Infrastructure and education as instruments of regional policy: evidence from Spain
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1. INTRODUCTION

Regional differences in economic activity within a country often lead government to promote more balanced local development. Regional policies have generally been supply oriented, reflecting the view that income disparities primarily reflect regional disparities in endowments of key factors of production. To help correct such differences, public intervention has focused on the attraction of productive investment and on the provision of training and infrastructure.

Can regional policy work? Many thought so in the 1950s and 1960s, when European governments pursued active policies of regional development, underpinned by theories of economists such as Myrdal, Hirschman and Kaldor. Subsequently, however, enthusiasm for regional policies has waned. As the neoclassical view became more prevalent among economists, the theoretical argument for regional policy – heavily dependent on increasing returns assumptions – was viewed with growing scepticism. At the same time, the disappointing results of years of experience with regional policy, coupled with budget cuts, forced governments to scale down their interventions.

Even so, in many countries regional policies still absorb a lot of resources and continue to be seen as a necessary response to regional imbalances considered unacceptable on distributional or political grounds. This is particularly so in the EC, where the reduction in efforts of individual nations to reduce internal
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disparities has been partly offset by the growing efforts at Community level in response to the perceived need for cohesion as a prerequisite for further economic integration. On a theoretical level, moreover, recent developments in growth economics and economic geography have rekindled interest in regional issues.

In this paper, we use the Spanish experience during the 1980s to explore the potential and actual effectiveness of some traditional instruments of regional policy. This evidence has potential relevance to many other countries. During the 1980s, regional issues received considerable attention following the decentralization of the Spanish state outlined in the 1978 Constitution. The Spanish government paid at least lip service to the need to reduce regional disparities. To some extent, redistribution mechanisms were built into the financing of the new regional governments. Following Spanish accession to the EC in 1986, transfers from the European Regional Development Fund (ERDF) and other Structural Funds (of which Spain is the largest recipient) also contributed to development of the poorer regions, mostly by financing infrastructure and training schemes. Hence, the period we study has displayed a fairly active regional policy.

We focus on three questions. First, can regional policy work in principle? More precisely, to what extent can public investment in infrastructure and education reduce observed differences in income levels across regions? Second, what has been the actual impact of such policies on regional inequality? Finally, given some reasonable allocation criterion (redistribution, efficiency or neutrality), where should we invest?

Section 2 introduces the theory and practice of regional policy. Section 3 develops and estimates a simple model of regional inequality built around a production function with inputs of human and public capital, and which we can then use to answer our three questions. Section 4 analyses the sources of regional inequality and regional convergence in Spain. To measure the potential and actual effectiveness of regional policy, we estimate both how much income inequality would be reduced if regional endowments of public and human capital were equalized, and the contribution of these factors to the actual reduction of income dispersion during the period. Section 5 discusses need and efficiency criteria for the allocation of public investment, examining the regional priorities each criterion implies and whether actual policy has conformed to these criteria or to political considerations. Section 6 studies the impact on Spain of the ERDF. Section 7 concludes with a brief summary and some thoughts on the policy implications of our results.

Our focus throughout the paper is on positive rather than normative issues, on the potential and actual impact of certain policies on the dispersion of regional incomes. Our analysis does bring out, however, that redistribution entails an efficiency cost. Hence, determination of the optimal policy involves a difficult trade-off, about which we have little to say. Our results may, however, provide some guidance as to the volume of resources required to achieve a given policy.
target, or the optimal allocation of a given volume of resources across regions under various criteria.

2. REGIONAL POLICY: THEORY AND PRACTICE

Regional policies are the set of measures by which governments try to influence the geographical distribution of economic activity. In this section we discuss the possible rationale for such measures and the European experience with them, with particular attention to the main features and evolution of EU regional policy. Finally, we briefly review the evolution of regional inequality in Europe and the extent to which empirical evidence may have some bearing both on the need for and the potential effectiveness of regional policy.

2.1. The case for regional policy

Regional policies may be classified in two groups according to their objectives. Regional development policies aim to promote growth of the poorer regions of a country, to reduce or eliminate any locational component of inequality in which people of similar characteristics have different incomes depending on their place of residence, which is considered unacceptable for political or equity reasons. Regional adjustment policies have shorter-run aims, to help regions cope with transitory difficulties arising, for example, from adverse sectorial shocks.

From this perspective, regional policies are nothing more than the territorial expression of two of the guiding principles of public intervention in the welfare state: the reduction of inequality and the provision of insurance against diversifiable risks. Hence, the standard rationale for many public policies may also be used to justify measures aimed at influencing the location of economic activity whenever the region can be shown to be a relevant unit for action. In addition, numerous authors have tried to build a case for regional development policies on the grounds of economic efficiency. Their argument is essentially that market forces lead to the increasing concentration of production in a few regions, and that, moreover, this process tends to go too far unless checked by corrective measures.

The conclusion that, in the absence of intervention, regional inequality tends to increase over time is controversial and linked to the view that increasing returns are pervasive. In standard neoclassical models, built on the assumption of decreasing returns to reproducible factors, income disparities arising from differences in regional capital/labour ratios diminish over time: both trade and factor flows tend to equalize factor prices. Proponents of regional policy, however, argue that increasing returns (often seen as arising from technological or pecuniary agglomeration externalities) generate a process of circular, cumulative causation leading to increasing concentration of production. Both capital and labour flow to the richer regions, which have the advantages of lower unit costs, higher wages and
larger market sizes. Labour market imperfections may further complicate matters. To the extent that social norms or nationwide collective bargaining prevent wages from fully reflecting regional productivity differentials, the cost advantage of the more developed regions is larger. Poorer regions suffer from above-average unemployment rates (see, for example, Myrdal, 1956; Hirschman, 1958; Kaldor, 1970).

Although for a long time the implications of increasing returns were neglected in the mainstream literature, the subject has recently received considerable attention both in connection with growth (starting with Romer, 1986, 1989) and in recent work on the ‘new’ economic geography. Krugman (1991a, 1991b, 1992) and Krugman and Venables (1990, 1993), for example, have analysed determinants of the spatial distribution of economic activity, focusing on the interaction between transport costs, increasing returns and market size. Their results, while still preliminary, seem consistent with the view that there may be important forces working for concentration, particularly when transport costs are low.

Even if market forces lead to increasing concentration, it does not necessarily follow that interfering with the location decisions of private agents leads to an efficiency gain (or even that governments can do much about it). As yet, we know of no clear-cut welfare results of an efficiency justification for regional policies in a well-articulated model. The literature, however, does identify some reasons why market outcomes may not be efficient, and it does seem plausible that intervention may sometimes be efficient in a world with adjustment costs and in which agents care about their place of residence.

2.2. Regional policy in practice

Whatever the merits of the ‘economic case’ for regional policies, governments often adopt them on equity grounds or in response to political pressures. Such policies have traditionally focused on attraction of manufacturing investment to depressed regions. There have also been sporadic attempts to discourage further expansion in areas already congested. A wide variety of instruments have been used to promote the growth of backward regions: investment grants, wage subsidies and tax allowances designed to influence private location decisions; licensing and zoning regulations; direct investment by public enterprises; and provision of various services and infrastructure. In many cases, it was considered important to concentrate initially on the promotion of growth centres or pôles de croissance to exploit agglomeration externalities, hoping that, once a critical mass was reached, industrialization would spontaneously spread to the surrounding area (see Perroux, 1950).

During the 1960s and early 1970s, many European governments pursued active regional policies with enthusiasm. In more recent years, the flow of resources was greatly reduced, partly for budget reasons, but also in response to an increasingly critical appraisal of the success of previous experiments. The effectiveness of
subsidies as a way to attract manufacturing investment was seen as questionable; and even where some success was achieved, the strategy often backfired as many mature industries came under increasing competition from emerging economies and had to downsize drastically. The resulting disenchantment has led, if not to the abandonment of regional policies, to a reassessment of the measures used in the past. In recent years, the emphasis has changed from attraction of external investment to promotion of the endogenous growth potential of backward regions, and from general investment subsidies to more selective policies aimed at development of human resources and provision of business services and technical support.¹

2.3. Regional policy in the EU

The EC and now the EU has been ambivalent about regional policy.² On the one hand, concern for economic cohesion has been a constant feature of the process of European integration. While the formation of the single market offered the promise of a significant increase in the output of the Community as a whole, the political viability of the project also required that the distribution of its benefits be perceived as fair by the constituent states and regions. Thus, the Treaty of Rome itself referred in Article 2 to the need to ensure the harmonious development of the EEC, and established an institution, the European Investment Bank, whose primary aim was to provide financing for the development of the poorer regions of the Community (Article 130a). On the other hand, the basic commitment to free markets and the removal of obstacles to competition was not easily compatible with an active regional policy. Indeed, state interference with market forces was deemed to be incompatible with the Union (Article 92). Although an exception to this general rule allowed national governments to provide aid to ‘regions where the standard of living is abnormally low or where there exists serious underemployment’, the treaty itself did not provide the instruments for a true Community-wide regional policy.

To a large extent, this state of affairs reflected the view that convergence in per-capita income levels would follow automatically from removal of institutional barriers to the movement of goods and factors. With the passage of time, however, the initial optimism turned into a more cautious assessment of the prospects for spontaneous reduction of regional inequality, particularly as countries with long-standing regional problems came to join the Community. In the poorer countries, there was even concern that completion of the single market project might widen existing disparities. The gradual development of an active cohesion policy at the

¹ For a more detailed discussion, see Cuadrado (1988), and Chapman and Walker (1991).
EU level was a response to these concerns. It became accepted that correction of regional income disparities, or at least the perception that some effort was being made in this direction, was a prerequisite for further integration. Thus, the ERDF, announced at the 1972 Paris summit, was justified as an instrument for correcting 'the structural and regional imbalances which might affect the realization of economic and monetary union' (Nevin, 1990). This was further consolidated by commitment to an active cohesion policy in the Single European Act. The main instruments were to be the Structural Funds, especially the ERDF, aimed at promoting the development of the poorer regions of the Union.

Figure 1 summarizes the evolution of Structural Fund budget allocations. Both the absolute size of the Funds and their weight in the overall EU budget have increased steadily over time. The ERDF and the European Social Fund (ESF) accounted for 21.8% of the EU budget and 0.25% of EU GDP in 1992, compared with only 8.6% and 0.07% respectively in 1979. In spite of their fast growth, however, the structural programmes are still too small to have a significant macroeconomic effect on recipient economies, even though their expenditures are highly concentrated on the regions with lower per-capita incomes. Annual Structural Fund grants are less than 2% of GDP even in the most favoured countries, and amount to only a fraction of the cost of the agricultural

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3 Article 1 of the Single European Act states that the Community 'shall aim at reducing disparities between the various regions and mitigating the backwardness of the less-favoured regions'.

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price-support programmes that absorb the lion’s share of the EU budget and
favour relatively rich agricultural regions in the central countries.

The allocation of the Structural Funds among different expenditure categories
reveals the EC Commission’s view that the structural weaknesses in the poorer
regions mainly reflect insufficient endowments of crucial productive factors. The
focus is clearly on supply-side policies, with a heavy emphasis on infrastructure and
training. Transport infrastructure has absorbed most of the resources of the
ERDF, particularly in the poorer countries, while most of the ESF disbursements
have gone to finance vocational training. In recent years, however, more resources
are being devoted to the provision of incentives to private investment and the
development of supporting business services and technical assistance.

2.4. Regional policy and regional convergence

Proponents of regional policy typically argue that, in the absence of active
intervention, regional inequality will tend to increase over time. On the whole, the
post-war European experience does not seem to confirm these fears. Figure 2
shows the evolution of three indices of regional inequality for a sample of several
European countries. Over the period as a whole, there has been a clear reduction
in the dispersion of regional per-capita incomes. On the other hand, this fact
cannot be taken as conclusive evidence against the need for cohesion policies either.

![Figure 2. Dispersion of regional per-capita income in Europe, 1950–90](image)

*Notes:* Income is measured by regional gross value added per capita, corrected for differences in
purchasing power. The figure shows the evolution of the coefficient of variation of the log of this
variable, together with the Theil and Atkinson (100) inequality indices. The sample contains the
regions of West Germany, Ireland, Holland and the UK (at the NUTS I level), Luxembourg, and the
regions of France and Italy (at the NUTS II level).

*Source:* EUROSTAT and Molle et al. (1980).

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4 For a discussion of the Commission’s diagnosis of the sources of regional disparities, see CCE (1992) and
Emerson et al. (1990).
According to Esteban (1994), the slight increase in inequality registered by the Theil index during the 1980s is largely the result of an increase in regional income dispersion within countries. To decompose observed regional inequality in the EU into its 'within' and across' country components, he uses a Theil index which can be written as the sum of an index of 'external' inequality across countries and a weighted average of 'internal' national indices of regional inequality. As shown in Figure 3, about half of the regional inequality is internal. Moreover, the weight of this latter component increased during the 1980s, while inequality across countries fell.5

Hence, recent developments provide some support for the view that one cannot rely on the market alone to eliminate regional differences, but it is still too early to tell whether the recent halt of convergence is more than a short-term development caused by large exogenous shocks. Even so, the current level of regional inequality in Europe is 'high' (for example, higher than that observed among American states), and there is widespread agreement that its reduction would be desirable.

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5 According to Esteban, the sharp divergence of internal and external inequality measures after 1986 suggests that the main beneficiaries of the completion of the Common Market have been the richer regions of the poorer countries, at the expense of the more backward regions of the richer member states.
Yet opinions about the effectiveness of active convergence policy vary considerably. Barro and Sala-i-Martín (1991) and especially Sala-i-Martín (1994) reach pessimistic conclusions in this regard. They find that the speed of regional convergence is very low in Europe and elsewhere, and are sceptical about government’s ability to speed up the process. Their main evidence in support of this conclusion is a remarkable empirical regularity: the apparent stability of the rate of convergence, 2% a year in a variety of samples. According to Sala-i-Martín, the fact that convergence takes place at practically the same speed within groups of territories supposedly characterized by very different levels of redistributive effort implies that such policies cannot be very effective.

This judgement may be too hasty. Governments can certainly influence the rate at which regions accumulate various productive factors, particularly infrastructure and human capital. If these factors affect productivity and the location of mobile private factors, there will be room for supply-side policies to influence the dispersion of regional incomes. The stability of the convergence coefficient across different samples may indicate that the redistributive effort has been too small to have a noticeable effect on the evolution of income disparities, and/or that the policies adopted in the past were not very effective, but it cannot be taken as evidence that regional policy per se is necessarily ineffective.6

2.5. Public inputs and regional policy

One key aim of this paper is to examine the question of the potential effectiveness of some of the traditional instruments of regional policy using a more direct approach. To this end, we develop a simple model of regional inequality in the following section. The model is essentially neoclassical in its assumptions. Hence, it ignores some of the mechanisms which, according to the recent literature on economic geography and endogenous growth, may generate income divergence among regions, and therefore some of the channels through which policy may affect the location of economic activity. In this sense, we provide a lower bound for what regional policy might achieve. Nonetheless, once we recognize that governments largely control the supply of some important productive inputs, there may be plenty of room for regional redistribution.

This does not necessarily mean that the primary goal of public investment should be to reduce income disparities across regions. As we have seen, the efficiency case for regional policy has yet to be made convincingly; nor is it our purpose here to build such a case. We do argue, however, that governments

6 In fact, recent work on Spain (Dolado et al., 1994; Mas et al., 1993b) suggests that variables such as education and public investment may indeed have an effect on regional convergence. Both sets of authors find that these and other variables are significant in convergence regression and that their inclusion increases the estimated speed of convergence.
should take explicit account of the regional implications of their investment
decisions; and to allocate public resources efficiently, it is important to have some
idea of their likely impact on the regional income distribution and of the relative
needs of the different regions.

3. A SIMPLE MODEL OF REGIONAL INEQUALITY

To analyse the determinants of regional income and its distribution, we use a
simple model in which education increases labour productivity and public capital
reduces transport costs. We assume that production occurs in two stages. First, a
number of geographically dispersed firms produce intermediate goods, then the
different components are shipped to assembly plants for production of the final
consumption good. This description gives rise to a nested aggregate production
function. We assume that the production of components requires only private
inputs. The output of intermediate goods $Y_i$ in region $i$ is given by a
Cobb–Douglas production function,

$$Y_i = B_i K_i^\alpha L_i^{1-\alpha} H_i^\beta$$

where $B$ is an index of total factor productivity, $H$ the average stock of human
capital per worker, $L$ employment, and $K$ the endowment of private capital. Final
regional output $X_i$ rises with the quantity of intermediate goods arriving at their
destination, thus introducing transport costs: a fraction of intermediate output
‘melts’ in transit. Transport costs increase with the land area $S$ of the region, but
decrease with the stock of public capital $P$. Finally, it seems reasonable to expect
that, if we double intermediate output, the stock of public capital and the size of
the region, final output will double. Hence, we assume that the second stage or
final output production function exhibits constant returns to scale

$$X_i = Y_i^\gamma P_i^\gamma S_i^{1-\gamma}$$

where $0 < \gamma < 1$ so that transport costs increase with land area. From (1) and
(2) we obtain the reduced-form production function capturing the influence of
both production and transport technologies

$$X_i = A_i K_i^{\alpha} L_i^{\beta} H_i^\nu P_i^\gamma S_i^{1-\alpha-\beta-\gamma}$$

where $\alpha = ac, \beta = (1 - a)c, \nu = bc$ and $A = B^c$.

To get around the lack of reliable data on regional stocks of private capital, we
assume that this factor is perfectly mobile, whereas public capital and labour are
fixed factors – in which case, under competitive conditions, private capital will flow
across regions until its marginal product is the same at all locations. In equilibrium,
the regional stock of this factor will be a function of the national capital stock and
the regional endowments of fixed inputs. As discussed in the appendix, we can
eliminate private capital from the regional production function and write $q_{it}$, the logarithm of output per employed worker in region $i$ at time $t$,

$$q_{it} = \phi_i + a_i + \theta_i h_{it} + \theta_p P_{it} - \theta_s s_{it} - \theta_l l_{it} \quad (4)$$

where $\phi$, a factor common to all regions, depends on the national capital/output ratio and lower-case letters denote the logarithms of $A, H, P, L$ and $S$. This reduced-form production function will allow us to calculate the contribution to regional income of the stocks of human and public capital, taking into account not only their direct effect on output, but also their indirect effect through the regional allocation of private capital.

Although the stock of public capital at the beginning of the period is predetermined, the level of employment and the average education of employed workers are endogenously determined. We start from the hypothesis that labour market rigidities may generate cross-regional differences in unemployment rates. In particular, we assume that union behaviour or social norms tend to ‘compress’ the wage scale, which, as a result, does not fully reflect educational differences across workers or regions. Thus, highly skilled labour will be cheap relative to its productivity, and firms prefer to hire more educated workers. At the aggregate level, this will make the (logarithm of the) regional employment rate ($l-f$) an increasing function of $h^*$, the level of schooling of the population:

$$l_{it} - f_{it} = \text{constant} + \Gamma_i h^* \quad (5)$$

where $f$ is the logarithm of the labour force. Moreover, if firms select workers according to schooling levels, there will be a gap between $h$, the average schooling of employed workers, and $h^*$, that of the adult population, and the size of this gap will decrease with the employment rate:

$$h_{it} = \text{constant} + h^*_{it} - \Gamma_{ht}(l_{it} - n_{it}) \quad (6)$$

where $n$ is the logarithm of population of working age. Finally, we assume that labour force participation depends on sociodemographic factors and the employment rate (a proxy for the probability of finding employment):

$$f_{it} - n_{it} = \text{constant} + \Gamma_{ft}(l_{it} - n_{it}) + \Gamma_{zt}z_{it} \quad (7)$$

where the vector $z$ includes the weight of the agricultural sector in total employment (a proxy for the ‘backwardness’ of each region), the weight of the 15–24 age group (the lowest participation rate group) in the total male population, and the average age of the female population (whose participation rate falls steadily with age).

The system formed by equations (4)–(7) is estimated by three-stage least squares using Spanish regional data for the years 1981, 1986 and 1990. (The appendix gives further details of data, econometric specification and empirical results.)
Table 1. Main empirical results

<table>
<thead>
<tr>
<th>Independent variables: estimated coefficient</th>
<th>Dependent variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Output per worker</td>
</tr>
<tr>
<td>$h$: average schooling of employed workers</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>(3.06)</td>
</tr>
<tr>
<td>$p$: stock of public capital</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>(3.30)</td>
</tr>
<tr>
<td>$s$: land area</td>
<td>-0.11</td>
</tr>
<tr>
<td></td>
<td>(3.46)</td>
</tr>
<tr>
<td>$h^*$: average schooling of adult population</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>(3.19)</td>
</tr>
</tbody>
</table>

Note: t-statistics in parentheses.

Table 1 shows the coefficients of the key variables of the production function and the employment equation. All these variables are significant and their coefficients have the expected sign. Both education and public capital are important determinants of regional productivity, although the coefficient of the first variable is more than twice that of the second. Land area also matters, adversely affecting output, other things being equal, by diluting the usefulness of a given quantity of infrastructure. While our specification does not yield estimates of the effect of private capital, under the conventional assumption that this coefficient is around one-third, the implied values of the remaining coefficients of the production function seem reasonable and in line with estimates from other studies (Munnell, 1992; Mankiw et al., 1992). Note too that the significance of the coefficient of education in the employment equation indicates the existence of wage rigidities of the postulated type.

4. REGIONAL INEQUALITY IN SPAIN: SOURCES AND EVOLUTION

Our empirical results suggest that public and human capital are important determinants of regional income. To go beyond this general statement, we now calculate the contribution of these two factors to regional income per capita and to its dispersion. Our results also provide an estimate of the potential impact of regional policies, together with an indicator of the situation of each region or autonomous community, which, used with proper caution, may help establish

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7 Assuming the elasticity of output with respect to private capital is 1/3, the estimated coefficients imply the following values for the elasticity of output with respect to the other factors: human capital = 0.373, public capital = 0.141, labour = 0.599 and land area = -0.074.
investment priorities. We then analyse briefly the process of regional convergence in Spain during the 1980s, and the role played by infrastructure and education.

Throughout the remainder of the paper, we rely on the model estimated in the previous section and on the same underlying data. Our methodology is briefly outlined in Box 1. The reduced form of the model, as discussed in section A4 of the appendix, also motivates the construction of an index $\hat{p}$ of the 'effective stock' of public capital as a weighted (geometric) average of two commonly used indicators of infrastructure: the stock of public capital per person and per unit of land area. The effective stock index summarizes the impact of public capital on regional income and productivity, taking account of both land area and population. It is a better indicator of the infrastructure needs of each region than either one of these variables by itself.

4.1. Education, infrastructure and regional inequality

To examine how public and human capital contribute to regional inequality, we take as reference a fictitious region endowed with the average stock of each factor (measured in logarithms) and an average level of income (and hence a zero value of the residual). The percentage difference between each community’s per-capita income and that of the fictitious region is a weighted sum of the percentage deviations from the mean of the endowments of each factor and a residual component capturing the effect of omitted variables and random disturbances. To interpret the results of the exercise, recall that we are attributing to public and human capital their indirect effect on output through the equilibrium allocation of private capital across regions. Hence, our figures should be interpreted as an estimate of the maximum impact on income of each of these factors in the medium or long run.

The results of these calculations are summarized in Figure 4, which, for each autonomous community, shows the relative income level that would result from the elimination of all differences among regions, except for the endowment of the factor under consideration. The total deviation of regional income per capita from the sample mean is the sum of the components shown in the graph, the contribution of sociodemographic variables, and the residual.8

As shown in Table 2, the coefficient of variation of (the logarithm of) income per capita was 19.5 in 1990. After eliminating the effect of the differences in average schooling and effective stocks of public capital, separately for each variable, the estimated value of this dispersion index drops to 15.8 or 14.5 respectively, and to

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8 In the figure, as throughout the paper, income per capita is regional value added divided by the working-age (15–64) population, so as to abstract as much as possible from the effects of differences across regions in the age structure of the population.
Box 1. Decomposing income per capita

Using our estimate of the system (4)-(7), it is easy to obtain a reduced-form equation which gives income per capita as a function of the exogenous variables of the model and a regression residual

\[ y_{it} = \gamma_{it} + \theta_{zc}z_{it} + \theta_{yh}hn_{it} + \theta_{p}\hat{p} + \varepsilon_{it} \]

where \( \gamma_{it} \) is constant across regions, \( \theta_{zc} \) and \( \theta_{yh} \) are functions of the parameters of the structural equations, \( \hat{p} \) is an index of the effective stock of public capital and \( \varepsilon \) is the regression residual.

For some purposes, it will be convenient to rewrite this equation in deviations from the sample mean. This procedure will allow us to express the relative income per capita of each region as a function of its relative endowments of various factors. That is, we can write a region's income per capita, expressed in (log) deviations from the sample mean, as a weighted sum of its factor endowments, other exogenous variables and the regression residual, all measured as percentage deviations from those of a fictional 'average region'. The resulting decomposition may be used to calculate the contribution of each exogenous variable to the relative income of a given region, or to estimate its income level under alternative assumptions on factor endowments. For the sample as a whole, we can quantify the contribution of each factor to income dispersion (by comparing the observed distribution with the one that would prevail if we eliminated all cross-regional differences in the given variable), and analyse income convergence as the net result of separate convergence processes for each one of its 'components'.

For some purposes, an alternative decomposition of log income per capita as the sum of the logarithms of output per worker and the employment and participation rates

\[ y_{it} = q_{it} + (f_{it} - n_{it}) + (l_{it} - f_{it}) \]

will also be useful.

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9 Notice that this is approximately equal to the percentage deviation of per-capita income in the given region from the geometric sample mean.
Figure 4. Education, public capital and regional inequality, 1990

Notes: Contribution of the stocks of public and human capital to regional inequality (measured by the percentage deviation of income per capita from the regional mean that would be induced by each factor alone). Education contributes to income per capita through both productivity and the employment ratio. The first of these channels accounts for around 60% of the total contribution of human capital to relative income.

Key to region names: And = Andalusia; Ara = Aragón; Ast = Asturias; Bal = Baleares; Cana = Canary Islands; Cant = Cantabria; C-L = Castile and León; C-M = Castile la Mancha; Cat = Catalonia; Val = Valencia; Gal = Galicia; Ext = Extremadura; Mad = Madrid; Mur = Murcia; Nav = Navarre; PV = Basque Country; Rio = Rioja.

only 13.1 when the regional endowments of both factors are equalized. Thus, the elimination of regional differences in the endowments of these two factors would reduce regional inequality by around one-third in the long run, with the contribution of human capital being slightly larger than that of public infrastructure.

Table 2. Contribution of human and public capital to regional inequality, 1990

<table>
<thead>
<tr>
<th></th>
<th>Output per worker</th>
<th>Employment rate</th>
<th>Income per capita</th>
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<tbody>
<tr>
<td></td>
<td>Coeffic. of variation</td>
<td>Index</td>
<td>Coeffic. of variation</td>
</tr>
<tr>
<td>Actual</td>
<td>15.76</td>
<td>100</td>
<td>8.75</td>
</tr>
<tr>
<td>Corrected by</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>human capital</td>
<td>12.02</td>
<td>76</td>
<td>8.12</td>
</tr>
<tr>
<td>public capital</td>
<td>11.51</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>both</td>
<td>9.14</td>
<td>58</td>
<td></td>
</tr>
</tbody>
</table>

Notes: All variables in logarithms. Top row shows coefficient of variation in 1990; other rows eliminate regional disparities in one or both endowments. Data on employment rate exclude Galicia (see appendix, section A3).
4.2. Regional convergence and its sources

We now turn to the determinants of the evolution of the regional income distribution. As an indicator of inequality, we use the coefficient of variation of the logarithm of per-capita income. The change in this index is one measure of the evolution of regional disparities. A second convergence measure is obtained from a regression of the change in each region’s relative income $\bar{y}_i$ on its initial value.\textsuperscript{10} For example, an estimated coefficient of $-0.10$ would imply that, in the case of the ‘representative region’, 10% of the initial deviation of per-capita income from the average had been eliminated during the period.

Clearly, a necessary condition for inequality to fall is that this coefficient be negative. The dispersion of relative incomes can fall only if poorer regions improve, on average, their position. But this is not sufficient: if deviations from the ‘average pattern’ are large enough, income dispersion can increase even if the representative region is converging towards the mean. Hence, the strength of convergence (measured by the reduction of the dispersion index) depends on two factors: the ‘average pattern’ described by the estimated coefficient, and the importance of the deviations from it, summarized by the $R^2$ of the convergence regression or the significance of the estimated coefficient.

Figure 5 summarizes the results of this exercise for 1981–90. We observe a slight convergence trend: although relative positions have not changed much, the initially poorer regions have tended to grow faster than the richer ones, on average eliminating 19.5% of their initial deviation from average per-capita income. But there are important exceptions: Baleares and Madrid, for example, increased their advantage over the average region, while Galicia and Asturias lost ground despite their low initial income levels. The net result was a reduction of 13% in the coefficient of variation of (the logarithm of) per-capita income.\textsuperscript{11}

What can be said about the sources of convergence? Our decomposition of per-capita income suggests that income convergence (or divergence) may be interpreted as the composition of different convergence processes in labour productivity and in participation and unemployment rates, which, in turn, reflect the evolution of factor endowments and sociodemographic factors. To measure the intensity of these processes, we repeat the preceding exercise for each of the components of per-capita income. Although neither the dispersion of per-capita

\textsuperscript{10} Although convergence equations can sometimes be interpreted as reduced forms of explicit growth models, here we prefer to think of this equation simply as a convenient way to summarize the data. Notice that, given the definition of the variables, the constant term will be zero in this regression.

\textsuperscript{11} These results were obtained using the regional output series constructed by the National Institute of Statistics (INE, 1993). Alternative sources yield a different picture of the evolution of regional income dispersion. Working with EUROSTAT figures, Esteban (1994) detects a slight increase in inequality. Similarly, Cuadrado (1991) finds that the dispersion of per-capita incomes has increased somewhat, using the series constructed by the research department of the Banco Bilbao-Vizcaya.
income nor its convergence coefficient is an exact weighted sum of the corresponding indices for various components, the exercise is an informal way of quantifying the contribution of different forces to the evolution of regional inequality.

Table 3 summarizes the results. Its first two columns show the coefficient of variation of the (logarithm of) each variable in 1981 and 1990, the last three give the results of convergence regressions in which the change in the relative position of each region is explained by the initial value of the same variable.

Looking first at ‘immediate’ determinants of income per capita, both labour productivity and the employment rate contributed to overall convergence. The behaviour of the two components of the overall employment rate is very different: while there is very clear convergence in participation rates, the dispersion of unemployment rates increased by more than 40% during the 1980s. The evolution of the human capital stock contributed significantly to the equalization of regional

12 The contribution of each factor to the dispersion of income per capita depends on its own dispersion, its impact on output and its covariance with other factors. Similarly, the convergence rate of income (measured by the slope coefficient of a convergence regression) is not a simple weighted average of the corresponding coefficients of the different factors. Even if each of these factors converged at a constant rate, per-capita income would not converge at a constant rate unless all the factors were converging at the same constant rate.
Table 3. Evolution of the dispersion of income per capita and its components

<table>
<thead>
<tr>
<th></th>
<th>Coefficient of variation</th>
<th>Convergence regression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1981</td>
<td>1990</td>
</tr>
<tr>
<td>Income per capita</td>
<td>22.39</td>
<td>19.49</td>
</tr>
<tr>
<td>Employment/pop. 14–65</td>
<td>12.07</td>
<td>9.02</td>
</tr>
<tr>
<td>Employment/labour force</td>
<td>4.21</td>
<td>6.00</td>
</tr>
<tr>
<td>Labour force/population 15–64</td>
<td>9.78</td>
<td>4.38</td>
</tr>
<tr>
<td>Output per employed worker</td>
<td>18.81</td>
<td>15.76</td>
</tr>
<tr>
<td>Public capital</td>
<td>31.36</td>
<td>29.73</td>
</tr>
<tr>
<td>Education (population)</td>
<td>13.06</td>
<td>11.06</td>
</tr>
</tbody>
</table>

Notes: All variables measured in log deviations from the geometric mean of the 17 regions. %Δ is the % change in the coefficient of variation over the period, β is the slope coefficient of a regression of the form Δ\(\bar{x}_i\) = α + β\(\bar{x}_{i0}\), t is the t-statistic of this coefficient, and R² is the coefficient of determination of the regression.

incomes. The coefficient of variation of the logarithm of this variable fell by 15.3%. Convergence in effective public capital stocks was less marked. The dispersion of this variable has decreased by only 5% over the 1980s.

In conclusion, our analysis indicates that differences in endowments of human and public capital account for about one-third of observed regional inequality. Although this leaves much still to be explained, it does suggest that traditional, supply-oriented policies can play an important role in promoting regional convergence. This potential, however, has not been fully exploited in Spain during the past decade. While the convergence of schooling levels has contributed significantly to the reduction of regional inequality, the evolution of infrastructure stocks in practice had only a minor impact on income disparities. Finally, sociodemographic factors also played an important role, as suggested by the rapid equalization of participation rates. This impact on income per capita was offset in part by an increase in the dispersion of unemployment rates.

5. PUBLIC INVESTMENT IN THE 1980S

This section looks in more detail at public investment policy in Spain during the 1980s. Our model suggests that the impact of this policy on regional inequality will depend on the total volume of investment, and on the extent to which resources are allocated across regions in inverse relation to their initial income per capita. As we have seen, the net contribution of public investment to the reduction of disparities was small, suggesting that considerations other than equity may have been at play. One question we ask in this section is what these other factors may be. Section 5.1 discusses three possible criteria for the regional allocation of public investment funds, and examines their implications for Spain, given regional income level and public capital stocks in 1990. Section 5.2 then investigates to what extent actual policy during the 1980s was guided by any of these criteria.
5.1. Three criteria for the regional allocation of public investment

If public investment is intended to reduce regional inequalities, the natural criterion is one of need: the goal would be to compensate, through the public provision of infrastructure, the other disadvantages of poor regions. Public investment decisions should perhaps be based on efficiency considerations rather than on need, in order to maximize national income, any necessary redistribution being achieved more efficiently ex post, through the tax and social insurance systems. A third possible criterion, an intermediate position, is what we may call neutrality: the state should ensure that differences in public capital stocks do not give an unfair advantage or disadvantage to any community. The goal would now be to equalize effective infrastructure endowments across regions.

To investigate the implications of the proposed criteria, and possible conflicts among them, we examine the priority ordering each induces in the Spanish regions, given their stocks of productive public capital and per-capita income levels in 1990. Table 4 shows the relative position of each region in terms of its effective stock of public capital, its income per capita and the expected return on public investment.\(^\text{13}\) Clearly, the investment priorities implied by the three criteria differ.

Table 4. Regional priorities in public investment, 1990

<table>
<thead>
<tr>
<th>Region</th>
<th>Effective capital</th>
<th>Rank</th>
<th>Income per capita</th>
<th>Rank</th>
<th>Expected return</th>
<th>Rank</th>
<th>Sum of rankings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galicia</td>
<td>66.09</td>
<td>2</td>
<td>75.37</td>
<td>3</td>
<td>113.24</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Andalusia</td>
<td>74.19</td>
<td>5</td>
<td>75.15</td>
<td>2</td>
<td>94.38</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>Extremadura</td>
<td>46.47</td>
<td>1</td>
<td>56.07</td>
<td>1</td>
<td>46.49</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Murcia</td>
<td>75.62</td>
<td>6</td>
<td>102.80</td>
<td>10</td>
<td>127.38</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Valencia</td>
<td>104.68</td>
<td>8</td>
<td>99.17</td>
<td>8</td>
<td>126.45</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td>Asturias</td>
<td>104.92</td>
<td>9</td>
<td>85.66</td>
<td>4</td>
<td>91.38</td>
<td>10</td>
<td>23</td>
</tr>
<tr>
<td>Cast. Léon</td>
<td>73.95</td>
<td>4</td>
<td>86.55</td>
<td>5</td>
<td>51.73</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Cast. la Mancha</td>
<td>70.99</td>
<td>3</td>
<td>88.73</td>
<td>6</td>
<td>42.28</td>
<td>17</td>
<td>26</td>
</tr>
<tr>
<td>Catalonia</td>
<td>105.54</td>
<td>11</td>
<td>117.76</td>
<td>13</td>
<td>152.97</td>
<td>2</td>
<td>26</td>
</tr>
<tr>
<td>Baleares</td>
<td>105.32</td>
<td>10</td>
<td>127.80</td>
<td>17</td>
<td>144.03</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Madrid</td>
<td>129.45</td>
<td>15</td>
<td>120.33</td>
<td>14</td>
<td>193.61</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Aragón</td>
<td>81.93</td>
<td>7</td>
<td>107.58</td>
<td>11</td>
<td>60.01</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Canary Islands</td>
<td>133.40</td>
<td>16</td>
<td>101.28</td>
<td>9</td>
<td>112.91</td>
<td>7</td>
<td>32</td>
</tr>
<tr>
<td>Cantabria</td>
<td>121.01</td>
<td>14</td>
<td>96.79</td>
<td>7</td>
<td>81.94</td>
<td>11</td>
<td>32</td>
</tr>
<tr>
<td>Basque Country</td>
<td>168.06</td>
<td>17</td>
<td>113.96</td>
<td>12</td>
<td>111.85</td>
<td>8</td>
<td>37</td>
</tr>
<tr>
<td>Navarre</td>
<td>117.61</td>
<td>12</td>
<td>123.23</td>
<td>16</td>
<td>76.41</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td>Rioja</td>
<td>120.77</td>
<td>13</td>
<td>121.78</td>
<td>15</td>
<td>72.95</td>
<td>13</td>
<td>41</td>
</tr>
</tbody>
</table>

Note: Sample average = 100 (all variables measured in logs).

\(^{13}\) With a Cobb–Douglas production function, the marginal product of each factor is proportional to its average product, the ratio of output to the stock of this input. Normalizing the log of the average product of public capital by its sample average (=100), we obtain the index of expected return in Table 4.
Figure 6. Equity vs efficiency in public investment

While the equity and neutrality criteria roughly agree that poorer autonomous communities should be given priority, the expected return is generally low in such regions; but the communities with higher marginal productivity of public investment are typically those with high income levels and effective infrastructure endowments.14

As a basis for a tentative overall ranking, the last column shows the sum of the rankings of each region according to the various criteria. This index is clearly weighted towards the poorer regions, as the effective stock and income per-capita indicators generate similar rankings. As an alternative, we combine these two variables into a single indicator of need by taking their average. Figure 6, which plots the position of each region in terms of this variable and the index of expected return, suggests a classification into four groups of autonomous communities, with rather fuzzy boundaries in some cases.

14 As well as Madrid, the autonomous communities where the expected return of public investment is highest are those of the so-called Mediterranean Arch (Catalonia, Valencia, Baleares and Murcia). See Figure 6.
There are several regions with relatively low levels of income and/or infrastructure endowment, in which public investment would also have a significant impact on productivity (Galicia, Valencia, Murcia, Andalusia and Asturias). Conversely, there is a group of relatively rich and/or well-endowed regions where the expected return on investment is not high (Cantabria, Navarre, Rioja, the Canary Islands and the Basque Country). The remaining regions fall into two groups: relatively poor regions in which the expected return on investment is rather low (Extremadura, Aragon and both Castiles), and rich regions in which the marginal product of public investment is very high (Madrid, Catalonia and Baleares).

Clearly, of these four groups the first deserves the highest priority for public investment, and the second the lowest priority. Although the index of expected return suggests that infrastructure investment is probably not the most efficient way to promote regional development in the third group, the conflict between the need and efficiency criteria is partly artificial: if the different productive inputs are complements, as may be expected, the productivity of public investment will be higher (for a given effective stock) in those regions which have larger endowments of other factors. Hence, an effort in other areas would also increase the return on public investment, which could still play an important role in combination with other instruments of regional policy.

5.2. Determinants of the regional allocation of public investment

If public investment decisions are the result of a planning process which tries to balance equity and efficiency considerations, we expect a correlation between the growth of regional infrastructure and the various indices of need and expected return developed in the previous section. Yet public investment may also respond to political considerations unrelated to equity or efficiency. Funds may flow to richer regions if wealth increases their ‘lobbying capacity’, or may be allocated among autonomous communities partly on the basis of political affinity with the central government.

To investigate the impact of these factors on the regional allocation of public investment in Spain, we regress a measure of investment intensity in each region during each half of the 1980s (the average annual growth rate of the stock of productive public capital) on the initial values of income per capita, the effective stock of public capital, the expected rate of return on public investment and three ‘political’ variables. Two of these variables measure the number of years in which the government of each region was held by the Socialist Party (PSOE) (which since 1982 has controlled the central government and, to a large extent, the allocation of investment funds), or by nationalist or regionalist groups (often seen as more active than national parties in pressing for larger budget allocations for their communities). The third political variable, DFORAL, is a dummy variable which
Table 5. Implicit criteria for public investment decisions
(dependent variable: growth rate of net stock of productive public capital)

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Regression version</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Expected return</td>
<td>0.023</td>
</tr>
<tr>
<td></td>
<td>(5.21)</td>
</tr>
<tr>
<td>Income per capita</td>
<td>-0.030</td>
</tr>
<tr>
<td></td>
<td>(1.89)</td>
</tr>
<tr>
<td>Effective public capital stock</td>
<td>-0.004</td>
</tr>
<tr>
<td></td>
<td>(0.44)</td>
</tr>
<tr>
<td>Dummy 1986–90</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td>(6.90)</td>
</tr>
<tr>
<td>DFORAL (Basque–Navarre dummy)</td>
<td>0.019</td>
</tr>
<tr>
<td></td>
<td>(3.26)</td>
</tr>
<tr>
<td>Years PSOE government</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
</tr>
<tr>
<td>Years nationalist government</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(0.46)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.767</td>
</tr>
</tbody>
</table>

Notes: Income per capita and public capital both in logarithms. Expected return is the logarithm of the average product of public capital, which is proportional to its marginal product. All regressions include a constant.

is equal to one for Navarre and the Basque Country, which, for historical reasons, have important fiscal privileges.15

Table 5 summarizes the results of various regressions which include different subsets of these variables. When all variables are included, only DFORAL and the expected return on investment are significant. The high correlation (0.802) between income per capita and effective infrastructure stocks, however, makes it very difficult to separate the effects of these two variables; when either one is omitted, the other one becomes significant. The party in power in each region remains insignificant in all specifications. These results suggest that both efficiency and equity considerations played a role in the allocation of public investment, efficiency probably receiving greater weight than equity. The negative effect of

15 In recent years, the Spanish state has become much more decentralized than before. Functions have been transferred to regional governments. Infrastructure investment is financed (and often co-financed) by three different levels of government: central, regional and local. With minor exceptions, taxes are collected by the national government, which then transfers to each regional government an amount determined by a complicated formula. For Navarre and the Basque Country, the procedure is the converse: regional institutions (actually provincial) collect most taxes and then pay the central government a given quota. This system allows the regional administrations of these communities to keep a larger amount of resources than the rest.
income seems to indicate that on average redistributive concerns outweighed the political influence of the richer regions. Finally, the insignificance of the political variables other than DFORAL suggests that the central government has not discriminated for or against regions on the basis of political affinity, although the fact that some regional governments have access to more resources does have a significant impact on their investment behaviour.

6. THE IMPACT OF THE ERDF

The European Regional Development Fund (ERDF) is the largest of the EU Structural Funds and the most important instrument of European regional policy. The Fund subsidizes actions aimed at improving the productive capacity of the poorer regions. Infrastructure provision has been the dominant component of ERDF expenditure, particularly in Spain.

In this section we examine the impact of ERDF programmes on regional output and inequality. We estimate the impact on net public capital formation during the period between Spanish accession to the EC in 1986 and the end of our sample in 1990. Next, we calculate the level of income per capita in each region in the absence of these funds, and compare the result with actual income in 1990 to quantify the redistributive impact of the ERDF. Such an exercise is based on the strong, but almost unavoidable, assumption that the ‘national’ component of public investment was unaltered by the existence of the ERDF.

To quantify the ERDF’s contribution to public capital formation, we need some assumptions. First, we assume that ERDF grants were used only to finance investment in productive infrastructure.\(^\text{16}\) Second, we recognize that ERDF grants cover only part of the cost of each action (around half, on average),\(^\text{17}\) and are destined, in principle, to finance projects which would not have been undertaken otherwise (the additionality requirement). In practice, the actual degree of additionality is uncertain. Some projects funded by the ERDF would have been undertaken anyway with national financing, but it is difficult to determine what part.

To summarize the joint effect of these two factors (subsidy rate and degree of additionality), we introduce a parameter that we call the multiplier. If ERDF expenditure were truly additional and the subsidy rate were 50%, each peseta of Fund grants would generate two additional pesetas of new public investment, a

\(^\text{16}\) Although this is not quite true, it is a reasonable approximation in Spain. According to the figures reported by the European Parliament (Parlamento Europeo, 1991), expenditure on infrastructure accounted for 98\% of total ERDF transfers to Spain in 1986 and 96\% in 1987. We have not found data disaggregated by expenditure categories for more recent years.

\(^\text{17}\) Using the figures reported by the Spanish Ministry of Economics (Ministerio de Economia y Hacienda, 1991), we calculate that the average subsidy rate for the Spanish ‘operative programmes’ approved in 1990 was almost exactly 50\%.
Table 6. Total ERDF contribution

<table>
<thead>
<tr>
<th>Region</th>
<th>To net formation of productive public capital (%)</th>
<th>To average regional productivity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>Andalusia</td>
<td>12.01</td>
<td>48.03</td>
</tr>
<tr>
<td>Aragón</td>
<td>7.24</td>
<td>28.95</td>
</tr>
<tr>
<td>Asturias</td>
<td>16.53</td>
<td>66.11</td>
</tr>
<tr>
<td>Baleares</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Canary Islands</td>
<td>8.20</td>
<td>32.79</td>
</tr>
<tr>
<td>Cantabria</td>
<td>5.35</td>
<td>21.39</td>
</tr>
<tr>
<td>Cast. Léon</td>
<td>18.38</td>
<td>73.52</td>
</tr>
<tr>
<td>Cast. Mancha</td>
<td>16.81</td>
<td>67.25</td>
</tr>
<tr>
<td>Cataluonia</td>
<td>2.63</td>
<td>10.51</td>
</tr>
<tr>
<td>Valencia</td>
<td>2.77</td>
<td>11.08</td>
</tr>
<tr>
<td>Galicia</td>
<td>11.74</td>
<td>46.95</td>
</tr>
<tr>
<td>Extremadura</td>
<td>10.00</td>
<td>40.01</td>
</tr>
<tr>
<td>Madrid</td>
<td>1.17</td>
<td>4.68</td>
</tr>
<tr>
<td>Murcia</td>
<td>7.82</td>
<td>31.26</td>
</tr>
<tr>
<td>Navarre</td>
<td>0.73</td>
<td>2.93</td>
</tr>
<tr>
<td>Basque Country</td>
<td>2.30</td>
<td>9.19</td>
</tr>
<tr>
<td>Rioja</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Spain</td>
<td><strong>8.37</strong></td>
<td><strong>33.48</strong></td>
</tr>
</tbody>
</table>

Table 7. ERDF's relative contribution

<table>
<thead>
<tr>
<th>Region</th>
<th>To the effective stock of public capital (%)</th>
<th>To average regional productivity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>Andalusia</td>
<td>2.28</td>
<td>9.83</td>
</tr>
<tr>
<td>Aragón</td>
<td>-0.51</td>
<td>-2.24</td>
</tr>
<tr>
<td>Asturias</td>
<td>1.69</td>
<td>7.19</td>
</tr>
<tr>
<td>Baleares</td>
<td>-1.59</td>
<td>-6.62</td>
</tr>
<tr>
<td>Canary Islands</td>
<td>0.08</td>
<td>0.22</td>
</tr>
<tr>
<td>Cantabria</td>
<td>-0.01</td>
<td>-0.14</td>
</tr>
<tr>
<td>Cast. Léon</td>
<td>0.72</td>
<td>2.95</td>
</tr>
<tr>
<td>Cast. Mancha</td>
<td>1.88</td>
<td>8.02</td>
</tr>
<tr>
<td>Catalonia</td>
<td>-1.16</td>
<td>-4.88</td>
</tr>
<tr>
<td>Valencia</td>
<td>-0.99</td>
<td>-4.20</td>
</tr>
<tr>
<td>Galicia</td>
<td>0.68</td>
<td>2.78</td>
</tr>
<tr>
<td>Extremadura</td>
<td>1.13</td>
<td>4.71</td>
</tr>
<tr>
<td>Madrid</td>
<td>-1.28</td>
<td>-5.40</td>
</tr>
<tr>
<td>Murcia</td>
<td>1.21</td>
<td>5.09</td>
</tr>
<tr>
<td>Navarre</td>
<td>-1.43</td>
<td>-6.00</td>
</tr>
<tr>
<td>Basque Country</td>
<td>-1.11</td>
<td>-4.68</td>
</tr>
<tr>
<td>Rioja</td>
<td>-1.59</td>
<td>-6.62</td>
</tr>
</tbody>
</table>

Note: Difference between the actual value of each variable (output per employed worker and effective stock of public capital, measured in % deviations from the interregional geometric mean) and their counterfactual value, after correcting for the estimated impact of ERDF grants. For example, ERDF transfers reduce the deviation of Andalusia's output per worker from the average by 2.08 points.
multiplier of 2. Although this assumption reflects the theoretical additionality requirement of EU regulations, it may be too optimistic in practice and must be interpreted as an upper bound. To obtain a lower bound, we will repeat all calculations with a multiplier of 0.5, so that each peseta of grants generates only 0.5 pesetas of truly additional investment.

We then proceed as follows. We start from the regionalized ERDF transfers during 1986–90, measured in 1990 pesetas. Applying the multiplier to Fund disbursements, we calculate the flow of ERDF-induced public investment in each region. Accumulating these flows using an annual depreciation rate of 5%, we obtain the Fund’s contribution to public capital, which we subtract from the actual net stock of public capital in 1990 to obtain a hypothetical infrastructure stock for each region. We can then use the reduced form of the model estimated in section 3 to determine the average (relative and absolute) productivity of each region in the absence of Fund transfers. We calculate the effective stock of public capital per capita corresponding to this counterfactual endowment, and correct actual income by its incremental contribution to arrive at a hypothetical income level. This is then used to determine the relative income of each region as the percentage deviation from a counterfactual regional average.

Figure 7. Allocation of ERDF vs income per capita without ERDF

Note: ERDF contribution to relative income per capita with mult. = 2 (Δy<sub>ERDF</sub>) vs (deviation from the mean of per-capita income, net of ERDF contribution, in 1990 (y<sub>corrected</sub>). The estimated equation is as follows:

\[ Δy_{ERDF} = 0 - 0.0473y_{corrected} \]

\[ R^2 = 0.710 \]

(6.07)
Table 8. ERDF impact on regional inequality
(inequality measure: coefficient of variation across communities)

<table>
<thead>
<tr>
<th>Effective stock of public capital</th>
<th>Actual CV</th>
<th>CV without ERDF If multiplier is Max. (%) Min. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Effective stock of public capital</td>
<td>29.73</td>
<td>33.46</td>
</tr>
<tr>
<td>Productivity</td>
<td>15.76</td>
<td>16.55</td>
</tr>
</tbody>
</table>

Our results are summarized in Tables 6 and 7 under two different assumptions about the multiplier: 'Max.' corresponds to a multiplier of 2, 'Min.' assumes a value of 0.5. The weight of ERDF in the net formation of productive public capital is considerable. For Spain as a whole, the Fund’s grants, together with the induced domestic expenditure, amount to somewhere between 8% and 33% of the total, depending on the assumed value of the multiplier. Under the more ‘optimistic’ assumption, ERDF contributions account for more than half the public investment effort in three regions (Asturias and both Castiles). The impact on per-capita income is much smaller but still significant. On average, per-capita output is between 0.34 and 1.40 percentage points higher than it would have been without EU grants. This figure increases to over 2.5 percentage points in Andalusia, Asturias and Castile la Mancha under the more favourable assumption about the multiplier.

Table 7 shows the impact of ERDF programmes on the relative situation of each region in terms of its effective stock of public capital and output per employed worker. For the former, the impact of the ERDF is important for some regions even under the more conservative assumptions. In Andalusia, Asturias and Castile la Mancha, for example, EU funds have contributed between 1.5 and 10 points to the relative endowment of infrastructures.

Overall, the allocation of ERDF transfers follows a clearly redistributive criterion. Even so, there are important deviations from the norm described by the regression line in Figure 7. Galicia, Extremadura and Valencia receive less resources than they should on the basis of their relative income; Asturias, Castile la Mancha, Andalusia and Murcia receive more.

The net effect on regional inequality is summarized in Table 8. ERDF programmes reduce slightly the dispersion of effective public capital stocks and relative incomes, although not as much as would be possible by distributing available resources strictly in inverse relation to the initial value of these variables. With a multiplier of 2, ERDF grants reduce the dispersion of regional productivity by around 5% and eliminate 4.7% of the deviation from the sample mean in the average region (see note to Figure 7).
7. SUMMARY AND POLICY IMPLICATIONS

To the extent that education and infrastructures have an impact on productivity and on the location of mobile private factors, policies that promote accumulation of these factors in poorer regions may be used to reduce regional disparities. Our results suggest that the potential effect of such policies is considerable. While there is an important component of inequality unexplained by the variables we consider, both education and infrastructure are important determinants of regional income. Equalization of schooling levels and effective stocks of public capital would reduce the dispersion of regional incomes in Spain by around one-third in the long run, with infrastructure accounting for a bit less than half this total.

Hence, supply-side regional policies may be effective in principle, but their actual impact on regional disparities depends on the overall volume of resources devoted to them and on the extent to which such resources are allocated across regions in inverse relation to initial income per capita. For Spain we find that, while equity considerations played some role in the allocation of infrastructure investment, redistribution has not been the dominant concern. As a result, the overall contribution of public investment to income convergence has been very small, accounting for only 1% of the observed reduction in inequality during the 1980s.

Transfers from the ERDF are the one exception to the rule in terms of their redistributive impact. These funds have been allocated among regions according to a need criterion and have had a significant impact on overall productivity growth and the equalization of regional incomes. Despite its limited size, the ERDF has added around 2 points to average regional productivity and reduced the dispersion of regional output per worker by around 5%. This figure represents one-third of the observed decrease in the dispersion of productivity during the 1980s, a significant amount.

We conclude that supply-side regional policies, including infrastructure investment, can work. Their relatively small impact on regional disparities (at least in Spain during the 1980s) is simply the result of the small size of the redistributive effort undertaken, though this does not necessarily imply that a larger effort in this direction is called for. Such a policy would involve an efficiency cost, reducing aggregate income below its potential level.

Our analysis does not establish the optimal level of regional redistribution, but it may throw some light on this difficult problem. First, in allocating a given volume of resources to achieve the maximum impact in terms of a given criterion, our indices of need and expected return, used with due caution, may be helpful in establishing regional priorities for public investment. Second, our findings suggest that the allocation of resources among alternative regional programmes (infrastructure versus education, for example) should be made taking into account regional needs in each area and their expected impact.
Finally, our framework may be used to estimate the resources required to achieve a target reduction of inequality, or to explore the equity and efficiency implications of alternative policies. To get a handle on the steepness of the equity–efficiency trade-off, for example, consider the following exercise. Suppose that all public investment during 1986–90 had been allocated across regions following the (clearly redistributive) pattern of ERDF grants. How would the situation differ from that observed in 1990? According to our calculations, national output would be lower by 1.2%, but the dispersion of the effective stocks of public capital and labour productivity (measured by their respective coefficients of variation) would have been reduced significantly (by 21.6 and 13.14%, respectively). Hence, a 1.2% loss of output would have bought roughly a doubling of the reduction of inequality observed during the period. We leave it to the reader to decide whether that is a good deal.

Discussion

Juan J. Dolado
CEMFI, Madrid

This is a stimulating paper on a subject that is hard to pin down empirically despite the volume of recent research. While the removal of barriers to trade and factor movements is generally seen to assist local economic growth, there is also widespread concern that laissez-faire may impair the development potential of the periphery. A stronger regional focus for economic policy has been sought. The authors’ attempt to use Spain as a laboratory for quantifying the effects of education and public infrastructure investment on regional income and its distribution is a welcome contribution to the current debate about the role of regional policy in European economic integration. Yet this is no easy task. The relationship between public infrastructure and growth has attracted so much attention lately that Gramlich (1994) has called it ‘a speculative bubble of economic research’. Despite the danger of diminishing returns, the authors have written a rather innovative paper and should be congratulated.

Their basic idea is simple: expand an aggregate production function to include public capital among its inputs. They depart from the traditional estimation of elasticities of a production function \( X = A^* F(L, K, H, P) \), where the notation for output and inputs is as in the paper, and \( A^* \) is usually interpreted as total factor productivity purged of the influence of public capital. Estimation of the (direct) elasticity of \( X \) with respect to \( P \) using different data and techniques has been a favourite topic of recent applied research (e.g. Auerbach, 1989; Munnell, 1992).

Instead, the authors assume a nested production function. Final output \( X \) depends positively on intermediate production \( Y \) and negatively on transport
costs $C$. Since $Y = AF(L, K, H)$ and $C = C(P, S)$, under the reasonable assumptions that $X$ exhibits constant returns to scale with respect to $Y$ and $C$, and that there is perfect private capital mobility across regions, we have $X = AF(L, H, P/L, P/S) = AF(L, H, \hat{P})$. $\hat{P}$ is the effective stock of public capital, a convex combination of public capital per capita, $P/L$, and per square kilometre, $P/S$. The main advantage of this method is that it yields a natural normalization for the public capital endowment of a region: it is diluted both by people and by land area. Other empirical studies usually rely on public capital per worker. Their neglect of area in measuring the effective input of, say, roads seems an important omission. In contrast, de la Fuente and Vives provide a coherent framework for ‘growth and dispersion accounting’, and assessing the contribution of public capital to regional income disparities.

Their approach, however, is not free of some standard criticisms in interpreting estimated elasticities of output with respect to inputs such as public capital. First, there is the difficult issue of reverse causality: most inputs are endogenous. The authors treat $L$ and $H$ as endogenous, but claim that $\hat{P}$ is predetermined if public capital data from the previous year are used. This is dubious because of serial correlation in the residuals of the production function, induced by technology shocks. So estimates of input contributions are vulnerable to simultaneity bias. I also doubt the validity of the instrument variables for employment $L$ and average years of schooling per worker $H$, which are derived from a ‘ranking by education’ employment model and a labour participation equation, and consist basically of the following variables: the schooling level of the working-age population $H^*$, the working-age population itself $N$, and a bunch of shift factors $\zeta$ in the labour supply function. For example, the extent to which $H^*$ is a valid instrument, given that $H$ is endogenous, is not at all clear to me: the stock of education is surely endogenous. Furthermore, some of the structural relationships that underlie the choice of instruments suffer from inconsistencies. For example, in equation (5) the regional employment rate $(L/F)$ is increasing in $H^*$. Yet in Table 3 the dispersion of $H^*$ is decreasing, whereas the dispersion of $(L/F)$ is increasing. As the authors acknowledge, a natural implication of this inconsistency is that the model does badly in explaining the persistence of (un)employment rates across regions – a key factor in the evolution of regional inequalities, as I point out below.

To get a more direct feel of how reasonable are their results, compute the output elasticities with respect to $H^*$ and $\hat{P}$ in the reduced-form (RF) equation $X/N = AF(H^*, \hat{P}, Z)$. These elasticities give the overall (direct plus indirect) effect of $H^*$, $\hat{P}$ and $\zeta$ on productivity, and are the basis of the growth and dispersion decompositions in the paper. Using the estimates reported in Table A1, I obtain the following RF equation (small letters being logarithms of capital letters):

$$x - n = 0.83 h^* + 0.21 \hat{p} + \epsilon$$
where \( \hat{e} \) is the remaining effect of \( A \) and \( Z \) plus the estimated residuals in each equation of the system. I think that 0.83 is a pretty high estimate of the long-run elasticity of education, while 0.21 is probably a low estimate of the elasticity of productive public capital. For example, using a common estimate of one-third for the elasticities of output with respect to human capital, physical capital and labour (as in the widely quoted study by Mankiw et al., 1992) would yield an overall elasticity of output with respect to human capital equal to 0.50, i.e. \( (1/3)/(2/3) \). I doubt that the further adjustment of \( H \) and \( L \) to changes in \( H^* \) could raise that value to 0.83, particularly given the above-mentioned weaknesses of the employment equation that constitutes the basis of the adjustment.

Conversely, I consider the estimated public capital elasticity to be too low, particularly as it reflects both the direct and indirect effect, including allocation of private capital across regions. In comparable regional econometric studies, Mera (1973) and Holtz-Eakin (1992) obtain estimates of the direct elasticities between 0.20 and 0.35 for the regions in Japan and for the states of the USA. Again taking one-third as a plausible value of the output elasticity of private capital, the overall elasticity will be between 0.3 and 0.4, well above the estimated value of 0.21. Summarizing the above arguments, there is probably an upward bias in the coefficient of \( H^* \) but a downward bias in the coefficient of \( \hat{P} \), both caused by an inadequate choice of instrumental variables.

My second criticism concerns the important conceptual issue of the existence of positive spillover effects from the infrastructure in one region to output in neighbouring regions. The authors ignore this issue, but in a similar study for Spanish regions, Mas et al. (1994) find that the direct elasticity of output with respect to productive public capital rises by 30% when the stock in each region is replaced by an index that includes infrastructure in adjacent regions. This too tends to play down the role of public capital in the authors' results.

Despite these criticisms, suppose we take the authors' estimates at face value. What do we learn from their counterfactual exercise? I see two main results. First, the potential of core infrastructure to reduce regional disparities is rather limited: only about one-third of regional income inequality would have disappeared had schooling levels and effective stocks of public capital been equal across regions in 1990. Second, the ERDF programme, notwithstanding its more redistributive role, raised regional per-capita income in 1990 by less than 2 percentage points and reduced dispersion by a mere 5%, even under the more optimistic assumption about the size of the multiplier.

On both counts, the contribution of supply-side regional policies seems rather small. The authors claim that this reflects the small size of the redistributive effort undertaken. I agree, but only partially. The most salient feature of the Spanish labour market is persistent differences in regional unemployment rates. I guess a large share of the remaining two-thirds of regional income dispersion unaccounted for by disparities in stocks of human and public capital can be explained by
extreme persistence of unemployment rate differentials, which can be traced back to two factors: the lack of response of both migration and regional wages to regional economic conditions.

As a result, adjustment is borne by employment and labour force participation: regional imbalances show up as unemployment rate differentials. According to Jimeno and Bentolila (1994), low interregional migration in the 1980s reflected deficient functioning of housing markets and idiosyncrasies in unemployment benefits, particularly in the southern regions of Andalusia and Extremadura. Wage rigidity is also related to the institutional characteristics of the wage-determination system, where wage floors set in sectorial wage agreements leave little scope for further bargaining at regional level. Unless these deficiencies are corrected, one should not expect an important role for the types of regional policy examined in this paper, irrespectively of the amount of resources used or their allocation criteria.

I also missed some further evidence on the role of EFRD grants in other European regions. Spain gets the lion’s share of EFRD grants (30% of total), but countries like Greece, Ireland, Italy and Portugal get about 15% each. In relation to either its GDP or investment, Spain gets only one-quarter as much as Greece, Portugal or Ireland. Given the significance of the current debate about the adequacy or otherwise of the new EU cohesion fund, the analysis of Spain, with all its idiosyncratic rigidities, may not be sufficient to make the case conclusively.

Finally, the extension of built-in stabilizers, such as those which cushion real adjustment problems at the regional level in the USA, are not discussed. This is an important issue because, in mitigating regional disparity, fiscal federalism may be more efficient than explicit regional policy. After all, the call for fiscal federalism within the EU is not merely political: it seems to be supported by recent developments in New Trade and New Growth theories, omitted in the paper, both of which handle the implications of economies of scale and network externalities for the location of productive activity (de la Dehesa and Krugman, 1993).

In conclusion, de la Fuente and Vives have written a stimulating but incomplete paper on a difficult and important problem. While I have emphasized some of the limitations of their analysis, on the whole there is more agreement than disagreement.

Riccardo Faini
University of Brescia and CEPR

There has been growing disenchantment with regional policy in Europe. In Italy, despite 40 years of massive efforts to promote self-sustaining growth in the relatively backward regions of the Mezzogiorno, regional disparities have not changed much. Unsurprisingly, political opposition to continuing support and income transfers to southern Italy has been mounting, as witnessed by the growth of regional parties in the North. In Great Britain, the Conservative government
succeeded in virtually dismantling the apparatus of regional policy designed to lift up the less developed regions in the North. The lack of success of regional policy has prompted many observers to question its effectiveness: Barro and Sala-i-Martín (1993) and Sala-i-Martín (1994) find that the speed of regional convergence is very similar across countries in spite of highly dissimilar efforts to promote regional equality.

The paper by de la Fuente and Vives tries to boost the case for regional policies. Their main finding is that a more ‘balanced’ distribution of public infrastructures across regions in Spain would affect the steady-state levels of productivity and income, and thereby reduce the level of regional inequalities. It is difficult not to be sympathetic about the main thrust of the paper. Previous studies have yet to demonstrate the ineffectiveness of regional policy. In particular, we still lack a counterfactual analysis of what would have happened, say, in southern Italy or in northern Britain in the absence of regional policy. The paper by de la Fuente and Vives moves some steps toward providing this counterfactual approach and may prove a valuable tool for regional policy analysts.

The authors, however, take a fairly traditional view of regional policy. They focus almost exclusively on the productivity impact of infrastructure provisions and of education policies, the traditional levers of regional policy. Such policy tools have not proved terribly successful in the past and, at any rate, are found to account for only a limited part of regional inequalities. Furthermore, there are compelling reasons to believe that other factors, such as widespread distortions in the goods, credit and labour markets, have played a highly significant role in hindering the process of regional convergence. It is therefore worth wondering whether the scope of regional policy should be expanded to include the removal of such distortions. These issues lie somewhat beyond the scope of this paper, but they can hardly be neglected in the overall design of regional policy. For instance, credit market distortions have been shown to play a substantial role in accounting for the poor performance of the Mezzogiorno economy (Faini et al., 1993).

Labour market distortions are another potential culprit. Formally, it is possible to build models where a national union will find it optimal to press for relatively higher wages in the relatively backward region (Burda and Funke, 1991). Similarly, in a two-region model with mobile capital, it can be shown that wages in both regions will be higher and less flexible with centralized national bargaining than with a regional wage-setting system. By providing more scope to regional wage bargaining, labour market policy may therefore improve the competitiveness of regional economies and their capacity to respond in a flexible way to regional shocks. These are not merely academic matters. One striking fact of the de la Fuente and Vives paper is that the most significant contribution to regional inequality in Spain comes from the behaviour of regional unemployment, whose dispersion increased by more than 40% during the 1980s.
In turn, nationwide wage setting may be partly responsible for the lack of flexibility at the regional level. This conclusion is shared by a recent study of Jimeno and Bentolila (1994), who argue that 'the single most important determinant for regional wage determination is nationwide sectoral wages'. Similarly, in the Italian Mezzogiorno, the unemployment rate steadily climbed during the 1980s to reach 20.4% in 1992. In the rest of the country, the unemployment rate stood at only 7.1%. The nationwide wage-setting process has resulted in uniform wage levels across the country in spite of major productivity differentials, and is therefore likely to account for a substantial portion of the unemployment differential. Overall, there are good reasons to believe that the exclusive emphasis on the issue of infrastructure provision in the design of regional policy is somewhat misplaced.

Returning to the impact of infrastructures, the paper's conclusions may be somewhat too optimistic on at least two counts. First, the authors assume private capital to be perfectly mobile across regions. Their estimates therefore also incorporate the indirect effect of public infrastructures on labour productivity. Indeed, by raising the marginal productivity of capital, public infrastructures will attract private investment, thereby further contributing to productivity growth. However, if private capital is not fully mobile, this approach is bound to overestimate the impact of infrastructure provision. Second, a better infrastructural endowment may not be an unconditional blessing for a backward region. Krugman and Venables in a number of papers have convincingly argued that a reduction in transportation costs, brought about, say, by better infrastructures, may adversely affect a relatively poor region, by prompting firms to move to richer regions (where they can better exploit scale and agglomeration economies) and serve from there the poor region markets. Similarly, in the case of southern Italy, I have myself tried to argue in an early paper (Faini, 1983) that the reduction in transportation cost between northern and southern Italy in the 1950s deprived firms in the Mezzogiorno from the natural protection they had previously received from high trade barriers, accelerating the process of deindustrialization in the South. Finally, urban economists are fond of recalling that in the 1950s local authorities were actively lobbying for highway projects, on the ground that proximity to a highway would yield great benefits to the local economies. However, these expectations were mostly met with disappointment, as the building of highways led to increased concentration of production rather than dispersed benefits.

General discussion

Gene Grossman argued that it was important to estimate two processes jointly. One needed a model for determining the dispersion of income, but one also
needed a political-economy model for determining the allocation of infrastructure to regions. This would endogenize public capital and would allow for discrimination among criteria for allocation of public capital. Furthermore, he suggested the use of a government objective function to estimate parameters reflecting preferences over regions, equality and national income.

Georges de Menil pointed out that the paper had two parts, one positive and one normative. The positive part was the political theory of allocation of public capital. The normative part should ask why regional policy is a desirable objective. Regarding the normative aspect, he suggested that attention should be drawn to income distribution among individuals rather than among regions.

Hans-Werner Sinn thought the normative question was twofold: where to offer public goods, and where people should live. He argued that the allocation of people would be optimal if there were no crowding externalities. Negative crowding externalities would be larger the more public goods being provided, while immigration to remote areas would reduce the externalities. Regional policy would be valid if there were overconcentration of people in central regions. Gene Grossman thought that regional policy was determined by politics not by a benevolent dictator, and therefore that the paper should have concentrated on the positive aspects rather than the normative. Angel de la Fuente replied that the purpose of the paper was not to take a stand on whether or not it is good to pursue regional policy. He acknowledged that some econometric issues remained in the empirical part, but thought that, given the data limitations, the paper had reached some clear and plausible conclusions.

**APPENDIX**

**A1. Derivation of the reduced-form production function**

Here we derive the reduced-form production function, equation (4) in section 3. Given perfect competition and capital mobility, the marginal product of private capital in region $i$ is

\[
\frac{\delta X_i}{\delta K_i} = \alpha A_i K_i^{\alpha-1} L_i^\beta H_i^\gamma P_i^\delta S_i^{1-\alpha-\beta-\gamma} = \frac{\alpha X_i}{K_i}
\]

and in equilibrium equals the market interest rate $r$, which is common to all regions. Inverting, we obtain a 'conditional demand' for private capital:

\[
K_i = \alpha X_i / r
\]  

(A1)

Capital market clearing requires that the sum of the regional demands equal the aggregate capital stock, $\bar{K}$, which will be taken as given. Thus $\bar{K} = \Sigma_i \alpha r^{-1} X_i = \alpha r^{-1} X$ where $X$ is national output. Substituting into (A1), the equilibrium stock of private capital in region $i$ is

\[
K_i = \alpha r^{-1} X_i = \alpha X_i K/(\alpha X) = K(X_i/X)
\]  

(A2)
We now eliminate private capital from the regional production functions. Using (A2), the production function (equation (3) of the text) becomes

\[ X_i = A_i \left( \frac{K}{X} \right)^{a} X_i^{\alpha} L_i^{\beta} H_i^{\gamma} P_i^{1-a-\beta-\gamma} \]

whence

\[ X_i = \Phi A_i L_i^{\beta} H_i^{\gamma} P_i^{1-a-\beta-\gamma} S_i^{1-\alpha} \]

where \( \Phi = \left( \frac{K}{X} \right)^{\alpha} \). Dividing both sides of (A3) by \( L \) yields average product per worker,

\[ Q_i = \frac{X_i}{L_i} = \Phi A_i H_i^{\gamma} P_i^{1-a-\beta-\gamma} S_i^{1-\alpha} L_i^{1-\gamma} \]

and, taking logs, we obtain equation (4) in the text.

### A2. Data

To estimate the model in section 3, we use Spanish regional data for 1981, 1986 and 1990. The income variable, \( q_{it} \), is (the logarithm of) gross regional value added per employed worker (millions of 1990 pesetas) reported by the National Institute of Statistics (INE, 1993). The education variables are average years of schooling of the employed labour force and of the working-age population, constructed by de la Fuente and da Rocha (1994) using National Census data for 1981 and 1991, the 1986 Municipal Census, and the Labour Force Survey (EPA).

For public capital, our starting point is the work of Mas et al. (1993a), who estimate stocks of roads and highways, urban structures and water supply works, using the detailed records of the various levels of government and a perpetual inventory method. Since their figures exclude ports, airports, toll highways and railroads, the omission of which may significantly alter the relative position of some regions, we constructed estimates of these variables using data on investment flows during the 1980s and on infrastructure stocks measured in physical units.

For ports and coastal infrastructure, Mas et al report a national total which we regionalize in proportion to an indicator of the capacity of port installations in each region in 1990 (freight-handling capacity in metric tonnes per year, from Piñero, 1992). For the remaining categories of infrastructure, sources are: annual investment flows by region and type of capital for 1980–90 (Nieves and Piñero, 1992); and indicators of stocks of infrastructure measured in physical units (e.g. kilometres of toll highways), which are available for the country as a whole in 1980 and 1990 (MOPT, 1994), and for each region in 1990 (Nieves and Piñero, 1992). Dividing the cumulative investment flows for the whole country during the 1980s by the increase in the stock measured in physical units during the same period, we obtain an estimate of the average unit cost of each type of infrastructure. We then use this figure to value the national stock in 1990, and allocate it among regions in proportion to physical capacity. Finally, we use the regional investment flows to work backwards to the 1985 and 1980 stocks.

These data have important limitations. Some of the series present inconsistencies and probably substantial measurement errors for some years and regions. In some cases, this problem is not troublesome for our purposes. For example, the regional output series we use is not really homogeneous over time, as there is a break in methodology in 1986, but
since we rely fundamentally on its cross-sectional variation, inconsistencies should not affect our results too much.

We are more concerned about another problem. Comparisons of regional income estimates from different sources reveal significant changes in the relative positions of a few regions. Hence, although we believe that the overall picture which comes out of the study is not misleading, our diagnosis of the situation of a specific region may be incorrect. Region-specific policy recommendations should therefore be taken with some caution.

A3. Specification and empirical results

In the empirical specification of the system formed by equations (4)-(7), we introduce period dummies, and a regional dummy for Galicia in all equations. The time dummies (D2 and D3) try to control for period-specific shocks and the effects of technical progress and capital accumulation. The dummy for Galicia reflects the region’s position as an extreme outlier in terms of its employment and participation rates - much higher than those observed in other regions with similar characteristics. The reason for this seems to be the pattern of land tenure. Galicia is heavily rural. Many people own small plots of land and report themselves as employed because they work a few hours at the family plot, inflating reported participation and employment rates, and distorting the relationships between employment and productivity, and between employment rates and the average education of the workforce.\(^{18}\)

Our equations are estimated by three-stage least squares. Given the available data (only three observations per region), we use a specification in levels, but it should be noted that, if the series are non-stationary and not cointegrated, this procedure may give misleading results. When better data become available, it will be interesting to re-examine the question using more sophisticated techniques.

The results reported in Table A1 are obtained after imposing the assumption of constant returns in all factors except human capital. This restriction is in fact weakly rejected by the data (the \(t\)-statistic for the null hypothesis that the restriction holds is 2.25). The unrestricted model yields a slightly higher coefficient for education and a slightly lower one for public capital, but the results reported in the text would not change much with these coefficients. We impose the constant returns restriction for convenience: it allows us to summarize the effect of public capital on productivity through an index which is a weighted average of the public capital stock per worker and per square kilometre of land area, as discussed in the following section.

A4. Reduced form and construction of the index of the effective stock of public capital

Solving equations (4)-(7) in the text, we obtain the reduced form for per-capita income

\[
y_{it} = c_{it} + \theta_{zp}z_{it} + \theta_{zp} + \theta_{p}p_{it} + \theta_{s}s_{it} - \theta_{n}n_{it} \tag{A4}
\]

\(^{18}\) This is not the case in other regions with large rural populations because the pattern of land ownership is much more concentrated: farms tend to be larger and rely primarily on hired, rather than family, labour.
Table A1. Empirical results

<table>
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<th>( f )</th>
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<td>(4.66)</td>
<td>(3.77)</td>
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</tr>
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<td>0.043</td>
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<td></td>
<td>(3.83)</td>
<td>(3.39)</td>
<td>(2.10)</td>
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<td>0.559</td>
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<td>(3.06)</td>
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<td>(3.30)</td>
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<td></td>
<td>(3.46)</td>
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<td>[1.00]</td>
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<td>(3.19)</td>
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<td>( hn )</td>
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<td>[1.00]</td>
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<td>( n )</td>
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<td>(2.95)</td>
<td>(4.04)</td>
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<tr>
<td>Agriculture</td>
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<td></td>
<td>(1.91)</td>
<td></td>
</tr>
<tr>
<td>15–24 age as % of male population</td>
<td></td>
<td></td>
<td></td>
<td>-1.012</td>
<td>(1.84)</td>
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<tr>
<td>Average age of female population</td>
<td></td>
<td></td>
<td></td>
<td>-0.045</td>
<td>(4.45)</td>
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<tr>
<td>( R^2 )</td>
<td></td>
<td>0.744</td>
<td>0.997</td>
<td>0.999</td>
<td>0.948</td>
</tr>
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</table>

Notes: \( t \)-statistics in parentheses. Coefficients in square brackets imposed.

where \( \phi_p \) is constant across regions and \( \theta_{2C} \) and \( \theta_{SH} \) are functions of the parameters of the structural equations.

Equation (A4) also motivates the construction of a composite index of the stock of public capital. Given constant returns to scale in all factors except human capital (i.e. if \( \theta_p = \theta_i + \theta_s \)), the expression within parentheses on the right-hand side of (A4) may be written:

\[
\theta_p + \theta_i s + \theta_n = \theta_p (p - n) + \theta_s (p - s) = \theta_s \left( \frac{\theta_p}{\theta_p} (p - n) + \frac{\theta_i}{\theta_p} (p - s) \right) \equiv \theta_s \hat{p}
\]

Hence, the impact of infrastructure, land area and population on the variable of interest may be summarized by a (geometric) weighted average of two commonly used indicators.
of infrastructure endowment: the stock of public capital per capita and per unit of land area. In the text, we refer to this variable as the effective stock of public capital, denoted by \( \hat{p} \).

REFERENCES


