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Does decentralization improve the efficiency in the allocation of public investment? Evidence from Spain

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DOES DECENTRALIZATION IMPROVE THE EFFICIENCY IN THE ALLOCATION OF PUBLIC INVESTMENT? EVIDENCE FROM SPAIN [a]

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ABSTRACT: The well-known "Decentralization Theorem" (Oates, 1972) establishes the superiority of decentralized public provision over the centralized case, which is not so sensitive to the diversity of expenditure needs among territories. We test this hypothesis using a unique Spanish database that provides information on road and educational infrastructure investment and capital stocks by region both before and after the decentralization of such responsibilities. We find that investment in both categories is much more sensitive to regional output and to infrastructure users and costs when sub-central governments have the responsibility over such services.

Key words: decentralization, growth, roads, human capital
JEL codes: D72, H54, H72, H77, I20

RESUMEN: El conocido "Teorema de la descentralización" (Oates, 1972) establece la superioridad de la provisión pública descentralizada en relación a la centralizada, pues ésta última no es tan sensible respecto de la diversidad de preferencias sobre los bienes y servicios públicos que pueden existir entre territorios. En este artículo, contrastamos esta hipótesis a partir de una muestra de datos que, por un lado, ofrece información sobre inversión en infraestructuras en carreteras y en educación y, por el otro, sobre los stocks regionales de capital antes y después de la descentralización de tales competencias de gasto. Los resultados del análisis demuestran que la inversión realizada en ambas categorías de gasto es mucho más sensible al output regional y a los costes y número de usuarios de los servicios respectivos cuando los gobiernos subcentrales tienen la competencia de inversión.

Palabras clave: Descentralización, crecimiento, carreteras, capital humano.
Clasificación JEL: D72, H54, H72, H77, I20.

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1. Introduction

From a normative point of view, the diversity of preferences among regions is probably the best-known reason that recommends a decentralized structure of government. According to the so-called “Decentralization Theorem” (Oates, 1972), “in the absence of cost-savings from the centralized provision of a good and of inter-jurisdictional externalities, the level of welfare will always be at least as high (and typically higher) if Pareto-efficient levels of consumption are provided in each jurisdiction than if any single uniform level of consumption is maintained across all jurisdictions” (p. 54). However, note that, for this prescription to hold, it is necessary to assume that the central government is not able to differentiate its provision among regions. Oates (1999) justifies it by means of the supposed better knowledge of state and local governments about the preferences and economic conditions of their constituency. Without that precise knowledge, and just having an “average” description of the preferences and economic conditions of all the citizens of the federation, the central government is “forced” to provide a uniform level of public goods across all the territories.

Nevertheless, why could not a central layer of government make an effort to achieve the same level of information than sub-central governments? Seabright (1996) and Cremer *et al.* (1996) have probably been the first papers to try to answer this question. The former considers that the power assigned by voters to politicians is part of an incomplete *contract*, where actions adopted by the latter are not verifiable. Given this, the only way to punish a politician is by means of elections. Then, in comparison with the decentralized case, a central government has fewer incentives to collect all the information concerning a particular constituency and to make full use of it, due to the relatively small electoral weight of that region in the federal election process. Similarly, Cremer *et al.* (1996) consider the information acquisition process as endogenous, being the incentives of sub-central government to gather information greater than those of the central one. More recently, Lockwood (2002) and Besley and Coate (2003) have provided structural political economy models of both the central and sub-central decision-making processes. In both papers, the decisions adopted by the central government –which can imply diversity across territories– and their relative efficiency with respect to those adopted in the decentralized scenario crucially depend on how the central legislature works.

Hence, the theoretical literature has developed what seems to be a consistent framework to analyze the advantages and disadvantages of decentralization. Despite this, it is surprising that there are virtually no formal tests of the hypotheses that derive from the "Decentralization Theorem". Remarkable exceptions to this rule are the papers by Strumpf and Oberholzer-Gee (2002) and Faguet (2004). The first paper tests whether the degree of heterogeneity is a determinant of the allocation of responsibilities among sub-central governments, confirming this hypothesis in the case of the liquor control in the US states. That is, the States with more heterogeneous preferences have been more prone to decentralize that responsibility at the local level of government. The paper by Faguet (2004) provides evidence that decentralization increased the responsiveness of various public investment categories to local needs in Bolivia.

Given their scarcity, more empirical analyses seem to be necessary to check the robustness of the results obtained. This is precisely our aim. We test whether the decentralization of the provision of public infrastructures in Spain has improved the efficiency in the allocation of investment funds. Our methodology consists of estimating an equation of the determinants of public investment in two main categories, *Roads* and *Education*, allowing the response of investment to its determinants – output, number of users, environmental cost factors and the political cloud of each region – to differ between regimens (i.e., centralized *vs.* decentralized provision). If the estimated coefficient of each investment determinant is the same in both regimes, we shall conclude that decentralization is not efficiency-enhancing. Otherwise, given the presumably better knowledge of expenditure needs by part of sub-central governments, investment decisions in the centralized case will not be optimal.

This misallocation of public investment may adversely impact regional growth. The link between better responsiveness to regional needs and economic growth was pointed out by

Oates (1993), who stated that "there surely are strong reasons, in principle, to believe that policies formulated for the provision of infrastructures and even human capital that are sensitive to regional or local conditions are likely to be more effective in encouraging economic development than centrally determined policies that ignore these geographical differences" (p. 240). That is, *a priori*, the greater responsiveness to local needs makes decentralization the institutionally efficient solution, that is, the one that maximizes economic growth[1]. That statement has helped us to select the two inputs used in the analysis (*Roads* and *Education*), which impact on growth has also been recognized by the literature (see, e.g., Afonso *et al.*, 2005, and Wöβmann, 2003). Moreover, some authors have suggested that the central government chooses an inefficient mix of roads and education. For example, De la Fuente *et al.* (2003) show that the social return of infrastructure investment (including roads) exceeds that on human capital in the richer Spanish regions, but the reverse is true in most of the poorer territories. From this finding, in order to increase the global effectiveness of regional policies, they conclude that a greater amount of education funds should be allocated to poorer regions, while redirecting part of the infrastructure resources towards richer areas[2].

The Spanish case provides a good chance to test the hypothesis that sub-central governments are more responsive to regional needs of public inputs than the central government, at least for two reasons. Firstly, Spain has suffered an important process of fiscal decentralization since the re-establishment of democracy and the approval of the Constitution in 1978[3]. The timing of decentralization has not been equal for all the sub-central governments (the so-called "Autonomous Communities"; AC's from now on). That is, some AC's have assumed the maximum level of responsibilities earlier than the others, although nowadays all of them have (more or less) the same level of responsibilities. Of the two investment categories analyzed, *Roads* were decentralized to all the AC's during the first half of the eighties, *Primary and Secondary Education* was decentralized only to the first group of AC's also during this period and to the rest of AC's at the end of the nineties, and *Tertiary Education* was decentralized during the

[1] A weakness of the literature on decentralization and growth is that, despite identifying a link between these two variables, it is obscure on its possible causes. The theoretical papers on this topic (see Zou, 1996; Davodi and Zou, 1998; or Zhang and Zou, 2001) obtain that the optimal degree of decentralization is determined by the relative productivity of the expenditure made by the different levels of government. However, these papers do not make explicit which are the supposed advantages of decentralized governments in promoting economic growth.

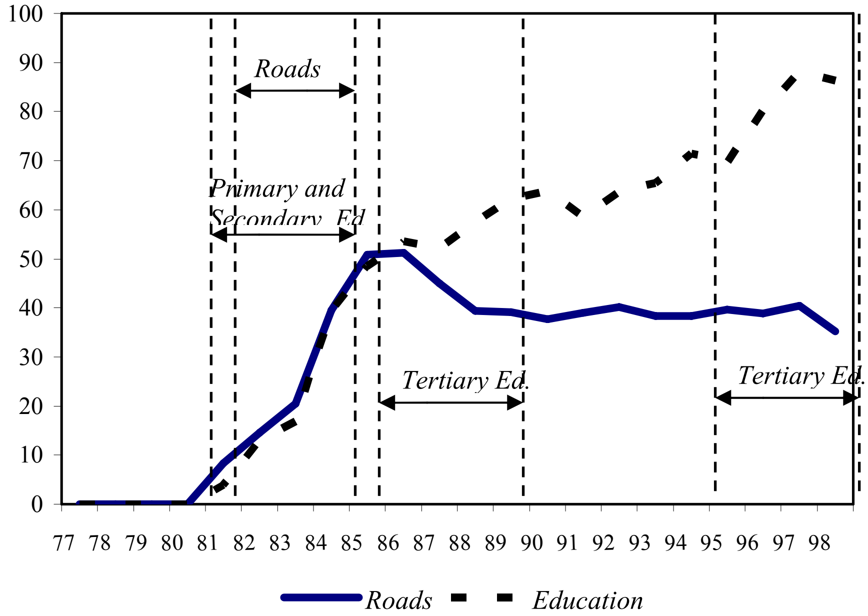
[2] In a similar vein, by means of a simulation model, Rioja (2005) shows for Latin America that re-allocating expenditures from public capital ("roads") to education can raise growth up to a threshold.

[3] In 1980, the central government was responsible for the 90% of total public expenditure and local governments for the rest. In 2002, once the main expenditure responsibilities (Health and Education) were transferred to all the regional governments (those expenditure responsibilities account for more than half of total public expenditures assigned to this layer of government), these are responsible for around a 33%, the central government for a 55%, and local governments for the rest. See Pérez (2002).

eighties for the first group and during the nineties for the second group. Figure 1 shows the evolution of the sub-central investment share in *Roads* and *Education* for the period analyzed (1977-98), specifying also the period of decentralization. Secondly, the Spanish case provides us with a unique database on public investment (total investment and investment made by the different layers of government) and capital stocks for the Spanish regions during this period (Fundación BBVA, 1998). This database includes road and education investment series during a long period comprising both centralization and decentralization years, and allows to identify the year of effective decentralization by looking at the first year were AC's investment in a given category is non-zero.

Figure 1.

Share of sub-central investment in total investment:
Investment in roads and education in 1977-1998



Notes: (1) Variables plotted are investment made by the Autonomous Communities (AC's) over investment made by AC's plus the central government; investment made by local governments is not considered here. (2) Investment education includes investment in primary, secondary and tertiary education. (3) Arrows signal periods of decentralization of responsibilities to sub-central governments (AC's). (4) Source: Fundación BBVA (1998) and own elaboration.

From the results obtained, the hypothesis of the "Decentralization Theorem" concerning the greater responsiveness of sub-central governments to local needs is clearly confirmed. Investment made by sub-central governments in both categories is much more sensitive to variations in output, users and environmental costs than central government, which suggests that the latter tends to underestimate expenditure needs in both investment categories.

The rest of the paper is organized as follows. In the next section, we develop a simple model that serves to establish and justify the equations to be estimated in the empirical section. In section 3, we describe some methodological aspects of the empirical implementation, the sample, variables and data sources, and the econometric issues. In section 4, we present the main results of the empirical analysis, and section 5 concludes.

2. Empirical framework

In this section, we develop a simple model that will allow us to posit a log-linear equation explaining the allocation of investment across categories (i.e., roads and education) and across regions. This framework should allow us to consider how decentralization will affect that allocation process, and thus to develop a test of the hypothesis that decentralization modifies the assignment of government resources across regions and across investment categories. We organize the section in the following way. First, we develop the model under the assumption that the main purposes of the government when allocating resources across regions and categories are to achieve efficiency (i.e., maximize output) and/or to satisfy political constituencies. This model aims to capture the investment allocation process across categories and regions made by a typical sub-central government. Therefore, the term region should not be identified here with a sub-central government, but with a smaller geographical area[4]. Second, we consider the effects of decentralization over this allocation process by comparing the behavior of this sub-central government with one hypothetical central government that cares about the same set of regions and that experiences some difficulties in ascertaining the technology of producing road services and human capital.

[4] This formulation is justified by the kind of data available, which allows us to investigate the allocation of investment across sub-regions inside each regional government. See section 3.2 for details.

2.1 Efficient allocation of public investment

The equation explaining the allocation of investment in road and educational infrastructure across regions is obtained from the development of a stylized model combining two different blocks: (i) a production function relating the infrastructure capital stock to regional output, and (ii) a social choice rule that states that government cares both about maximizing total output and about satisfying political constituencies.

(i) The production function

For each region *i* and year *t*, output depends on A_{it}, which is a positive and neutral factor efficiency parameter, on inputs such as labor L_{it} and private capital K_{it}, and on the services provided by road infrastructures, Z_{it}, and by human capital H_{it}. Hence, the regional production function takes the form:

$$Y_{it} = A_{it}.F(L_{it}, K_{it}, Z_{it}, H_{it}) \quad (1)$$

Both Z_{it} and H_{it} depend on the provision of public inputs, that is, the services provided by roads depend on the road capital stock, R_{it}, while those provided by human capital depend on the stock of educational infrastructures, E_{it}. Most papers analyzing the effects of infrastructures on economic growth implicitly assume that services provided by public capital are non-rival, and so use R_{it} and E_{it} instead of Z_{it} and H_{it}. We posit instead a more general function of the determinants of Z_{it} and H_{it} that allows for the possibility that these infrastructures are congested to some extent, and so the services they provide depend on their size but also on their level of utilization and on other environmental cost factors (Bradford *et al.*, 1969). Assuming for the moment a flexible relationship, in the case of roads, we have:

$$Z_{it} = Z(R_{it}, U_{it}, r_{it}) \quad (2a)$$

where R_{it} = road stock, U_{it} = road use, and r_{it} = environmental cost factors, such that $\partial Z/\partial R>0$, $\partial Z/\partial U<0$ and $\partial Z/\partial r<0$[5]. That is, road services (e.g., speed and safety) are higher the higher the road infrastructure stock (e.g., quality-adjusted km of roads built), but lower the higher the number of users of that stock and the higher the costs of building that infrastructure in a given region. Although the literature on the estimation of road congestion effects is not new (see, e.g., Inman, 1978), there are only a few papers considering the effects of road congestion on economic growth. Some of them are theoretical (Fisher and Turnovsky, 1998, and Glomm and Ravikumar, 2000) and identify road users by means of the level of private capital (i.e., $U_{it} \approx K_{it}$). The empirical papers that estimate the effects of road congestion on growth use more direct measures of utilization, such as the number of km-year driven by vehicles (Fernald, 1999, and Boarnet, 2001). Fernald (1999) analyzed the effects of increased road use for the US aggregate with time series data, but was not able to find any significant effect of congestion on economic growth. Using a translog specification of expression (2a), Boarnet (2001) finds evidence of detrimental growth effects of road congestion in the Californian counties. Other papers have tried to quantify the effects of utilization (e.g., number of vehicles, number of km-year driven, etc.) and cost variables (e.g., land area, urbanization patterns, etc.) on the regional allocation of road investment in Spain (Bosch and Espasa, 1999; and Castells and Solé-Ollé, 2005). The results of these papers suggest that the Spanish government invests more in roads in regions with high levels of congestion and costs.

In the case of educational infrastructures, the relationship between human capital and the infrastructure stock, users and costs can be expressed as:

$$H_{it} = H(E_{it}, S_{it}, e_{it}) \qquad (2b)$$

where E_{it} = educational infrastructure stock, S_{it} = users of that stock, and e_{it} =

[5]The most common functional form used to account for congestion is one that assumes a constant elasticity. In the case of roads, this function can be expressed as: $Z_{it}=R_{it}/(U_{it}^{\alpha}r_i^{\beta})$, where α=1 in the case of a private good, and α=0 in the case of a pure public good. Fernald (1999) has used it, but it has been criticized on the grounds of exhibiting decreasing marginal congestion, while theory (Edwards, 1990) and empirical analysis (Inman, 1978) suggest that congestion should be growing in the margin.

environmental factors that raise the cost of education, such that $\partial H/\partial E>0$, $\partial H/\partial S<0$ and $\partial H/\partial e<0$. That is, the services provided by human capital (e.g., average level of knowledge of the labor force) are higher the higher the educational infrastructure stock (e.g., quality-adjusted schools and university facilities built), but lower the higher the number of students using these facilities, and lower the higher the previous human capital stock, that proxies the level of investment on human capital made by the families. Other environmental cost variables, such as the land area of the region, urbanization patterns, or building costs, may also have some impact on the services that can be obtained from a given stock of educational infrastructure. This specification is similar to the one used in the literature on the estimation of education production functions (see, e.g., Das *et al.*, 2004). Early evidence suggested that family inputs have a clearer impact on educational outcomes than public inputs (Hanushek, 1986 and 2003, for surveys), but recent analyses suggest that public resources have influence as well (Card and Krueger, 1992; Gymah-Brempagn and Gyapong, 1991 and 1992; Krueger, 2003; Das *et al.*, 2004). These results also hold at the macro-regional level in Spain; De la Fuente *et al.* (2003) find that both spending per student and the average years of study of the population have a positive impact on educational outcomes of Spanish regions[6]. The effect of both types of infrastructures on output can be expressed as:

$$\frac{\partial Y_{it}}{\partial R_{it}} = A_{it}.\frac{\partial F_{it}}{\partial Z_{it}}.\frac{\partial Z_{it}}{\partial R_{it}} = \left(\frac{\partial F_{it}}{\partial Z_{it}}.\frac{Z_{it}}{F_{it}}\right)\left(\frac{\partial Z_{it}}{\partial R_{it}}.\frac{R_{it}}{Z_{it}}\right).\frac{Y_{it}}{R_{it}} = \varepsilon_{it}^{YZ}.\varepsilon_{it}^{ZR}.\frac{Y_{it}}{R_{it}} \tag{3a}$$

$$\frac{\partial Y_{it}}{\partial E_{it}} = A_{it}.\frac{\partial F_{it}}{\partial H_{it}}.\frac{\partial H_{it}}{\partial E_{it}} = \left(\frac{\partial F_{it}}{\partial H_{it}}.\frac{H_{it}}{F_{it}}\right)\left(\frac{\partial H_{it}}{\partial E_{it}}.\frac{E_{it}}{H_{it}}\right).\frac{Y_{it}}{E_{it}} = \varepsilon_{it}^{YH}.\varepsilon_{it}^{HE}.\frac{Y_{it}}{E_{it}} \tag{3b}$$

Three elements appear in both expressions: (i) the elasticity of output to the services provided by the infrastructures (ε_{it}^{YZ} and ε_{it}^{YH}), (ii) the elasticity of infrastructure services to changes in the infrastructure stock (ε_{it}^{ZR} and ε_{it}^{HE}), and (iii) the ratio of Y_{it} to R_{it} and to E_{it}. As most of the analysis on the growth effects of infrastructures (see, e.g., Aschauer, 1989; Holtz-Eakin, 1994), we assume the elasticity of output to infrastructure services is constant:

[6] Another strand of literature uses cost functions to estimate the effect of these variables, using data on US school districts (Chambers, 1980; Downes and Pogue, 1994; Duncombe and Yinger, 2003).

$$\varepsilon_{it}^{YZ} = \varepsilon^{YZ} \qquad \text{and} \qquad \varepsilon_{it}^{YH} = \varepsilon^{YH} \tag{4}$$

We also assume that the elasticity of infrastructure services to the stock depends on the number of users and on environmental cost factors included in expressions (2a) and (2b):

$$\varepsilon_{it}^{ZR} = \varepsilon^{ZR} \left(U_{it} / R_{it} \right)^{\gamma} . r_{it}^{\eta} \qquad \text{and} \qquad \varepsilon_{it}^{HE} = \varepsilon^{HE} \left(S_{it} / E_{it} \right)^{\kappa} . e_{it}^{\mu} \tag{5}$$

where ε^{ZR} and ε^{HE} are the average value of these elasticities for the country, and γ, η, κ and μ are non-zero parameters. We expect γ and κ to be positive. For example, in the case of roads, it means that the impact of an improvement in the road stock on speed depends on the number of users. In fact, some empirical work suggests that the increase in speed when the infrastructure is improved is higher the more this stock is used (Inman, 1978). Boarnet (2001) inserts a translog specification for expression (2a) into a production function, and also finds evidence that the impact of a road improvement is higher the higher the level of road use. In the case of educational infrastructures, it means that the impact of an increase in the infrastructure stock on educational performance is higher the higher the level of enrollment. The empirical research on education production and cost functions suggests that there are substantial economies of scale and density in the provision of education (see, e.g., Downes and Pogue, 1994, and Duncombe and Yinger, 2003). However, although it may seem intuitive, there are no results in the literature confirming or rejecting that the effect of an improvement on educational results is higher the more crowded are the facilities.

A similar interpretation can be made in the case of the environmental cost variables. Take the case of education. The main environmental cost variable considered here is the average number of years of schooling of the population, which will measure the level of family educational inputs. We expect this variable to have a positive impact on educational attainment, and so to reduce the costs of achieving a given level of education. Regarding its role in (5), we can expect that the impact of investment in educational infrastructures on human capital will be higher the higher (the lower) the average level of schooling in the population if family and public inputs are complementary (substitutive). Since some empirical research on educational production functions suggests that public inputs and family inputs are substitutes (see, e.g., Das *et al*., 2004), we expect that the parameter μ will be negative in this case. Unfortunately, the literature does not provide a general guide with respect to the sign of η and μ for other cost variables, and one has to proceed separately for each variable. However, as will become clear below, we are not interested in the sign of these variables, but only in the change in the value of the coefficients as a result of decentralization.

Substituting (4) and (5) into (3a) and (3b) we have:

$$\frac{\partial Y_{it}}{\partial R_{it}} = \varepsilon^{YZ}.\varepsilon^{ZR}.(U_{it}/R_{it})^{\gamma}.r_{it}^{\eta}.\frac{Y_{it}}{R_{it}} \quad \text{and} \quad \frac{\partial Y_{it}}{\partial E_{it}} = \varepsilon^{YH}.\varepsilon^{HE}.(S_{it}/E_{it})^{\kappa}.e_{it}^{\mu}.\frac{Y_{it}}{E_{it}} \tag{6}$$

(ii) The social choice rule

We assume that road and educational investment is allocated among regions “as if” a government’s social welfare function –defined over the distribution of output among all regions– were maximized subject to a budget constraint. For the moment, we assume that this function represents the preferences of a sub-central government. In the next section, we will deal with the impact of decentralization by assuming that a similar function can be defined for the central government, with the arguments being exactly the same set of regions.

This social welfare function can be analytically expressed as:

$$W_t = \sum_i \Psi_{it}.Y_{it} \tag{7}$$

where Y_{it} is output of region i in year t and the parameters Ψ_{it} are the political weights assigned to each region, and add to one for a given year. If $\Psi_{it}=\Psi_t$, then the government simply aims at maximizing total output (i.e., Y_t) and the allocation of public investment will be optimal, conditional on the knowledge of the parameters of the production function (1) and on the level of resources available for investment. If $\Psi_{it} \neq \Psi_t$, the distribution of public investment will deviate from output maximization, and so will not be efficient.

Simplicity is the main advantage of this approach, since allows obtaining a solution easy to implement at the empirical level. As we will show, following this approach, we will obtain an equation explaining the determinants of government's investment in different regions that is additive in output and political factors, which permits decomposing investment variance in a share due to the efficiency concern and a share due to politics. One drawback of this approach might be that it does not provide a structural model of government behavior. However, recent work in the political economy field ends up with similar specifications, where output and political factors are additively combined (see, e.g., Dixit and Londregan, 1998).

(iii) Optimal infrastructure stock

The problem of the government consists of choosing a regional distribution of roads and educational investment to maximize expression (7), taking into account the effect of both types of infrastructure on output (6), and an exogenous budget constraint:

$$\sum_{i}(I_{it}^{r}+I_{it}^{e})\leq \bar{I}_{t} \tag{8}$$

where I_{it}^{r} and I_{it}^{e} are road and educational investment in region *i* and year *t*, and $\bar{I}_{t}$ is the amount of resources available to invest in a given year *t*. We take $\bar{I}_{t}$ as given and constant across regions. This assumption is consistent with investment budgeting practices in Spain, since the overall level of investment for a given year is determined before its distribution by categories and regions[7]. The assumptions are also consistent with our empirical purpose, since we will analyze the empirical factors that drive the regional distribution of investment, having controlled for the annual investment effort.

[7] In Spain, this amount used to be determined each year during the budgetary process depending on the availability of resources and the need for fiscal consolidation. A budgetary committee then ranks all planned investment projects, and the amount of resources available for investment determines the number of these projects to be undertook next year.

Differentiating (7) subject to (8) and (6) with respect to road and education investment in a given region and year, we obtain the following first order conditions:

$$\frac{\partial W_t}{\partial I_{it}^r} = \frac{\partial W_t}{\partial Y_{it}}.\frac{\partial Y_{it}}{\partial R_{it}}.\frac{\partial R_{it}}{\partial I_{it}^r} - \lambda_t = 0 \qquad \text{and} \qquad \frac{\partial W_t}{\partial I_{it}^e} = \frac{\partial W_t}{\partial Y_{it}}.\frac{\partial Y_{it}}{\partial E_{it}}.\frac{\partial E_{it}}{\partial I_{it}^e} - \lambda_t = 0 \qquad (9)$$

where λ_t is the marginal cost of public revenues, which we permit to vary from year to year. The different terms of expression (9) can be obtained by differentiation of (7) and from (6), taking into account (8) and $\partial R_{it} / \partial I_{it}^r = \partial E_{it} / \partial I_{it}^e = 1$. Substituting these expressions into (9) and rearranging, we obtain the following alternative formulation:

$$\frac{\varepsilon^{YZ}.\varepsilon^{ZR}.(U_{it} / R_{it})^{\gamma}.r_{it}^{\eta}}{R_{it} / Y_{it}} = \frac{\lambda_t}{\Psi_{it}} \qquad \text{and} \qquad \frac{\varepsilon^{YH}\varepsilon^{HE}.(S_{it} / E_{it})^{\kappa}.e_{it}^{\mu}}{E_{it} / Y_{it}} = \frac{\lambda_t}{\Psi_{it}} \qquad (10)$$

The left-hand side is the marginal benefit of infrastructure, while the right-hand side is the marginal cost of investment. The former is higher the higher the elasticity of output to infrastructure services, and the higher the level of utilization and other environmental cost factors. The marginal cost does not only depend on the marginal cost of public funds (λ_t), but is lower in those regions with more political cloud (higher ψ_{it}). Combining both expressions, we obtain the ratio between the desired capital stocks for both types of infrastructures:

$$\frac{R_{it}}{E_{it}} = \frac{\varepsilon^{YZ}.\varepsilon^{ZR}.(U_{it} / R_{it})^{\gamma}.r_{it}^{\eta}.}{\varepsilon^{YH}.\varepsilon^{HE}.(S_{it} / E_{it})^{\kappa}.e_{it}^{\mu}.} \qquad (11)$$

This expression implies that the government should divide overall investment resources between both inputs with the objective of equalizing marginal benefits. Taking logs in (10) and rearranging, we are able to obtain the following expression for the desired stock of infrastructures for each region ($\log R_{it}^*$ and $\log E_{it}^*$):

$$\log R_{it}^* = B_t + \frac{1}{1+\gamma}\log Y_{it} + \frac{\gamma}{1+\gamma}\log U_{it} + \frac{\eta}{1+\gamma}\log r_{it} + \frac{1}{1+\gamma}\log \Psi_{it} \qquad (12a)$$

$$\log E_{it}^{*} = D_t + \frac{1}{1+\kappa}\log Y_{it} + \frac{\kappa}{1+\kappa}\log S_{it} + \frac{\mu}{1+\kappa}\log e_{it} + \frac{1}{1+\kappa}\log \Psi_{it} \qquad (12b)$$

where $B_t = (\log\varepsilon^{YZ} + \log\varepsilon^{ZR} - \log\lambda_t)/(1+\gamma)$ and $D_t = (\log\varepsilon^{YH} + \log\varepsilon^{HE} - \log\lambda_t)/(1+\kappa)$. Therefore, the road and education capital stocks that the government plans for a region depend on various factors: (i) the average productivity of each type of infrastructure across all regions ($\log\varepsilon^{YZ}$ and $\log\varepsilon^{YH}$), the average effect of capital stocks on road and education services ($\log\varepsilon^{ZR}$ and $\log\varepsilon^{HE}$), and the resources available to invest in a given year $(\log\lambda_t)$, (ii) the differential productivity of these infrastructures in that region, which is influenced by the regional output ($\log Y_{it}$), the amount of users ($\log U_{it}$ and $\log S_{it}$) and the environmental cost variables ($\log r_{it}$ and $\log e_{it}$), and (iii) the political cloud of the region ($\log\Psi_{it}$).

2.2 The effects of decentralization

Following the previous insights, we now consider the key hypothesis that regional governments have better access to information about the technologies for producing road services and human capital. Accordingly, we will assume that while regional governments correctly apprehend the effect of R_{it}, U_{it} and r_{it} on Z_{it} (and similarly of E_{it}, S_{it} and e_{it} on H_{it}), the central government experiences some problems in ascertaining the impact of these variables on infrastructures services. To allow for this assumption, we amend expression (5) in the following way:

$$\varepsilon_{it}^{ZR} = \varepsilon^{ZR}.(U_{it}/R_{it})^{\gamma.\varphi_t}.r_{it}^{\eta.\varphi_t} \qquad \text{and} \qquad \varepsilon_{it}^{HE} = \varepsilon^{HE}(S_{it}/E_{it})^{\kappa.\theta_t}.e_{it}^{\mu.\theta_t} \qquad (13)$$

where $\varphi_t = 1 + (1 - decr_t).\sigma$ and $\theta_t = 1 + (1 - dece_t).\tau$, and $decr_t$ and $dece_t$ are dummies equal to one in the case of decentralized provision of roads and education, respectively, and zero otherwise[8]. In the case of decentralization, $\varphi_t = 1$ and $\theta_t = 1$, and expression (13) reduces to (5). In the case of centralization, the exponents φ_t and θ_t are lower (higher) than one when the parameters σ and τ are negative (positive), and so the perceived impact of the different variables on infrastructure services are underestimated (overestimated).

Maximizing again (7) subject to (8), but now taking into account (13) and rearranging, we obtain the expressions for the desired stocks of roads and educational infrastructures:

$$\log R_{it}^{*} = B_t^{'} + \frac{1}{1+\varphi_t.\gamma}\log Y_{it} + \frac{\varphi_t.\gamma}{1+\varphi_t.\gamma}\log U_{it} + \frac{\varphi_t.\eta}{1+\varphi_t.\gamma}\log r_{it} + \frac{1}{1+\varphi_t.\gamma}\log \Psi_{it} \qquad (14a)$$

$$\log E_{it}^{*} = D_t^{'} + \frac{1}{1+\theta_t.\kappa}\log Y_{it} + \frac{\theta_t.\kappa}{1+\theta_t.\kappa}\log S_{it} + \frac{\theta_t.\mu}{1+\theta_t.\kappa}\log e_{it} + \frac{1}{1+\theta_t.\kappa}\log \Psi_{it} \qquad (14b)$$

with

$$B_t^{'} = (\log \varepsilon^{YZ} + \log \varepsilon^{ZR} - \log \lambda_t)/(1+\phi_t.\gamma) \text{ and } D_t^{'} = (\log \varepsilon^{YH} + \log \varepsilon^{HE} - \log \lambda_t)/(1+\theta_t.\kappa)$$

Under decentralization, being $\varphi_t = \theta_t = 1$, these expressions are just (12a) and (12b). Under centralization, when $\varphi_{it} \neq 1$ and $\theta_{it} \neq 1$, the coefficients of the different variables in (14a) and (14b) may be either higher or lower than those under decentralization in (12a) and (12b). If $0 \leq \varphi_{it} \leq 1$ and $0 \leq \theta_{it} \leq 1$, the central government underestimates the effect of the different variables and, accordingly, the coefficients are lower than in the case of centralization. If $\varphi_{it} > 1$ and $\theta_{it} > 1$, the central government overestimates the effect of the different variables and, accordingly, the coefficients are higher than in the case of centralization. Which of these two situations prevails in practice is an empirical matter. In any case, if $\varphi_{it} \neq 1$ and $\theta_{it} \neq 1$, the ratio between the two capital stocks in (11) will be distorted and the central government will tend to allocate too

[8] Note that *decr*$_t$ and *dece*$_t$ do only change from year to year and not across regions. This is because, we want to analyze the allocation of investment across regions belonging to the same sub-central government and decentralization occurred the same year for all of them.

much or too few money to roads with respect to educational infrastructures. Thus, the important issue to take into account is that, under decentralization, the coefficients of all the variables might be different than under centralization.

Finally, in order to clarify the testing procedure, and recalling that $\varphi_t = 1 + (1 - decr_t).\sigma$ and $\theta_t = 1 + (1 - dece_t).\tau$, it is useful to redefine expressions (14a) and (14b) as:

$$\log R_{it}^{*} = B_t^{'} + (\alpha^Y + \beta^Y .decr_t).\log Y_{it} + (\alpha^U + \beta^U .decr_t).\log U_{it} + (\alpha^r + \beta^r .decr_t).\log r_{it} + (\alpha^\Psi + \beta^\Psi .decr_t).\log \Psi_{it} \quad (15a)$$

$$\log E_{it}^{*} = D_t^{'} + (\varepsilon^Y + \xi^Y .dece_t).\log Y_{it} + (\varepsilon^S + \xi^S .dece_t).\log S_{it} + (\varepsilon^e + \xi^e .dece_t).\log e_{it} + (\varepsilon^\Psi + \xi^\Psi .dece_t).\log \Psi_{it} \quad (15b)$$

Hence, our hypothesis implies that the coefficients of the different variables interacted with the decentralization dummies should be different from zero, since the effect of these variables on the desired capital stocks differs across regimes (centralized and decentralized).

3. Empirical implementation

3.1 Some methodological aspects

Some further issues must be taken into account to ensure (15a) and (15b) are implementable and the results of the estimation tell us something about the relative responsiveness of centralized and decentralized system to regional needs: (i) design of the test and sample selection, (ii) inclusion of regional, time and time×sub-central government effects, (iii) dynamics of investment decisions, and (iv) timing and identification of the political factors.

(i) Design of the test and sample selection

The empirical exercise aims at testing the hypothesis that sub-central governments do a better job than the central government in forecasting regional road and education needs. We wish to isolate this effect from any other influence of decentralization on the allocation of investment across regions. An accurate selection of the data used to perform this test is fundamental.

Recall that (15a) and (15b) represent the capital stock desired by the government in two categories (roads and education) and in the different sub-regions belonging to the jurisdiction of a sub-central government. This means that to test our hypothesis we should use data corresponding to different sub-regions belonging to the same regional government. For each of these sub-regions (of size smaller than that of the sub-central jurisdiction), we need a time series of data of road and educational infrastructure stocks, which should include enough number of years of both regimes (centralized and decentralized), in order to test if the coefficients of the different variables differ across regimes. Fortunately, we have had access to data for Spain that complies with all these prerequisites. We will provide details about it in section 3.2. For the moment, just mention that we have data on road and educational investment and capital stocks for the period 1976-98 for all the NUTS-3 regions in Spain (so-called ‘provincias’). This period fits well our purposes, since there are episodes of decentralization of road and education responsibilities distributed across the period, the concrete year depending on the category and on the sub-central government involved (see Figure 1). Using investment data by level of government (central and sub-central) for each NUTS-3 during this period, we are able to detect the precise year when road or education responsibilities were decentralized to each of the sub-central governments, and so to define the dummies $decr_t$ and $dece_t$.

Since we are interested in explaining the allocation of road and educational investment across the NUTS-3 regions of a given sub-central government (AC’s, corresponding to *Eurostat*’s NUTS-2 regions), we will use the observations of all the NUTS-3 regions belonging to sub-central governments with more than one NUTS-3 region[9]. The

[9] Out of 17 sub-central governments in Spain, 6 have one NUTS-3 region, and 11 have more than one.

inclusion in the sample of the sub-central governments with only one NUTS-3 region is unnecessary, since we will include in the equation time effects specific to all the regions belonging to the same sub-central government. This procedure is coherent with (15a) and (15b), where the overall amount of resources devoted to the jurisdiction of a sub-central government (accounted by $\log\lambda_t$) is fixed. Moreover, proceeding in this way is better than estimating the equation using data aggregated to the NUTS-2 level for various reasons. Firstly, there would be a loss of observations, from 44 to 17 each year. Secondly, we would be analyzing only the decision of the government (either central or sub-central) as to how much to invest in roads *vs.* education, but we would loss information about the decisions regarding how to allocate investment in roads and in education across sub-regions within the sub-central jurisdiction. Thirdly, Spanish sub-central governments had a very small degree of tax autonomy during that period; so the amount of investment in roads and education was conditioned under decentralization by the overall amount of grant resources received. One of the effects of decentralization could have precisely been to shift the overall amount of resources allocated to the jurisdictions of the different sub-central governments. If this were the case, it would be very difficult to identify changes in the allocation of resources between categories (i.e., roads and education). What can be expected in this case is that rich sub-central governments (those that receive more monies after decentralization) will increase their investment in roads, education, and in any other service responsibility they had. In order to purge the effects of overall resource changes due to decentralization, it seems better to analyze the distribution of sub-central investment across these categories and across the different NUTS-3 regions belonging to its jurisdiction.

(ii) Individual and time effects

Some measurement problems recommend including time and regional effects in the investment equations (15a) and (15b). First, it is difficult to quantify the terms $B_t^{'}$ and $D_t^{'}$, which include invariant factors across regions but that change over time as, for example, the amount of resources available to invest in the jurisdiction of the sub-central government (i.e., $\log\lambda_t$) or an indicator of the decentralization status (i.e., φ_t). Although it is possible to include variables measuring the resources available to sub-central governments during the decentralization years, there is no way to quantify the amount of budgetary resources allocated to each sub-central jurisdiction during the centralization years. One way to control for this is to include a set of time effects specific to each sub-central government (i.e., f_{jt}, where t indicates year and j indicates sub-central government).

Second, some of the environmental cost variables that are candidates to be included in r_{it} and e_{it} are very difficult to measure and/or do not change over time (e.g., land area, topography, weather). These effects can be controlled through the inclusion of regional effects (f_i). Notice that environmental cost factors are interacted with $decr_t$ or $dece_t$. This means that the impact of cost variables should be allowed to change before and after decentralization takes place. We take into account this possibility by including two different sets of regional effects: f_i^r and $decr_t \times f_i^{d,r}$, in the roads equation, and f_i^e and $dece_t \times f_i^{d,e}$, in the education equation.

(iii) Dynamics

To develop an estimable model based on (15a) and (15b), we assume that adjusting the road and educational capital stocks to their desired long-run level entails significant costs. We assume that the increase in the infrastructure stock will be a portion (ρ^r and ρ^e, for roads and education, respectively) of the difference between the desired stock ($\log R_{it}^*$ and $\log E_{it}^*$) and the perceived stock of the previous year ($\phi_t . \log R_{it-1}$ and $\theta_t . \log E_{it-1}$):

$$\Delta \log R_{it} = \rho^r (\log R_{it}^* - \varphi_t \log R_{it-1}) \quad \text{and} \quad \Delta \log E_{it} = \rho^e (\log E_{it}^* - \theta_t \log E_{it-1}) \qquad (16)$$

That is, we are considering that the central government also has more difficulties in appraising the actual level of road and educational infrastructures in the regions than sub-central governments. This assumption is consistent with the treatment given to the different user and environmental cost variables included in equation (13).

After some operations on the permanent inventory equation, we are able to write[10]:

$$\Delta \log R_{it} \cong (I_{it}^{r} / R_{it-1}) - \delta^{r} \qquad \text{and} \qquad \Delta \log E_{it} \cong (I_{it}^{e} / E_{it-1}) - \delta^{e} \qquad (17)$$

Where I_{it}^{r} and I_{it}^{e} are gross investment in roads and educational infrastructures, and δ^{r} and δ^{e} are the depreciation rates of these capital stocks. Using again $\phi_t = 1 + (1 - decr_t).\sigma$ and $\theta_t = 1 + (1 - dece_t).\tau$, including regional and time effects in (15a) and (15b), and substituting these expressions and (17) in (16), after some algebra, we obtain the investment equations:

$$\begin{aligned} I_{it}^{r} / R_{it-1} &= -(\rho^{r} + \rho^{r}.\beta^{R}.decr_t).\log R_{it-1} \\ &+ (\rho^{r}.\alpha^{Y} + \rho^{r}.\beta^{Y}.decr_t).\log Y_{it} + (\rho^{r}.\alpha^{U} + \rho^{r}.\beta^{U}.decr_t).\log U_{it} \\ &+ (\rho^{r}.\alpha^{r} + \rho^{r}.\beta^{r}.decr_t).\log r_{it} + (\rho^{r}.\alpha^{\Psi} + \rho^{r}.\beta^{\Psi}.decr_t).\log \Psi_{it} + f_i^{r} + (decr_t \times f_i^{d,r}) + f_{jt} \end{aligned} \qquad (18a)$$

$$\begin{aligned} I_{it}^{e} / E_{it-1} &= -(\rho^{e} + \rho^{e}.\beta^{E}.decr_t).\log E_{it-1} \\ &+ (\rho^{e}.\varepsilon^{Y} + \rho^{e}.\xi^{Y}.dece_t).\log Y_{it} + (\rho^{e}.\varepsilon^{S} + \rho^{e}.\xi^{S}.dece_t).\log S_{it} \\ &+ (\rho^{e}.\varepsilon^{e} + \rho^{e}.\xi^{e}.dece_t).\log e_{it} + (\rho^{e}.\varepsilon^{\Psi} + \rho^{e}.\xi^{\Psi}.dece_t).\log \Psi_{it} + f_i^{e} + (dece_t \times f_i^{d,e}) + f_{jt} \end{aligned} \qquad (18b)$$

where $\delta^{r,e}$ are picked up by the respective fixed effects. Estimation of dynamic panel equations like these poses some econometric problems. We will explain in detail the econometric procedure latter; for the moment, it suffices to note that the obtaining of the equations finally estimated will require transforming the model in first differences[11]:

[10]Rearranging the inventory equation and taking logs, we get $\Delta \log R_{it} = \log(1 + I_{it}^{r} / R_{it-1} - \delta^{r})$; the left hand side can be approximated by $I_{it}^{r} / R_{it-1} - \delta^{r}$ when this expression approaches zero.

[11] Given that there are two sets of regional effects (one for each regime), the first-differences transformation must be done separately for each regime. Thus, we loose two cross-sections after differentiation instead of one.

$$I_{it}^{r}/R_{it-1} = (1-\rho^{r}-\rho^{r}.\beta^{R}.decr_{t}).(I_{it-1}^{r}/R_{it-2}) + (\rho^{r}.\alpha^{Y}+\rho^{r}.\beta^{Y}.decr_{t}).\Delta\log Y_{it}$$
$$+(\rho^{r}.\alpha^{U}+\rho^{r}.\beta^{U}.decr_{t}).\Delta\log U_{it} + (\rho^{r}.\alpha^{r}+\rho^{r}.\beta^{r}.decr_{t}).\Delta\log r_{it} \qquad (19a)$$
$$+(\rho^{r}.\alpha^{\Psi}+\rho^{r}.\beta^{\Psi}.decr_{t}).\Delta\log\Psi_{it} + f_{jt}^{'}$$

$$I_{it}^{e}/E_{it-1} = (1-\rho^{e}-\rho^{e}.\beta^{E}.decr_{t}).(I_{it-1}^{e}/E_{it-2}) + (\rho^{e}.\varepsilon^{Y}+\rho^{e}.\xi^{Y}.dece_{t}).\Delta\log Y_{it}$$
$$+(\rho^{e}.\varepsilon^{S}+\rho^{e}.\xi^{S}.dece_{t}).\Delta\log S_{it} + (\rho^{e}.\varepsilon^{e}+\rho^{e}.\xi^{e}.dece_{t}).\Delta\log e_{it} \qquad (19b)$$
$$+(\rho^{e}.\varepsilon^{\Psi}+\rho^{e}.\xi^{\Psi}.dece_{t}).\Delta\log\Psi_{it} + f'_{jt}$$

(iv) Political factors

Expressions (19a) and (19b) imply that –once one has been able to control for fixed regional effects – increased political cloud ($\Delta\log\Psi_{it}$) instead of its level ($\log\Psi_{it}$) is what is deemed to influence investment in roads and education infrastructures. Thus, as in the case of the other variables, the equations suggest that we should rely only on time-series variation in order to identify the effect of political variables. However, the variable we use to make $\log\Psi_{it}$ operative (i.e., the vote share of the incumbent; see section 3.2) is measured only when an election is held (at time *t*=*k*), and is constant until the next election (at time *t*=*k*+4). This means that, once first differences are taken, the political variables are zero all the non-election years and different from zero the year after an election. Therefore, the source of variation of these variables may not suffice to identify their effects on the allocation of investment.

However, some authors have documented differential electoral cycle effects of political traits (see, e.g., Besley and Case, 1995, and Millimet *et al*., 2004, for the case of U.S. gubernatorial term limits). We take this into account and, following Castells and Solé-Ollé (2005), combine election-dependent political data with different effects along the cycle to obtain:

$$\log\Psi_{it} = [\beta_0.d_0 + \beta_1.d_1 + \beta_2.d_2 + \beta_3.d_3].\log\Psi_k \qquad (20)$$

Where d_0 is a dummy variable equal to one if we are in an election year, and d_1, d_2 and

d_3 are dummies equal to one if we are one year, two years and three years before a new election, respectively. The β parameters measure the effect of political variables at those dates; the effects are expected to be (at least) non-decreasing as the new election approaches (i.e., $\beta_3 \leq \beta_2 \leq \beta_1 \leq \beta_0$). Taking first-differences in (20) and rearranging we obtain:

$$\begin{aligned}\Delta \log \Psi_{it} = \beta_3.d_3.\Delta \log \Psi_k + (\beta_3 - \beta_0).d_3.\log \Psi_{k-1} + \\ \left[(\beta_0 - \beta_1).d_0 + (\beta_1 - \beta_2).d_1 + (\beta_2 - \beta_3).d_2\right].\log \Psi_k\end{aligned} \quad (21)$$

This expression states that we should include in the investment equation: i) the variable in first-differences interacted with the first-year-of-term dummy (i.e., d_3), ii) the variable in levels corresponding to the previous term of office also interacted with d_3, and iii) the variables in levels of the present electoral term of office interacted with the dummies of each of the remaining years until the next election (i.e., d_2, d_1 and d_0). The first and third effects are deemed to be non-negative (if $\beta_3 \geq 0$ and $\beta_3 \leq \beta_2 \leq \beta_1 \leq \beta_0$) and the second one is negative (since $\beta_3 \leq \beta_0$). In practice, the pattern of influence of a political variable along the electoral cycle may be simpler. There are two main possibilities that should be tested empirically. The first one is to assume that the effects of a political variable are the same irrespective of the position in the cycle (i.e., H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta$). In this case (21) simplifies to:

$$\Delta \log \Psi_{it} = \beta.\Delta \log \Psi_k.d_3 \quad (22a)$$

If this is the case, only the change in a political trait after an election should be included in the equation. The second one is to assume that the additional effect of a variable is the same irrespective of the position in the cycle (i.e., H_0: $(\beta_0 - \beta_1) = (\beta_1 - \beta_2) = (\beta_2 - \beta_3) = \Delta\beta$):

$$\Delta \log \Psi_{it} = \Delta\beta.\log \Psi_k.\left[d_0 + d_1 + d_2\right] + \beta_3.\Delta \log \Psi_k.d_3 + 3\Delta\beta.\log \Psi_{k-1}.d_3 \quad (22b)$$

In this case, the three variables should be included, but the coefficient of the actual term of office variables remains constant. Our empirical strategy will be to estimate the investment equations (19a) and (19b) with the three variables ($\log \Psi_k, \Delta \log \Psi_k$ and $\log \Psi_{k-1}$) and then test these two hypotheses. These three variables are computed each year with data corresponding to central or sub-central elections, depending on which of these two contests is the relevant one for the regime we are analyzing. Accordingly, the dummies used in (22b) indicate either the position along the central or the sub-central electoral cycle.

3.2 Sample, variables and data sources

(i) Sample and investment data

As we previously explained, (19a) and (19b) will be estimated with data on road and education investment made by the public sector (i.e., central + subcentral) in each of the 44 Spanish regions (NUTS-3) belonging to the subcentral governments with more than one NUTS-3 region, during the period 1977-98. The source of regional data is Fundación BBVA (1998), "The capital stock in Spain and its territorial distribution". This database – which has been previously used in many empirical analysis estimating production functions and which accuracy is widely accepted[12] – provides information on public investment and capital stocks – computed from investment series using the annual inventory method – of the main public spending categories (i.e., roads, railroads, ports, airports, urban infrastructures, water transportation and treatment, education and health), from 1965 to 1998.

The reasons why we choose NUTS-3 regions instead of NUTS-2 ones were explained in the section 3.1. The period analyzed was chosen because it is necessary to include observations of the two different regimes (centralized and decentralized) in order to be able to estimate the value of the parameters in both cases. Note that although the series in our database date back to 1965, we choose to begin in 1977. The reason of the decision is that in this year the first democratic elections in Spain took place. It would

[12] See e.g,., Mas *et al*. (1996), and De la Fuente and Vives (1995) for analysis using this data set; and Mas *et al*.(2000) for a description of the method of calculation of capital stocks.

not have been possible to use our political cloud variables before that data, as they are computed using electoral data.

To identify these two situations we compute the $desr_{it}$, $desp_{it}$ and $dest_{it}$ dummies, for roads, primary and secondary education, and tertiary education, respectively. These dummies take the value of zero under centralization and one under decentralization, and have been computed using either time series of the investment made by the two levels of government in these categories or data on the year of the legal transfer of responsibilities. Investment data by level of government also comes from the Fundación BBVA (1998). In the case of roads and primary and secondary education, decentralization can be detected by the switch form zero investment to positive investment by a sub-central government in a given year. This is not the case for tertiary education, because this responsibility was decentralized latter on, when the sub-central governments were already spending on other types of education. In this case we use information of the data of the legal transfer of the responsibility.

The road and education investment series are provided at a high level of aggregation, which poses some problems to our procedure. Firstly, the road series is the aggregate of investment both in intra-regional and in inter-regional roads, but only the first type of roads was decentralized. This means that road investment in the decentralized regime does not include only investment made by sub-central governments but also investment made by the central government in inter-regional roads. Given that the central government does not behave differently before and after decentralizing intra-regional roads, the change in the response of overall investment to regional needs with decentralization should reflect only the different responsiveness of central and sub-central governments to intra-regional road needs. Secondly, the education series is the aggregate of primary, secondary and tertiary education; all these types of education have been decentralized, but the timing depends on the category and year. Hence, there is not one change of regime but two: the decentralization of primary and secondary education, and the decentralization of tertiary education. There are two ways of proceeding in this case. The first one is estimating different parameters for each of the three regimes (centralization, decentralization of primary and secondary education, and decentralization of the three categories). The second one consists of using only two regimes, but computing the decentralization dummy as: $dese_{it} = \omega_i \times desp_{it} + (1- \omega_i) \times dest_{it}$, where ω_i is the average weight of primary and secondary education investment on total education investment in the sub-central government *i*. Since the analysis suggests that there are no significant changes in the three-regime case, we will present only the two-regime results.

(ii) Economic variables

Explanatory variables are classified into two groups: economic variables and political variables. Table 1 summarizes their definitions and data sources. The first economic variable included both in the road and education equation is regional output ($\Delta \log Y_{it}$), measured as real regional GDP at market prices. The second group of economic variables included measures the number of users of the infrastructures (i.e., $\Delta \log U_{it}$ and $\Delta \log S_{it}$, for roads and education, respectively). In the case of roads, users are measured by means of the number of industrial vehicles (e.g., trucks and vans, $\Delta \log Veh_{it}$), and by the number of km-year driven by vehicles ($\Delta \log Km_{it}$). The second one seems to be a better measure, being the first one only a crude proxy of the level of traffic. This suggests that these two variables should not enter simultaneously in the equation, but in alternative specifications. There is, however, one independent rationale for the inclusion of the number of vehicles in the equation. As Fernald (1999) shows, the marginal productivity of road services may be higher in regions with industries intensive in the use of transportation services. The results in Castells and Solé (2005) and Castells *et al.* (2005) suggest that in fact this intensity is correlated with the number of industrial vehicles. Thus, we will provide results using simultaneously both variables. The measure of users included in the case of education is simply the schooling age population, measured as the population of age 6 to 25 ($\Delta \log Young_{it}$)[13].

[13] One may argue that the schooling age population may be a crude proxy of the actual number of users, at least in the cases of upper-secondary and tertiary education since participation is not compulsory, and that it may be better to use directly the number of students. The problem here rests on the difficulty of getting consistent information on the number of students by region for all the full period of analysis. However, in order to control for this fact we have included in the equations some of the possible determinants of the participation rate: unemployment, average years of study of the population, and GDP. The last two variables were already included in the original specification. As for the unemployment rate, its coefficient was barely significant and the results were qualitatively unaltered, so we decided, at the end, not to present the results including this variable.

Table 1. *Variable definitions and data sources*

	Mean (*s.d.*)	*Definition*	*Sources*
I_{it}^{r} / R_{it-1}	0.121 (0.113)	Road investment by all the levels of government divided by the previous year's capital stock	Fundación BBVA (1998), & Population Statistics, Instituto Nacional de Estadística (INE)
I_{it}^{e} / E_{it-1}	0.116 (0.132)	Education investment by all the levels of government divided by the previous year's capital stock	
$decr_{it}$	0.706	Dummy equal to one if the regional government has the responsibility of providing regional roads	Fundación BBVA (1998) and own elaboration
$dece_{it}$	0.366	Weighted sum of a dummy equal to one if the regional government has the responsibility of providing primary and secondary education, and a dummy equal to one if the regional government has the responsibility of providing higher education, with the weights being the average share of both education levels in total education investment	
$\Delta \log Y_{it}$	0.011 (0.023)	Growth rate of output	Regional Accounts & Population Statistics, Instituto Nacional de Estadística (INE)
$\Delta \log Veh_{it}$	0.024 (0.014)	Growth rate of the number of vehicles	Ministerio de Fomento
$\Delta \log Km_{it}$	0.096 (0.075)	Growth rate of km run by vehicles per year	Ministerio de Fomento
$\Delta \log Young_{it}$	0.005 (0.009)	Growth rate of population 6 to 24 years old	Instituto Nacional de Estadística (INE)
$\Delta \log Years_{it}$	0.007 (0.006)	Growth rate of average years of education	Instituto Nacional de Estadística (INE) and own elaboration
$\log v_{ik}$	0.441 (0.152)	Incumbent's share of votes in the last election, computed as a weighted share of the central and sub-central incumbent's vote share	Anuario El País, www.eleweb.es and Own elaboration

Notes: (1) In the case of dummy variables only the mean is presented, and should be interpreted as the proportion of regions in this situation during the period analyzed.

The third group of economic variables includes the environmental cost factors (i.e., $\Delta\log r_{it}$ and $\Delta\log e_{it}$, for roads and education, respectively). In the case of roads, most of the relevant cost factors (e.g., land area, urbanization patterns, topography or weather) can be considered as time invariant. Thus, we do not include them in the equation, and consider that the regional fixed effects pick up the cost factors. Something similar happens with cost factors in the case of education. However, in this case, we include a time-varying environmental cost variable: the average number of years of education of the population ($\Delta \log Years_{it}$). As we explained in section two, this variable proxies educational inputs provided by the family, which are expected to have a positive influence on human capital and to be substitute of publicly provided education inputs[14]. This variable has been computed by multiplying the share of population aged 25 and over by education level (i.e., illiterates, primary, lower secondary, upper secondary, and higher education) by the duration of studies at each level (using the data provided in De la Fuente *et al*., 2003) and then summing up across categories.

(iii) Political variables

The term Ψ_{it} accounts for the political influence of each region in obtaining investment funds from the layer of government responsible of distributing them. A growing literature analyses the political factors leading the regional allocation of public funds (Levitt and Snyder, 1995, Johansson, 2003, Dahlberg and Johansson, 2002, Cadot *et al*., 1999, and Case, 2001). In these papers, the main determinants of regional redistribution are, for example, the marginal electoral gains to be obtained in the region, the desire to benefit party constituencies, or the presence of active interest groups. Here we will only focus on the second factor, assuming that the government will allocate more resources to the districts were higher political support is obtained, aiming thus at providing benefits to the voters that remain loyal to the party. This is the case, for example, of the model developed by Cox and McCubins (1986). In this model, the parties' purpose is to win the election, but because they are risk-averse they prefer to invest in the voter groups whose support is guaranteed[15]. We take this factor into account by including a

[14] In order to measure family inputs, we also tried with other the variables: unemployment, non-EU immigrants, and illiterates, but the results did not improve very much.

[15] An alternative hypothesis is obtained when considering that the strategy of the government consists of investing in those regions where there are more swing voters (i.e., voters that are indifferent between the parties, see e.g., Lindbeck and Weibull, 1987, Dixit and Londregan, 1998, Snyder, 1989). Several papers have tested this hypothesis with mixed evidence (see, e.g., Wright, 1974, Case, 2001, Johansson, 2003, Dahlberg and Johansson, 2002, and Strömberg, 2004). It is not always easy to disentangle both hypotheses from the data; for example, the political support hypothesis is often tested including the vote share of the incumbent and the swing voter hypothesis including the difference between the vote share and 50%. Both hypotheses can be disentangled when swing voters are quantified directly with a measure of the density of voter at the cut-point, but this is not feasible in our case (as in Dahlberg and Johansson, 2002).

variable that measures the absolute electoral support received by the incumbent party (in the central or in the regional government): the incumbent's *vote share* in the last election (log v_{ik}). We expect this variable to have a positive influence on investment allocated to a region. Of course, alternative hypotheses could have been considered and other political variables included in the equation, but we consider that the present approach is satisfactory, given data constraints and the mere role of political variables as controls in our equation[16].

Finally, we have to deal with the fact that in many cases the decentralization regime does not mean that sub-central governments are the only agents investing in infrastructures, and so Ψ_{it} picks up the political cloud the region has both for the central and sub-central government. This never happens in the centralization regime: the only government investing is the central one. But in the case of roads, investment in the decentralization regime also includes investment made by the central government in inter-regional roads. In the case of education, some sub-central governments first got the responsibilities in primary and secondary education and some years later in tertiary education, but during all the period investment in education includes all these categories. The way to deal with this problem is computing the vote share variable as a weighted sum of those corresponding to each of the two government tiers, being weights the share of investment in a given category made by each tier during that year and in that region. That is, we have $\log v_{ik} = \omega_{it}^{c} \times \log v_{ik}^{c} + (1-\omega_{it}^{c}) \times \log v_{ik}^{s}$, where c and s indicate central and sub-central, respectively, and ω_{it}^{c} is the share of investment made in by the central government in a given category (e.g., roads or education). Obviously, when these political variables are allowed to have a different effect depending on the position in the electoral cycle, two different sets of dummies (for the central and sub-central electoral cycles) are used. That is, at the end, the exact value of the vote share variable in a given region and year depends on the vote shares of the

[16]See Castells and Solé-Ollé (2005) for the use of wider array of political variables to explain the regional allocation of transportation investment in Spain in the period 1987-94. Unfortunately the information needed to compute some of these variables is not available for a longer period. Some of the variables included can be easily computed for all the period (e.g., a dummy indicating if the parties in the central and sub-central governments have a similar ideology, and dummy indicating if the parties in the sub-central government are pivotal in the central legislative). However, these variables have the same value for all the regions belonging to the jurisdiction of the same sub-central government and, therefore, cannot be used jointly with a set of sub-central government time effects.

parties in the central and sub-central governments in the past central and sub-central elections, weighted by the participation of each tier in the investment made that year, and on the exact position in both electoral cycles.

3.3 Econometric issues

Note that (19a) and (19b) include the lagged value of the dependent variable (i.e., I^r_{it-1}/R_{it-2} and I^e_{it-1}/R_{it-2}, for roads and education, respectively). In addition to that, if the error term in the levels equation (ε_{it}) was uncorrelated, then the error term in the differenced equation will show negative first order autocorrelation (ε_{it} -ε_{it-1}). If this is the case, the lagged dependent variable will be correlated with the error term and OLS estimators will be biased if the number of years in the panel is small (Nickel, 1981, and Arellano and Bond, 1991). Although the time series of our database is quite large (from 1977 to 1998), the real length of the series is shorter because we are estimating different coefficients for both regimes (centralized and decentralized). The solution to this problem consists of estimating these equations by the Generalized Method of Moments (GMM), using lagged values of variables in levels as instruments (Anderson and Hsiao, 1981; Holtz-Eakin, Newey and Rosen, 1988; Arellano and Bond, 1991)[17]. We will use as instruments six lags of the infrastructure stock (logR_{t-2} to logR_{t-7} or log E_{t-2} to log E_{t-7}). The number of instruments will be the same for all the years in the sample. This procedure does not suppose loosing any of the cross-sections, because we have information for the instruments in years preceding those used in the analysis[18].

In addition to this, note that the output growth variable included in equations (19a) and (19b) must be considered endogenous. In fact, the production function used to derive our equation (expression (1)) ultimately tells us that output depends on the road and educational capital stocks, and so output growth is enhanced by investment in these

[17] In principle, in presence of heteroscedasticy, it is more efficient to use the two-step GMM procedure. However, simulations performed by Arellano and Bond (1991) suggest that standard errors for the two-step estimators can be a poor guide for hypothesis testing in typical sample sizes; in these cases, inference based on standard errors for the one-step estimator seems to be more reliable (see Arellano and Bond, 1991 and Blundell and Bond, 1998, for further discussion).

[18] The equations have been estimated with the GMM command of TSP 4.5.

infrastructures. To cope with this problem we also instrument output growth with six lags of its level ($\log Y_{t-2}$ to $\log Y_{t-7}$).

The assumption of no serial correlation in ε_{it} is crucial to guarantee the consistency of the GMM estimator. For this reason, we will provide two tests of serial correlation. We expect to find first order serial correlation in the residuals but not second order serial correlation. We also include a Sargan test of overidentifying restrictions to check for the validity of the set of instruments (Arellano y Bond, 1991). This test is distributed under the null of instrument validity as a χ^2 with degrees of freedom equal to the number of overidentifying restrictions.

4. Results

Tables 2 and 3 present the results obtained in the estimation of road and education investment equations, respectively. The explanatory capacity of the model is high in both cases, with an adjusted R^2 around 70% in the road investment case and around 50% in the case of education investment. The bottom of both tables shows the results of a battery of specification statistics. The serial correlation tests show that there is first order serial correlation in the residuals of the differenced model, but not second order correlation. This fact gives us some confidence about the appropriateness of the instrument set, which is confirmed by the Sargan test. In all the cases, the time effects are significant, and also the time × sub-central government effects, so regional investment in road and in education are influenced by some factors that vary yearly but that are common to all the regions belonging to the same sub-central government (e.g., the overall amount of resources). Both the regional effects and the region × decentralization effects are significant, which means that some omitted time invariant factors influence investment (e.g., cost factors), and in a stronger way after decentralization.

We begin with the discussion of the road investment equation. The first three columns of Table 2 show the results when we impose the constraint that the coefficients should be the same across regimes. The first column shows the OLS results and the second and third columns show the GMM results, the second including only the economic variables and the third one including also the political cloud variables. Regarding the results obtained, we must highlight the following conclusions. Firstly, economic determinants seem to have more explanatory capacity than political variables. The R^2 increases only a little bit when political factors are added to the equation (i.e., from 0.714 to 0.746). Secondly, the results show that investment adjusts slowly towards its long-run value. The value of the adjustment coefficient ρ^r is 0.4. Thirdly, the results also show that infrastructure investment is sensitive to output growth ($\Delta \log Y_{it}$) and the coefficient is statistically significant at conventional levels, with a value of 0.31, implying a long-run value around 0.77 (see Table 4 for the estimated values of structural parameters). That is, a 1 per cent increase in output leads to a 0.77 increase in the road stock that the government plans to build in a region.

Table 2: *Effects of decentralization on road investment* (I_{it}^{r} / R_{it-1}).

Sample of 44 *regions during* 1977-1998 (44 × 22 – 44 × 2 = 880 *obs.*)[(1)].

	(1) OLS	(2) GMM	(4) GMM	(5) OLS	(6) GMM	(7) GMM
i) *Lagged investment*						
I_{it}^{r} / R_{it-1}	0.676[(2)] (27.234)***	0.585 (16.169)***	0.600 (15.104) ***	0.650 (7.300)***	0.655 (4.201)**	0.672 (5.241) ***
$decr_{it} \times (I_{it}^{r} / R_{it-1})$	--.--	--.--	--.--	0.029 (1.542)	-0.054 (-1.320)	-0.030 (-0.841)
ii) *Economic variables*						
$\Delta \log Y_{it}$	0.344 (7.765)***	0.329 (3.349)***	0.311 (2.511)**	0.168 (2.459)**	0.156 (2.393)**	0.160 (2.413)**
$decr_{it} \times \Delta \log Y_{it}$	--.--	--.--	--.--	0.062 (4.056)***	0.143 (3.334)***	0.120 (3.100) ***
$\Delta \log Veh_{it}$	0.052 (1.753)*	0.072 (2.373)**	0.069 (2.103) **	0.024 (1.855)*	0.025 (1.347)	0.019 (1.520)
$decr_{it} \times \Delta \log Veh_{it}$	--.--	--.--	--.--	0.121 (3.740)***	0.164 (4.361)***	0.146 (3.654) ***
$\Delta \log Km_{it}$	0.013 (1.442)	0.017 (2.100)**	0.020 (2.341)**	0.004 (1.537)	0.004 (1.702)*	0.004 (1.805) *
$decr_{it} \times \Delta \log Km_{it}$	--.--	--.--	--.--	0.005 (1.991)**	0.010 (2.574)**	0.012 (2.741)**
iii) *Political cloud*						
$\log v_{ik} \times [d_0 + d_1 + d_2]$	--.--	--.--	0.002 (2.226)***	--.--	--.--	0.001 (1.989)**
$decr_{it} \times \log v_{ik} \times [d_0 + d_1 + d_2]$	--.--	--.--	---.--	--.--	--.--	0.002 (1.541)
$\Delta \log v_{ik} \times d_3$	--.--	--.--	0.001 (2.456)**	--.--	--.--	0.001 (2.312)**
$decr_{it} \times \Delta \log v_{ik} .d_3$	--.--	--.--	---.--	--.--	--.--	0.000 (1.521)
$\log v_{ik-1} \times d_3$	--.--	--.--	-0.004 (-1.624)	--.--	--.--	-0.003 (-1.554)
$decr_{it} \times \log v_{ik-1} \times d_3$	--.--	--.--	---.--	--.--	--.--	-0.001 (-0.312)
R^2-*adj.*	0.727	0.714	0.746	0.732	0.725	0.744
Wald-test: f_t [(3)]	163.06***	158.64***	163.77**	171.21***	163.06***	160.25***
Wald -test: f_{jt} [(3)]	218.52**	220.33**	230.11**	232.46**	218.52**	200.58**
Wald -test: f_i [(3)]	150.10***	146.59***	140.21***	151.58***	150.10***	163.20***
Wald -test: $dec_{it} \times f$ [(3)]	65.12**	71.54**	68.54**	72.45**	68.27**	65.47**
Wald (d_0=d_1=d_2) [(4)]	--.--	--.--	0.320	--.--	--.--	0.295
LM (1st *order corr.*) [(5)]	--.--	-2.590***	-2.609***	--.--	-2.820***	-2.746***
LM (2nd *order corr.*) [(5)]	--.--	-0.691	-0.300	--.--	-0.601	-0.322
Sargan (*instr. validity*) [(6)]	--.--	0.007 [0.999]	0.008 [0.999]	--.--	0.008 [0.999]	0.009 [0.999]

Notes: (1) Sample includes the 44 NUTS-3 regions ("provincias") belonging to 11 sub-central governments (NUTS-2 regions) with more than one NUTS-3 region; the period goes from 1977 to 1998 but since the data has been differenced in order to eliminate both the regional effects (f_i) and the regional-decentralization effects ($dec_{it} \times f_i$), two years are lost. (2) t-statistics in brackets; ***, ** & * indicate that the coefficient is statistically significant at the 99, 95 and 90% levels, respectively. (3) Wald tests on the significance of time effects, time × sub-central government effects, region effects, and region×decentralization effects. (4) Wald test of the null hypothesis H_0: (β_0-β_1)=(β_1-β_2)=(β_2-β_3)=$\Delta\beta$; (5) LM tests on first and second order error correlation. (6) Sargan test statistic of instrument validity (distributed under the null of instrument validity as a $\chi^2(q)$, with q=number of overidentifying restrictions) and p-value (in brackets); endogenous variables in the GMM estimation are lagged investment and output growth and instruments are $\log R_{it-2}$ to $\log R_{it-7}$, and $\log Y_{it-2}$, to $\log Y_{it-7}$.

Table 3: *Effects of decentralization on education investment* (I^e_{it} / E_{it-1}).
Sample of 44 *regions during* 1977-1998 ($44 \times 22 - 44 \times 2 = 880$ *obs.*)[(1)].

	(1) OLS	(2) GMM	(4) GMM	(5) OLS	(6) GMM	(7) GMM
i) *Lagged investment*						
I^e_{it} / E_{it-1}	0.596[(2)]	0.677	0.634	0.655	0.645	0.630
	(23.526)***	(10.876)***	(8.774)***	(20.341)***	(10.210)***	(8.942)***
$dece_{it} \times (I^e_{it} / E_{it-1})$	--.--	--.--	--.--	0.015	-0.023	-0.010
				(1.324)	(1.120)	(-0.841)
ii) *Economic variables*						
$\Delta \log Y_{it}$	0.185	0.221	0.200	0.166	0.168	0.160
	(2.893)***	(3.294)***	(3.541)***	(3.550)***	(2.710)***	(2.351)**
$dece_{it} \times \Delta \log Y_{it}$	--.--	--.--	--.--	0.115	0.122	0.136
				(7.514)***	(7.724)***	(6.987)***
$\Delta \log Young_{it}$	0.277	0.276	0.255	0.165	0.247	0.255
	(6.972)***	(6.662)***	(6.510)***	(4.231)***	(3.551)***	(3.746)***
$dece_{it} \times \Delta \log Young_{it}$	--.--	--.--	--.--	0.125	0.111	0.100
				(8.437)***	(8.223)***	(7.874)***
$\Delta \log Years_{it}$	-0.110	-0.196	-0.184	-0.175	-0.170	-0.174
	(-1.023)	(-2.162)**	(-2.103)**	(-0.693)	(-1.767)*	(-1.521)
$dece_{it} \times \Delta \log Years_{it}$	--.--	--.--	--.--	-0.021	-0.099	-0.124
				(-0.652)	(-2.325)**	(-1.845)*
iii) *Political cloud*						
$\log v_{ik} \times [d_0 + d_1 + d_2]$	--.--	--.--	0.001	--.--	--.--	0.000
			(1.654)*			(1.748)*
$dece_{it} \times \log v_{ik} \times [d_0 + d_1 + d_2]$	--.--	--.--	---.--	--.--	--.--	-0.210
						(-0.364)
$\Delta \log v_{ik} \times d_3$	--.--	--.--	0.000	--.--	--.--	0.001
			(1.359)			(1.525)
$dece_{it} \times \Delta \log v_{ik} .d_3$	--.--	--.--	---.--	--.--	--.--	0.001
						(0.701)
$\log v_{ik-1} \times d_3$	--.--	--.--	-0.002	--.--	--.--	-0.002
			(-1.005)			(-1.300)
$dece_{it} \times \log v_{ik-1} \times d_3$	--.--	--.--	---.--	--.--	--.--	-0.001
						(-1.360)
R^2*-adj.*	0.527	0.514	0.556	0.532	0.525	0.550
Wald-test: f_t [(3)]	163.06***	158.64***	163.77**	171.21***	163.06***	163.10***
Wald -test: f_{jt} [(3)]	218.52**	220.33**	230.11**	232.46**	218.52**	200.41**
Wald -test: f_i [(3)]	150.10***	146.59***	140.21***	151.58***	150.10***	149.20***
Wald -test: $dec_{it} \times f$ [(3)]	65.12**	71.54**	68.54**	72.45**	68.27**	65.24**
Wald (d_0=d_1=d_2) [(4)]	--.--	--.--	0.543	--.--	--.--	0.412
LM (1st *order corr.*) [(5)]	--.--	-3.541***	-3.059***	--.--	-2.541***	-2.741***
LM (2nd *order corr.*) [(5)]	--.--	-0.664	-0.541	--.--	-0.804	-0.553
Sargan (*instr. validity*) [(4)]	--.--	0.021	0.017	--.--	0.018	0.011
		[0.995]	[0.996]		[0.997]	[0.997]

Notes: See Table 2.

Fourthly, the two utilization variables (i.e., industrial vehicles, $\Delta \log Veh_{it}$, and Km-year driven by vehicles, $\Delta \log Km_{it}$) have a positive and statistically significant impact on road investment. The long-term effect (see Table 4) is 0.17 and 0.05, for vehicles and km-year, respectively. Fifthly, political variables appear with the expected sign and two out of three are statistically significant. Before discussing the sign and significance of the variables, note that we include in the equation three different variables to measure each concept: the vote share of the last election held in levels ($\log v_{ik}$) interacted with the period not including the first year of the mandate (d_0+d_1+d_2), this variable in differences ($\Delta \log v_{ik}$) interacted with the first-year dummy (d_3), and the vote share in levels corresponding to the previous term of office ($\log v_{ik-1}$) interacted with the first-year dummy. At the bottom of the table, we include a Wald test of the hypothesis H_0: $(\beta_0-\beta_1)=(\beta_1-\beta_2)=(\beta_2-\beta_3)=\Delta\beta$ to justify the appropriateness of this specification. According to it, this hypothesis cannot be rejected, that is, the effect of the incumbents' vote share increases steadily as the next election approaches. Also note that the coefficients of the variables in levels and in differences are both positive, and the coefficient of the lagged variable in levels is negative; all these results were expected (see section 3.1).

Columns (5) to (7) of Table 2 repeat the estimation of the road investment equation allowing now for different coefficients in the two regimes (centralized and decentralized). This is done by including the same variables than before and these variables interacted with the decentralization dummy ($decr_{it}$). Several conclusions are obtained from these results. Firstly, investment does not adjust more slowly in the centralized than in the decentralized case. According to the interpretation given to expression (16), this would mean that the knowledge of the central government regarding the actual level of road infrastructures in a region is accurate. Secondly, we cannot say the same regarding the information of the central government on road needs, since it tends to underestimate the impact of vehicles and km-year driven on road requirements. This can be seen by noting that the coefficients of these variables interacted with the decentralization dummy are positive and statistically significant. Moreover, the bias seems to be considerable. In the case of vehicles, for example, the coefficient in the case of centralization (the base category) is not statistically significant and the coefficient in the case of decentralization is eight times bigger (see Table 4). In the case of km-year, the coefficient under decentralization is four times bigger than under centralization. Thirdly, even the impact of output growth on road investment is bigger under decentralization than under centralization, although here the differences between regimes are smaller (i.e., the structural parameters are now 0.76 and 0.43, in the decentralization and centralization cases, respectively). Therefore, sub-central governments seem to be more sensitive than the central government to the additional road requirements created by economic growth. Fourthly, although the impact of the political variables also is bigger under decentralization, the coefficients of the interacted variables are not statistically significant at conventional levels.

Table 4: *Effects of economic variables on desired road and education capital stocks in the two regimes* (*centralization and decentralization*). *Long-run parameters.*

	Roads		*Education*	
	$decr_{it}=0$	$decr_{it}=1$	$dece_{it}=0$	$dece_{it}=1$
ρ^r	0.368 (5.421)***	0.330 (3.521)**	--.--	--.--
ρ^e	--.--	--.--	0.485 (2.451)**	0.894 (2.514)**
$\Delta \log Y_{it}$	0.434 (3.216)***	0.761 (4.789)***	0.485 (2.451)**	0.894 (2.514)**
$\Delta \log Veh_{it}$	0.052 (1.510)	0.448 (4.236)***	--.--	--.--
$\Delta \log Km_{it}$	0.011 (1.759)*	0.043 (4.789)***	--.--	--.--
$\Delta \log Young_{it}$	--.--	--.--	0.768 (3.324)***	1.069 (4.965)***
$\Delta \log Years_{it}$	--.--	--.--	-0.532 (-1.541)	-0.897 (-4.230)***

Note: *z* statistics in brackets; ***=coefficient significant at the 99%, level **=coefficient significant at the 95% level, *=coefficient significant at the 90% level.

Let's go now for the results of the estimation of the educational investment equation in Table 3. The organization of the table is the same than that of Table 2, and the results are alike. We highlight the following conclusions. Firstly, the speed of adjustment is very similar to that of road investment with ρ^e around 0.37 (column 4) and equal across regimes (column 7). Secondly, the growth in the number of users and costs has a statistically significant impact on investment allocated to a region. The impact of the school-age population ($\Delta \log Young_{it}$) is positive, with a long-run impact around 0.7 (see Table 4), while the impact of average years of schooling of the population ($\Delta \log Years_{it}$) is negative, with a long-run impact of -0.5. According to the interpretation provided in section 3, this negative sign means that public and family inputs are substitutes in the production of human capital. The impact of these two variables is also stronger in the decentralization regime than in the centralization one; the long-run coefficients for school-age population is 1.07 and 0.77 in each of these two regimes; in the case of average years of education, these coefficients are -0.90 and -0.53, respectively, and the coefficient of the centralization regime is not statistically significant. Thirdly, output growth also has a positive and significant impact on investment allocation, with a long-run parameter of 0.55, and its impact differs between regimes, with long-run values of 0.48 and 0.89, in the centralization and decentralization cases, respectively. Thus, when the regional economy grows, the government invests more in roads and educational facilities in the region, but much less in the case of the central government. Fourthly, the sign of the vote share variables is also the expected one, and its impact does not seem to differ between regimes. However, only $\log v_{ik}$ appears to be statistically significant at the 90% level. These results suggest that roads are a better political instrument to satisfy constituencies than schools.

5. Conclusions

This paper has tested the hypothesis that sub-central governments have better information than the central government regarding the road and educational infrastructure needs of their jurisdictions. To test this hypothesis we made use of a unique database that provides information on road and education investment and capital stocks in the Spanish regions during a long period that covers both pre- and post-decentralization years. To isolate other possible effects of decentralization on investment decisions we analyzed how the central and sub-central governments assigned a given amount of money between two categories and across the sub-regions that belong to the jurisdiction of the regional government. The design of the test is possible because the database provides information at the NUTS-3 level while sub-central governments in Spain (AC's) correspond to *Eurostat*'s NUTS-2 regions. Making use of panel data techniques (i.e., introducing time × sub-central government fixed effects), we guarantee that the changes in investment are not due to changes in the overall level of resources devoted to a sub-central government as a result of the decentralization process.

Several interesting results arise from the analysis. Firstly, road and educational investment made by sub-central governments in Spain is much more sensitive to changes in output, users and costs than the investment made by the central government. This suggests that the central government underestimates regional investment requirements. Secondly, the political cloud of a region also has some impact on the allocation of road and education investment, but this impact is the same both before and after decentralization. Thirdly, if sub-central governments are more responsive to needs than the central government, the composition of the capital stock under centralization is not efficient. That is, under centralization, too much investment in roads is made in some regions and too much investment in education is made in others.

Note that decentralization would have eliminated this distortion. In theory, this efficiency cost can be measured in terms of lost output growth. To perform such a calculation one should simulate the alternative capital stock distribution that would have arisen without decentralization. Then, one should be able to compute the marginal productivity of road and education capital of each region, which depends on the factors identified in expression (6). Unfortunately, although our procedure allows us to analyze the effect of decentralization on efficiency, it does not provide the value of the technology parameters needed to compute expression (6). Probably, a non-linear estimation of expressions (19a) and (19b) would be necessary to carry out that task, which we reserve for future work. However, given the huge difference between the parameters of the economic variables estimated for the centralization and decentralization regimes, we believe that this efficiency cost might be substantial.

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