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The regional allocation of infrastructure investment: The role of equity, efficiency and political factors

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Abstract

This paper analyses the main determinants of the regional allocation of infrastructure investment. The estimated investment equation is derived from a general specification of the government's objective function (Berhman and Craig, Am. Econom. Rev. 77 (1987) 315), which accounts both for the equity–efficiency trade-off and for deviations from this rule that arise because of political factors. The reaction of investment to changes in the regional output provides information about the strength of the equity–efficiency trade-off. The main political factor considered is a measurement of the electoral productivity of funds invested in each region. The equation is estimated from panel data on investment and the capital stock of transportation infrastructure (i.e., roads, rails, ports and airports) for the Spanish departments (NUTS3) during the period 1987–1996. We use a dynamic specification of the equation that allows for slow adjustment and which is estimated by GMM methods (Arellano and Bond, Rev. Econom. Stud. 58 (1991) 277). The results suggest that efficiency criteria play only a limited role in the geographical distribution of government infrastructure investment. Specific regional infrastructure needs and political factors both appear to be factors that do explain the regional allocation of infrastructure investment.
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1. Introduction

In most countries, the government has considerable discretion over policy in the allocation of infrastructure investment across regions. For example, it is by far easier to reallocate road funds from one region to another than it is to carry out the same redistribution through public employment or consumption. Redistribution of infrastructure investments from one region to another cannot be considered as random: It obeys both economic and political motives. The purpose of this paper is to analyze these motives, asking, for example, whether infrastructure investment is directed to regions with high project impact, following an efficiency criterion, or, on the other hand, whether redistribution is the main criterion guiding the regional allocation of infrastructure investment, funds being devoted to regions with low output levels. Of course, there is also the possibility that none of these objectives coincide with government aims, and that these are based on pure political interest. Following this intuition, we may therefore ask: What are these political drivers and what is their influence on observed infrastructure investment allocations?

We have tried to answer these questions by estimating an equation that picks up the main determinants of the allocation of infrastructure investment among the Spanish regions. The estimated investment equation is theoretically derived from a very general specification of the objective function of government, which accounts both for the equity–efficiency trade-off and for deviations from this rule arising from political factors. The equation is estimated from panel data on investment and the capital stock of transportation infrastructure (i.e., roads, railroads, ports and airports) for the Spanish departments (NUTS3) during the period 1987–1996. We estimate separate investment equations for the central and the regional governments (NUTS2). We selected transportation infrastructures for two reasons. Firstly, they are the most relevant infrastructural category in Spain, accounting for nearly 70% of total productive infrastructure investment (Ministerio de Fomento, 2001). Secondly, these are the infrastructures that show the greatest impact on output in production function analyses with Spanish data (see, e.g., Mas et al., 1996).[1] Casual observation also shows that most demands for infrastructure improvements by regional business groups focus on transportation projects. We feel that evidence on the Spanish experience will be of interest across Europe, also for various reasons. Firstly, as far as we are aware, this is one of the first papers to analyze this topic with data corresponding to a European country. The paper by Cadot et al. (1999), performing a similar analysis in the case of the French regions, is the main exception. Secondly, as a part of infrastructure projects in Spain are financed by European funds, it is of wide European interest to know what the criteria are that explain the regional allocation of infrastructure investment.

[1] Other sizable productive infrastructure categories, such as water projects and urban infrastructures (nearly 25%; Ministerio de Fomento, 2001) do not show any effect on output in empirical analyses. Neither do we consider the effect of investments in social infrastructures (e.g., health, education and so on) because investment in these categories is less easily diverted from one region to the other and, currently, investments in these categories are the full responsibility of regional governments.

The paper is related to the literature analyzing the determinants of public investment. Among these papers we could cite the works of Holtz-Eakin and Rosen (1989, 1993) and Petchey et al. (2000). But both papers focus on aggregate investment spending decisions. Papers analyzing governmental allocation of expenditure across jurisdictions are less common. Among these we should include some works that quantify the efficiency–equity trade-off implicit in the territorial distribution of public services (see, e.g., Berhman and Craig, 1987; Craig and Heikkila, 1989), or other recent papers that focus on political motivations driving the distribution of intergovernmental grants and other public programs (e.g., Levitt and Snyder, 1995; Cadot et al., 1999; Case, 2001; Dahlberg and Johansson, 2002; Johansson, 2003). However, as we mentioned previously, only the paper by Cadot et al. (1999) is specifically centered on infrastructure investment allocation. In the Spanish case, some empirical papers have previously analyzed the rules implicit in the territorial distribution of public investment (De la Fuente, 1999, 2001; Bosch and Espasa, 1999). These papers do not account for political factors, which have been previously considered by Boix (1998) and Vives and de la Fuente (1995).[2] The main difference between this literature and our work is that our equation is theoretically derived. This allows us to analyze the equity–efficiency trade-off and political influences simultaneously.

In our case, and with the sole purpose of guiding the specification of the equation explaining the distribution of infrastructure investment, we have modeled the behavior of the government as having a well-defined objective function with the output levels of all regions appearing as arguments. Our approach can be considered an extension of Berhman and Craig (1987) in the case of productive public investment. Another difference with this paper is the inclusion of political factors in the equation. As we mentioned previously, our work also shares some similarities with that of Cadot et al. (1999) analyzing the regional distribution of infrastructure spending in France. However, these authors focus on lobbying by business groups, while we focus mainly on electoral politics. The main political driver we consider is a measure of the political productivity of funds invested in each region, computed as a combination of the incumbent's marginal probability of gaining/loosing a representative, electoral turnover and the influence of 'swing voters'.

The paper is organized as follows. In Section 2 we introduce a simple model of infrastructure allocation across regions. This model allows us to obtain an infrastructure allocation equation. In Section 3 we introduce some modifications that need to be taken into account before estimating the investment equation; the data base and econometric procedures are also discussed in this section. The results are presented in Section 4. Finally, Section 5 concludes with an outline of the possible utility of the results and a brief discussion of some economic policy implications.

[2] The first author reaches the conclusion that they were quite important during the 1980s but the other paper (focusing specifically on infrastructure allocation) concludes that they are not relevant.

2. A model of infrastructure allocation across regions

The equation explaining the allocation of investment in transportation infrastructure across regions is obtained from the development of a stylized model combining two different blocks: (i) A production function relating the capital stock of infrastructure to regional output and (ii) a social choice rule that states that investment in a region depends on its output per capita. We begin with the production block, introducing the objective function at a second stage. As the empirical analysis deals with transportation infrastructure, the discussion from now on will explicitly refer to the output effects of this type of infrastructure.

2.1. Production function

Following Fernald (1999), we suppose that, for each region i and year t, output depends on inputs such as non-transportation private capital K_{it}, labour L_{it}, and transport services that are produced within the region, T_{it}. Output also depends on the Hicks-neutral level of technology, P_{it}. Transport services depend upon the flow of services provided by the government's infrastructure (Z_{it}) and a transportation input internal to regional firms such as, for example, the stock of industrial vehicles (X_{it}). [3] Hence, the regional production function takes the form

$$Y_{it} = P_{it}F(K_{it}, L_{it}, T(X_{it}, Z_{it})). \tag{1}$$

Most papers analyzing the growth effects of infrastructures implicitly assume that services provided by public capital are non-rival. Only recently some papers have appeared extending the basic model to include congestion effects, both theoretically (Fisher and Turnovsky, 1998; Glomm and Ravikumar, 1994) and empirically (Fernald, 1999; Boarnet, 2001). We have also taken the fact that transportation infrastructures may be congested into account and, therefore, that the services provided by the infrastructure stock (Z_{it}) depend not only on its size (C_{it}) but also on the level of utilization (U_{it}). [4] We also consider that infrastructure costs (ς_i) may differ across regions due to some intrinsic and time-invariant factor (e.g., orography). We assume for the moment a flexible relationship among these variables, $Z_{it} = Z((C_{it}/\varsigma_i), U_{it})$, imposing only that $Z_c > 0$ and $Z_u < 0$. [5]

[3] From now on we will make reference to this input as vehicles, although its definition is somewhat more general. We must note that Fernald's (1999) model was applied exclusively to roads. Therefore there was a straightforward connection between vehicles and roads in that case. We feel, however, that the connection of vehicles and other transportation infrastructures (e.g., railroads, ports and airports) is equally plausible, given that inter-modality is a common feature of transportation of both people and goods nowadays.

[4] In the case of roads, utilization can be measured by number of kilometers driven. In the case of railroads, ports and airports by number of passengers and tons of goods transported.

[5] The most common functional form used to account for congestion is one that assumes a constant elasticity, like: $Z_{it} = (C_{it}/\varsigma_i)/U_{it}^{\alpha}$, where $\alpha = 1$ in the case of a private good and $\alpha = 0$ in the case of a pure public (non-congested) good. This functional form has been used by Fernald (1999), but it has been criticized on the grounds of exhibiting decreasing marginal congestion while theory (Edwards, 1990) and empirical analysis of road use (Inman, 1978) suggest that congestion should be growing in the margin.

Assuming now that firms are perfectly competitive and have constant returns to scale to private factors, which can be instantaneously adjusted, let F_J represent the derivative of the production function F with respect to input J. Cost minimization implies that the elasticity of output with respect to J, $F_J J/F$, equals the proportion of input to revenue, S_J. It is assumed that if there are no economic profits the proportion to private inputs is equal to one. Given these assumptions and the specification of Z_{it}, the effect on output of an increase in infrastructures can be expressed as

$$F_c = F_z Z_c \frac{1}{\varsigma_i} = \left(\frac{F_z Z_{it}}{F_x X_{it}}\right)\left(\frac{F_x X_{it}}{F_{it}}\right)\left(\frac{Z_c C_{it}}{Z_{it}}\right)\frac{1}{\varsigma_i}\frac{F_{it}}{C_{it}} = \omega_{it} S^x_{it} E^c_{it}(1/\varsigma_i)\frac{F_{it}}{C_{it}}, \tag{2}$$

where $F_c = \partial F/\partial C$, $F_z = \partial F/\partial Z$ and $Z_c = \partial Z/\partial(C/\varsigma)$. The five elements that appear in F_c are: (i) the ratio between the elasticity of output to government transportation services and the elasticity of output to vehicles (ω_{it}), (ii) the share of vehicles in output (S^x_{it}), (iii) the elasticity of infrastructure services to changes in the infrastructure stock (E^c_{it}), (iv) the region-specific costs ($1/\varsigma_i$), and (v) the ratio of F_{it} to C_{it}. We expect ω_{it} to be positive, which captures the notion that relatively vehicle-intensive sectors are also intensive in the use of government transportation infrastructure. Further assumptions about technology help to simplify this expression and aid the interpretation of the results. Expression (2) can be simplified if we suppose that T_{it} is separable from K_{it} and L_{it} and is produced with the same Cobb–Douglas technology in all the regions, so $\omega_{it} = \omega$:

$$F_c = \omega S^x_{it} E^c_{it}(1/\varsigma_i)\frac{F_{it}}{C_{it}}. \tag{3}$$

Expression (3) states that the marginal effect of transportation infrastructure differs from region to region. The effect is greater the lower is the ratio of infrastructure stock to production. But this effect is also greater the higher is the share of vehicles in output, which means that infrastructure needs may also depend on the regional industrial mix. It is also greater the higher is the elasticity of infrastructure services to the stock. As we will argue below, it is quite possible for E^c_{it} to increase with utilization, which means that the marginal effect is greater where congestion is high. Finally, investment will have a lower impact the higher are region-specific costs.

2.2. Social choice rule

We assume that transportation infrastructure investment is distributed among regions as if there were a constrained maximization of the government's social welfare function, defined over the distribution of output among all the regions. This approach is applicable both to the central and to each of the regional governments. The central government will be concerned about all the regions in the country, while a regional government will only be concerned about the smaller subset of regions belonging to its jurisdiction. Following the approach of Berhman and Craig (1987), we use a CES social welfare function that allows varying degrees of relative regional inequality aversion and, at the same time, unequal treatment of regions with the same output levels.[6] This social welfare function can be expressed as

$$W_t = \left(\sum_i N_{it} \Psi_{it} (Y_{it}/N_{it})^{\phi} \right)^{1/\phi}, \tag{4}$$

where N_{it} and Y_{it}/N_{it} are population and output per capita of region i in year t. The ϕ parameter quantifies the aversion to regional output inequality, and its range of variation goes from $-\infty$ to one. As ϕ becomes more negative, inequality aversion increases. When $\phi \to -\infty$, the function approaches pure equity. In the intermediate Cobb–Douglas case ϕ is zero. And if ϕ is equal to one, then the government is exclusively worried about efficiency. In this case, W equals national output ($W = Y$). The estimation of the ϕ parameter is one of the main purposes of the paper, since its value will tell us about the relative weight assigned to efficiency and redistribution in investment allocation. The parameters Ψ_{it} differ from region to region and relate to equal vs. unequal concern. If there is equal concern, $\Psi_{it} = \Psi_t$ for all regions. If there is unequal concern, Ψ_{it} depends on a region's specific characteristics. These parameters are, therefore, an indicator of the deviation of government investment from an investment allocation rule strictly based on the equity–efficiency trade-off implicit in the ϕ parameter. In our context the most straight-forward interpretation of the Ψ_{it} parameters is to consider that they pick up political considerations that make a region attractive enough to the government to justify a deviation from the equity–efficiency rule. As we will see in the empirical section, electoral considerations (e.g., the political productivity of the region, measured using information on the number of votes needed to gain or lose a political representative, on turnover and on the influence of 'swing voters') play an important role in the distribution of transportation investment across regions.[7]

The main advantage of this approach to the social decision rule when applied to the distribution of public investment across regions is its relative simplicity, allowing a solution to be obtained that is easy to implement at the empirical level. As we will show below, with this approach we will obtain an equation explaining the determinants of government investment in different regions that is additive in output and political factors. This fact makes it possible to separate investment variance into the part due to the equity–efficiency trade-off and the part due to politics. One drawback with this may be that the approach does not provide a structural model of government behavior. However, it should be remembered that recent theoretical articles in the field of political

[6] See Berhman and Craig (1987) and Craig and Heikkila (1989) for empirical studies applying this methodology to the distribution of police inputs among city districts, and Berhman and Sah (1984) for a paper applying it to the distribution of international aid across developing countries.

[7] It must be noted that Berhman and Craig (1987) use economic and demographic variables in order to account for Ψ_{it}. Although these could also be included in our analysis we feel that they would ultimately account for the political clout of the region. It is less clear that they would pick up differences in needs, since this factor has been already accounted for by the specific form of the production function.

economy arrive at very similar specifications, where output and political factors are additively combined.[8]

2.3. Optimal infrastructure stock

The problem for the government is to choose a regional distribution of transportation investment that maximizes function (4), taking into account the effect of transportation infrastructure capital on output (3), and an exogenous budget constraint such as

$$\sum_i I_{it} \leqslant R_t, \tag{5}$$

where I_{it} is investment in region i and year t and R_t are resources available to invest in transportation infrastructure in a given year t. We take R_t as given and constant across regions. The first 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.[9] This first assumption is also consistent with our empirical purpose, since we will analyze the empirical factors that drive the regional distribution of investment, controlling for total investment effort made in a given year. Thus, we do not aim to explain why the total amount of investment made by the government changes from year to year. The second assumption, constancy of available resources across regions, picks up the fact that the government is dividing a common pie among the different regions. However, this procedure does not account for the fact that some funds are earmarked for specific regions. To be exact some regions are entitled to a minimum investment level from resources that come from European Funds (e.g., ERDF, Cohesion Fund) and from Spanish regional policy. To control for this fact we could have included this minimum amount as an additional constraint. The problem is, however, that we are not able to measure it at the geographical level we employ in the analysis. If the restriction is not binding (i.e., if the level of investment in the region is finally higher than the minimum) the omission will be irrelevant. However, nothing guarantees that this would happen in practice. As we will explain in more detail in the empirical section we will try to control for this by including an interaction of the set of time effects with a dummy that identifies the regions that are entitled to these funds as explanatory variables.

Differentiating (4) subject to (3) and (5) with respect to transportation investment in a given region and year, we obtain the following first-order condition:

$$\frac{\partial W_t}{\partial (Y_{it}/N_{it})} \cdot \frac{\partial (Y_{it}/N_{it})}{\partial C_{it}} \cdot \frac{\partial C_{it}}{\partial I_{it}} - \lambda_t = 0 \quad \forall i, \tag{6a}$$

[8] See, for example, the work of Dixit and Londregan (1998), which models politicians as having partisan preferences with respect to the efficiency–equity trade-off, but also as caring about reelection.

[9] For example, in the case of the central government, this amount is determined each year depending on the availability of resources and the need for fiscal consolidation. All planned investment projects are then ranked by a budgetary committee, and the amount of resources available for investment determines the number of these projects to be undertaken in the next year.

where λ_t is the marginal cost of public revenues, that we allow to change from year to year. The different terms of expression (6a) can be obtained by the differentiation of (4) and (3), taking into account (5) and $\partial C_{it}/\partial I_{it} = 1$. Substituting these expressions again into (6a) and rearranging them we obtain an alternative formulation of the governments' capital allocation rule:

$$\frac{\omega S_{it}^{x} E_{it}^{c}}{\varsigma_i (C_{it}/Y_{it})} = \lambda_t^* \left(\frac{(Y_{it}/N_{it})^{1-\phi}}{\Psi_{it}} \right) \quad \forall i, \tag{6b}$$

where $\lambda_t^* = \lambda_t W_t^{(1-\phi)/\phi}$. The left-hand side of this expression is the marginal product of infrastructure, and the right-hand side is the governments' marginal cost of investment. Note that this marginal cost does not depend solely on the marginal cost of public funds (λ_t^*). If the government is averse to inequality ($\phi < 1$), the marginal cost of investing in a rich region is higher than that of investing in a poor one. Similarly, the marginal cost is lower in regions with more political clout (higher Ψ_{it}).

Taking logs in (6b) and rearranging them, we are able to obtain the following expression for the desired stock of infrastructures for each region ($\ln C_{it}^*$):

$$\ln C_{it}^* = B_{it} + \phi \ln Y_{it} + (1-\phi) \ln N_{it} + \ln S_{it}^{x} + \ln E_{it}^{c} + \ln \Psi_{it}, \tag{7}$$

where $B_{it} = \ln \omega - \ln \varsigma_i + (1-\phi)/\phi \ln W_t - \lambda_t$. Expression (7) can be interpreted as follows. The capital stock that the government plans for a region depends on the efficiency–equity trade-off, implicit in the linear combination of output and population. Note than in the pure efficiency case (i.e., when $\phi = 1$), population disappears from the equation and the coefficient of output is equal to one. If the social welfare function is Cobb–Douglas, then $\phi = 0$ and only population (with a coefficient of one) appears in the equation. As ϕ becomes more negative, output appears in the equation with a negative coefficient and population with a positive coefficient that is higher than one. Note that for the government to have equity concerns, ϕ need not be negative; it suffices if ϕ is lower than one.

Therefore, Eq. (7) provides a simple way to test for the strength of efficiency and equity in the regional distribution of investment. Moreover, note that this test requires the inclusion in the equation of different kinds of controls. Firstly, it includes variables accounting for different regional infrastructure needs, picked up by the vehicle output-share ($\ln S_{it}^{x}$) and variables related to congestion ($\ln E_{it}^{c}$). Secondly, it also includes variables related to the political clout of the region ($\ln \Psi_{it}$). Therefore, we can conclude that Eq. (7) provides a characterization of the factors leading to regional investment allocation: Efficiency–equity trade-off, infrastructure needs and political factors.

3. Empirical implementation

3.1. Some methodological aspects

Some further aspects should be taken into account to ensure that Eq. (7) is implementable: (i) the inclusion of individual and time effects, (ii) the dynamics of investment decisions, (iii) multiple levels of government investing in transportation infrastructures at the same time, and (iv) the timing and identification of the effects of political factors.

3.1.1. Individual and time effects

Some measurement problems make including both individual and time effects in the investment equation (7) recommendable. Firstly, it is difficult to quantify the B_{it} term. Observe from (7) that, in the case of the central government, this term includes some factors that are invariant across regions (i.e., $\ln W_t$ and λ_t) and that can be controlled through the inclusion of time effects (f_t). In the case of regional governments, these terms will differ from government to government. In this case one could have used a different set of time effects for each regional government. However, to keep the model as simple as possible we prefer in this case to measure λ_t directly with information regarding the financial resources (taxes and grants) at the disposal of the regional government. We will provide more detail about this in the next section. The term B_{it} also includes $\ln \varsigma_i$, that picks up structural characteristics that influence infrastructure costs. The measurement of these factors is rather difficult and the use of proxies tends not to work well in the Spanish case; these effects can be controlled through the inclusion of individual effects (f_i).

Secondly, the model is not able to fully capture the overall institutional complexity involved in providing and financing infrastructure investment. For example, some regional governments in Spain have more transportation investment responsibilities than others. As the division of responsibilities in this area has not changed during the period analyzed, we can control for this fact by including individual effects in the equation. Another example are earmarked investment funds since, as we explained before, their quantification presents enormous difficulties. By including regional effects we control for the fact that some regions receive these funds while others do not, a trait that is constant through the period. By including time effects we control for the fact that the total amount of funds received has changed over time. However, these funding increases only benefit the recipient regions. Because of this we include an interaction between time effects and a dummy equal to one for a recipient region (η_i). Therefore, B_{it} can be expressed as $B_{it} = f_i + f_t + \eta_i \times f_t + \varepsilon_{it}$, being ε_{it} an uncorrelated error term with zero mean and constant variance.

3.1.2. Dynamics

To develop a model that can be estimated based on expression (7) we make two assumptions: (i) The decision made by the government to allocate infrastructure investment to a region in time t is based upon expectations of time t variable values formed in the previous time period ($t-1$); (ii) it is difficult for the government to instantaneously adapt the allocation of investment to a region after a change in its characteristics. For the economic variables included in (7) we assume that the value expected in period t is equal to the value in $t-1$ (e.g., $\ln Y_{it}^{\mathrm{e}} = \ln Y_{it-1}$).[10]

[10] This assumption has an intuitive appeal because investment decisions are most likely to be based on the most recent data available from each region. These data generally will be for the previous calendar year, given that investment projects are included in the budget during its formulation.

Expectations regarding political variables ($\ln \Psi^{e}_{it}$) are modelled differently. As we will explain in more detail later, most of the political variables at our disposal are measured only when one election is held (at time $t = k$) and are constant until the next election (at time $t=k+4$). Therefore, these traits should be assumed to be a priori knowledge of the government during the electoral mandate. However, some authors have documented differential electoral cycle effects of political traits (see, e.g., Besley and Case (1995) and Millimet et al. (2003) for the case of US gubernatorial term limits). Combining election-dependent political data with different effects through the cycle we obtain

$$\ln \Psi^{e}_{it} = \beta_j \ln \Psi_k, \tag{8}$$

where j indexes the position in the electoral cycle (i.e., election year, one year from the election, two years, and so on), and k indexes the government's mandate (i.e., one to three, the number of mandates covered in our sample). This rule means that the yearly update in political information only depends on the position in the electoral cycle.

The second assumption recognizes that adjusting the capital stock to its long-run value entails significant costs. We assume that the infrastructure stock will be the last period stock (i.e., $\ln C_{it-1}$) plus a portion (ρ) of the difference between that stock and the desired stock ($\ln C^{*}_{it}$):

$$\ln C_{it} = \ln C_{it-1} + \rho(\ln C^{*}_{it} - \ln C_{it-1}). \tag{9}$$

Now, using regional and time effects, accounting for the stated expectations rule, and substituting (9) in (7), we obtain, after some algebra, the following expression:

$$\begin{aligned} \ln C_{it} = {} & (1-\rho)\ln C_{it-1} + \rho\phi \ln Y_{it-1} + \rho(1-\phi)\ln N_{it-1} \\ & + \rho \ln S^{x}_{it-1} + \rho \ln E^{c}_{it-1} + \rho\beta_j \ln \Psi_k + f_i + f_t + \eta_i f_t + \varepsilon_{it}. \end{aligned} \tag{10}$$

Estimation of a dynamic panel equation like this poses some econometric problems. All the transformations commonly used to eliminate regional effects introduce correlation between the lagged endogenous variable and the error term, biasing OLS estimators if the time dimension of the panel is not large (Arellano and Bond, 1991). A possible solution to this problem consists of taking first differences in (10) and then estimating the resulting equation by instrumental variables or GMM (Anderson and Hsiao, 1981; Holtz-Eakin et al., 1988; Arellano and Bond, 1991). We will explain the econometric procedure in more detail later; for the moment it suffices to note that it will require the estimation of the model in first differences. Therefore, expression (10) becomes

$$\begin{aligned} \Delta \ln C_{it} = {} & (1-\rho)\Delta \ln C_{it-1} + \rho\phi\, \Delta \ln Y_{it-1} + \rho(1-\phi)\Delta \ln N_{it-1} \\ & + \rho\Delta \ln S^{x}_{it-1} + \rho\Delta \ln E^{c}_{it-1} + \rho\Delta(\beta_j \ln \Psi_k) + f_t + \eta_i f_t + \Delta\varepsilon_{it}. \end{aligned} \tag{11}$$

3.1.3. Multiple levels of government

Eq. (11) aims to explain the change in the transportation infrastructure stock of the central (or regional) government allocated to different regions. However, unfortunately, available data for the central government (and also for the regional governments) refers to investment instead of capital stocks.[11] But, as expressions (10) and (11) suggest it would not be appropriate to analyze investment behavior without considering the previous level of capital stock. Moreover, since in Spain different layers of government invest in transportation infrastructures, it may not be appropriate to analyze the central government's investment decisions without taking into account the investment made by sub-national governments (and vice versa).[12] Therefore, it might be appropriate to account for the substitutability/complementarity in the production function of the infrastructures introduced by the existence of different layers of government. This interrelation may ultimately make central (and regional) investment depend on investment made by the other layers.[13] This section proposes a simple transformation in order to be able to estimate the model with investment made by the central (and regional) government as the dependent variable and with the investment made by the other layers of government as an additional explanatory variable. We now illustrate the transformation used in the case of the central government. The procedure in the case of regional governments is the same. Firstly, after some operations on the permanent inventory equation we are able to write[14]

$$\Delta \ln C_{it} \cong (I_{it}/C_{it-1}) - \delta. \tag{12}$$

Secondly, we assume that when computing the increase of the capital stock, the central government considers both the increase due to its own investment and a proportion θ of the investment made by the other levels of government. This parameter measures the degree of substitutability between investments made by different levels of government. If $\theta = 1$, the central government is indifferent about which level of government is ultimately responsible for the increase in the capital stock. If $\theta = 0$, the investment projects of the different levels of government are completely independent. Of course, in the current period, the central government does not know the investment that will be made by the other layers. We now assume that the central government expects that investment made by other layers will be roughly the same as the year before. Taking this into account we can then express (12) as

$$\Delta \ln C_{it} \cong I^{\mathrm{c}}_{it}/C_{it-1} + \theta(I^{\mathrm{o}}_{it-1}/C_{it-2}), \tag{13}$$

where c is central and o means 'other layers' (i.e., regional+local). In the case of $\Delta \ln C_{it-1}$, the central government already knows the amount invested the year before and we can write

$$\Delta \ln C_{it-1} \cong I^{\mathrm{c}}_{it-1}/C_{it-2} + \theta(I^{\mathrm{o}}_{it-1}/C_{it-2}). \tag{14}$$

[11] As we will explain in the next section, the available data base does not provide information on capital stocks by level of government (Fundación BBVA, 1998). The capital stock provided is total capital stock but information about gross investment is presented by level of government.

[12] For example, both the central government and the regional and local governments have some road responsibilities. Although the nature of these roads differs among layers (i.e., the central government has sole responsibility for inter-regional motorways), they cannot be considered independent inputs.

[13] See Aronsson et al. (2000) for an analysis of interactions in the spending of different layers of government in Sweden. In that case, the source of expenditure interactions is the relationship among goods in the utility function, not among factors in the production function.

[14] By rearranging the permanent inventory equation and after taking logs we find that $\Delta \ln C_{it} = \ln(1 + I_{it}/C_{it-1} - \delta)$; the left-hand side can be approximated by $I_{it}/C_{it-1} - \delta$ when this expression approaches zero.

Substituting expressions (13) and (14) in (11) and ordering terms, we obtain the following equation explaining the investment made by the central government, I^{c}_{it}/C_{it-1}:

$$\begin{aligned} I^{c}_{it}/C_{it-1} = {} & (1-\rho)(I^{c}_{it-1}/C_{it-2}) - \rho\theta(I^{o}_{it-1}/C_{it-2}) + \rho\phi\Delta\ln Y_{it-1} \\ & + \rho(1-\phi)\Delta\ln N_{it-1} + \rho\Delta\ln S^{x}_{it-1} + \rho\Delta\ln E^{c}_{it-1} + \rho\Delta(\beta_j \ln\Psi_k) \\ & + f_t + \eta_i f_t + \Delta\varepsilon_{it}. \end{aligned} \tag{15}$$

This expression states that the investment made by the central government in a region in a given year depends not only on the investment it made the year before (due to sluggish adjustment), but also on the investment made the year before by other layers of government. The significance of other layers' investment will provide a check of the need to include this variable in the equation.

Eq. (15) constitutes the focus of the empirical analysis. This equation will be estimated with data corresponding to the infrastructure investment made by the Spanish central government during the period 1987–1996. A companion equation will be estimated with data on investment made during the same period by the Spanish regional governments. This specification will differ a little from that of the central government. The main difference is that now we are pooling information about different governments into a single equation. The parameter λ_t (appearing as a part of B_{it}) cannot be considered constant across regions, because regionally financed investment depends on the budget constraint of subnational governments, which is not identical across regions. Some variables should, therefore, be included in the equation to account for the differences in the financial resources available to each regional government. Secondly, the set of political factors to be considered should be different, reflecting the specific traits of each regional government. Finally, one may wonder if it is appropriate to pool the observations of different governments into a single equation. This consideration may be relevant for the estimation of the degree of aversion to inequality (ϕ), since it may well depend on the ideology of the party in the government. We will come again to this issue at the end of the paper, providing estimates of the ϕ parameter for various subsamples of regional governments (i.e., leftists vs. rightists).

3.1.4. Political factors

Expression (15) tells us that it is increased political clout ($\Delta\ln\Psi^{e}_{it} = \Delta(\beta_j \ln\Psi_k)$) instead of its level ($\ln\Psi^{e}_{it} = \beta_j \ln\Psi_k$) that is deemed to influence investment. Therefore, as in the case of the other variables, we rely on time-series variation in order to identify the political variables. But as this effect is assumed to change during the political cycle, there are in fact two sources of time series variation; first, the change in the values of the political variables, experienced only after an election; second, the varying effect through the electoral cycle. These two effects will be more evident after rewriting expression (9) as

$$\ln\Psi^{e}_{it} = [\beta_0 d_0 + \beta_1 d_1 + \beta_2 d_2 + \beta_3 d_3]\ln\Psi_k, \tag{16}$$

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 respectively one year, two years and three years before a new election. The β parameters measure the effect of political variables at these dates; the effects are expected to be (at least) non-decreasing as the new election approaches (i.e., $\beta_3 \leqslant \beta_2 \leqslant \beta_1 \leqslant \beta_0$). Taking first-differences in (16) and rearranging we obtain

$$\Delta \ln \Psi_{it}^{e} = \beta_3 d_3 \Delta \ln \Psi_k + (\beta_3 - \beta_0) d_3 \ln \Psi_{k-1} + [(\beta_0 - \beta_1) d_0 + (\beta_1 - \beta_2) d_1 + (\beta_2 - \beta_3) d_2] \ln \Psi_k. \tag{17}$$

This expression states that we should include the following in the investment equation: (i) the variables in first-differences interacted with the first-year-of-mandate dummy (i.e., d_3), (ii) the variables in levels corresponding to the previous mandate also interacted with d_3, and (iii) the variables in levels of the present electoral mandate 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 $\beta_3 \geqslant 0$ and $\beta_3 \leqslant \beta_2 \leqslant \beta_1 \leqslant \beta_0$) and the second one is negative (since $\beta_3 \leqslant \beta_0$). In practice, the pattern of influence of political variables through the electoral cycle may be simpler. There are two main possibilities that should be tested in the empirical analysis. 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 (17) simplifies to

$$\Delta \ln \Psi_{it}^{e} = \beta \Delta \ln \Psi_k d_3. \tag{18a}$$

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: $(\beta_0 - \beta_1) = (\beta_1 - \beta_2) = (\beta_2 - \beta_3) = \Delta\beta$). In this case (17) simplifies to

$$\Delta \ln \Psi_{it}^{e} = \Delta\beta \ln \Psi_k [d_0 + d_1 + d_2] + \beta_3 \Delta \ln \Psi_k d_3 + 3\Delta\beta \ln \Psi_{k-1} d_3. \tag{18a}$$

In this case, the three variables should be included, but the coefficient of the actual mandate variables is constant. Our empirical strategy will be to estimate the investment equation (15) with the three variables ($\ln \Psi_k, \Delta \ln \Psi_k$ and $\ln \Psi_{k-1}$) and then test these two hypotheses.

3.2. Sample, variables and data sources

3.2.1. Sample and investment data

Eq. (15) will be estimated separately with data on transportation infrastructure investment made by the central and regional governments in each of the 50 Spanish departments (NUTS3) during the period 1987–1996. The source of data on capital stock and infrastructure investment by government level and region is: Fundación BBVA (1998), “The capital stock in Spain and its territorial distribution”. This data base has been previously used in many empirical analyses estimating production functions and its accuracy is widely accepted.[15]

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

Two different equations will be estimated, one for total transportation investment (including roads, railroads, ports and airports) and another one for roads, that are the main category covering more than half of all transportation investments. It was decided not to include separate regressions for other categories because, firstly, each of them represents a low share of the total and, secondly, because their analysis is affected by some problems. For example, investments in nodal infrastructures (e.g., ports and airports) only occur in the regions having these facilities. Investments in these categories also usually come in big individual projects, meaning that a higher volatility is observed in the series of regional investment (e.g., the construction of a high-speed railroad may cause a spike in investment in one period not repeated in the following years). However, it was felt that a broader category would not be equally affected by this problem. We chose NUTS3 regions as a unit of analysis (instead of NUTS2) for three reasons. Firstly, because of a pure econometric concern about the number of observations available ($N = 50$ instead of $N = 17$ in the case of NUTS2). Secondly, because the calculation of some of the variables included in the model only has sense in the NUTS3 case. For example, as will be explained later, some political variables are included to pick up the electoral clout of the regions. But since electoral jurisdictions for general elections in Spain are NUTS3 regions it may be inappropriate to tie the electoral incentives to larger areas. Thirdly, because in order to analyze the territorial allocation of regional investment, the size of the units analyzed must be smaller than that of the regional government jurisdictions. [16]

There are also various reasons that justify the focus on the period 1987–1996. The first one is that while data on regional allocation of investment and capital stocks are available for Spain for a longer period (see Fundación BBVA, 1998), information about investments made by the different layers of government is not available until the eighties. The second one is that the current infrastructure responsibilities of regional governments (*Comunidades Autónomas*) were not completed until the middle of the 1980s. [17] Therefore, it is important to exclude this first period from the analysis. The third reason is that the information needed to quantify some of the variables (i.e., those coming from the production function, such as vehicles and utilization) is not available for a longer period.

3.2.2. Economic variables

Explanatory variables can be classified into three groups: Economic variables, political variables and control variables that pick up the financial resources of regional governments. Table 1 summarizes the definitions of the variables and data sources. Among economic variables, we have included both lagged output ($\Delta \ln Y_{it-1}$) and population ($\Delta \ln N_{it-1}$) growth, and variables coming directly from the specification of the production function ($\Delta \ln S^x_{it}$ and $\Delta \ln E^c_{it}$).

[16] We have to admit that this is not true for all regional governments, since six of them only contain one NUTS3 region. To overcome this problem we have re-estimated the regional investment equations dropping these observations (in this case, we have 44 yearly observations instead of 50). The results are qualitatively the same as those presented in the next section and are available upon request.

[17] In addition to this, the regional financing system was highly provisional until the second half of that decade.

Table 1
Variable definitions and data sources

	Mean (s.d.)	Definition	Sources
I_t^c/C_{t-1}	0.057 (0.049)	Transportation investment by the central government divided by the previous year's capital stock	Fundación BBVA (1998)
	0.055 (0.053)	Road investment by the central government divided by the previous year's capital stock	
I_t^r/C_{t-1}	0.048 (0.034)	Transportation investment by the regional government divided by the previous year's capital stock	Fundación BBVA (1998)
	0.051 (0.035)	Road investment by the regional government divided by the previous year's capital stock	
$\Delta \ln Y_{t-1}$	0.028 (0.037)	Output growth rate	Regional Accounts, Instituto Nacional de Estadística (INE)
$\Delta \ln N_{t-1}$	0.001 (0.010)	Population growth rate	Population Statistics, Instituto Nacional de Estadística (INE)
$\Delta \ln(Trucks_{t-1}/Y_{t-1})$	0.032 (0.026)	Growth rate of the ratio of trucks to output	Ministerio de Fomento
$\Delta \ln Km_{t-1}$	0.022 (0.085)	Growth rate of vehicles-km per year	Ministerio de Fomento
$\Delta \ln Rail_{t-1}$	0.011 (0.030)	Growth rate in rail passengers per year	RENFE
$\Delta \ln Port_{t-1}$	0.015 (0.077)	Growth rate in tons transported per year	Ministerio de Fomento
$\Delta \ln Air_{t-1}$	0.047 (0.632)	Growth rate in air passengers per year	Ministerio de Fomento
$\lvert(e_k/E_k) - 0.5\rvert$	0.081 (0.173)	Margin (in absolute value) of the incumbent's representatives in the regional government	Anuario EL PaíS and own calculation
e_k/E_k	0.404 (0.605)	Share of socialist representatives in the regional government	Anuario EL PaíS and own calculation
m_k	9412 (6302)	Number of votes needed for the central incumbent to gain/lose a representative in the last election	Anuario EL PaíS and own calculation
	6160 (7421)	Number of votes needed for the regional incumbent to gain/lose a representative in the last election	Anuario EL PaíS and own calculation
t_k	0.503 (0.081)	Turnover in the central legislative elections	Anuario EL PaíS
	0.528 (0.061)	Turnover in the regional legislative elections	

Table 1 (*Continued*)

	Mean (s.d.)	Definition	Sources
f_k	0.336 (0.194)	Cut-point density, central legislative elections	Anuario EL PaíS and own calculation
	0.309 (0.163)	Cut-point density, regional legislative elections	
v_k	0.447 (0.089)	Central incumbent's share of votes in the last election	Anuario EL PaíS
	0.392 (0.132)	Regional incumbent's share of votes in the last election	
$d\,pivot_k$[a]	0.018	Dummy equal to one if a regional party gives support to the minority central government	Own calculation
$dleft(R)_k$[a]	0.506	Dummy equal to one if the regional government is on the left-wing spectrum of the political arena	Anuario EL PaíS
$dmin(R)_k$[a]	0.408	Dummy equal to one if the regional government is a coalition or minority government	Anuario EL PaíS
$\Delta \ln Rinc_{t-1}$	0.125 (0.148)	Growth of regional general revenues (Own taxes and charges + Ceded taxes + General transfers from the central gov. − General transfers to the central gov.)	Liquidación de los Presupuestos de las CCAA & Informe sobre financiación de las CCAA (Ministerio de Economía)
$\Delta \ln Rcap_{t-1}$	0.064 (0.162)	Growth of regional capital revenues (European funds + Spanish regional policy + joint tasks + other specific grants)	Liquidación de los Presupuestos de las CCAA & Informe sobre financiación de las CCAA (Ministerio de Economía)
$\Delta \ln Debt_{t-1}$	0.230 (0.134)	Growth in net debt of the regional government	Anuario Estadístico (Banco de España)

[a] 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.

Output growth is real regional GDP growth at market prices. The share of vehicles in output (S^x_{it-1}) has been proxied by a log-linear relationship among the number of trucks and GDP, of the form: $S^x_{it-1} = (Trucks_{it-1}/Y_{it-1})^{\varepsilon}$. Trucks are the actual number of trucks and other industrial vehicles in each region. This is the best way to deal with this problem, given the unavailability of information on vehicle capital stocks.[18] The elasticity of infrastructure services to infrastructure stock ($\Delta \ln E^c_{it-1}$) has been proxied

[18] Of course, it would have been more appropriate to follow the procedure used in Fernald (1999); that is, to compute the annual consumption of vehicle services as the product of vehicle stock and user cost of capital.

by variables quantifying the growth in the number of users. That is, we assume that the effect of an increase in the stock (e.g., reduction of congestion) is higher the higher is the level of users of this stock.[19] The variables used to compute the increase in the number of users have been selected to represent different kinds of transportation infrastructures. In the case of roads the variable used is the increase in the number of kilometers per year travelled by vehicles in the region ($\Delta \ln Km_{it-1}$). For airports and railroads, we use growth in passengers/year ($\Delta \ln Air_{it-1}$ and $\Delta \ln Rail_{it-1}$),[20] and in the case of ports, yearly growth in tons of goods transported ($\Delta \ln Port_{it-1}$).

3.2.3. Political variables

Variables included in the Ψ_{it} term pick up political factors considered by the government when allocating funds to the regions. Some recent political economy papers may help in selecting these variables (Levitt and Snyder, 1995; Johansson, 2003; Dahlberg and Johansson, 2002; Cadot et al., 1999; 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 focus on the first two factors, which will be named *electoral productivity* and *partisanship.*

Electoral productivity. Some theoretical papers (see, e.g., Lindbeck and Weibull, 1988, Dixit and Londregan, 1998, Snyder, 1989) suggest that parties will allocate more resources to the constituencies where the marginal electoral gains to be obtained are higher. In our case, we consider that the electoral productivity of a region can be represented as the product of four factors: (i) the probability that an additional representative elected in the region is pivotal (g_{ik}), (ii) the probability of gaining or loosing that additional representative (r_{ik}), (iii) electoral turnover (t_{ik}), and (iv) the influence of 'swing voters' in the region (f_{ik}, i.e., the probability that voters will change their vote from one party to another in response to a change in output per capita):[21, 22]

$$\ln \Psi_{ik} = \beta_j \ln(g_{ik} \times r_{ik} \times t_{ik} \times f_{ik}) = \beta_j[\ln g_{ik} + \ln r_{ik} + \ln t_{ik} + \ln f_{ik}]. \tag{18}$$

We have made an effort to measure the different factors in (18) in a way that is consistent with the traits of the Spanish political system.[23] The probability that a

[19] Many empirical papers use a constant-elasticity specification of the level of services provided by infrastructures: $Z_{it} = (C_{it}/\varsigma_i)/U_{it}^{\alpha}$. Note, however, that in this case $E_{it}^{c} = 1$ in all the regions and this term will disappear from our specification. To allow E_{it}^{c} depends on the number of users one has to posit a more general functional form, as for example the translog function used by Boarnet (2001).

[20] In this last case the data is available only for the period 1991–1996. Because of this the equations in which this variable appears have been estimated with only the data belonging to this sample.

[21] Note that all variables are indexed by k. This means that their value only changes from election to election. However, as has been described previously, we will allow for differential effects through the electoral cycle.

[22] This specification can be derived from a simple political economy model of regional infrastructure allocation (see the appendix).

[23] Most of the papers that have already considered similar variables (see, e.g., Wright, 1974; Case, 2001; Johansson, 2003; Dahlberg and Johansson, 2002; Strömberg, 2001) focus on political competition in bipartisan (and often winner-takes-all) systems. However, this may not be entirely appropriate in our case, given the presence of multiple parties and the use of the d'Hondt formula to translate votes into representatives.

representative from the region is pivotal (g_{ik}) has been measured in a different way for the central and the regional governments. In the case of the central government, we take this factor into account by including a dummy equal to one if there are *pivotal representatives* from the region (i.e., $d\,pivot_k$). This happened in the past only when some regional parties gave support to the central government's minority government during the period 1993–1996.[24] We expect this variable to have a positive effect on investment. In the case of the regional government, we include a variable measuring the regional *government's margin* of representatives. This has been measured as the absolute value of the distance between the share of government representatives of the main party in the government and 50% (i.e., $|(e_k/E_k) - 0.5|$). The hypothesis here is that an additional representative will be more valuable the lower is this margin.[25]

The probability of gaining/losing an additional representative (i.e., r_{ik}) has been measured as $1/m_{ik}$, where m_{ik} is the *vote margin* or number of votes that the incumbent party would have needed to gain or loose one additional representative in the region in the last election. This variable has been computed for every central and regional legislative election[26] through a very simple algorithm that reproduces the workings of the d'Hondt rule. In the case of the central government, we computed the number of votes needed for the socialist government (the incumbent in all the contests) to gain/lose a representative in the upper chamber (*Congreso*). The variable m_{it} is then computed as the minimum of these two values for each region.[27] In the regional case we computed the number of votes needed for the main party in government (which is not always the socialist party) to gain/lose a representative in the regional parliament, and then chose the minimum of these two values. As is apparent from expression (18), this variable ($r_{ik} = 1/m_{ik}$) is expected to have a positive effect on electoral productivity and, therefore, on infrastructure investment received by a region (i.e., the more votes that are needed to win or loose a representative, the lower is the probability that a vote changes the result).

The third variable in (18) is *Electoral turnover* (t_{ik}) and has been computed as the ratio between total votes cast in the central (or regional) elections and regional population. We expect that the effects of this variable on investment are positive.[28] The last variable in (18) aims to capture the influence of *swing voters* (f_{ik}) in a given

[24] In these years the socialists were in minority in the central government and received the support of the nationalist parties governing in Catalonia, Basque Country and Canary Islands.

[25] This distance has also been computed with data on the representatives of all the parties in the regional government. The variable was usually statistically significant only when computed with data on the main party. To save space these additional results will not be presented. They are, however, available upon request.

[26] Elections at the central level were held in 1982, 1986, 1989 and 1993. At the regional level, elections were held in most of the cases in 1983, 1987, 1991 and 1995. Four regional governments (i.e., Galicia, Catalonia, Basque Country and Andalucia) have, however, a different electoral cycle.

[27] The calculation assumes that all the votes lost or gained by the incumbent are gained or lost by the second party in number of votes in the region. We repeated the calculation with different vote shifting assumptions (e.g., distribution according to previous vote share). However, the results of the variable $1/m_{it}$ in the investment equation are not qualitatively altered. In both cases, central and regional, we also estimated some investment equations with positive and negative margin variables. The results were similar in both cases.

[28] If turnover is considered exogenous (see, e.g., Strömberg, 2001), then a given increase in the incumbent's vote share translates to higher additional votes per capita the higher is electoral turnover.

region. The argument here is that it is more profitable for the incumbent to invest in the regions where more voters are likely to swing from one party to the other (see, e.g., Lindbeck and Weibull, 1988; Dixit and Londregan, 1998). To compute this variable, we employ a procedure, used by Wright (1974) and Strömberg (2001) in their analyses of the regional allocation of New Deal Spending. Firstly, we collected information on the socialist vote share in all the elections held in Spain since the beginning of the 1980s.[29] Secondly, we pooled the vote-share obtained in all these elections to perform a separate regression for each region, with a time trend and a different constant for each election type (i.e., central, regional and other) as explanatory variables. The idea behind this procedure is to purge the results of the progressive loss of socialist votes during those years (see, e.g., Boix, 1998) and at the same time to allow for a different socialist regional long-term vote-share for each election type. Thirdly, we used these results to compute a vote density function for the socialist vote in each region. To do so we assume that the socialist votes are distributed normally with a mean equal to the estimated long-run vote-share (i.e., the estimated constant for each type of election) and a standard deviation equal to its standard error. As the estimated constant and standard error are different for each election type, we are able to obtain two different densities, one for the central legislative elections and another for the regional elections. Fourthly, we compute the cut-point density for each election used in the empirical analysis (f_{ik}) using the simulated density (central or regional) and the socialist result in that election.

The four variables that appear in (18) will be first introduced into the equations separately. We will use, however, a composite variable called *electoral productivity* that combines the three last variables (i.e., $\ln p_{ik} = \ln r_{ik} + \ln t_{ik} + \ln f_{ik}$), that are supposed to have identical coefficients (see the appendix). We have included only these three variables because they were measured directly, while the first one (g_{ik}) was measured only with the help of proxies.

Partisan support. Other papers, however, suggest that parties will allocate more resources to the districts where they obtain greater political support. This is the case, for example, of the model developed by Cox and McCubbins (1986). In this model, the parties' purpose is still to win the election, but because they are risk-averse they find it too risky to invest in swing voter groups and prefer to invest in the safer support groups. We take this factor into account by including a 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 (v_{ik}). We expect this variable to have a positive sign.

In the case of the central government, partisan support to win the elections may also come from the party's presence in regional governments (Grossman, 1994). The central government's investment equation will include two additional variables that try to pick up this effect. The first variable accounts for the similarity of the partisan orientation of the central and the regional governments; as in all the period analyzed the central government was controlled by the socialist party, the variable used is a dummy equal to one for a *leftist regional government* ($dleft(R)_{it}$). The second one tries to measure

[29] This gives a total of 21 elections, six of them were elections to the central legislative assembly, six were elections to the regional parliaments, five were local elections and four elections to the European parliament.

the ideological congruence between the central and the regional government; we expect that congruence is maximal when all the members of the regional government are socialists. The variable used to measure this effect is simply the socialist share of the regional government (e_{ik}/E_{ik}), computed as the ratio between socialist representatives in the regional parliament and the representatives of all the parties that give support to the regional government. We expect a positive effect of these two variables on infrastructure investment.

Some additional political variables are included in the regional investment equations. The first of these are three dummies picking up the position in the electoral cycle: d_0 for an election year, and d_1 and d_2 for one and two years before a regional election. It should be remembered that all the political variables will be allowed to have different slopes at different moments of the cycle; therefore, it seems natural to allow for different intercepts also. However, the inclusion of these constants in the central government's investment equation is not possible because they do not have cross-section variation and their influence is picked up by time effects. The other political variables are a dummy equal to one for a *leftist regional government* ($dleft(R)_{ik}$) and for a *minority regional government* ($dmin(R)_{ik}$). Note that these variables will be the same for all departments belonging to the same regional government, so they are not related to the political clout of a given department, but to political influences on the overall level of regional investment. The signs of these variables are uncertain. Although one generally expects a higher spending propensity from governments on the left, it may well happen that they spend more on other services provided by regional governments (e.g., health and education) and less on productive infrastructure services. Something similar may happen regarding the minority variable. Some papers suggest that governments with a low degree of internal cohesion will spend more due to the greater difficulty they have in stopping the redistributive pressures they face (see, e.g., Roubini and Sachs, 1989; Alt and Lowry, 1995). However, this effect needs not to be the same in all expenditure categories. A possible story may be, for example, a cut in investment projects due, precisely, to the success of other redistributive programs.

Finally, the regional investment equation should also include some variables accounting for the budget constraint of each regional government (λ_{it}). These variables are: The lagged growth rate of unconditional revenues ($\Delta \ln Rev_{it-1}$), of capital transfers ($\Delta \ln Cap_{it-1}$), and of the debt level ($\Delta \ln Debt_{it-1}$). All these variables are computed for the NUTS2 region that is the level of aggregation corresponding to regional governments in Spain. Therefore, its value is the same for all the NUTS3 regions included under the same regional government. The sign expected is positive in the case of the resource variables and negative in the case of debt.

3.3. Econometric issues

Before estimating Eq. (15) two main econometric issues should be addressed: (i) Devise a procedure to check that the restrictions on the coefficients implied by the model hold and (ii) the estimation of a dynamic panel data model.

Regarding the first question, note that the sum of the coefficients of I^c_{it-1}/C_{it-2}, $\Delta \ln Y_{it-1}$ and $\Delta \ln N_{it-1}$ is equal to one (i.e., $(1-\rho)+\rho\phi+\rho(1-\phi)=1$). This is a linear constraint on parameter values that should be tested in order to check the reliability of the theoretical model. To ease the interpretation of this test we have estimated the equation with $\Delta \ln(Y_{it-1}/N_{it-1})$ as the explanatory variable. Note that in this case the constraint now implies that the coefficients on I^{c}_{it-1}/C_{it-2} and $\Delta \ln N_{it-1}$ add to one. We will provide a Wald test on the validity of this constraint below the estimated coefficient of $\Delta \ln N_{it-1}$. Giving some of the results in advance, we can say that the null hypothesis that the sum of these coefficients is equal to one cannot be rejected in any of the cases at conventional statistical significance levels.

Regarding the second problem, note that the equation in first differences (15) includes the lagged value of the dependent variable (I_{it-1}/C_{it-2}). 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 ($\varepsilon_{it} - \varepsilon_{it-1}$). 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 (Arellano and Bond, 1991). The solution to this problem consists of estimating Eq. (15) by the Generalized Method of Moments (GMM), using lagged values of variables in levels as instruments (Arellano and Bond, 1991).[30] In our case, we will use as instruments for I_{it-1}/C_{it-2} six lags of the infrastructure stock ($\ln C_{t-2}$ to $\ln C_{t-7}$). These instruments will be the same for all the years in the sample. This procedure will not mean the loss of any of the cross-sections, because we have information for the instruments in years preceding those used in the analysis.[31]

The assumption of no serial correlation in ε_{it} is crucial to guaranteeing 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 and 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 the central government's investment equation. Table 2 shows the results that correspond to the 'economic model' while Table 3 extends the equation to account for the influence of political factors. Tables 4 and 5 show the results obtained when repeating the exercise for the investment made by regional governments. The explanatory capacity of the model is high in both cases, with an adjusted R^2 around 60% in the central government's case and around 70% in the case of regional governments. The bottom of both tables shows

[30] In principle, in the 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).

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

Table 2
Economic determinants of infrastructure investment, Central government 1987–1996 (GMM estimation; dependent variable: I^{c}_{t-1}/C_{t-2}. $N \times T = 50 \times 10 = 500$)

	Transportation			Roads	
	(2a)	(2b)	(2c)	(2d)	(2e)
(i) Lagged investment					
I^{c}_{t-1}/C_{t-2}	0.703	0.688	0.694	0.657	0.639
	(9.410)***	(7.152)***	(8.257)***	(10.214)***	(9.648)***
I^{o}_{t-1}/C_{t-2}	−0.028	−0.027	−0.024	−0.028	−0.031
	(−2.014)**	(−2.214)**	(−2.106)**	(2.141)**	(−2.354)**
(ii) Equity–efficiency trade-off					
$\Delta \ln(Y_{t-1}/N_{t-1})$	0.279	0.255	0.262	0.263	0.272
	(4.415)***	(4.664)***	(4.073)***	(3.741)***	(3.868)***
$\Delta \ln N_{t-1}$	0.247	0.286	0.274	0.311	0.297
	(7.144)***	(6.514)***	(6.057)***	(4.510)***	(4.303)***
$[Wald(I^{c}_{t-1}/C_{t-2} + \Delta \ln N_{t-1} = 1)]$[a]	[0.964]	[0.906]	[0.816]	[0.193]	[2.162]
(iii) Infrastructure needs					
$\Delta \ln(Trucks_{t-1}/Y_{t-1})$	0.189	0.174	0.165	0.245	0.226
	(2.878)***	(2.551)**	(2.692)***	(3.450)***	(3.303)***
$\Delta \ln Km_{t-1}$	—	0.011	0.016	—	0.020
		(1.459)	(1.618)		(1.504)
$\Delta \ln Rail_{t-1}$	—	0.035	—	—	—
		(1.581)			
$\Delta \ln Port_{t-1}$	—	0.003	0.004	—	—
		(0.247)	(0.336)		
$\Delta \ln Air_{t-1}$	—	0.009	0.011	—	—
		(2.008)**	(2.210)**		
R^2	0.590	0.602	0.607	0.571	0.585
$Wald(f_t$ vs. $f_t)$[b]	7.882***	6.924***	6.804***	7.142***	8.331***
$Wald(\eta_i \times f_t$ vs. $f_t)$[c]	0.181	0.200	0.210	0.157	0.192
LM (first-order serial corr.)[d]	−2.360***	−2.541***	−2.741***	−2.639***	−2.870***
LM (second-order serial corr.)[d]	−0.657	−0.963	−0.574	−0.156	−0.123
Sargan (instrument validity)[e]	0.007	0.007	0.008	0.018	0.011
	[0.999]	[0.999]	[0.999]	[0.997]	[0.997]

Notes: Figures in parenthesis are t-statistics.
***, ** and * = statistically significant at the 99%, 95% and 90% levels, respectively.
[a]Wald test of the null hypothesis that the coefficients of lagged investment plus the coefficient of population growth add to one.
[b]Wald test of the null hypothesis of equality of the time effects.
[c]Wald test of the null hypothesis of equality between the generic time effects and the time effects specific to regional funds recipients.
[d]LM tests on first- and second-order error correlation.
[e]Sargan test statistic of instrument validity (distributed under the null of instrument validity as a $\chi^2(q)$, with q = number of instruments) and p-value (in brackets); the instruments used are $\ln C_{t-2}$ to $\ln C_{t-7}$.

Table 3
Political determinants of infrastructure investment, Central government, 1987–1996 (GMM estimation; dependent variable: I^{c}_{t}/C_{t-1}. $N \times T = 50 \times 10 = 500$)

	Transportation				Roads			
	(3a)	(3b)	(3c)	(3d)	(3e)	(3f)	(3g)	(3h)
(i) *Lagged investment*								
I^{c}_{t-1}/C_{t-2}	0.697	0.698	0.663	0.667	0.602	0.601	0.606	0.610
	(8.492)***	(8.521)***	(7.609)***	(7.632)***	(8.480)***	(8.729)***	(8.610)***	(8.729)***
I^{o}_{t-1}/C_{t-2}	−0.026	−0.030	−0.028	−0.031	−0.028	−0.024	−0.030	−0.031
	(−2.411)**	(−2.567)**	(−2.214)**	(−2.114)**	(−2.302)**	(−2.210)**	(−2.510)**	(−2.604)**
(ii) *Equity–efficiency trade-off*								
$\Delta \ln(Y_{t-1}/N_{t-1})$	0.276	0.273	0.158	0.160	0.261	0.267	0.163	0.166
	(4.140)***	(4.106)***	(2.179)**	(2.282)**	(2.089)**	(2.710)***	(2.674)***	(2.723)***
$\Delta \ln N_{t-1}$	0.280	0.279	0.263	0.262	0.359	0.355	0.353	0.348
	(6.090)***	(6.093)***	(6.692)***	(6.648)***	(4.911)***	(4.894)***	(4.901)***	(4.893)***
$[Wald(I^{c}_{t-1}/C_{t-2} + \Delta \ln N_{t-1} = 1)]$	[0.641]	[0.700]	[0.751]	[0.803]	[0.741]	[0.862]	[0.651]	[0.842]
(iii) *Infrastructure needs*								
$\Delta \ln(Trucks_{t-1}/Y_{t-1})$	0.187	0.183	0.054	0.057	0.248	0.249	0.107	0.109
	(2.902)***	(2.849)***	(2.014)**	(2.087)**	(2.081)**	(2.100)**	(2.151)**	(2.072)**
$\Delta \ln Km_{t-1}$	0.019	0.019	0.014	0.014	0.021	0.018	0.020	0.018
	(1.321)	(1.347)	(1.914)*	(1.667)*	(1.012)	(1.507)	(1.934)*	(1.800)*
$\Delta \ln Port_{t-1}$	0.007	0.006	0.019	0.020	—	—	—	—
	(0.457)	(0.419)	(1.110)	(1.163)				
$\Delta \ln Air_{t-1}$	0.003	0.005	0.003	0.003	—	—	—	—
	(1.678)*	(1.387)	(1.861)*	(1.784)*				
(iv) *Political influences*								
(i): *Electoral productivity*								
Vote margin:								
$\Delta \ln(1/m_k) \times d_3$[a]	0.052	—	0.041	—	0.060	—	0.062	—
	(2.045)**		(1.674)*		(1.505)		(2.110)**	

Table 3 (*Continued*)

	Transportation				Roads			
	(3a)	(3b)	(3c)	(3d)	(3e)	(3f)	(3g)	(3h)
$\ln(1/m_{k-1}) \times d_3$	−0.032	—	−0.025	—	−0.031	—	−0.027	—
	(−2.103)**		(−1.846)*		(−1.600)		(−1.436)	
$\ln(1/m_k) \times (d_0 + d_1 + d_2)$[a]	0.014	—	0.012	—	0.012	—	0.013	—
	(2.411)**		(2.119)**		(2.269)**		(2.159)***	
$[Wald(d_0 = d_1 = d_2)]$[c]	[0.400]	—	[0.450]	—	[0.702]	—	[0.800]	—
Turnover:								
$\Delta \ln t_k \times d_3$	0.057	—	0.040	—	0.060	—	0.068	—
	(2.322)**		(2.110)**		(1.756)*		(1.495)	
$\ln t_{k-1} \times d_3$	−0.030	—	−0.028	—	−0.037	—	−0.021	—
	(−1.874)*		(−1.985)**		(−1.211)		(−1.774)*	
$\ln t_k \times (d_0 + d_1 + d_2)$	0.016	—	0.022	—	0.016	—	0.015	—
	(2.741)***		(2.361)**		(2.450)**		(2.369)**	
$[Wald(d_0 = d_1 = d_2)]$[b]	[1.697]	—	[2.103]	—	[2.362]	—	[2.010]	—
Swing voters:								
$\Delta \ln f_k \times d_3$	0.040	—	0.038	—	0.039	—	0.036	—
	(1.314)		(1.236)		(1.540)		(1.301)	
$\ln f_{k-1} \times d_3$	−0.034	—	−0.030	—	−0.041	—	−0.030	—
	(−1.236)		(−1.569)		(−1.005)		(−0.974)	
$\ln f_{k\times}(d_0 + d_1 + d_2)$	0.025	—	0.030	—	0.028	—	0.025	—
	(1.754)*		(1.689)*		(1.405)		(1.300)	
$[Wald(d_0 = d_1 = d_2)]$[b]	[0.123]	—	[0.114]	—	[0.201]	—	[0.265]	—
Electoral productivity: $\ln p_k = \ln(1/m_k) + \ln t_k + \ln f_k$								
$\Delta \ln p_{k\times} d_3$	—	0.061	—	0.048	—	0.057	—	0.062
		(2.314)**		(1.874)*		(2.314)**		(2.412)**
$\ln p_{k-1\times} d_3$	—	−0.034	—	−0.030	—	−0.041	—	−0.035
		(−2.441)**		(−2.341)**		(−1.645)		(−1.514)

Table 3 (*Continued*)

	Transportation				Roads			
	(3a)	(3b)	(3c)	(3d)	(3e)	(3f)	(3g)	(3h)
$\ln p_{k\times}(d_0+d_1+d_2)$	—	0.013	—	0.014	—	0.014	—	0.015
		(2.920)***		(2.874)***		(2.656)***		(2.659)***
$[Wald(d_0=d_1=d_2)]$	[0.326]	[0.569]	[0.847]	[0.576]	[0.651]	[0.400]	[0.741]	[0.741]
$[Wald(\ln(1/m_k)+\ln t_k+\ln f_k)]^{\mathrm{c}}$	[1.561]	[1.236]	[1.290]	[1.637]	[2.136]	[2.310]	[2.465]	[2.133]
Pivotal representatives:								
$\Delta d\ pivot_k \times d_3$	0.008	0.009	0.009	0.008	0.011	0.012	0.012	0.010
	(1.765)*	(2.078)**	(2.015)**	(1.771)*	(2.511)***	(2.600)**	(2.717)***	(2.863)***
$[Wald(d_0=d_1=d_2=0)]^{\mathrm{d}}$	[0.954]	[0.356]	[0.231]	[0.999]	[0.894]	[0.981]0	[0.800]0	[0.110]
(v) *Political influences* (ii): *Partisanship*								
Vote share:								
$\Delta \ln v_k \times d_3$	—	—	0.003	0.003	—	—	0.004	0.006
			(0.369)	(0.405)			(0.412)	(0.621)
$[Wald(d_0=d_1=d_2=0)]^{\mathrm{d}}$	—	—	[0.591]	[0.214]	—	—	[0.495]	[0.211]
Leftist regional government:								
$\Delta dleft(R)_k \times d_3$	—	—	0.003	0.003	—	—	0.004	0.004
			(2.223)**	(2.415)**			(2.362)**	(2.641)***
$[Wald(d_0=d_1=d_2=0)]^{\mathrm{d}}$	—	—	[0.478]	[0.001]	—	—	[0.412]	[0.592]

Table 3 (*Continued*)

	Transportation				Roads			
	(3a)	(3b)	(3c)	(3d)	(3e)	(3f)	(3g)	(3h)
Share of regional representatives:								
$\Delta \ln(e_k/E_k) \times d_3$	—	—	0.002	0.001	—	—	0.002	0.002
			(2.345)**	(2.104)**			(2.567)**	(2.831)***
$[Wald(d_0 = d_1 = d_2 = 0)]^{d}$	—	—	[0.210]	[0.651]	—	—	[0.332]	[0.456]
R^2	0.615	0.617	0.628	0.626	0.614	0.613	0.629	0.622
$Wald(f_t$ vs. $f)$	8.332***	7.412***	8.314***	9.447***	6.541***	6.754***	6.664***	7.028***
$Wald(\eta_i \times f_t$ vs. $f_t)$	0.112	0.241	0.185	0.152	0.145	0.187	0.210	0.203
LM (first-order serial corr.)	−2.540***	−2.691***	−2.891***	−3.110***	−2.789***	−2.802***	−2.776***	−2.836***
LM (second-order serial corr.)	−0.550	−0.469	−0.764	−0.536	−0.452	−0.444	−0.204	−0.317
Sargan (instrument validity)	0.009	0.008	0.009	0.010	0.007	0.008	0.007	0.008
	[0.999]	[0.999]	[0.999]	[0.999]	[0.999]	[0.999]	[0.999]	[0.999]

Notes: See Table 1.

[a] d_0, d_1, d_2 and d_3 are dummies equal to one in the election year and 1, 2 and 3 years before the election.

[b] Wald test of the null hypothesis H_0: $(\beta_0 - \beta_1) = (\beta_1 - \beta_2) = (\beta_2 - \beta_3) = \Delta\beta$.

[c] Wald test of the null hypothesis that the effects of the coefficient of the three variables composing p_{ik} are equal.

[d] Wald test of the null hypothesis H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta$.

Table 4
Economic determinants of infrastructure investment, Regional governments 1987–1996 (GMM estimation. Dependent variable: I^{r}_t/C_{t-1}. $N \times T = 50 \times 10 = 500$)

	Transportation			Roads	
	(4a)	(4b)	(4c)	(4d)	(4e)
(i) *Lagged investment*					
$I^{\mathrm{r}}_{t-1}/C_{t-2}$	0.801	0.770	0.781	0.652	0.671
	(8.174)***	(7.561)***	(8.487)***	(5.410)***	(6.412)***
$I^{\mathrm{o}}_{t-1}/C_{t-2}$	−0.030	−0.028	−0.029	−0.035	−0.033
	(−2.541)**	(−2.136)**	(−2.416)**	(−2.411)**	(−2.599)**
(ii) *Equity–efficiency trade-off*					
$\Delta \ln(Y_{t-1}/N_{t-1})$	0.166	0.174	0.175	0.314	0.312
	(4.172)***	(3.874)***	(4.440)***	(5.410)***	(5.446)***
$\Delta \ln N_{t-1}$	0.179	0.251	0.252	0.269	0.240
	(5.410)***	(4.661)***	(6.253)***	(6.415)***	(5.317)***
$[Wald(I^{\mathrm{r}}_{t-1}/C_{t-2} + \Delta \ln N_{t-1} = 1)]$	[0.815]	[1.014]	[1.147]	[1.842]	[2.162]
(iii) *Infrastructure needs*					
$\Delta \ln(Trucks_{t-1}/Y_{t-1})$	0.167	0.174	0.170	0.261	0.248
	(4.571)***	(4.664)***	(4.440)***	(5.319)***	(5.565)***
$\Delta \ln Km_{t-1}$	—	0.014	0.018	—	0.016
		(1.874)*	(2.151)**		(1.661)*
$\Delta \ln Rail_{t-1}$	—	0.021	—	—	—
		(1.412)			
$\Delta \ln Port_{t-1}$	—	0.004	0.003	—	—
		(1.245)	(1.004)		
$\Delta \ln Air_{t-1}$	—	0.002	0.002	—	—
		(1.687)*	(1.774)*		
(iv) *Financial resources*					
$\Delta \ln Rinc_{t-1}$	0.005	0.007	0.008	0.009	0.010
	(1.401)	(1.600)	(2.236)**	(2.000)**	(1.806)*
$\Delta \ln Rcap_{t-1}$	0.011	0.011	0.012	0.009	0.008
	(1.566)	(1.269)	(1.794)*	(1.561)	(1.239)
$\Delta \ln Debt_{t-1}$	−0.002	−0.005	−0.007	−0.002	−0.002
	(−2.341)**	(−2.687)**	(−2.544)**	(−1.754)*	(−2.022)**
R^2	0.693	0.697	0.707	0.610	0.629
$Wald(f_t$ vs. $f)$	6.841***	7.104***	6.839***	6.941***	7.412***
$Wald(\eta_i \times f_t$ vs. $f_t)$	0.157	0.166	0.214	0.172	0.199
LM (first-order serial corr.)	−3.621***	−3.324***	−3.019***	−3.215***	−3.261***
LM (second-order serial corr.)	−0.220	−0.123	−0.100	−0.258	−0.364
Sargan (instrument validity)	0.005	0.005	0.006	0.003	0.004
	[0.999]	[0.999]	[0.999]	[0.999]	[0.999]

Note: See Table 1.

Table 5
Political determinants of infrastructure investment, Regional governments, 1987–1996 (GMM estimation. Dependent variable: I_t^{r}/C_{t-1}. $N \times T = 50 \times 10 = 500$)

	Transportation				Roads			
	(5a)	(5b)	(5c)	(5d)	(5e)	(5f)	(5g)	(5h)
(i) *Lagged investment*								
$I_{t-1}^{\mathrm{r}}/C_{t-2}$	0.828	0.835	0.811	0.792	0.739	0.730	0.689	0.699
	(8.869)***	(9.147)***	(8.970)***	(8.722)***	(8.812)***	(8.623)***	(7.985)***	(8.125)***
$I_{t-1}^{\mathrm{o}}/C_{t-2}$	−0.025	−0.025	−0.024	−0.025	−0.028	−0.027	−0.030	−0.031
	(−2.104)**	(−2.314)**	(−2.150)**	(−2.346)**	(−2.316)**	(−2.644)***	(−2.154)**	(−2.554)**
(ii) *Equity–efficiency trade-off*								
$\Delta \ln(Y_{t-1}/N_{t-1})$	0.154	0.142	0.141	0.146	0.206	0.228	0.238	0.211
	(3.811)***	(3.380)***	(3.379)***	(3.478)***	(4.441)***	(5.028)***	(5.167)***	(4.434)***
$\Delta \ln N_{t-1}$	0.165	0.166	0.164	0.179	0.290	0.298	0.289	0.295
	(7.364)***	(7.904)***	(5.837)***	(5.721)***	(6.942)***	(6.828)***	(6.572)***	(6.837)***
$[Wald(I_{t-1}^{\mathrm{r}}/C_{t-2} + \Delta \ln N_{t-1} = 1)]$	[0.789]	[0.657]	[1.258]	[0.985]	[0.687]	[1.147]	[1.061]	[1.114]
(iii) *Infrastructure needs*								
$\Delta \ln(Trucks_{t-1}/Y_{t-1})$	0.158	0.139	0.075	0.070	0.202	0.232	0.136	0.123
	(3.949)***	(3.390)***	(3.275)***	(3.389)***	(4.339)***	(4.897)***	(4.935)***	(4.176)***
$\Delta \ln Km_{t-1}$	0.018	0.023	0.021	0.021	0.025	0.018	0.014	0.023
	(2.268)**	(2.625)***	(2.441)**	(2.310)**	(2.755)**	(1.992)*	(2.526)**	(2.460)**
$\Delta \ln Port_{t-1}$	0.003	0.003	0.003	0.003	—	—	—	—
	(0.068)	(0.073)	(0.162)	(0.297)				
$\Delta \ln Air_{t-1}$	0.002	0.002	0.002	0.002				
	(3.679)***	(4.131)***	(3.580)***	(3.635)***				
(iv) *Financial resources*								
$\Delta \ln Rinc_{t-1}$	0.012	0.013	0.010	0.010	0.010	0.011	0.012	0.013
	(1.568)	(1.624)	(1.471)	(1.611)	(2.119)**	(2.355)**	(1.874)*	(2.491)**

Table 5 (*Continued*)

	Transportation				Roads			
	(5a)	(5b)	(5c)	(5d)	(5e)	(5f)	(5g)	(5h)
$\Delta \ln Rcap_{t-1}$	0.008	0.009	0.011	0.009	0.018	0.020	0.022	0.023
	(1.441)	(1.564)	(1.201)	(1.002)	(1.690)*	(1.436)	(1.423)	(1.886)*
$\Delta \ln Debt_{t-1}$	−0.018	−0.020	−0.021	−0.017	−0.016	−0.021	−0.022	−0.020
	(−1.896)*	(−2.110)*	(−2.571)*	(−2.348)*	(−1.967)*	(−1.741)*	(−2.114)**	(−1.789)*
(iv) *Political influences* (i): *Electoral productivity*								
Vote margin:								
$\Delta \ln(1/m_k) \times d_3$	0.019	—	0.018	—	0.020	—	0.022	—
	(2.102)**		(2.236)**		(2.112)**		(2.114)**	
$\ln(1/m_{k-1}) \times d_3$	−0.031	—	−0.027	—	−0.032	—	−0.038	—
	(−2.210)**		(−1.987)*		(−2.024)**		(−1.698)*	
$\ln(1/m_k) \times (d_0 + d_1 + d_2)$	0.010	—	0.011	—	0.012	—	0.014	—
	(2.121)**		(2.004)**		(2.124)**		(2.024)**	
$[Wald(d_0 = d_1 = d_2)]$	[0.512]	—	[0.456]	—	[0.666]	—	[0.711]	—
Turnover:								
$\Delta \ln t_k \times d_3$	0.012	—	0.011	—	0.008	—	0.009	—
	(1.314)		(1.514)		(1.741)*		(1.880)*	
$\ln t_{k-1} \times d_3$	−0.024	—	−0.023	—	−0.027	—	−0.031	—
	(−1.651)*		(−1.874)*		(−2.120)**		(−2.264)**	
$\ln t_k \times (d_0 + d_1 + d_2)$	0.006	—	0.011	—	0.013	—	0.015	—
	(1.301)		(1.504)		(1.967)*		(2.000)**	
$[Wald(d_0 = d_1 = d_2)]$	[0.211]	—	[0.325]	—	[0.681]	—	[0.789]	—
Swing voters:								
$\Delta \ln f_k \times d_3$	0.015	—	0.010	—	0.011	—	0.013	—
	(1.367)		(1.624)*		(1.232)		(1.520)	
$\ln f_{k-1} \times d_3$	−0.020	—	−0.021	—	−0.017	—	−0.024	—
	(−2.236)**		(−2.104)**		(−2.223)**		(−2.169)**	

Table 5 (*continued*)

	Transportation				Roads			
	(5a)	(5b)	(5c)	(5d)	(5e)	(5f)	(5g)	(5h)
$\ln f_k \times (d_0 + d_1 + d_2)$	0.007	—	0.005	—	0.007	—	0.006	—
	(2.224)**		(2.387)**		(2.441)**		(2.698)**	
$[Wald(d_0 = d_1 = d_2)]$	[0.789]	—	[0.963]	—	[1.347]	—	[1.635]	—
Electoral productivity (i): $\ln p_k = \ln(1/m_k) + \ln t_k + \ln f_k$								
$\Delta \ln p_k \times d_3$	—	0.020	—	0.019	—	0.021	—	0.021
		(2.456)**		(2.769)**		(2.013)**		(2.126)**
$\ln p_{k-1} \times d_3$	—	−0.030	—	−0.023	—	−0.037	—	−0.035
		(−2.104)**		(−1.874)*		(−2.340)**		(−2.114)**
$\ln p_k \times (d_0 + d_1 + d_2)$	—	0.012	—	0.011	—	0.013	—	0.015
		(2.379)**		(2.078)**		(2.322)**		(2.237)**
$[Wald(d_0 = d_1 = d_2)]$	—	[0.436]	—	[0.505]	—	[0.711]	—	[0.635]
Margin of representatives:								
$\Delta \ln \lvert (e_k/E_k) - 0.5 \rvert \times d_3$	−0.015	−0.012	−0.014	−0.012	−0.015	−0.016	−0.017	−0.019
	(−1.541)	(−1.231)	(−1.004)	(−1.147)	(−1.220)	(−1.204)	(−0.904)	(−0.805)
$\ln \lvert (e_k/E_k) - 0.5 \rvert \times d_3$	0.020	0.019	0.021	0.018	0.015	0.022	0.023	0.026
	(1.867)*	(1.680)*	(1.904)*	(2.001)**	(1.605)*	(1.894)*	(2.032)*	(2.148)**
$\ln \lvert (e_k/E_k) - 0.5 \rvert \times (d_0 + d_1 + d_2)$	−0.005	−0.005	−0.005	−0.004	−0.005	−0.006	−0.006	−0.006
	(−2.262)**	(−2.164)**	(−2.262)**	(−2.101)**	(−1.841)*	(−2.241)**	(−2.305)*	(−2.119)**
$[Wald(d_0 = d_1 = d_2)]$	[0.326]	[0.569]	[0.847]	[0.576]	[0.651]	[0.400]	[0.741]	[0.694]
Electoral cycle:								
d_0	0.003	0.003	0.003	0.003	0.001	0.001	0.002	0.002
	(2.541)**	(2.410)**	(2.124)**	(2.311)**	(1.524)	(1.361)	(1.845)	(1.748)
d_1	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.002
	(2.158)**	(2.598)**	(2.073)**	(2.558)**	(1.241)	(1.425)	(1.334)	(1.004)
d_2	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001
	(1.641)	(1.789)*	(1.895)*	(1.520)	(1.630)	(1.487)	(1.259)	(1.374)
$[Wald(d_0 = d_1 = d_2)]$	[2.557]	[2.558]	[2.357]	[2.646]	[2.236]	[2.108]	[2.367]	[2.367]

Table 5 (*continued*)

	Transportation				Roads			
	(5a)	(5b)	(5c)	(5d)	(5e)	(5f)	(5g)	(5h)
(v) *Political influences* (ii): *Partisanship and other*								
Main party vote share:								
$\Delta \ln v_k \times d_3$	—	—	0.003	0.004	—	—	0.008	0.005
			(0.960)	(1.129)			(1.325)	(1.437)
$[Wald(d_0 = d_1 = d_2 = 0)]$	—	—	[0.724]	[0.961]	—	—	[0.888]	[0.907]
Leftist regional government:								
$\Delta dleft(R)_k \times d_3$	—	—	−0.009	−0.009	—	—	−0.012	−0.012
			(−3.784)***	(−4.199)***			(−4.392)***	(−4.862)***
$[Wald(d_0 = d_1 = d_2 = 0)]$	—	—	[0.268]	[0.809]	—	—	[0.775]	[0.001]
Minority regional government:								
$\Delta dmin(R)_k \times d_3$	—	—	0.003	0.003	—	—	0.001	0.003
			(4.697)***	(5.887)***			(1.686)*	(1.412)
$[Wald(d_3 = d_1 = d_2 = 0)]$	—	—	[0.254]	[0.657]	—	—	[0.201]	[0.654]
R^2	0.709	0.712	0.722	0.721	0.621	0.620	0.649	0.648
$Wald(f_t \text{ vs. } f)$	7.365***	6.698***	8.201***	7.219***	6.904***	6.001***	5.671***	6.391***
$Wald(\eta_i \times f_t \text{ vs. } f_t)$	0.212	0.341	0.425	0.563	0.239	0.255	0.498	0.567
LM (first-order serial corr.)	−3.478***	−3.562***	−3.008***	−3.665***	−2.593***	−2.891***	−2.777***	−2.982***
LM (second-order serial corr.)	−0.887	−0.941	−1.211	−1.002	−0.569	−0.604	−0.512	−0.336
Sargan (instrument validity)	0.006	0.007	0.007	0.006	0.005	0.007	0.006	0.007
	[0.999]	[0.999]	[0.999]	[0.999]	[0.999]	[0.999]	[0.999]	[0.999]

Note: See Tables 1 and 2.

the results of a battery of specification statistics. In all the cases, the time effects are significant but the hypothesis that they are the same both for regions receiving and not receiving earmarked investment funds cannot be rejected. Also the serial correlation tests show that there is first-order serial correlation in the residuals of the differenced model but no second-order correlation. This fact gives us some confidence in the appropriateness of the instrument set that is confirmed by the Sargan test.

We begin with the discussion of the central government's results. The first three columns in Table 2 correspond to the investment made by the central government in transportation infrastructure, while the other two correspond to the investment in roads. Columns (2a) and (2d) show the results of a specification that includes only the following as variables: Lagged investment made by the central government and lagged investment made by other layers of government, output and population growth, and growth of the ratio of trucks to output. Columns (2b) and (2e) show the results obtained when adding the utilization variables. The specification in column (2c) is the same as in column (2b) but excluding the variable for railway passengers, which is available only for a shorter time period. These equations are extended in Table 3 to include the political variables. The first four columns of Table 3 show the results for transportation investment and the last four for road investment. The first two columns in each category add only the political variables included in the category *Electoral productivity*, while the last two also include the variables included in the category *Partisanship.* Columns (3a) and (3c) for transportation, and (3e) and (3g) for roads present the disaggregated results for each component of electoral productivity (p_{ik}). Columns (3b) and (3d) for transportation, and (3f) and (3h) for roads, present the results when only the composite indicator is used.

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 slightly when political factors are added to the equation (i.e., from 0.607 to 0.628 in the case of transportation, and from 0.585 to 0.629 in the case of roads).[32] This interpretation may be, however, a little misleading, since nearly 75% of the explanatory capacity of the 'economic model' is due to the fact that the system is not in its long-run equilibrium. This means that in the case of roads political variables explain nearly 25% of the variance not explained by this fact; this proportion is reduced to roughly a 15% in the case of transportation. We will come back to this issue below, when discussing the results obtained for each political variable. Secondly, the inclusion of *Electoral productivity* variables (the first two columns of Table 3) does not alter substantially the conclusions regarding economic variables that are obtained in Table 2. The inclusion of the full set of political variables (the last two columns of Table 3), although it does not affect the statistical significance of the variables, does in fact have some influence on the size of some relevant coefficients. Therefore, in analyzing the results of the 'economic variables', we will focus on columns (3c) and (3d), for transportation, and (3g) and (3h), for roads.

Thirdly, the results in these columns show that investment adjusts slowly towards its long-run value. The value of the adjustment coefficient ρ is 0.333 and 0.390, for

[32] These R^2 correspond to the equation with the full set of economic and political variables.

Table 6
Structural parameters of key variables

	Central government		Regional governments	
	Transportation	Roads	Transportation	Roads
Sluggishness (ρ)	0.333	0.390	0.208	0.301
	(7.632)***	(8.729)***	(8.722)***	(8.125)***
Substitutability (θ)	−0.093	−0.089	−0.120	−0.103
	(−2.514)**	(−2.700)***	(−2.104)**	(−2.371)**
Equity–efficiency trade-off (ϕ)	0.450	0.425	0.702	0.700
	(2.174)**	(2.640)***	(4.123)***	(3.793)***
Infrastructure needs:				
$\ln(Trucks/Y)$	0.177	0.279	0.336	0.315
	(2.080)**	(2.141)**	(2.774)***	(3.663)***
$\ln Km$	0.042	0.046	0.101	0.076
	(1.405)	(1.741)*	(2.003)**	(2.247)**
$\ln Air$	0.009	—	0.009	—
	(1.704)*		(2.879)***	
Electoral productivity:				
$\ln p \times d_3$	0.144	0.158	0.075	0.075
	(1.741)*	(2.241)**	(1.997)*	(2.007)**
$\ln p \times d_2$	0.186	0.197	0.137	0.124
	(2.310)**	(2.201)**	(2.244)**	(2.100)**
$\ln p \times d_1$	0.228	0.235	0.157	0.173
	(2.500)**	(2.345)**	(2.170)**	(2.135)**
$\ln p \times d_0$	0.270	0.273	0.219	0.222
	(2.241)**	(2.510)**	(2.307)**	(2.342)**

Notes: Statistics in brackets; *** = coefficient significant at the 99%, level ** = coefficient significant at the 95% level, * = coefficient significant at the 90% level. Only variables that appear to be statistically significant in some cases are included. Political variables other than electoral productivity are not considered here.

transportation and roads, respectively. In addition, the coefficient for investment made by other layers of government is negative and statistically significant. The θ parameter is around -0.09 in both cases. This result is consistent with the substitutability hypothesis.

Fourthly, the results also show that infrastructure investment is sensitive to per capita output growth and the coefficients are statistically significant at a conventional level. This happens irrespective of the category analyzed (i.e., transportation or roads). The coefficient is around 0.16 in both cases (3d and 3h), implying a value for ϕ around 0.40 (see Table 6 for the estimated values of structural parameters). According to this result, the central government does not exclusively follow an efficiency criteria when allocating infrastructure investment across regions (recall that this requires $\phi = 1$). The coefficient of population growth is nearly one less the coefficient of lagged investment in all the equations; moreover, the hypothesis that the sum of both coefficients is equal to one cannot be rejected, according to the Wald test. Therefore, the main results are consistent with the predictions of the theoretical model.

Fifthly, the growth in the output-share of transportation services (S^x), proxied by $\Delta \ln(Trucks_{t-1}/Y_{t-1})$, also has a positive and highly statistically significant impact on investment. The long-term effect (see Table 6) is 0.177 and 0.279, for transportation and roads, respectively. Therefore, although vehicle-intensity may be a better proxy for transportation service intensity in the case of roads, it has also a considerable effect in the case of other transportation infrastructures. The utilization variables appear to have a lower impact on investment. The growth in vehicle-kilometers ($\Delta \ln Km_{t-1}$) has a positive impact in all the equations, although the coefficient is significant only at the 90% level. The long-term coefficient of this variable (Table 6) is 0.042 and 0.046 for transportation and roads, respectively. So, the effect is higher (but not much higher) in the case of roads. Growing utilization of railroads, ports and airports also has a positive impact on transportation investment, although only the last variable is significant at the 90% level.

Sixthly, the political variables appear, in general, with the expected sign. Columns (3a) and (3c) for transportation, and (3e) and (3g) for roads, show the disaggregated results for the three components of *Electoral productivity*. Before discussing the sign and significance of the variables we should note that we include three different variables in the equation to measure each concept: The variable in levels interacted for the period not including the first year of the mandate ($d_0 + d_1 + d_2$), the variable in differences interacted with the first-year dummy (d_3), and the variable in levels corresponding to the previous mandate interacted with the first-year dummy. Just below the results for each variable we include a Wald test on 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 this test, this hypothesis cannot be rejected in any of those cases; this means that the effect of these variables increases steadily as the next election approaches. Note also that the coefficient 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 as expected (see Section 3). Regarding the effects of each variable, the impact of vote margin ($\ln(1/m_k)$) and turnover ($\ln t_k$) is statistically significant in most cases. This is not the case of the 'swing voters' variable ($\ln f_k$): Although the signs are as expected the coefficients are not in general statistically significant. We suspect that this may be due to multicollinearity problems, since the first two variables are correlated with the third one (i.e., with correlation coefficients equal to 0.541 and 0.631, respectively). If this is the case, it could be more efficient to re-estimate the equation imposing the constraint that the coefficient of the three variables is the same. This amounts to estimating the equation with the *Electoral productivity* variable ($\ln p_{ik}$). The results are shown in columns (3b) and (3d), for transportation, and (3f) and (3h) for roads. Most of the parameters are now statistically significant. Just below these results we provide a Wald test that indicates that the null hypothesis of equality of the coefficient of the three variables that compose $\ln p_{ik}$ cannot be rejected.

The remaining political variables have been included in Table 3 only in first-differences. This is because the Wald test on H_0: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta$ indicates that this hypothesis cannot be rejected (included just below the results for each variable). That is, the coefficients of the variables in levels are not statistically significant, which means that the effect of these variables is constant throughout the electoral cycle. Regarding specific variables, the effect of *pivotal representatives* on investment is positive and statistically significant, both for transportation and for roads. Regional parties giving support to the minority central government during the last socialist mandate were able to attract more investment projects to their region. The effect on investment of the *vote share* obtained in the region by the party of the central government is positive but is not statistically significant. However, *leftist regional governments* (i.e., those governed by the party that is also that of the central government) are able to attract more infrastructure investment to their jurisdictions. This effect is reinforced when the *Share of regional representatives* that is socialist increases. These two variables are statistically significant at the 95% level. Overall, the results of the political variables provide evidence in favour of the *Electoral productivity* model (Lindbeck and Weibull, 1988; Dixit and Londregan, 1998). The validity of the *Partisanship* model is mixed: Constituency support (i.e., *vote share*) does not influence investment (Cox and McCubbins, 1986) but central–regional partisan interaction does have some effect (Grossman, 1994).

Let us now move on to the discussion of the regional government's results. These are provided in Tables 4 and 5. Table 4 presents the results of the 'economic model' and Table 5 the results of the equation expanded to include the political variables. The organization of these tables is the same as that used before; the only appreciable differences are that, in this case, we include from the beginning the variables that aim to pick up the influence of the financial resources of each regional government, and that the set of political variables does not fully coincide with those of the central government. The results obtained are similar; because of this we only discuss the results that differ markedly from the previous ones.

Firstly, also in this case infrastructure investment adjusts slowly to its long-run level. The adjustment parameter ρ is equal to 0.208 and 0.301 for transportation and roads (see Table 6). These values are lower than those of the central government. Secondly, the coefficient estimated for the investment made by other layers of government is also negative and statistically significant. The θ parameter is around -0.12 and -0.10, for transportation and roads, respectively. These values are higher than those of the central government. Thirdly, the coefficient of per capita output is 0.146 and 0.211 for transportation and roads, respectively (see columns (3d) and (3h)). Although these values are similar to those of the central government, the long-run impact is much higher in this case, giving an inequality aversion parameter (ϕ) of 0.702 and 0.700 for transportation and roads, respectively. Therefore, the results suggest that Spanish regional governments seem to be more efficiency-oriented ($\phi \approx 0.7$) than the central government ($\phi \approx 0.4$). Fourthly, the results for the infrastructure needs variables are also similar. The coefficients of $\Delta \ln Km_{t-1}$ and $\Delta \ln Air_{t-1}$ are now statistically 95% significant in all the cases. The fact that adjustment is slower than in the previous case produces, however, higher long-run coefficients. For example, the long-run coefficient of $\Delta \ln(Trucks_{t-1}/Y_{t-1})$ is now 0.336 and 0.315, for transportation and roads, respectively. The long-run coefficient of $\Delta \ln Km_{t-1}$ is 0.101 and 0.076 (more or less twice as much as before).

Fifthly, the variables measuring *Electoral productivity* in this case also have the expected effect on infrastructure investment. In this case, both the *vote margin* ($\ln(1/m_k)$)

and '*swing voters*' ($\ln f_k$) had a statistically significant effect when introduced separately. This is not the case with *turnover* ($\ln t_k$), however, at least in the transportation equations. Again, multicollinearity may be behind these results. This conclusion is reinforced by the fact that all the coefficients become statistically significant when *Electoral productivity* ($\ln p_k$) is introduced alone into the equations. Moreover, as in the central government's case, the equality of coefficients of the different component of p_k cannot be rejected by a standard Wald test. The incumbent's *margin of representatives* in the regional government (i.e., the distance to the majority) has a negative impact on regional infrastructure investment: The safer the incumbents feel the less they try to buy votes with infrastructure projects. Finally, the electoral cycle dummies have the expected positive sign but they are significant only in the case of transportation investment. Sixthly, the results of the political variables measuring *Partisanship and other influences* are mixed. As in the central government's case, the incumbent's *vote share* has a positive impact on investment but the coefficient is not statistically significant. Therefore, neither in this case are we able to provide evidence on the *Partisanship* hypothesis (Cox and McCubbins, 1986). The other results in this category are that *Leftist regional governments* invest significantly less in infrastructures and that *Minority regional governments* tend to invest more, although the coefficient is 95% significant only in the case of transportation. Note that the effect of these three variables has been identified from first-differenced variables, as the Wald tests suggest that this is the appropriate specification. This means that these effects are constant throughout the electoral cycle. Seventh, the variables accounting for the budget constraint appear with the expected sign: Unconditional revenues ($\Delta \ln Rev_{it}$) and capital funds ($\Delta \ln Cap_{it}$) have a positive effect while debt has a negative effect ($\Delta \ln Debt_{it}$). The coefficient of capital funds (in most equations) and that of unconditional revenues (in the transportation equations) is not significant at conventional levels.

Finally, to get a comprehensive picture of all these results, see the structural parameter estimates presented in Table 6. To summarize, the results suggest that the main differences between the investment behavior of the central and regional governments are: (i) Regional governments need more time to adjust to the long-run equilibrium, (ii) are more inclined towards efficiency, and (iii) are more responsive to infrastructure needs. Results (i) and (iii) may seem incompatible. It can happen, however, that regional governments are in fact more responsive to regional needs, as some authors suggest (see, e.g., Seabright, 1996), but that financial constraints impede that they attend the demand quickly in the short run. This may have been the case of Spanish regional governments during the period, since they did not have substantial tax power and depended exclusively on transfers from the centre. Result (ii) can have two different explanations. Firstly, inequality within regional governments is much lower than inequality between regions and this may have some influence on the reduced taste for redistribution of regional governments. Secondly, the regional government results may be the consequence of the tastes for redistribution of different parties. To analyze this we repeated the estimation of the regional investment equation for two different samples: Left and right wing regional governments. Most of the results obtained were qualitatively similar but the inequality aversion parameter was much higher in the case of governments on the right ($\phi \approx 0.8$) than for governments on the left

($\phi \approx 0.4$).[33] In both cases the parameters are statistically significant. It seems therefore, that the differences in ϕ between the central and regional governments in Spain are due to ideological differences between the parties in control at different layers of government.

The bottom panel of Table 6 presents the long-run effects of the main political variable included both in the central and the regional investment equations (*Electoral productivity*). Using expressions (16) and (17a) we have computed the effects throughout the electoral cycle. Note that in all cases the effect is positive from the beginning and grows steadily as the new election approaches. The maximum impact occurs during the election year (d_0) and is around 0.27 and 0.22, for the central and regional governments respectively.[34] Note that these elasticities are lower than one, the elasticity predicted for this variable by the theory (see the appendix). This suggests that, in fact, political considerations only play a limited role in the allocation of infrastructure investment. The equity–efficiency trade-off, embedded in the ideological position of political parties or in legal and constitutional constraints must be responsible for this result.

5. Conclusions

This paper has analyzed the main determinants of transportation infrastructure investment allocation across regions. The investment equation is derived from a simple theoretical model that accounts simultaneously for an efficiency–equity trade-off, political factors and specific regional infrastructures needs. This equation has been estimated with data on transportation investment and capital stock in 50 Spanish NUTS3 regions. We have separately analyzed the investment made by the central and regional governments. The results suggest that both levels of government balance equity and efficiency in the allocation of infrastructure investment. Infrastructure investment by regional governments seems to be more inclined towards efficiency, although this may be due to the fact that the central government was governed by the left during all the period while leftist control of regional governments was not complete. Technical aspects influencing the output effects of transportation infrastructure provision (i.e., output-vehicle share, level of utilization) also appear to be relevant. However, government motives are not confined to the efficiency–equity trade-off: Political considerations also play a role in the regional investment allocation process. The government invests more in the regions where electoral productivity is higher.

We consider that the result obtained may be useful both in terms of valued added to the literature on the economic effects of infrastructures and in analyzing economic policy options. For example, both the theoretical model and the results suggest that infrastructure capital responds positively to output growth. This will ultimately mean that infrastructure capital should be considered as endogenous in production

[33] These results are not presented to save space but are available from the authors upon request.

[34] This value is similar to the obtained in the literature by Strömberg (2001) for the 'swing voters' variable with a cross-section of US counties.

function estimation. Although this concern has been raised by many authors (Duffy-Deno and Eberts, 1991; Tatom, 1991, 1993; Cadot et al., 1999; Fernald, 1999; Röller and Waverman, 2000) it is not always clear at all how to proceed to solve the econometric problem. Our results may help in the selection of instruments to be used in the estimation of the production function.

Another possible application of the results of the paper consists of combining the coefficient estimates (mainly that of the efficiency–equity trade off, ϕ) with an estimate of the output-elasticity of infrastructure capital to compute the efficiency loss of a given allocation rule. This result may help in order to appropriately judge the desirability of maintaining current redistributive regional policies. The model also allows us to calculate the possible welfare loss due to unequal treatment arising from political discrimination. A calculation like this would help to evaluate the need to maintain the actual ability of the central government to change regional investment allocation at will or, on the contrary, the appropriateness of a reform based on objective rules. This paper is only a modest step towards an understanding of the problems and further and deeper analyses would be needed in the future. Possible improvements and extensions may include, for example, the consideration of private transportation infrastructures, the proper treatment of nodal infrastructures, or the estimation of the effects of European regional funds on infrastructure investment made by different layers of government.

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Appendix. A simple political-economy model of infrastructure allocation

In this section, we sketch a simple model that accounts for the different political factors included in Section 3 under the heading *Electoral productivity*. The model is based on a simple reduced-form political objective function and we do not try to explicitly model the details of party competition. The current theoretical literature on party competition does not provide any empirically tractable model of multiparty competition. However, we feel that our approach helps in identifying the main political forces at work in Spain.

We assume that the party in the government tries to maximize the number of representatives obtained in the legislative election. More precisely, the objective function is the sum of the representatives obtained in each region (e_i) weighted by the (exogenous) probability (g_i) that a representative is pivotal in the formation of the government: $\sum_i g_{it}e_{it}$. The government allocates infrastructure investment across regions in order to maximize this function subject to the budget constraint. The FOC of this problem is

$$g_{it}\,\frac{\partial e_{it}}{\partial v_{it}}\,\frac{\partial v_{it}}{\partial (Y_{it}/N_{it})}\,\frac{\partial (Y_{it}/N_{it})}{\partial C_{it}}\,\frac{\partial C_{it}}{\partial I_{it}}-\lambda_t=0.$$

That is, the marginal political benefit of allocating investment to a region should be equal to the marginal political cost of public funds. The marginal benefit is equal to the product of: (i) the probability of a pivotal representative (g_{it}), (ii) the marginal effects of votes on representatives ($\partial e_{it}/\partial v_i$), (iii) the effect of output on votes ($\partial v_{it}/\partial(Y_{it}/N_{it})$), and (iv) the effect of investment on output ($\partial(Y_{it}/N_{it})/\partial C_{it}$). The $\partial e_{it}/\partial v_{it}$ term captures the probability of gaining or losing a representative (r_{it}), and can be measured as $r_{it}=1/m_{it}$, where m_{it} are the votes that are needed to gain/lose a representative. To find an expression for $\partial v_{it}/\partial(Y_{it}/N_{it})$, the number of votes can be expressed as $v_{it}=N_{it}t_{it}F(Y_{it}/N_{it})$, where N_{it} is population, t_{it} is electoral turnover (assumed to be exogenous), and $F_i(Y_{it}/N_{it})$ is the vote share of the incumbent, F_i being a regional-specific incumbent's vote distribution function. Using these expressions we obtain: $\partial v_{it}/\partial(Y_{it}/N_{it})=N_{it}t_{it}f_{it}$ where f_{it} is the density at the cut-point and measures the effect of 'swing voters' (i.e., voters that are indifferent between the incumbent and the challenger). Once we have substituted this in the FOC and accounting for the effects of infrastructure on output we obtain

$$g_{it}r_{it}t_{it}f_{it}\omega S^x_{it}E^c_{it}(1/\varsigma_i)\frac{Y_{it}}{C_{it}}-\lambda_t=0.$$

Then, taking logs, we obtain an expression for the capital stock desired by the government:

$$\ln C_{it}=B_{it}+\ln Y_{it}+\ln S^x_{it}+\ln E^c_{it}+(\ln g_{it}+\ln r_{it}+\ln t_{it}+\ln f_{it}).$$

Note that this expression is very similar to the one in (7). In fact, they are equivalent once one sets $\phi=1$ and identifies the terms in parenthesis with the unequal treatment factors (i.e., $\ln\Psi_{it}\approx\ln g_{it}+\ln r_{it}+\ln t_{it}+\ln f_{it}$).

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