IS THE ALLOCATION OF PUBLIC CAPITAL ACROSS THE SPANISH REGIONS TOO REDISTRIBUTIVE?

*Angel de la Fuente**

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* Instituto de Análisis Económico (CSIC) y Ministerio de Hacienda.

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Correspondence to: Angel de la Fuente. Instituto de Análisis Económico, Campus de la Universidad Autónoma de Barcelona, 08193, Bellaterra, Barcelona, Spain, *Tel:* 34-93-580-6612. *Fax:* 34-93-580-1452. *E-Mail address:* delafuente@uab.es.

Abstract

This paper compares the observed distribution of the stock of infrastructures across the Spanish regions with the optimal allocation derived from a planning problem in which the observed degree of ex-post redistribution is taken as given. The results suggest that Spanish public investment policy has been too redistributive.

Non-technical summary

Concern about the unequal development of different parts of their territory has often led national (and supranational) governments to adopt active policies of regional redistribution. Both the Spanish government and the European Union currently devote large sums to improving the productive capacity of their less developed regions through direct public investment (especially in infrastructures but also in training programmes) and through subsidies to private investment.

These policies have often been questioned. Perhaps the main objection to them is that, since there exist better instruments for the redistribution of income across individuals, it would be preferable to assign public investment purely on efficiency grounds (and not to distort the allocation of private capital), so as to maximize national ouput, and then carry out any desired redistribution through the tax and social protection systems.

One objetive of the paper is to examine the validity of this criticism. While the proposed two-stage policy is certainly optimal in a frictionless world, I argue that some degree of redistribution through public investment is part of the optimal policy package in a second-best world where there exist limitations on the amount of redistribution that can be achieved through alternative, more direct, mechanisms.

Hence, there is indeed room for regional policies. But this does not mean that the policies we observe in Spain and elsewhere are necessarily optimal. To evaluate them, we need a model that can be used to compute the optimal allocation of infrastructures across regions in a world with imperfect mechanisms for personal redistribution. In this paper I use a simplified version of such a model, orginally developed by Caminal (2001), adapted in a way that lends itself easily to calibration using readily available data and the results of some previous empirical studies. My version of the model takes as given the observed degree of ex-post regional redistribution through taxes and public spending and yields a simple characterization of the optimal (second-best) allocation of public investment across regions. This second-best allocation depends on the regional distribution of disposable income (after taxes and transfers) and involves a deviation from efficiency in favour of poorer regions.

To evaluate public investment policy in Spain, I compare this optimal allocation with the observed one (or more precisely, the rates of return on infrastructure capital under both allocations). As can be expected, the results of the exercise depend to some extent on assumptions concerning the values of two key parameters: one that captures the degree of social aversion to inequality and a second one that measures the "non-productive" fraction of the population-- i.e. the weight of those who do not not benefit directly from infrastructure investment in their region of residence and, as a result, favour an efficient investment policy because it maximizes the net transfers they receive though the social protection system. For plausible values of the second parameter, I find that the conclusion that redistribution through public investment has been carried too far holds for any degree of aversion to inequality.

1. Introduction

Over the last fifteen or twenty years the Spanish government has pursued an active policy of regional redistribution through public investment in infrastructure. This policy has been the subject of an ongoing controversy. While the governments of the poorer regions often press for even greater investment grants on equity grounds, those of the richer ones regularly complain about a deficit of infrastructures that they consider harmful not only for their own territories but also for the economic performance of the country as a whole.

This paper attempts to evaluate the economic merits of these competing claims by applying a straightforward welfare analysis to the problem at hand. To determine whether the regional allocation of the Spanish stock of infrastructures is too redistributive, I will use a simplified version of a model of the optimal allocation of public investment developed by Caminal (2001), adapted in a way that lends itself easily to calibration using readily available data and the results of some previous empirical studies. My version of the model takes as given the observed degree of ex-post regional redistribution through taxes and public spending and yields a simple characterization of the optimal (second-best) allocation of public investment across regions. This second-best allocation, which involves a deviation from efficiency in favour of poorer regions, is then compared to the observed allocation of the public capital stock to evaluate the latter. As can be expected, the results of the exercise depend to some extent on assumptions concerning the values of certain parameters, but they do suggest that, in all probability, redistribution through public investment has indeed been carried too far.

The paper is organized as follows. Section 2 contains some general considerations about the suitability of public investment as a redistributive tool and sketches a model of optimal investment allocation that is formally developed in the Appendix. Section 3 discusses the calibration of the model and presents the results of the exercise. Section 4 closes with a brief summary and a discussion of some policy implications.

2. Should public investment be used as a redistributive tool and to what extent?

Perhaps the main argument against investment-based redistributive regional policies is that there are better ways to achieve the same objectives. Critics of these programmes often argue that it would be preferable to allocate infrastructure investment in accordance to a strict efficiency criterion, thereby maximizing aggregate output, and then perform any desired redistribution ex-post, through the tax and social protection system.

It is certainly true that tax policies and social expenditure programmes are better suited than public investment for the redistribution of income. One key advantage of these instruments is that, since they can be tailored to individual circumstances, they will be more effective in reaching the neediest segments of the population than infrastructure investment, which works by raising the productivity of private factors and will therefore benefit employed workers and the recipients of capital income more than needier groups.

While this observation certainly implies that the bulk of personal redistribution must be done through instruments designed specifically for this purpose, it does not necessarily follow that there is no need for redistributive regional policies. This stronger result (of strict *separation* between investment decisions and redistribution) will not hold if there are any limitations on the available mechanisms for ex-post redistribution that prevent the implementation of the first-best strategy of maximizing income through investment and redistributing it optimally ex-post. In practice, the existence of such limitations seems indisputable. My calculations for the case of Spain, for instance, suggest that any output gains derived from a more efficient investment policy would tend to stay disproportionately in the richer regions, leaving the poorer ones worse off than under the current situation.[1]

Hence, there is indeed room for regional policies as part of the optimal policy package in a second-best world. But this does not mean that the policies we observe in Spain and elsewhere are necessarily optimal. To evaluate them, we

[1] See de la Fuente (2001b). I estimate that a certain change in Spanish investment policy during the period 1990-95 (which would increase the weight given to efficiency considerations) would have raised Spanish national income by around 300.000 million pesetas (mptas.). This figure is the net result of an output gain of 600.000 mptas. in a set of regions that comprise approximately 50% of the Spanish population and a loss of 300.000 mptas. in the remaining ones. Taxes and public expenditures would redistribute part of the gains towards the second set of regions, but not nearly enough to fully compensate them. According to my estimates, their loss of disposable income would be around 170.000 mptas. or a billion euros.

need a model that can be used to compute the optimal allocation of infrastructures across regions. The rest of this section sketches one such model building on the work of Caminal (2001). The formal details are in the Appendix.

A simple model of the optimal allocation of infrastructures

Consider a country formed by two regions that differ in their productivity. Gross income in each region increases, although at a decreasing rate,[2] with its stock of infrastructures but depends also on other factors not controlled by the government in such a way that output per employed worker in the first region (the "rich" region) is always higher than in the second one (the "poor" region) for equal stocks of public capital per worker. We will assume that the central government has a given budget for infrastructure investment and that it can redistribute income ex-post through taxes and subsidies. Putting ourselves in the shoes of a hypothetical minister of Public Works, whom we will assume to be benevolent and averse to inequality, we want to determine how much we should invest in each region.

One possibility would be to follow a pure efficiency criterion; that is, set regional investment levels so as to maximize national income. To do this, we would have to assign the available resources in such a way that the return on the last euro invested in each region (measured by the induced increase in output) is the same for all of them. Otherwise it would always be possible to increase aggregate output by shifting resources to the region with the highest return. For future reference, let us take note of this condition of equal returns as the practical expression of the criterion for efficient investment.

The maximization of national output does not necessarily imply the maximization of welfare, which is the natural criterion for the design of public policies. It seems reasonable to assume that individual welfare increases less than proportionately with income, for each additional euro of earnings will be used to satisfy needs that are increasingly less basic. If this is true, aggregate welfare, understood as the sum of the utilities of all citizens, can be increased by redistributing income from rich to poor, even if this has a cost in terms of lower output.

Under the welfare maximization criterion, the relevant consideration for the correct allocation of public infrastructures is not their contribution to regional

[2] That is, we assume there are decreasing returns to the stock of public capital.

output but their marginal impact on welfare, which depends both on the output generated by the last euro invested in each region and on how much this output is valued by its recipients. By the same logic as before, the contribution of the last euro to welfare must be equal in all territories. But since the same output gain will generate a greater welfare increase in the poor region, the optimality condition will hold with a lower rate of return on investment in the poor region than in the rich one. That is, it will be optimal to "distort" the allocation of public capital in favour of the poor region.[3] Investment there will be higher than required by the efficiency criterion (and its return will be correspondingly lower) because although its payoff in terms of output will be relatively low, its contribution to welfare will be high. The situation will be just the opposite in the rich region.

How large should these compensating deviations from efficiency be? The model I have just sketched gives a precise answer to this question in the form of a simple formula that can be used to calculate the optimal rate of return on public capital in each region as a function of the levels of disposable income of all territories and a parameter that measures the degree of ex-post redistribution. Working back from these optimal rates of return (using a production function) it is possible to obtain the optimal distribution across regions of the stock of infrastructures.

Before writing down this formula, I have to explain two features of the model developed in the Appendix that I have not discussed so far. The first feature is a very simplified description of the redistributive impact of the fiscal system. The model assumes that the representative resident of each region receives a net subsidy (or pays a net tax) that is a given fration θ of the difference between average gross income per capita in the country as a whole and his own gross income. Roughly speaking, the *redistribution coefficient*, θ, tells us what fraction of income disparities is eliminated ex-post by taxes and government expenditures.

The second feature attempts to make the model a bit more realistic and, as we will see below, is crucial for my results. I have introduced in the model a fictional region (*region 0)* to which I will attribute (independently of where they really live) all the non-productive citizens of the country -- that is, all those individuals who do not benefit directly from productive public investment in

[3] This does not necessarily mean that investment per worker will be higher in the poor region than in the rich one, only that the first will receive more resources and the second less than if investment were allocated following a pure efficiency criterion.

their region of residence. I will return below to the question of what segments of the population should be included in this group. For now, the important thing to note is that, as Caminal (2001) emphasizes, the existence of this segment of the population tends to bring the optimal allocation of public capital closer to the one that would dictate the efficiency criterion. The reason is that the members of this group will be interested only in the maximization of aggregate income because the transfers they receive are an increasing function of this variable and are independent of the stock of public capital of the (geographical) region where they live.[4]

We can now turn to the formula that characterizes the optimal distribution of the stock of productive public capital. Proceeding in the way described in the Appendix, and under the additional assumption that the utility function is isoelastic, it is easy to show that the optimal rates of return *(ROPT)* on public capital (i.e. the optimal marginal product of this factor) in any two regions *j* and *k* will satisfy the following relation:

$$(1)\quad \frac{ROPT_k}{ROPT_j} = \frac{(1-\theta)\dfrac{1}{x_j^{\sigma}} + \theta\left(\alpha_o \dfrac{1}{x_o^{\sigma}} + \sum_{i=1}^{n} \alpha_i \dfrac{1}{x_i^{\sigma}}\right)}{(1-\theta)\dfrac{1}{x_k^{\sigma}} + \theta\left(\alpha_o \dfrac{1}{x_o^{\sigma}} + \sum_{i=1}^{n} \alpha_i \dfrac{1}{x_i^{\sigma}}\right)}$$

where x_i is average disposable income (after taxes and subsidies) in region i, α_i its share of the national population, n the number of geographical regions in the country and θ the parameter that measures the degree of ex-post redistribution. The subscript zero refers to the fictional region formed by the unproductive segment of the population. The terms of the form $1/x^{\sigma}$ that appear in (1) are the marginal utilities of the representative residents of the different regions, i.e. the contributions to their welfare (or to the function used by planner to evaluate it) of the last euro of disposable income. The parameter σ measures the degree of aversion to inequality (or preference for redistribution) of the planner (or any interested observer). If σ is large, the marginal utility of disposable income is much higher for poor than for rich citizens and this increases the planner's inclination to transfer resources from rich to poor regions so as to maximize total welfare.

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[4] Clearly, this will only be true as long as there is a national system of personal redistribution that is applied uniformly across all regions. Until now this has (roughly) been the case in Spain. It is possible, however, that the ongoing process of fiscal decentralization may gradually weaken this system in the future by giving regional governments greater discretion on tax and social protection policies. Such a development would strengthen the case for ex-ante redistribution through regional policies.

Equation (1) is simply the formal expression of the already mentioned condition for an optimum, namely that the contribution to welfare of the last euro invested in each region must be the same in all cases. To obtain it, we have taken into account the fact that, under our assumptions, investment in any region afects not only the income of its residents (which it does directly, through an increase in their productivity), but also the average income in the entire country and, through the ex-post redistribution system, the disposable incomes of all regions. As a result, the term that appears in the right-hand side (both in the numerator and in the denominator) is not the marginal utility of the region we are considering ($1/x_k^{\sigma}$) but a weighted average of this variable and the average marginal utility of all the citizens of the country (captured by the term inside the parenthesis), with weights that reflect the existing degree of ex-post redistribution, θ.

The implications of (1) have already been noted above: the optimal allocation of public capital will be distorted in favour of region *k* (investment there will have a lower rate of return than in region *j*) if and only if *k* has a lower per capita disposable income than *j*, and the size of the distortion will increase with the difference between the per capita disposable incomes of the two regions. Equation (1) also implies that the optimal degree of redistribution through public investment (which we can proxy by the dispersion of the optimal rates of return) will be an increasing function of the level of regional inequality that remains after the operation of the ex-post redistribution system. If disposable income per capita is the same in all regions (or, equivalently, if $\theta = 1$) the right-hand side of (1) is equal to one and the rate of return on public capital should be the same in all regions, as required by the efficiency criterion. As income disparities increase, optimal investment levels will be set in order to partially offset them and this will translate into an increase in the dispersion of the optimal rates of return on public capital.

3. Is the allocation of public capital across the Spanish regions too redistributive?

In this section I will use the model sketched above to evaluate Spain's regional investment policy. My strategy will be quite simple: I will compute the optimal rates of return given by equation (1) and compare them with the observed rates of return on infrastructures to try to determine whether the regional distribution of the stock of this factor is close or far from the optimum and in what direction. Since equation (1) is written in relative terms, I will divide both optimal and observed rates of return by their respective sample averages and analyze the relationship between the variables so normalized.

Data and model calibration

To perform the required calculations I will need data on output levels, population and infrastructure stocks in the Spanish regions and an estimate of their disposable incomes and the degree of ex-post redistribution. The regional data refer to 1995 and come from the publications of Fundación BBVA cited in the references. Regional output is measured by gross value added deflated with a common national price index. The measure of the (net) real stock of infrastructures includes roads and highways (including toll highways), ports, airports, railroads, urban structures and water works. The estimate of the regional redistribution coefficient I will use ($\theta = 0.33$) is taken from de la Fuente (2001a), where I also construct regional fiscal balances that are used to estimate regional disposable incomes in the manner discussed below.[5]

I estimate the observed rate of return on infrastructures using data on the stock of this factor and regional output. Under the assumption that the production function is Cobb-Douglas, it is easy to show that marginal products are proportional to average products, so relative rates of return on infrastructure can be computed using observed average products (i.e. the ratio of output to the stock of productive public capital in each region).

Given values of σ and θ, to compute the optimal rates of return given in equation (1) we need estimates of regional disposable incomes (x_i) and population shares (α_i). The simplest case is the one where we assume that $\alpha_o = 0$, that is, that there are no non-productive citizens. In this case, α_i is simply the share of region i in the national population in 1995, which I will call ω_i. Per capita disposable income in each region (x_i) is then obtained by adding to its gross income per capita (gross value added) its per capita fiscal balance. Hence, my measure of disposable income includes the value of the services provided by the government in each region as well as net cash transfers from the public budget.

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[5] The fiscal balance of a region is defined as the difference between public expenditure in the region and the taxes borne by its citizens. The estimates given in de la Fuente (2001a) refer to the period 1990-98. Here I use the average value over this period of per capita fiscal balances measured as a fraction of national income per capita. The estimate of the redistribution coefficient θ is obtained from a regression of per capita regional fiscal balances on relative gross incomes per capita.

When the non-productive fraction of the population is positive ($\alpha_o > 0$), the procedure is modified in the natural way under the assumptions that i) the share of this group in the population is the same in all geographical regions, and ii) the income per capita of its members (which comes entirely from government transfers) is given by θy in all regions. In this case, α_i is the weight of the productive population of geographical region *i* in the national total and can be obtained from the observed population shares (ω_i) using:

$$(2)\ \alpha_i = (1-\alpha_o)\omega_i.$$

Next, I reestimate the per capita disposable income of the productive population, subtracting from the total disposable income of each region the part imputed to its non-productive citizens and reducing the denominator in proportion to the population we are now attributing to region *0*. If we denote by x_i our original estimate of per capita disposable income in region i, by x_0 (= θy) the average disposable income of the non-productive population and by x_i' the disposable income of the productive segment of region *i*'s population, we will have

$$x_i = (1-\alpha_o)x_i' + \alpha_o x_0,$$

from where

$$(3)\ x_i' = \frac{x_i - \alpha_o x_0}{1-\alpha_o}\ .$$

Some of the simplifying assumptions implicit in these calculations are clearly restrictive. In general terms, however, they can be expected to bias the results in favour of redistribution through public investment, thereby reinforcing my conclusion that it has been carried too far. The use of a representative agent is an example of this because it amounts to the assumption that public investment has the same impact on the incomes of all (productive) residents of a region. In fact, it may be expected that the benefits from infrastructure will be roughly proportional to productivity. Hence, public investment may actually increase income inequality within each region and this would decrease its attractiveness as a redistributive tool. The assumption of a uniform share of non-productive citizens across regions has a similar effect. In fact, the weight of this group is higher in the poorer regions than in richer one. But this implies that income differences across (the productive residents of) both groups of regions are actually lower than we are assuming, thereby reducing the need for redistribution.

Testing for excess redistribution

Proceeding in the manner outlined above, I can obtain estimates of the observed *(ROBS)* and optimal (*ROPT)* rates of return on infrastructure investment in each territory. My objective is then to check whether these two variables are approximately equal and, if this is not the case, to determine whether the differences between them reflect an excess or a deficit of redistribution through public investment.

To analyze the relationship between observed and optimal rates of return on infrastructure, I will estimate (for different combinations of values of σ and α_o) an equation of the form

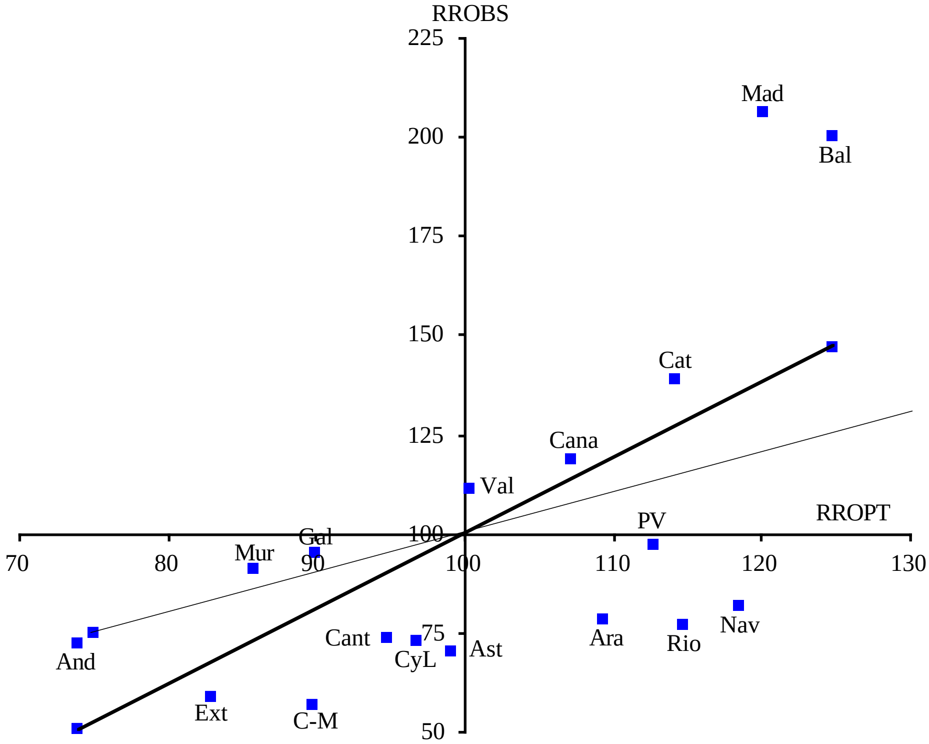
$$(5)\ (RROBS_i - 100) = c^*(RROPT_i - 100)$$

where *RROBS* and *RROPT* denote the relative values of observed and optimal rates of return and are obtained by normalizing both variables by their respective sample means.

If the observed and optimal distributions of relative rates of return on infrastructure were the same, *c* would be equal to one. If the estimated value of *c* is significantly greater than one, the observed rates of return will be above their optimal values in those regions where the latter are high (that is, in the rich regions, where investment should be below its efficient level), and below their optimal levels in the regions where the latter are low (i.e. in the poor regions). Hence, we will be investing too little in the rich regions and too much in the poor ones, and we will have to conclude that the observed degree of redistribution is too high. If the value of *c* is below one, we will be in the opposite situation and the observed degree of redistribution through public investment will be too low.

Figure 1 illustrates the exercise for specific values of the parameters σ and α_o which, as we will see below, can probably be considered reasonable. The observed rate of return on infrastructure investment (normalized by its sample average) is measured on the vertical axis and the optimal rate of return on the horizontal one. The thinner line is the diagonal (although it does not look like it because the scale is different in each axis) and corresponds to the case where c = 1, indicating that the observed and optimal rates of return are equal on average. In those regions located above the diagonal, the observed return on infrastructure is higher than the optimal one, signaling that investment is too low given its expected return and the region's disposable income. The thicker line describes the fitted relation between observed and optimal rates of return. In the case shown in the figure, the fitted line is steeper than the diagonal (that is, $c > 1$), implying that the observed degree of redistribution is too high given the assumed values of the parameters.

Figure 1: Observed vs. optimal relative rate of return on infrastructures (with $\alpha_o = 0.15$ and $\sigma = 2$)



- *Key:* And = Andalucía; Ext = Extremadura; Mur = Murcia; C-M = Castilla la Mancha; Gal = Galicia; Cant = Cantabria; CyL = Castilla y León; Ast = Asturias; Val = Valencia; Cana = Canarias; Ara = Aragón; PV = País Vasco; Rio = Rioja; Cat = Cataluña; Nav = Navarra; Mad = Madrid and Bal = Baleares.

As we have already noted, the result of the estimation will depend on the values of σ and α_o that are used to compute the optimal rates of return. Table 1 shows the estimates of c obtained for different combinations of these parameters. I have hightlighted in bold type those cases in which we cannot reject with a reasonable degree of confidence the hypothesis that the observed distribution of the stock of infrastructures is approximately optimal or even falls short of the optimal degree of redistribution. If we assume that the entire population is productive (that is, if $\alpha_o = 0$), the conclusion about the optimality of the observed distribution of the stock of public capital depends crucially on the value of the parameter that measures the degree of aversion to inequality *(σ)*. The hypothesis that the degree of redistribution is too high can be rejected for all values of σ higher than two.

Table 1: Estimates of *c* for different combinations of α_0 and σ

σ	$\alpha_0 = 0$	$\alpha_0 = 0,10$	$\alpha_0 = 0,15$	$\alpha_0 = 0,20$	$\alpha_0 = 0,30$
0,5	5,44	5,39	5,36	5,35	5,33
1	2,73	2,82	2,88	2,95	3,11
2	**1,35**	**1,70**	1,91	2,15	2,75
3	**0,88**	**1,72**	2,21	2,80	4,41
4	**0,64**	2,45	3,57	4,99	9,31
5	**0,51**	4,28	6,88	10,41	22,21
8	**0,32**	38,63	74,26	130,57	371,86

- *Note:* we show in boldface those estimates of *c* which are below one and those for which the p-value of the Wald test for the null hypothesis that $c = 1$ is greater than 0.15.

This ambiguity tends to disappear once we assign to α_0 (the non-productive share of the population) values above 10%. Notice than when α_0 is positive, the estimated value of *c* varies with σ in a non-monotonic way following a U-shaped pattern. The decreasing branch of the U is easily explained: the optimum is close to the efficient distribution of investment when the planner is not very averse to inequality, and will become more redistributive as his aversion to inequality becomes stronger. When $\alpha_0 > 0$, however, this situation will eventually be inverted because a planner who is very averse to inequality will put a very high value on transfers going to the non-productive population (which is the poorest group). For relatively high values of α_0, the conclusion that the observed allocation of public capital is too redistributive will hold for any value of the coefficient of aversion to inequality.

This takes us to the question of what may be a reasonable value for α_0. If we interpret the model literally, α_0 would be the fraction of the population that is not currently employed, and since this figure is well above 50%, the conclusion that moving towards a more efficient investment policy would be a good idea would be inescapable. But if we try to interpret the model in a more reasonable way, the problem becomes harder because there are important segments of the non-employed population that benefit rather directly from (current or past) infrastructure investment. These groups include the dependents of employed workers and a good share of those in retirement, as their pensions will (generally) depend on their social insurance contributions, which are proportional to their wages and therefore, presumably, to their level of productivity.

Table 2: Share in the total population around 1995 of various types of less-favoured groups

not employed	69.58%
population over 65	15.13%
unemployed	9.04%
unemployed not entitled to contributive insurance payments	7.46%
recipients of non-contributive pensions	1.29%
% of households whose members are all unemployed	3.11%
% of persons who live in poor households	18.08%

- *Sources:* Fundación BBVA, Family budget survey of 1991 and Yearbook of Labour and Social Statistics for various years between 1991 and 1995. The poverty threshold for the figure in the last row is set at 50% of average Spanish income per capita.

It is not easy, therefore, to identify the "correct" value of α_0. To give us some idea of the range of potentially reasonable values of this parameter, Table 2 shows the weight in the total Spanish population of various disadvantaged groups that may be plausible candidates for inclusion in region *0*. On the basis of these data, it may be tentatively concluded that α_0 should be somewhere between 9% (if we include only the unemployed not entitled to contributive insurance payments and the recipients of non-contributive pensions) and 18% if we include all those who live in poor households (defined as those whose per capita income lies below one half the national average). For this range of values of α_0, all estimates of c are greater than one, although it is also true that with $\alpha_0 = 0.10$ we cannot confidently rule out the possibility that the observed policy is optimal for some values of σ. Hence, our conclusions must be somewhat tentative. But the exercise does suggest that, in all likelihood, the regional allocation of the stock of infrastructures is too redistributive. A change in investment criteria in the direction of greater attention to efficiency considerations would most likely be desirable independently on the degree of aversion to inequality of the observer.

4. Conclusion

In this paper I have argued that redistributive regional policies can be justified as part of the optimal policy package in a second-best world where there are limits on the feasible degree of ex-post personal redistribution. The optimal intensity of such policies will depend on the amount of regional inequality that remains after ex-post redistribution and on the degree of social aversion to inequality.

My analysis of the Spanish case suggests that current regional policies have exceeded this optimal degree of redistribution. Hence, average welfare could be increased by raising the weight given to efficiency considerations in the regional allocation of infrastructure investment. In practice, this would involve investing a lot more in some of the richest regions and considerably less in some of the poorest ones.

I will conclude with two brief comments on the implications of my results for the design of European cohesion policy. The first one is that my conclusions cannot be directly extrapolated to the EU as a whole. Since per capita income differences across member countries are large and there is very little ex-post redistribution going on at this level, the same type of analysis is likely to lead to very different conclusions. The second comment is that the reorientation of Spanish public investment policy that I am advocating would almost surely lead to a conflict with the criteria governing the allocation of the EU Structural Funds that cofinance a significant fraction of such investment. In my view, it may be desirable to switch to national criteria for the allocation of these funds, leaving their regional distribution at the discretion of member states.

Appendix: A formal model

Consider a country formed by $n+1$ regions ($i = 0, 1, \ldots, n$) with shares α_i in the national population. Regions 1 through n are "real" geographical regions, and region 0 is a fictional region to which we attribute the entire non-productive population of the country, independently of its geographical region of residence. Gross income per worker in region i is given by a per capita production function of the form

$$(1)\ y_i = A_i f(p_i)$$

where $f()$ is an increasing, concave and differentiable function, p_i is the per worker stock of productive public capital in region i and A_i a productivity index that summarizes the effects of the endowments of private productive factors and the level of technical efficiency of the region. Since the residents of region 0 are by assumption non-productive, we will set $A_0 = y_0 = 0$.

The central government is endowed with a given investment budget that must be allocated among the geographical regions and can use taxes and subsidies to redistribute income ex-post. Letting P denote the available investment funds per capita, the resource constraint requires that

$$(2)\ \sum_i \alpha_i p_i \leq P.$$

Per capita disposable income in region i (x_i) will be given by

$$(3)\ x_i = y_i + z_i$$

where z_i is the net per capita subsidy to residents of region i (or the taxes they bear if z is negative). The government's budget constraint requires that the average value of these subsidies be non-positive, that is

$$(4)\ \sum_i \alpha_i z_i \leq 0.$$

Finally, the government chooses the instruments under its control so as to maximize the average utility of its citizens, given by

$$(5)\ W = \sum_i \alpha_i U(x_i)$$

where $U()$ is an increasing, concave and differentiable function.[6]

[6] The assumption that the production and utility functions are concave is important. In the first case, concavity amounts to decreasing returns to public capital and implies that it will

It will be useful to consider two alternative versions of this problem. In the first one (that yields the strict *separation* result mentioned in the text), the central government can redistribute income without any limitations through lump-sum taxes and subsidies. Formally, the planner solves the following problem

$$(P.1)\ \max_{p_k, z_k} \left\{ \sum_{i=0}^{n} \alpha_i U\big(A_i f(p_i) + z_i\big)\ \ s.t.\ \sum_{i=0}^{n} \alpha_i p_i \le P \ and \ \sum_{i=0}^{n} \alpha_i z_i \le 0 \right\}.$$

Forming the Lagrangian,

$$£ = \sum_{i=0}^{n} \alpha_i U\big(A_i f(p_i) + z_i\big) + \lambda\left(P - \sum_{i=0}^{n} \alpha_i p_i \right) - \mu\left(\sum_{i=0}^{n} \alpha_i z_i \right),$$

where λ and μ are the multipliers associated with the constraints (2) and (4), and differentiating it with respect to z_k and p_k we obtain the first-order conditions:

$$(6)\ A_k f'(p_k) = \frac{\lambda}{U'(x_k)} \quad for\ all\ k = 1 \ldots n$$

$$(7)\ U'(x_k) = \mu \quad for\ all\ k = 0, 1 \ldots n.$$

Equation (7) requires the equality of marginal utilities, and hence of disposable incomes, across all regions (including region *0*). Given this result of "complete redistribution", equation (6) implies that the marginal product of public capital should be the same in all geographical regions. This condition of efficiency in investment ensures that aggregate output will be maximized.

It is worth emphasizing that the result of efficiency in investment only holds when there is complete redistribution. In fact, what equation (6) requires is the equality across regions of the marginal contribution of public investment to welfare, and not to output. The relevant term ($U'(x_i)A_i f'(p_i)$) depends on two different factors: the contribution of public investment to output, measured by its marginal product, $A_i f'(p_i)$, and the contribution of this marginal output to welfare, $U'(x_i)$, which depends on the level of disposable income. If disposable income differs across regions, so will the optimal marginal productivities of public capital, implying a violation of the efficiency criterion. In particular, the marginal product of public capital will be greater than under the efficiency criterion (and the level of investment correspondingly lower) in those regions

not be optimal to concentrate all infrastructures in the most productive region. In the second, the assumption implies dreasing marginal utility of income and makes it optimal to redistribute from rich to poor regions.

with high disposable incomes, and the opposite will be true in the poorer regions. Given this, it is not at all surprising that if we impose any reasonable restriction on the government's capacity to redistribute income ex-post, the optimal policy will involve some deviation from efficiency in investment.

In the second version of the planning problem we will analyze, it will be assumed that the subsidy to the representative resident of each region is a constant fraction θ of the difference between average income per capita in the whole country (y) and his own gross income (y_i). Under this assumption, average disposable income in region i (x_i) will be given by

$$(8)\ x_i = y_i + \theta(y - y_i) = (1-\theta)y_i + \theta y$$

where

$$(9)\ y = \sum_i \alpha_i y_i.$$

Hence, we are assuming that the operation of the entire fiscal system can be summarized by a single parameter θ (which we will call the *redistribution coefficient*). It is easy to check that the budget constraint requiring that net transfers be equal to tax revenues, ie. that

$$\sum_i \alpha_i \theta(y_i - y) = 0,$$

is automatically satisfied with this formulation.

Under these assumptions, the government's problem can be written

$$(P.2)\ \max_{p_k} \left\{ \sum_{i=0}^{n} \alpha_i U\left[(1-\theta)A_i f(p_i) + \theta \sum_{j=0}^{n} \alpha_j A_j f(p_j) \right] s.t.\ \sum_{i=0}^{n} \alpha_i p_i \le P \right\}$$

and differentiation of the appropriate Lagrangian,

$$\pounds = \sum_{i=0}^{n} \alpha_i U\left[(1-\theta)A_i f(p_i) + \theta \sum_{j=0}^{n} \alpha_j A_j f(p_j) \right] + \lambda\left(P - \sum_{i=0}^{n} \alpha_i p_i \right)$$

yields the first-order condition

$$\frac{\partial \pounds}{\partial p_k} = \alpha_k U'(x_k)(1-\theta)A_k f'(p_k) + \sum_{i=0}^{n} \alpha_i U'(x_i)\theta \alpha_k A_k f'(p_k) - \lambda \alpha_k = 0$$

from where

$$A_k f'(p_k) = \frac{\lambda}{(1-\theta)U'(x_k) + \theta \sum_{i=0}^{n} \alpha_i U'(x_i)} .$$

Hence, the ratio the marginal product of public capital in any two regions *j* and *k* must satisfy the following condition at an optimum:

$$(10)\quad \frac{A_k f'(p_k)}{A_j f'(p_j)} = \frac{(1-\theta)U'(x_j) + \theta\left(\alpha_o U'(x_o) + \sum_{i=1}^{n} \alpha_i U'(x_i)\right)}{(1-\theta)U'(x_k) + \theta\left(\alpha_o U'(x_o) + \sum_{i=1}^{n} \alpha_i U'(x_i)\right)}$$

Under the assumption that ex-post redistribution is incomplete (i.e. that $\theta < 1$) investment will be distorted in favour of the poorer region. (The optimal marginal product of infrastructures will be lower in region *j* than in region *k* whenever $x_j < x_k$). This will certainly be the case under the current Spanish fiscal system, where θ is around one third when we consider the redistributive impact of both taxes and public expenditures.

It is interesting to note that the marginal utility of the citizens of region *0* (the non-productive segment of the population) plays an important role in equation (10). Although this segment of the population does not benefit directly from public investment, it does benefit indirectly through the ex-post redistribution mechanism. And since the system assigns each member of this group a constant fraction of per capita national income, he or she always prefers an efficient investment policy that maximizes this magnitude. As a result, when the weight of region *0* is large, the optimal policy is close to the efficient one. Notice that if $\alpha_o U'(x_o)$ is large (that is, if the share of non-productive citizens is large or their marginal utility is high because they are very poor), this term will dominate the other ones and the ratio that appears on the right-hand side of (10) will be close to 1, which is the value it would adopt under a pure efficiency criterion.

Equation (1) in the text is obtained from equation (10) above under the assumption that the utility function is isoelastic.

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