills production

Producers of the intermediate differentiated goods face the demand derived from the final good production and solve the following problem:

$$\max_{h_{it}} \Pi_t = p(h_{it})h_{it} - eh_{it}, \tag{13}$$

where $p(h_{it})$ is the demand function derived from the production function of the firm in the final goods sector in (10) and the last term is the total cost of producing h_{it} units. Having monopoly power, the producers set the price at a markup over the marginal cost e, where the markup is inversely proportional to the elasticity of the demand curve. Together with the profit

definition in (13), this implies a constant price

$$p_t = p = \frac{e}{\alpha_3}. \tag{14}$$

Consequently, the profit will be

$$\Pi_t = eh_t \left(\frac{1 - \alpha_3}{\alpha_3} \right). \tag{15}$$

Also, in equilibrium, agents must be indifferent between being employed in goods production and being an entrepreneur expanding the range of skills by $BA_t^\gamma X_{E,t}^\theta$, thus receiving the profits associated with it. This translates into:

$$w_t = BA_t^\gamma X_{E,t}^\theta \ \Pi_t, \tag{16}$$

where $BA_t^\gamma X_{E,t}^\theta$ is the number of new skills/intermediate goods and Π_t is the profit per skill/intermediate good.

4.2 Equilibrium

A competitive equilibrium in a one-region economy is defined to be a set of sequences of *allocations* $\{c_t, c_{t+1}, s_t, \phi_t, h_{it}, k_t\}_{t=0}^\infty$ and *prices* $\{p_t, w_t, q_t\}_{t=0}^\infty$ such that, for a given set of government *policies* $\{\tau, X_{M,t}, X_{E,t}\}_{t=0}^\infty$:

1) Given the *prices*, the allocations $\{c_t, c_{t+1}, s_t\}_{t=0}^\infty$ solve the household problem;

2) Given the *prices*, the allocations $\{k_t, h_{it}\}_{t=0}^\infty$ solve the firm's problems in both sectors;

3) The sequence $\{\phi_t\}_{t=0}^\infty$ satisfies the intersectoral labor allocation condition (16);

4) Prices are determined by (11) and (14);

5) Good market clears so that $C_{t,t} + C_{t-1,t} = Y_t$;

6) Government budget is balanced.

Government expenditures on each of the outlays is assumed to be a fixed

proportion κ_E or κ_G of the budget size R_t

$$X_{E,t} = \kappa_E R_t, \; \kappa_E > 0 \tag{17}$$

$$X_{G,t} = \kappa_G R_t, \; \kappa_G > 0, \; \kappa_G + \kappa_E \leqslant 1. \tag{18}$$

Since government taxes all income produced in the region, irrespective of where the factors' owners are located, in equilibrium, the budget is a fraction of the total output, so we can redefine the public expenditures as shares of output

$$X_{E,t} \;=\; \Delta_E Y_t = \tau \kappa_E Y_t \tag{19}$$

$$X_{G,t} \;=\; \Delta_G Y_t = \tau \kappa_G Y_t. \tag{20}$$

In the following we focus on finding and characterizing a balanced growth path for this economy. Solving (10) for h_t gives:

$$h_t = \left(\frac{\alpha_3^2 \; \widehat{X}_{G,t}^{\epsilon} \; K_t^{\alpha_1} \; (\phi_t N_t)^{\alpha_2}}{e} \right)^{\frac{1}{1-\alpha_3}}. \tag{21}$$

Using (21) and (15) in (16) we get:

$$B \; X_{E,t}^{\theta} A_t^{\gamma} \; e \; h_t \left(\frac{1-\alpha_3}{\alpha_3} \right) = \alpha_2 \; \widehat{X}_{G,t}^{\epsilon} \; K_t^{\alpha_1} \; (\phi_t N_t)^{\alpha_2 - 1} \; A_t \; h_t^{\alpha_3}$$

and from here

$$\phi_t = \frac{\alpha_2 \; A_t^{1-\gamma}}{B \; X_{E,t}^{\theta} \; \alpha_3^2 \; N_t} \left(\frac{\alpha_3}{1-\alpha_3} \right) = \frac{A_t^{1-\gamma}}{B \; X_{E,t}^{\theta} \; N_t} \frac{\alpha_2}{\alpha_3(1-\alpha_3)}. \tag{22}$$

Using (12) and (21) in the production function (3) to get:

$$
\begin{aligned}
Y_t \;&=\; \widehat{X}_{G,t}^{\epsilon}\left(\frac{\alpha_1}{q}Y_t\right)^{\alpha_1}(\phi N_t)^{\alpha_2}\,A_t\left(\frac{\alpha_3^2\,\widehat{X}_{G,t}^{\epsilon}\,K_t^{\alpha_1}\,(\phi_t N_t)^{\alpha_2}}{e}\right)^{\frac{\alpha_3}{1-\alpha_3}} \\
&=\; A_t\left(\widehat{X}_{G,t}\right)^{\frac{\epsilon}{1-\alpha_3}}\left(\frac{\alpha_1}{q}\right)^{\frac{\alpha_1}{1-\alpha_3}}\left(\frac{\alpha_3^2}{e}\right)^{\frac{\alpha_3}{1-\alpha_3}}(\phi N_t)^{\frac{\alpha_2}{1-\alpha_3}}Y^{\frac{\alpha_1}{1-\alpha_3}}
\end{aligned}
$$

Plugging in ϕ_t from (22) and $\widehat{X}_{G,t}^{\epsilon}$ from (4) obtains:

$$
\begin{aligned}
Y_t \;=\;& A_t\left(\frac{\alpha_1}{q}\right)^{\frac{\alpha_1}{1-\alpha_3}}\left(\frac{\alpha_3^2}{e}\right)^{\frac{\alpha_3}{1-\alpha_3}}\left(\frac{\alpha_2}{\alpha_3(1-\alpha_3)}\right)^{\frac{\alpha_2}{1-\alpha_3}} \\
&\times\left(\frac{X_{G,t}}{K_t^{\rho}}\right)^{\frac{\epsilon}{1-\alpha_3}}\left(\frac{A_t^{1-\gamma}}{B\,X_{E,t}^{\theta}}\right)^{\frac{\alpha_2}{1-\alpha_3}}Y_t^{\frac{\alpha_1}{1-\alpha_3}} \\[2mm]
\;=\;& \left(\underbrace{\left(\frac{\alpha_1}{q}\right)^{-\rho\epsilon+\alpha_1}\left(\frac{\alpha_3^2}{e}\right)^{\alpha_3}\left(\frac{\alpha_2}{\alpha_3 B(1-\alpha_3)}\right)^{\alpha_2}}_{F}\right)^{\frac{1}{1-\alpha_3}} \\
&\times(\Delta_G Y_t)^{\frac{\epsilon}{1-\alpha_3}}(\Delta_E Y_t)^{-\frac{\theta\alpha_2}{1-\alpha_3}}Y_t^{\frac{-\rho\epsilon+\alpha_1}{1-\alpha_3}}A_t^{1+\frac{\alpha_2(1-\gamma)}{1-\alpha_3}}
\end{aligned}
$$

$$
Y_t = F^{\frac{1}{\Gamma}}\Delta_G^{\frac{\varepsilon}{\Gamma}}\,\Delta_E^{-\frac{\theta\alpha_2}{\Gamma}}A_t^{\frac{1-\alpha_3+\alpha_2(1-\gamma)}{\Gamma}} \tag{23}
$$

where

$$
\Gamma = 1 - \alpha_3 - \alpha_1 - \varepsilon(1-\rho) + \alpha_2\theta.
$$

We use the last expression for Y_t with (19) and solve for $X_{E,t}$. The resulting expression is substituted in (22). Thus,

$$
\begin{aligned}
\phi_t =\;& \frac{\alpha_2}{\alpha_3(1-\alpha_3)\,B\,N_t} \\
&\times\underbrace{\left(F^{\frac{1}{\Gamma}}\Delta_G^{\frac{\varepsilon}{\Gamma}}\,\Delta_E^{-\frac{\theta\alpha_2}{\Gamma}}\right)^{-\theta}}_{D}\times A_t^{1-\gamma-\frac{[1-\alpha_3+(1-\gamma)\alpha_2]\theta}{\Gamma}}.
\end{aligned} \tag{24}
$$

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We seek a steady state in growth rates of output and the range of intermediate goods. The existence of such a steady-state is guaranteed by the assumption of constant returns to scale in the hired factors (see for example Jones and Manuelli (1997)). On a balanced growth path, the fraction of raw labor in total employment ϕ_t is independent of A_t and is pinned down by the knife-edge condition below, obtained by setting the power of A_t in (24) to zero.

$$\frac{[1 - \alpha_3 + (1 - \gamma)\alpha_2]\,\theta}{\Gamma} = 1 - \gamma. \tag{25}$$

Such knife-edge conditions are unavoidable if one wants to obtain balanced growth.

Denote the second term in (24) D so that

$$\phi_t = \phi = \frac{\alpha_2}{\alpha_3\,(1 - \alpha_3)\,\upsilon\,N_t}\,D,$$

which also ensure from (6) that A grows at a constant rate. Using (19) and (20) we get:

$$
\begin{aligned}
\frac{A_{t+1}}{A_t} &= g_A = (1 - \delta) + B\,(1 - \phi)\,N_t\,(\Delta_E Y_t)^\theta A_t^{\gamma - 1} \tag{26} \\
&= (1 - \delta) + B\,(1 - \phi)\,N_t\,(\Delta_E)^{\theta(1 - \frac{\theta\alpha_2}{\Gamma})} F^{\frac{\theta}{\Gamma}} \Delta_G^{\frac{\epsilon\theta}{\Gamma}} \\
&= (1 - \delta) + B\,(1 - \phi)\,N_t\,(\tau\kappa_E)^{\theta(1 - \frac{\theta\alpha_2}{\Gamma})} F^{\frac{\theta}{\Gamma}} (\tau\kappa_G)^{\frac{\epsilon\theta}{\Gamma}}.
\end{aligned}
$$

The output then grows at rate

$$g_Y = (g_A)^{\frac{1 - \alpha_3 + (1 - \gamma)\alpha_2}{\Gamma}} = g_A^{\frac{1 - \gamma}{\theta}}. \tag{27}$$

As the interest rate is given and there is no leisure-labor trade-off while the public capital is productive, in this model the growth rate is a function of the size of the transfers given by $\tau\kappa_E$ and $\tau\kappa_G$. As in Barro (1990), there are optimal budget shares κ_E and κ_G such that g_Y is maximized. These are given by

$$\kappa_E = \frac{\Gamma - \alpha_2\theta}{\Gamma - \alpha_2\theta + \varepsilon} = 1 - \frac{\varepsilon}{\alpha_2 + \varepsilon\rho};\ \ \kappa_G = 1 - \kappa_E. \tag{28}$$

The growth rate of output depends directly on the labor force, so that,

ceteris paribus, a larger economy will grow faster, due mainly to the larger growth of the skill range produced in that economy. This feature will be used to extend the model to the two region case with migration, as detailed in the next section.

5 Two region case

In the previous section, we characterized a single region by its growth rate g_Y, the fraction of population working in skills production ϕ and the optimal composition of public goods provision, κ_E and κ_G. We now extend the model to the case of a two-region economy, that could be thought of as a country. The final good is assumed to be homogenous across regions and its price is normalized to 1. Therefore, no trade occurs in equilibrium and the final good markets clear in each region.

Two new issues are of interest. First, any initial difference of per capita incomes in the two regions will generate migration and potentially divergence both in output levels and growth rates since the population size which now varies in both regions over time is one of the major determinants of growth, as given by (26) and (27). Second, the inter-regional transfers will directly affect economic growth in the receiving region as public investment in infrastructure and education enter the production functions. Moreover, these public investments will indirectly influence the growth in the rich region as well, by altering the migration patterns.

5.1 Migration

By the non-arbitrage condition (16), the wage earned by labor is equal in equilibrium to the profit earned by producers of the new skills/intermediate goods. Thus, we can consider the utility level of a representative agent from a given region when considering the migration decision. There are no migration costs. In each period, equilibrium migration m_t, between the two

regions is given implicitly by the equality

$$U\left(c_{1,t}, c_{1,t+1}, a_{1,t}\left(\frac{N_{1,t} - m_t}{L_1}\right)\right) = U\left(c_{2,t}, c_{2,t+1}, a_{2,t}\left(\frac{N_{2,t} + m_t}{L_2}\right)\right),$$
(29)

where U denotes the utility enjoyed in each region and $c_{j,t}$, $c_{j,t+1}$, $a_{j,t}$, $N_{j,t}$, L_j refer respectively to consumption flows, congestion costs, population and area in region j, where $j = 1, 2$. Notice that migration at time t affects the fraction of people employed in each sector, ϕ_t, but not the existing stock of skills A_t. The effect of current migration on the number of intermediate goods will only show up in future periods through the law of motion for A_t.

Given some initial differences in population or technology, the regional economy dynamics is characterized by sustained migration and divergence in output. Given sufficient spatial redistribution, convergence can also obtain. The migration pattern depends on the congestion parameters specified in the utility function: ω, η and $\widetilde{N}$, which capture the scale effect, the rate of growth and the threshold at which congestion become positive. In this model, both national and supranational transfers can reverse this pattern given they are sufficiently large. Moreover, the effect of both types of transfers depends on the shares allocated to infrastructure and human capital formation.

5.2 Inter-regional transfers

We model two types of inter-regional transfers, depending on their source: national level redistributive transfers and supranational cohesion (or structural) funds. While national level transfers will necessarily have to be financed perhaps by the other region, external transfers will accrue to a region's budget without diminishing the resources in other region. We model the structural funds as a fraction of the poor region's GDP accruing to its public budget.

$$SF_t = \Delta^{SF} Y_{1t} = \Sigma \, \tau Y_{1t}$$

where Δ^{SF} and Σ are the fractions of structural funds in total output and total tax revenue of the lagging region, respectively. Thus, the amounts invested in education and infrastructure in the poor region are given by the

following expressions:

$$\begin{aligned}
X_{E,1,t} &= \tau(\kappa_E + \kappa_E^{SF})Y_t = \Delta_E Y_t, \quad\quad (30)\\
X_{G,1,t} &= \tau(\kappa_G + \kappa_G^{SF})Y_t = \Delta_G Y_t,
\end{aligned}$$

where κ_E^{SF} and κ_G^{SF} are the shares devoted to education and infrastructure.

Notice that the structural funds enter the government budget constraint (7) only on the expenditure and not on the revenue side. Our modelling of these structural funds corresponds to what Chatterjee et al. (2003) call "productive transfer". This implies that all structural funds are used in their entirety to augment the productive government expenditures; there is no unproductive expenditure or waste.

In the calibration section we look at the changes in both the size of the structural funds (Δ^{SF}) and their composition ($\kappa_E^{SF}, \kappa_G^{SF}$).

5.3 Equilibrium

A *competitive equilibrium* in a two region economy ($j = 1, 2$) is a set of sequences of *allocations* $\{c_{j,t}, c_{j,t+1}, s_{j,t}, \phi_{j,t}, h_{j,it}, k_{j,t}\}_{t=0}^{\infty}$, *prices* $\{p_{j,t}, w_{j,t}, q_{j,t}\}_{t=0}^{\infty}$ and migration flows $\{m_t\}_{t=0}^{\infty}$ such that, in each region, for a given set of government *policies* $\{\tau_j, X_{G,j,t}, X_{E,j,t}\}_{t=0}^{\infty}$:

1) Given the *prices*, the allocations $\{c_{j,t}, c_{j,t+1}, s_{j,t}\}_{t=0}^{\infty}$ solve the household problem;

2) Given the *prices*, the allocations $\{\phi_{j,t}, h_{j,it}\}_{t=0}^{\infty}$ solve the firm's problems in both sectors;

3) The sequence $\{\phi_{j,t}\}_{t=0}^{\infty}$ satisfies the intersectoral labor allocation condition (16);

4) The migration flow $\{m_t\}_{t=0}^{\infty}$ solves the utility indifference condition given by (29) each period;

5) Prices are determined by (11) and (14);

6) Final good markets clear so that $C_{j,t,t} + C_{j,t-1,t} = Y_{j,t}$;

7) Government budget is balanced.

Region	Labor force ('000) in 1977	GDP in 1977 (mil PPS*/cap.)	Below 75% of EU average	GDP	Average growth rates 1977-1993
Lisboa e Vale do Tejo	866.2	8018	no	8018	2.29%
Norte	1591.0	5136	yes		
Centro	516.6	4945	yes	5163**	0.6%
Alentejo	143.5	5768	yes		
Algarve	83.2	5604	yes		

*Purchasing Power Standard **population weighted

Table 2: Portuguese regions

6   Calibration

To study the effects of spatial redistribution policies, we calibrate the model to the case of Portugal. As shown in Table 1, the ratio of the richest to the poorest region has increased steadily over the last three decades. As the present model deals with only two regions, we cannot directly make use of the level 2 NUTS[3] (NUTS 2) regional data. We divide the country in two groups (rich and poor) of NUTS 2 regions. The rich group includes regions with GDP per capita greater than 75% of the EU average (only *Lisabona e Vale do Tejo* makes the cut) while the poor group collects together the regions whose GDP per capita is under this cut-off. Thus, the second group includes the regions eligible to receive structural funds.

We calibrate the model to match the GDP per capita ratios between the two groups in two different years which are 25 years apart, namely 1977 and 2002. We use the CRENOS dataset for the 1977 values and Eurostat data for 2002. In both cases, regional GDP per capita is expressed in purchasing power parities and the cluster averages are weighted by population. Below, we describe the benchmark values chosen for the parameters in the model.

To get values for the populations in the two regions in 1977, $N_{1,1}$ and $N_{2,1}$ we apply the normalization $N_{1,1} = 1$ and then use the area weighted employment numbers in the two clusters to get $N_{2,1} = 1.323$. The land area

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[3]Nomenclature des unités territoriales statistiques

of each region L is set to 1. We normalize $A_{1,1}$, the initial skill range in the poor region to 1 and calibrate $A_{2,1}$.

Gollin (2002) estimates the share of employee compensation in GDP, adjusted for the income earned by self-employed and proprietors. In the case of Portugal, that share ranges between 0.62 and 0.82 in 1990, while the unadjusted share in 1981 is 0.476. Using data for Portugal between 1965-1995, Ligthart (2000) obtains an overall labor share of 0.67. Since we are not aware of separate estimates for skilled and unskilled labor in Portugal, we choose $\alpha_2 + \alpha_3$ to be 0.7. This yields, by the assumption of constant returns to scale in the hired factors, $\alpha_1 = 0.3$, which is in line with estimates used by Blanchard (1998) and Conesa and Kehoe (2003) for European countries. The capital depreciation rate δ_k is set to a fairly standard value of 6% annually.

The coefficient of public education, θ is pinned down by the knife-edge condition (25). The value used here, $\theta = 0.219$ is slightly higher than the value constructed by Rangazas (2000) in the context of the US. The elasticity of output with respect to public capital, ε is set to a value of 0.22, which is in line with estimates obtained by Ligthart (2000) for Portugal. Estimates of this elasticity vary in the empirical literature depending on the type of data and the econometric methodology used. While time series studies obtain estimates as high as 0.4, panel data studies with fixed effects find much lower values[4]. Since the elasticities of the two public investment types determine the optimal mix of public policies, in the benchmark model we want to ensure that the two elasticities are as close as possible given the empirically relevant ranges and the constraint imposed by (25).

Since a period in this model is 30 years we expect skills' obsolescence will diminish the variety of such goods available in each period. Therefore we set δ to 0.9. The discount factor is 0.99 annually and the exogenous world-wide interest rate was set to 4% per year.

The scale ω and the convexity η of the congestion cost are set to match migration data. We used inter-regional migration data for the periods 1979-

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[4]Romp & de Haan (2005) provide a comprehensive review on estimates for public capital elasticity.

81 and 1989-91 reported in Rees et al. (1999) to estimate a net immigration rate in Lisabona e Vale do Tejo of 0.91% of the total population, during the first period of our model. The break-in point for congestion $\widetilde{N}$ is normalized such that there is zero congestion in the absence of migration. This yields $\widetilde{N} = N_{2,1}$, the initial population in the rich region. The migration pattern is determined by using these values in the indifference condition (29).

In the production of skills, B is normalized to 1. We calibrate the existing skills coefficient in the production of skills γ, the marginal cost of intermediate goods/skills e, the public capital congestion coefficient ρ, and $A_{2,1}$, the initial skill range in region 2, to match the output ratio in the two regions in the first two periods, the average growth rate of the rich region during the first period of the model and to maintain the approximate equality of θ and ε. We incorporate the actual national and supranational regional policies in the calibration. We can then perform counterfactual experiments to study the impact of these policies.

6.1 Government Policies

According to OECD (1992), the ratio of total tax revenue to GDP is of 35.2% in 1990. We proxy Δ_G by the average gross public capital formation as a fraction of GDP. According to OECD (2005), this figure is approximately 4% for Portugal for the period 1977-2004. Therefore the value for κ_G is obtained using equation (20), that is, by dividing Δ_G by the tax rate. We obtain a value for κ_G of 0.114. This value should be considered an upper bound since public capital in OECD (2005) includes types of capital that do not enter directly in the production function, such as public recreational facilities and the public capital in the judicial system. The corresponding parameter for public education, κ_E is calibrated in a similar manner. Data on the share of education spending in GDP (Δ_E) is available only from 1995 on and it is approximately 6%. Thus, we set κ_E to 0.175. Table 3 summarizes the parametrization.

Parameter		Value	Parameter		Value
Discount factor	β	0.67	Tax rate	τ	0.352
Y production					
physical cap. share	α_1	0.3			
raw labor share	α_2	0.3	Public capital	κ_G	0.1
skilled labor share	α_3	0.4	Public education	κ_E	0.15
public capital share	ε	0.22			
				η	4.1
K congestion	ρ	2.26	Agglomeration	$\widetilde{N}$	1.323
				ω	40
			Initial skill range	A_1	1
				A_2	2.17
h production	e	2e-6	Initial population	N_1	1
				N_2	1.323
A production					
Public educ. share	θ	0.219	Annual interest rate		4%
Existing skills share	γ	0.77	Annual K deprec.		6%
productivity	B	1			
depreciation	δ	0.9			

Table 3: Calibration for the benchmark model

6.1.1 Supra-national redistribution (Structural funds)

Rodriguez-Pose and Fratesi (2004) estimate that the total development support under the structural funds has never exceeded 4% of the GDP in the poorest areas. Given the tax rate of 35.2%, this corresponds to a share of 11.36% of the region's budget. We take this value to be the benchmark and later examine the changes in this percentage. Thus, the budget of the poor region increases by 11.36%, while the rich region's budget remains unchanged. In terms of composition of the structural funds, Ederveen et al. (2006) suggest that around 20% of all available funds are spent on infrastructure projects. Suedekum (2005) reports that 30% of the funds are directed to improvements in human capital in the lagging regions. Since we only model the two main outlays of the EU regional policy, we use these numbers as relative weights: 0.4 and 0.6, respectively.

6.1.2 National redistribution

While the focus of the model is on supra-national policies, we cannot overlook the amount of national level redistribution that has an effect on reducing the gap between rich and poor regions. To capture this effect, we use EUROSTAT data on government transfers to households and tax revenues collected in each of the five regions in the years of 1999 and 2001. The corresponding figures for 1999 are presented in Table 4 below. However, data on transfers to households provide an incomplete picture of national redistribution. To get a better estimate of total government transfers we need to add resources transferred from the central budget to the local governments through the national redistribution programs[5]. Dias and Silva (2004) report the central government transfers to municipalities as percentage of each region's GDP. We use them to calculate the transfers received by each region through the equalization funds. Then we add these numbers to the households transfers to get the total government transfers. The difference between the total amount of taxes and contributions collected and the government transfers represents the government consumption. This makes up about 8% of the total tax revenues. Consequently, we adjust the total taxes paid in each region for the government consumption to get an estimate of the amount contributed towards redistribution purposes.

Next, the degree of redistribution is given by the ratio of receipts by region to total funds distributed. As shown in Table 4, we get a ratio of 0.17 for the poor region and 0.24 for the rich one, meaning that the poor region gets 17% more than it paid in taxes while the rich region gets only 76% of what it contributed. We do the same calculations for 2001 and we get 0.19 and 0.26 for the poor and rich, respectively. Taking the mean values for those two years, we set the redistribution shares to 18% and 25% of the tax revenues in the poor and rich regions.

Table 5 contains results from the above parametrization of the bench-

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[5]These programs include the Financial Balance Fund, Municipalities' General Fund, Municipal Cohesion Fund and Parish Financing Fund. The resouces under these programs are trasferred in the form of grants from the State to the local governments (municipalities and parishes).

Region name	Social transfers	Regional redistribution	Total received	Total contributed (adjusted for government consumption)	Redistribution (% of contributions)
Lisboa e Vale do Tejo	6,415	230	6,645	8,018	- 24%
Norte	6,486	417			
Centro	4,858	382	14,517	12,377	+ 17%
Alentejo	1,426	213			
Algarve	675	60			

*numbers are in million euros

Table 4: National level redistribution

mark model. While the model is able to match the relative output evolution, it implies the annual average growth rate for the poor region was 1.69%, which is high relative to the actual annual growth rate of 0.62%. Also, according to the data, the share of people employed as raw labor rather than in the production of new ideas is higher in the poor region. In table 5, ϕ_1 and ϕ_2 are measured by the fraction of the labor force employed in agriculture. This is almost certainly an underestimate of the fraction of the labor force that does not contribute to the production of new skills. What matters for our purposes here is that in our model, as well as in reality, the fraction of the labor force producing new ideas is higher in the rich region than in the poor region. Also, due to continuing migration, the raw labor share in the poor region increases over time after an initial increase.

Figure 1 shows the evolution of the economy over six periods or about 150 years. The period 1977-2002 corresponds to the first time period in the model. Structural funds alone have a two-fold effect on the share of labor force in the knowledge producing sector. First, more public spending augments labor productivity with the *existing* range of skills (due to infrastructure). In the same time it also expands the future skills variety (through public education). Thus, structural funds yield an increase in the growth rate of the region and a shift of the labor force toward idea-producing employment. However, persistent migration, even at low levels, reverses this

Variables		Year/Period	Data	Model
Av. annual growth rate (poor region)	g_{y1}	1977-1993	0.6%	1.69%
Av. annual growth rate (rich region)	g_{y2}	1977-1993	2.29%	2.29%
Output ratio (rich/poor)	$\frac{Y_2}{Y_1}$	1977	1.553	1.549
		2002	1.757	1.759
Internal Migration (% total population)		1977-1993	0.91%	1.14%
Empl. in final good production (poor region)	ϕ_1	1977	32.4%	47.0%
Empl. in final good production (rich region)	ϕ_2	1977	6.3%	40.6%

Table 5: Benchmark model outcomes

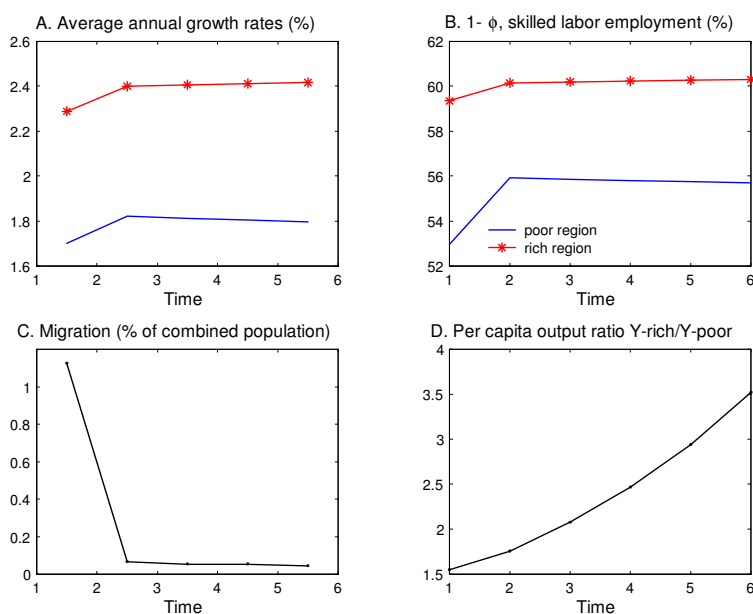shift through the scale effects on the growth rate, despite continuing allocation of structural funds.

Figure 1: Time paths in a two-region economy with migration

7 Policy experiments

The effects of development funds can now be assessed along two dimensions. We first look at the effect of varying the size of structural funds while keeping their structure i.e. the budget shares the same. Second, we allow the composition of funding to change. We need to keep in mind that the regions' budget shares for infrastructure and human capital investment will also matter for the effectiveness of the structural funds in as much as they differ from the optimal shares predicted by the model. Under the above parametrization, the optimal shares in (28) are:

$$\kappa_E^* = 1 - \frac{\varepsilon}{\alpha_2 + \varepsilon\rho} = 1 - \frac{0.22}{0.3 + 0.22 \cdot 2.26} = 0.72\% \text{ and } \kappa_G^* = 1 - \kappa_E = 28\%.$$

On the other hand, the data suggests that national level public investment in education and infrastructure account for 15% and respectively 10% of total revenues, which translates into 60% and respectively 40% of total public investment. Comparing the observed shares against those obtained in the model, there seems to be some underinvestment in human capital formation. The direction and the size of the bias can be used to derive normative implications for the optimal allocations of the supplementary resources available through structural funds.

Proposition 1 *Denote the observed shares of the regional budget going to infrastructure and educations before structural funds are disbursed, as κ_E and κ_G and the total structural funds expressed as a share in the regional budget of the poor region with Σ. Denote the growth maximizing shares for the two outlays κ_E^{SF} and κ_G^{SF}. Then,*

1. If $\kappa_E > \kappa_E^*$ and $\kappa_E - \kappa_E^* \geqslant \Sigma$, then $\kappa_E^{SF} = 0$ ($\kappa_G^{SF} = 100$);

2. If $\kappa_E < \kappa_E^*$ and $\kappa_E^* - \kappa_E \geqslant \Sigma$, then $\kappa_E^{SF} = 100$ ($\kappa_G^{SF} = 0$);

3. If $\kappa_E < \kappa_E^*$ and $\kappa_E^* - \kappa_E < \Sigma$, then $0 < \kappa_E^{SF} < 100$ ($0 < \kappa_G^{SF} < 100$);

Thus, it is straightforward to see that if the actual budget shares in the poor region are relatively far from the optimal budget shares, structural

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Size of structural funds (%) - Δ^{SF}	0	4*	8	12
1st period av. gr. rate (poor region)	1.428	1.690	1.904	2.067
2nd period av. gr. rate (rich region)	2.406	2.399	2.394	2.388
Output ratio (rich/poor) 1977	1.549	1.549	1.549	1.549
Output ratio (rich/poor) 2002	1.901	1.759	1.660	1.586
Divergence (% change in output ratio)	23	14	7	2
Migration (% total population)	1.191	1.126	1.070	1.013

* Benchmark

Table 6: Changes in the size of structural funds

funds should be entirely allocated either to infrastructure or education, depending on which is underfunded. If regional shares are close to optimal values, then structural funds should be split such that the *after-redistribution* shares are optimal.

7.1 Changes in the size of structural funds

The initial parametrization used a share of structural funds in the poor region's budget of 11.36% or 4% of its GDP. Table 6 shows counterfactual experiments on the magnitude of funds available.

The structural funds appear to have sizable impact on the growth rate of the lagging region. In the absence of structural funds, the economy of the poor region would grow at a rate of 1.42% per year. In the benchmark case, in which the structural funds are 4% of GDP, the poor region grows at 1.69% annually. Changing the size of the structural funds has substantial effects in the poor region, while first period growth in the rich region is unaffected. Eliminating all structural funds would lower the growth rate in the poor region to 1.42% per year, while a doubling of the structural funds will increase the growth rate in the poor region to 1.9% annually. Migration from the poor region to the rich region is modestly influenced by structural funds, changing from 1.13% in the benchmark case to 1.07% if funds are doubled. Changes in migration influence next period growth in the rich region but, as shown in Table 6, these changes are negligible.

In the benchmark case, the inequality between regions, measured by the

change in the output ratio, increases by around 14% (from 1.55 to 1.76). Increasing structural funds to 8% of the poor region's GDP would halve this number, while funds disbursements of up to 12% of the regional GDP would slow the divergence to only 2% (from 1.55 to 1.59), in terms of the output gap change. However, using the current parametrization, funds of this magnitude do not generate enough growth to have the poor region catch up with the rich region in one model period. This result is consistent with the finding in Boldrin and Canova (2001) of very slow, if any, convergence in the EU in the presence of structural funds disbursements.
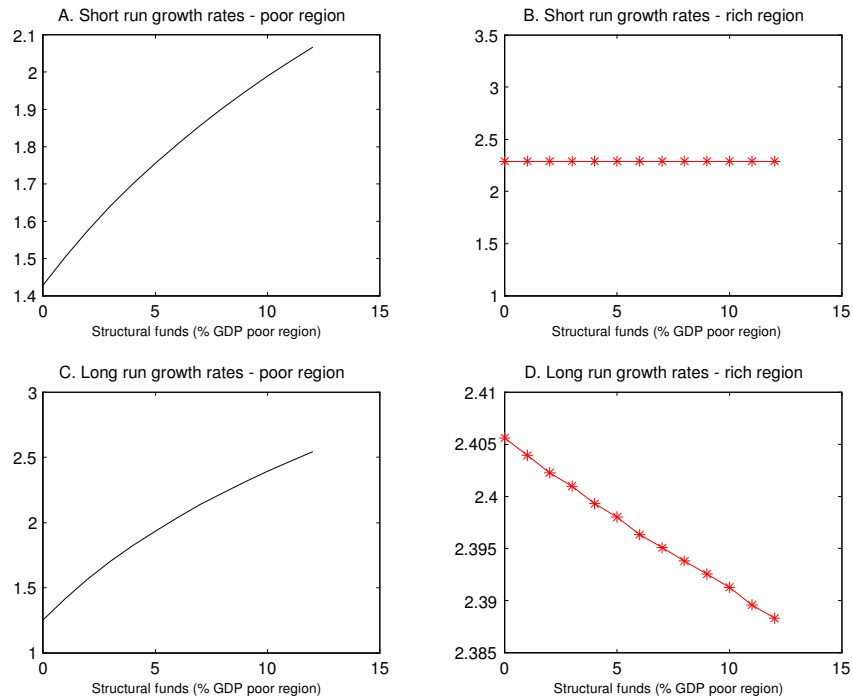

Figure 2: Short and long run effects of the size of structural funds

We can summarize the role of structural funds as follows: first, regional convergence can be attained given the structural funds are sufficiently large; second, in this model, structural funds diminish disparities by raising the productivity of the labor force in both sectors. With increased structural

funds, migration goes down, as people enjoy increasing returns in the local labor market size. This decline in migration hurts the rich region, whose future growth rates also depend on its population size.

To clarify these effects, notice that current output Y_t depends only on the current range of intermediate goods A_t, which is determined at $t-1$ and on the current amount of structural funds. Thus, first period structural funds affect the stock of skills used only in the next period. The effect of structural funds can then be decomposed into a direct, short run, impact on output and long run effect through the range of skills available in that economy. The poor region benefits from more structural funds both in the short run and the long run, while the rich region is not influenced in the short run, since the range of skills in the first period is predetermined. However, in the long run, more structural funds generate less migration which in turn means a lower increase in the range of skills in the rich region. Since policy induced changes in migration are rather small, this effect is also small.

7.2   Changes in the composition of structural funds

In this section, we study how the relative shares of structural funds expenditure for infrastructure and human capital formation influence the equilibrium outcomes in the two regions. The model suggests that there is a growth maximizing allocation of infrastructure and public education investment. If, due to various reasons, the allocations from the national government are not optimal, structural funds can adjust the mix in the right direction, provided they are used optimally.

To see how these objectives depend on the composition of structural funds, we consider alternative budget shares while keeping the total amount 10% of poor regions' GDP, as shown in Table 7.

Changes in the *current* structural funds allocations for education and infrastructure have both short and long run effects (see Figure 3). The poor region's growth rate in the first period (short run) is maximized if all structural funds are used for infrastructure projects. This happens because first period structural funds can change the growth rate for that period

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$\Delta^{SF} = 10\%$							*	
Structural funds, infrastructure share	0	10	20	30	40	...	90	100
1st period av. gr. rate (poor region)	1.089	1.368	1.603	1.807	1.989		2.743	2.883
2nd period av. gr. rate (rich region)	2.402	2.399	2.396	2.393	2.391		2.382	2.381
2nd period av. gr. rate (poor region)	2.404	2.431	2.435	2.422	2.392		2.006	1.863
Output ratio (rich/poor) 1977	1.549	1.549	1.549	1.549	1.549		1.549	1.549
Output ratio (rich/poor) 2002	2.105	1.941	1.813	1.709	1.621		1.305	1.253
Divergence (% change in output ratio)	36	26	17	10	5		-15.8	-19.1
Migration	1.157	1.122	1.091	1.065	1.044	...	0.952	0.939

* denotes the benchmark composition of structural funds

Table 7: Changes in the composition of structural funds

only through the output, since the current range of skills is predetermined and since the national policy allocates too much of the government budget to education relative to the optimum. The optimal allocation for the first period can be determined by using (23), together with the definition of structural funds shares (30).

$$Y_1 = F^{\frac{1}{\Gamma}} \tau^{\frac{\varepsilon}{\Gamma} - \frac{\theta\alpha_2}{\Gamma}} (\kappa_E + (1 - \kappa_G^{SF}))^{\frac{\varepsilon}{\Gamma}} \ (\kappa_G + \kappa_G^{SF})^{-\frac{\theta\alpha_2}{\Gamma}} A_1^{\frac{1 - \alpha_3 + \alpha_2(1-\gamma)}{\Gamma}}$$

Since Y_0 and A_1 are predetermined the first period growth depends only on the expression $(\kappa_E + (1 - \kappa_G^{SF}))^{\frac{\varepsilon}{\Gamma}} \ (\kappa_G + \kappa_G^{SF})^{-\frac{\theta\alpha_2}{\Gamma}}$ where the local budget shares are fixed. The optimal allocation then is

$$\kappa_{G,1}^{SF} = \max \left(\frac{2\varepsilon - (\varepsilon + \theta\alpha_2)\kappa_G}{(\varepsilon + \theta\alpha_2)}, 1 \right)$$

It is straightforward to show that, under the current parametrization and the current national policy, this share is actually one.

From the second period onward (long run), the optimal allocation depends on the size of structural funds relative to the gap between the actual local budget shares and the optimal ones, according to Proposition 1. As explained before, the rich region is affected only with a lag. However, the welfare of the rich region is maximized if the structural funds are spent only

on human capital formation in the lagging region. This is because a higher share spent on education, which will affect next period range of skill only, implies that infrastructure spending must be lower, decreasing the current productivity and wages and hence prompting people to leave from the poor to the rich region. This is consistent with results in Suedekum (2005), who shows in a different set-up that excessive education investment can lead to brain-drain, lowering output in the affected region.

Panel C of Figure 3 reveals that the budget share that maximizes long-run growth in the poor area calls for 20% of structural funds to go to infrastructure investment. The hump-shaped relationship between the budget allocation and growth obtained here is analogous to a result obtained in Barro (1990) and other similar models. Of course, the location of the peak depends upon the technology parameters as well as national Portuguese policy parameters. Notice also that the effects on the poor region growth of changing the structural funds allocations are modest. Increasing the share going to infrastructure from 20% to 60% decreases output long-run growth by approximately 0.2% annually (from 2.42% to 2.25%).
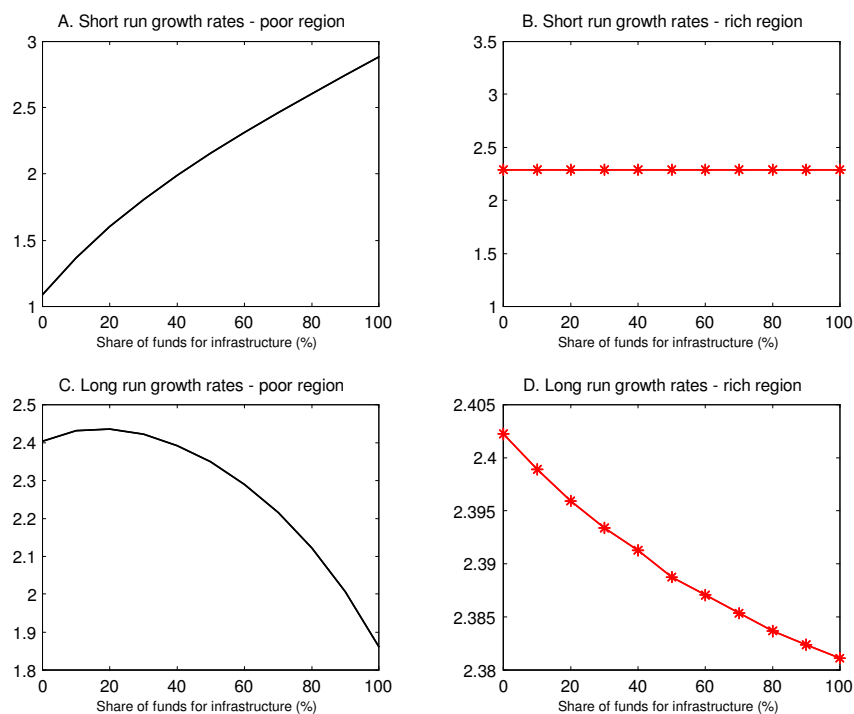
Figure 3: Short and long run effects of the composition of structural funds

When migration is a channel for growth, policies that reduce migration from the poor regions to rich regions, will necessarily make the latter worse off, suggesting that whenever the allocation of structural funds is decided at the national level, rich regions will favor a high share of investment in public education. The finding raises some questions with regard to the mechanisms used to allocate structural funds. Brakman et al. (2005) and Ederveen et al. (2006) report that regional policy is biased towards infrastructure, while other studies, like Midelfart-Knarvik and Overman (2002), point out that investments in human capital formation can be undesirable, since they may counteract the comparative advantage of the lagging regions. In this model, the optimal shares of supranational funding depend not only on the relative productivities of infrastructure and public education, but also on the timing of such funding. Thus, the regions may have different preferences over the

allocations of structural funds, even in the long run. This can lead to political economy problems and biases in the cohesion policy implementation, if the eligibility of projects financed by supranational money is partly decided at national level. This can be true even when the mix of local policies is set optimally, since the composition of the structural funds may still depart from it.

8   Conclusion

In this paper we have introduced a dynamic model that allows us to study the effects of regional redistribution policies such as the European Structural Funds. Our model allows for occupational choice within regions as well as factor mobility and residential choice among regions. Economic growth in the model is driven by the endogenous expansion of ideas or new skills. The government in the model finances both infrastructure investment and public education expenditure. The model is calibrated to the Portuguese economy.

First, we find that increasing the size of the structural funds allows the poorer regions to catch up faster to the richer regions. This effect is of modest size. Between 1977 and 2002 the income ratio between rich and poor regions increased from about 1.56 to about 1.76. Even a tripling of the current structural funds received by Portugal from 4% to 12% of GDP will not return this ratio back to its 1977 level. Second, the growth implications of allocating structural funds between education and infrastructure vary between the short run and the long run. Third, the growth effects of changing budget allocations are sizeable. Fourth, we also find that the allocation of the structural funds that maximizes growth in the poor region (or minimizes divergence between the poor regions) is not optimal for the rich region since it induces sub optimal migration.

Our model has relied on a few simplifying assumptions. We assumed that migration is costless. We also assumed that skills of workers are not sector or activity specific. It stands to reason that work in the rich region requires different skills than work in the poor regions. We plan to introduce such features in future work. Our model has pointed to a potentially

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important political conflict about the allocation of the structural funds between infrastructure and education expenditures. The precise nature, the severity and the implications of this conflict are worthy topics for future investigations.

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9 Appendix

In this section, we perform sensitivity analysis of the policy experiments with respect to changes in ε and θ. We allow ε to vary around the benchmark value used in the calibration. The knife-edge condition, required for balanced-growth, then gives the corresponding θ. Below, we summarize the effects of doubling the structural funds when ε and θ change.

ε	0.22	0.17	0.22	0.27
θ	0.219	0.196	0.219	0.244
Size of structural funds (%) - Δ^{SF}	4*	8	8	8
1st period av. gr. rate (poor region)	1.428	2.056	1.904	1.781
2nd period av. gr. rate (rich region)	2.406	2.864	2.394	2.014
Output ratio (rich/poor) 1977	1.549	2.028	1.660	1.415
Output ratio (rich/poor) 2002	1.901	2.317	1.742	1.385
Migration	1.191	1.170	1.070	0.952

* Benchmark

Table 8: Sensitivity of changes in the size of structural funds to changes in ε and θ.

Given that θ is pinned down by the knife-edge condition, increasing ε tends to increase θ as well. Economies with higher values of ε and θ have smaller effects on the growth rates as structural funds allocations are increased. This is due to the fact that the shares of national level investments in infrastructure and education are kept constant at observed values, while the model yields optimal shares that are function of parameters, in particular of α_2 and ε (see equation 28). While in the benchmark model the differences between observed and optimal shares are small, they increase as ε increases in the sensitivity analysis. This inefficiency outweighs the increase in the marginal productivity of public investments. Moreover, the effect of changing the size of structural fund budget on migration is smaller the larger are θ and ε. Figure 4 shows the sensitivity of short and long run growth rates in both regions.
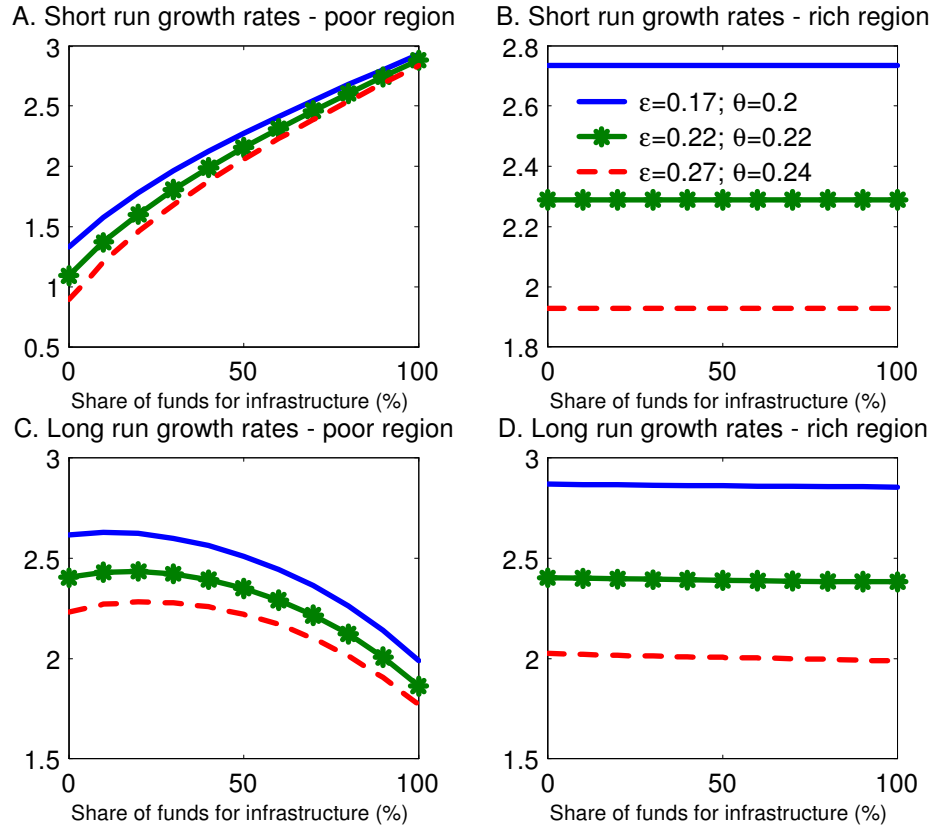
Figure 4: Sensitivity of the structural funds composition effect to changes in ε and θ.