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Contribution to Productivity or Pork Barrel?
The Two Faces of Infrastructure Investment

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Contribution to Productivity or Pork Barrel?

The Two Faces of Infrastructure Investment [*]

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Abstract

This paper proposes a simultaneous-equation approach to the estimation of the contribution of transport infrastructure accumulation to regional growth. We model explicitly the political-economy process driving infrastructure investments; in doing so, we eliminate a potential source of bias in production-function estimates and generate testable hypotheses on the forces that shape infrastructure policy. Our empirical findings on a panel of France's regions over 1985-92 suggest that electoral concerns and influence activities were, indeed, significant determinants of the cross-regional allocation of transportation infrastructure investments. By contrast, we find little evidence of concern for the maximization of economic returns to infrastructure spending, even after controlling for pork-barrel.

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1 Introduction

The contribution of public infrastructure capital to growth is still today a largely unsettled question in spite of a massive amount of research sparked by the influential work of Aschauer (1989a, b). Early studies of the link between public capital and growth were fraught with logical and econometric difficulties, the most important of which are discussed by Gramlich (1994) and, more recently, by Haughwout (2002). In addition to the important aggregation issues discussed by Haughwout, some authors argued that the direction of causation was unclear (see Eisner, 1991; Tatom, 1993; or Holtz-Eakin, 1994). For instance, Holtz-Eakin remarked that "it is tempting to infer a causal relationship from public-sector capital to productivity, but the evidence does not justify this step. It is just as easy to imagine the reverse scenario in which deteriorating economic conditions reduce capital-stock growth" (1994, p. 12). Disagreement over the meaning of elasticity estimates was not limited to time-series studies. Holtz-Eakin (1988), Munnell (1990a,b) and Garcia-Milà (1992) also found positive elasticities of output to public capital using panel data at the state level (although their estimates were smaller than Aschauer's) but state-level evidence was vulnerable to similar criticism: quoting again Holtz-Eakin (1994, p. 13), "[b]ecause more prosperous states are likely to spend more on public capital, there will be a positive correlation between the state-specific effects and public sector capital. This should not be confused, however, with the notion that greater public capital leads a state to be more productive". Holtz-Eakin's own approach consisted of introducing fixed effects in the specification of the error structure in order to control for unobserved state characteristics. But, as he himself remarked (p. 13), "in doing so the investigator ignores the information from cross-state variation in the variables", which is of course unfortunate given that in a panel of short duration a substantial part of the information comes, precisely, from the data's cross-sectional variation.

This paper addresses the endogeneity issue directly,[1] by using simultaneous-equation estimation (see Hulten, 1995 for a discussion; see also Tatom, 1993). A few authors followed this approach, e.g. Duffy-Deno and Eberts (1991) or Flores de Frutos and Pereira (1993), and nevertheless found significant elasticities of output to infrastructure capital. But the key question, if one believes that the endogeneity issue matters, is how infrastructure in-

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[1]By "endogeneity issue" we mean endogeneity of public infrastructure investments. By contrast, unlike Haughwout (2002) we do not consider endogenous location of firms or households. The issue is discussed further in section 3.2 below.

vestment decisions should be modelled. Clearly, the "second equation" should be grounded in a theory of how public infrastructure investment decisions are made. Indeed, Gramlich (1994) rightly points out that the primary interest of the infrastructure debate is not so much in the battle over elasticity estimates as in the implied policy debate. In his words, "rather than asking whether there is a shortage, it seems more helpful to ask what, if any, policies should be changed" (p. 1190). This type of normative question presupposes that institutions and policy choices are designed to maximize social welfare. But are they? A growing literature, at the frontier of economics and political science, views economic-policy decisions as resulting from the maximization by incumbent politicians of objective functions that may depart from social welfare, under constraints that are primarily political (see Dixit, 1996; Drazen, 2000; Persson and Tabellini, 2000; or Grossman and Helpman, 2001, for recent surveys).

In this perspective, the present paper is a contribution to bridging the gap between the infrastructure and political-economics literatures (see also, *inter alia*, Crain and Oakley, 1995, Besley and Coate, 1998, Lizzeri and Persico, 2001, or Milesi-Ferretti, Perotti and Rostagno, 2002). A number of theoretical approaches are available to model the relevant decision-making processes, depending on the institutional context (e.g. direct vs. indirect democracy, legislature involvement vs. delegation to executive agencies) and on behavioral assumptions (e.g. partisan vs. opportunitistic politicians). As infrastructure investment is not an area in which partisanship creates strong dividing lines, we use a model with office-motivated politicians and probabilistic voting, to which we add influence activites. The model is then tested on a French data set. Using French data has both benefits and costs. On one hand, widespread accusations of corruption and pork barrel, in the press and elsewhere,[2] give a fairly strong prior in favor of their existence. On the other hand, there is little transparency about contributions from lobbies which are, unlike in the US, neither published nor even officially recorded, and consequently cannot be observed directly.

In order to proxy for lobbying, we assume that firms have sunk investments giving them vested interests in the quality of the infrastructure in regions where they have production units ("establishments"). We also posit that a firm with a large establishment in a given region should be expected to lobby harder than other firms for the maintenance and upgrading of that region's infrastructure, for three reasons. First, large establishments

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[2]See e.g. de Closets (1992), Mény (1992), Etchegoyen (1995), Lorenzi (1995), or "100 lobbies qui font la loi en France", *Capital*, June 18, 1998.

produce, on average, for more distant markets (as higher volumes must be absorbed by wider geographical areas); as a result, they use highways and railways more intensively than others and are consequently more concerned about their maintenance and upgrading. Second, large establishments are typically owned by firms with headquarters in Paris; those firms are likely to be in a better position to effectively reinforce local lobbying by direct access to national policy-makers. Third, although we do not deal explicitly with collective-action problems in mobilizing local political resources, such problems are likely to be easier overcome for a few firms with large stakes, such as Michelin in Auvergne or Citroën in Bretagne, than for a host of small or medium-sized local firms. For all these reasons, we take the number of large establishments in a region as a proxy for the intensity of that region's lobbying for transportation infrastructure investment.

Although this indirect approach by itself may not be powerful enough to provide unambiguous evidence of pork barrel, the combination of voting with lobbying in the model generates a number of testable results, including, as is typical in voting models, a disproportionate share of favors going to swing voters. The importance of the latter in each region is proxied with two alternative variables. The first is the difference, in absolute value, between the scores of the right-wing and left-wing coalitions in recent elections. This is not really a 'swing voter' variable, but rather a measure of how heated the electoral race was, which is slightly different but nevertheless also conducive of political favors. The second is the combined score of Jean-Marie Le Pen's *Front National* and a fringe hunters' party called *Chasse, pêche, nature et tradition.* The rationale for taking the *Front National* as a measure of swing voters is as follows. Although the party's platform is clearly at the extreme right wing of the political spectrum,[3] a number of observers[4] have noted the heterogeneity of its constituency, which includes, *inter alia*, disgruntled communist voters attracted by Le Pen's populist anti-establishment themes as much as by his right-wing ones (law and order and social conservatism). Similarly, the hunters' party, important in the Southwest, is essentially anti-Brussels and anti-environmentalist. During our sample period, the Socialists had not yet concluded any alliance with the Green party, and had in fact fairly bad relations with Greenpeace and environmentalist groups. Thus, the hunters-vs.-environmentalists is-

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[3]Created in 1972 and led since then by Jean-Marie Le Pen, the *Front National* is an extreme-right wing party whose rhetoric is a mixture of social conservatism, anti-establishment populism, protectionism and xenophobia.

[4]See for instance Mayer and Perrineau (1996), Chiche and Rey (1995), Franceries (1993).

sue cut across the left-wing/right-wing divide, and using pork-barrel politics to try and woo hunters or Le Pen voters made sense for either right-wing or left-wing governments.

Indeed, the data suggests that this is precisely what they did, as both measures of pork barrel (lobbying- and vote-based) tell essentially the same story. Although vote-based evidence of pork barrel is more direct than lobby-based, our estimates of electoral and lobbying influences should be seen as complementary rather than as a test of one hypothesis against the other. However, the simultaneity bias from estimating a production function alone turned out to be negligible, as single-equation elasticity estimates are almost identical to those obtained by simultaneous estimation of both equations. The reason is that infrastructure stocks are too large relative to investments for feedback influences to be felt over a sample period of less than a decade.

The remainder of this paper is organized as follows. In section 2, we set up a simple stripped-down model highlighting how electoral and lobbying incentives interact to shape the policy choices of elected politicians. In section 3, we report the results of empirical testing of the model's hypotheses on a French data set. Section 4 concludes.

2   The model

Consider the following problem. A country is made of two regions indexed by $j = 1, 2$, and a decision must be made on what quantity of a local public good x should be supplied in region one,[5] given that it is financed by a nationwide linear income tax. Prior to the decision, an election is held nationally and the only issue on which two candidates A and B position themselves is "how much x should be built in region one". In each region, voters have identical, single-peaked preferences over the interval of feasible values for x. Region j's population is a fraction α_j of the country's total population, which is also taken as its electorate and is normalized to equal one (so per-capita and aggregate variables are the same).

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[5]Restricting the set-up to one local public good only makes it possible to cast the story in a simple and tractable framework. A limited form of multi-dimensionality (two local public goods instead of one) is considered in the appendix along the lines of Blomquist and Christiansen (1999). As can be seen (and is well-known in the political-economy literature) multidimensionality vastly complicates matters but the flavor of the results is essentially the same.

2.1 Preferences

Letting U_j be the utility function of a representative voter in region j and c_j her consumption of an aggregate of private goods, taken together as the numéraire,

$$U_j\left(c_j, x\right) = c_j + u(I_j x) \tag{1}$$

where $u(.)$ is an increasing, concave function with $\lim_{x \to \infty} u'(x) = 0$ and $\lim_{x \to 0} u'(x) = \infty$, and I_j is an indicator function equal to one if $j = 1$ and zero otherwise. Let τ be the flat rate of an income tax, and y_j the representative voter's income. Her budget constraint is then

$$c_j = (1 - \tau)\, y_j$$

which, upon substitution into (1), gives the indirect utility function

$$V_j\left(\tau, y_j, x\right) = (1 - \tau)\, y_j + u(I_j x). \tag{2}$$

Let $y = \alpha_1 y_1 + \alpha_2 y_2$ be national income. The government's own budget constraint implies

$$x = \tau y$$

which can be substituted into (2), giving finally

$$v_j\left(y_j, x\right) = \left(1 - \frac{x}{y}\right) y_j + u\left(I_j x\right). \tag{3}$$

The socially optimal provision of x, x^*, is the solution to

$$\max_x \ \alpha_1 v_1 + \alpha_2 v_2$$

which, after substituting from (3) and taking the first-order condition, gives

$$u'(x^*) = 1/\alpha_1. \tag{4}$$

As u' is a decreasing function of x, the amount of public good provided in region one is (unsurprisingly) an increasing function of its size. With only one region condition (4) would become $u'(x) = 1$. Conversely, if region one were to shrink to zero, the following limit would apply:

$$\lim_{\alpha_1 \to 0} x^* = 0.$$

Regional preferences naturally differ from the national social optimum. Let x_1 the amount preferred by voters in region one and x_2 the amount preferred by voters in region two (both with regard to the amount of public good provided *to region one*). Differentiating (3) with respect to x gives respectively

$$u'(x_1) = y_1/y \tag{5}$$

and

$$x_2 = 0.$$

The second result is obvious: region two pays but does not get anything and therefore opposes any positive amount of x. The first one shows that region one wants more of the public good than is socially optimal. To see this, observe that $y_1/y < 1/\alpha_1$ is equivalent to $\alpha_1 y_1 < y$ which is always true provided that $\alpha_2 y_2 > 0$.

2.2 Electoral competition and lobbying

2.2.1 Politicians

Let x^A be the amount of x announced as an electoral platform by candidate A and similarly for B. Platforms are binding. Candidates are neither pure office-seekers as in Downs' (1957) nor pure partisans as in Wittman (1973) or Blomquist and Christiansen (1999). Instead, they maximize an expected rent equal to the product of the probability of being elected times an office rent, itself made of two components. The first is an exogenous term ρ that should be thought of as a pure ego rent. The second is an endogenous term $R(x)$ that should be interpreted as a post-political life reward (position on a board or so) offered by a lobby interested in x and conditioned on the policy promised and implemented. Thus, $R(x)$ can be reaped by A only if A has been voted in. Candidate A's utility is

$$v^A = \begin{cases} \rho + R(x^A) & \text{if } A \text{ is elected} \\ 0 & \text{otherwise.} \end{cases}$$

Let $\pi^A(x^A, x^B)$ be the probability that candidate A is elected given platforms x^A and x^B. Candidate A's problem is thus

$$\max_{x^A} \pi^A(x^A, x^B) \left[\rho + R(x^A) \right].$$

The presence of $R(x^A)$ in the maximand implies a trade-off for candidate A: placating voters to get elected or placating the lobby to get a fat reward should he get elected.

2.2.2 Voters

Voting is probabilistic, and voting decisions have three determinants.[6] The first is the utility differential implied by the two platforms, $\Delta v_j = v_j(x^A) - v_j(x^B)$, which, upon substitution of (3), can be written as

$$\Delta v_j = u\left(I_j x^A\right) - u\left(I_j x^B\right) - \left(x^A - x^B\right) y_j/y. \tag{6}$$

The second is an exogenous, nationwide popularity factor ι in favor of A. The third is a random shock σ_{ij} whose realization is individual (hence the index i) but i.i.d (independantly and identically distributed) across individuals in region j (hence the index j). The distribution of σ_{ij} is uniform over the interval $[-1/2b_j; 1/2b_j]$, which implies that it is centered on zero, and common knowledge. Finally, its realization is known only at the time of voting, i.e. after candidates have announced their (binding) platforms.

The role of σ_{ij} and its "variable support" distribution is to characterize the volatility of regional electorates. A high value of b_j means a narrow support for the distribution of σ_{ij}. In order to fix ideas, take two extreme cases: $b_j = 0$ and b_j "very large". In the former case, the random component of voting behaviour disappears and an arbitrarily small departure of x^A from x^B in the direction opposite to region j's preferred value would make A lose all of j's votes at once. Conversely, with a very wide support (b_j large), no matter how far x^A is from x^B in the wrong direction, a realization of σ_{ij} sufficiently large to make j's voters prefer A is nevertheless possible.

Conditional on the realization of σ_{ij}, the probability that voter i in region j votes for A is

$$\pi_{ij}^A = \pi_{ij}(x^A, \sigma_{ij}) = \begin{cases} 1 & \text{if } \Delta v_j + \iota > \sigma_{ij}, \\ 1/2 & \text{if } \Delta v_j + \iota = \sigma_{ij}, \\ 0 & \text{otherwise.} \end{cases} \tag{7}$$

Let $\sigma_j = \Delta v_j + \iota$ be the value of σ_{ij} characterizing class j's "marginal voter", i.e. the voter who is just indifferent between A and B. By the assumption that preferences are single-peaked, σ_j is unique, all voters i such that $\sigma_{ij} < \sigma_j$ vote for A, and all such that $\sigma_{ij} > \sigma_j$ vote for B. Ex ante (before the realization of σ_{ij}), all voters in region j are identical since σ_{ij} is i.i.d. Let $\pi_j^A = \pi_j(x^A)$ be the (unconditional) probability that any one of them votes

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[6]The treatment of voter behaviour here follows Persson and Tabellini's error-distribution model (Persson and Tabellini, 2000).

for A. Given that the distribution of σ_{ij} is uniform over $[-1/2b_j; 1/2b_j]$,

$$\pi_j^A = \text{ prob } (\sigma_{ij} < \sigma_j) = \frac{\sigma_j + 1/2b_j}{1/2b_j + 1/2b_j} = \frac{1}{2} + b_j\sigma_j. \tag{8}$$

This is the probability that a representative region-j individual votes for A and is also A's expected share of region j's vote. A's expected share of the vote nationwide, π^A, is then

$$\pi^A = \sum_{j=1}^{2} \alpha_j \pi_j^A = \sum_j \alpha_j \left(\frac{1}{2} + b_j\sigma_j \right) = \frac{1}{2} + \sum_j \alpha_j b_j \sigma_j. \tag{9}$$

Substituting for σ_j, we have

$$\pi^A = \frac{1}{2} + \sum_j \alpha_j b_j \left(\Delta v_j + \iota \right),$$

which is everywhere a continuous function of x^A given x^B.

2.3 Electoral equilibrium

Candidate A's problem is to maximize π^A by choice of x^A given x^B, i.e. to solve

$$\max_{x^A} \left[\frac{1}{2} + \sum_j \alpha_j b_j \left(\Delta v_j + \iota \right) \right] \left[\rho + R(x^A) \right] \tag{10}$$

and candidate B's problem is

$$\max_{x^B} \left[\frac{1}{2} - \sum_j \alpha_j b_j \left(\Delta v_j + \iota \right) \right] \left[\rho + R(x^B) \right] \tag{11}$$

It is apparent from the form of (10) and (11) that in equilibrium both candidates offer the same platform ($x^A = x^B$) and election probabilities are just equal one half each ($\pi^A = \pi^B = 1/2$). Identical platforms come in this case from the fact that both candidates cater to the wishes of the same lobby. If they each had a favored lobby and the lobbies had extreme positions, platforms would be pulled in opposite directions as if candidates were partisan.

Given the equilibrium's symmetry, we analyze A's platform only. Taking the first-order condition of (10) after substituting for Δv_j from (6) and rearranging gives

$$\phi(x^A) \equiv \left[\alpha_1 b_1 u'(x^A) - \left(\alpha_1 b_1 y_1 + \alpha_2 b_2 y_2 \right) / y \right] \left[\rho + R(x^A) \right] + \pi^A R'(x^A) = 0, \tag{12}$$

or, after rearrangement,

$$u'(x^A) = \frac{1}{y} \left[y_1 + \frac{\alpha_2 b_2}{\alpha_1 b_1} y_2 \right] - \frac{\pi^A R' \left(x^A \right)}{\alpha_1 b_1 \left[\rho + R(x^A) \right]}. \tag{13}$$

In order to interpret this expression, consider first the case where lobbying plays no role because the reward function is flat ($R' = 0$). Then (13) reduces to

$$u'(x^A) = \frac{1}{y}\left[y_1 + \frac{\alpha_2 b_2}{\alpha_1 b_1} y_2\right]. \tag{14}$$

The social optimum is attained if regions one and two are of equal electoral sizes ($\alpha_1 = \alpha_2 = 1/2$) and have the same electoral behaviour ($b_1 = b_2$) because then (14) reduces to

$$u'(x^A) = \frac{y_1 + y_2}{y} = \frac{y_1 + y_2}{(y_1 + y_2)/2} = \frac{1}{\alpha_1} = u'(x^*).$$

The effect of an increase in b_1 can be seen as follows. Under the second-order condition (which is easily shown to hold), $\partial\phi/\partial x^A < 0$ since ϕ is the objective function's first derivative. Writing ϕ and ϕ' as functions of the choice variable x^A and parameter b_1, we have, at the optimum,

$$\frac{\partial\phi}{\partial x^A}\frac{dx^A}{db_1} + \frac{\partial\phi}{\partial b_1} \equiv 0,$$

so dx^A/db_1 has the sign of $\partial\phi/\partial b_1$. Taking the partial derivative of (12) with respect to b_1 at the equilibrium gives

$$\left.\frac{\partial\phi}{\partial b_1}\right|_{x^A=x^B} = \alpha_1\left[u'\left(x^A\right) - \frac{y_1}{y}\right]\left[\rho + R(x^A)\right].$$

Thus dx^A/db_1 has the sign of $u'(x_1) - y_1/y$. This expression is zero at region one's preferred level of x (see (5)), and is positive for lower values of x. Absent any lobbying, by (14) the electoral outcome is always less than region one's preferred level, so swing voters get more in equilibrium.

Consider now the lobbying effect. Electoral motives are "neutralized" by setting $b_1 = b_2 = b$ for some arbitrary value of b. Then (12) reduces to

$$\left[\alpha_1 b_1 u'(x^A) - b\right]\left[\rho + R(x^A)\right] + \pi^A R'(x^A) = 0$$

or

$$u'(x^A) = \frac{1}{\alpha_1} - \frac{\pi^A R'\left(x^A\right)}{\alpha_1 b\left[\rho + R(x^A)\right]}. \tag{15}$$

Recall that $1/\alpha_1$ is, by (4), the socially optimal level of x. Thus, x^A departs from the social optimum by the second term, which reduces the expression's right-hand side given that $R' > 0$. Thus, lobbying raises the value of x^A above the social optimum.

The lobbying term highlights an interesting effect of incumbency or popularity advantages. Given that π^A is a linearly increasing function of A's popularity factor ι, a higher

value of ι raises the second term of the RHS of (15). This reduces the algebraic value of the RHS, which reduces the LHS, which, since u' is a decreasing function, raises x^A. So for a given reward function a strong, popular incumbent will be more inclined to placate the lobby than a little-known challenger because the latter discounts the reward by the probability of not getting elected. This means that, ceteris paribus, the platforms of opposition parties with little chances of winning can be expected to be less polluted by special interests than those of strong parties with exogenously-high chances of being elected. This suggest that parties having been in power for long uninterrupted stretches —such as the Gaullists in France during the 1960's or the PRI in Mexico— seemed so cozy with domestic lobbies not just because of the familiarity created by repeated interaction, but also because taking reelection for granted tilts politician incentives away from electoral motives and in favor of lobbies.

A strong rent from being in office (high ρ) has the opposite effect because it raises the intrinsic value of being in power relative to the extrinsic motivation of getting rewarded later on.

Electoral and lobbying incentives act as perfect substitutes in (12) since their effects are additive. But the combination adds a twist to the "swing-voter" effect. Suppose that the lobby is so aggressive, i.e. that R' is so high, that x is pushed beyond y_1/y, the level preferred by region one's voters. Then electoral and lobbying motives work at cross-purposes, as region one's voters would rather have less and pay lower taxes. This suggests an indirect (and admittedly limited) test of the strength of lobbying influences: if the volatility of a region's electorate leads, in equilibrium, to more of the public good being provided to that region, then as per the model's logic lobbying influences can be interpreted as "not so strong".

Although highly simplified, the model outlined so far is suggestive of a number of variables that can be considered as likely drivers of infrastructure investment decisions. The following section takes some of these hypotheses to the data.

3   Empirical estimation

In this section, we estimate simultaneously a system of two equations. The first is a production function $Q = f(K, L, X)$ of the Cobb-Douglas form:

$$\ln Q_{it} = \alpha_{0t} + \alpha_\ell \ln L_{it} + \alpha_k \ln K_{it} + \alpha_x \ln X_{it} \tag{16}$$

where, using subscripts i for regions and t for time, aggregate value added at the regional level (Q_{it}) is regressed in log form on fixed time-effects (α_{0t}, $t = 1 \ldots T$), employment (L_{it}) and the stocks of capital (K_{it}) and transportation infrastructure equipment (X_{it})..Using lowercase letters to denote variables per worker, so $q_{it} = Q_{it}/\ell_{it}$, and so on, (16) can be rewritten as

$$\ln q_{it} = \alpha_{0t} + \widetilde{\alpha}_\ell \ln \ell_{it} + \alpha_k \ln k_{it} + \alpha_x \ln x_{it},$$

where $\widetilde{\alpha}_\ell = \alpha_k + \alpha_x + \alpha_\ell - 1$. Constant returns to scale are rejected if $\widetilde{\alpha}_\ell$ is estimated to be significantly different from zero. The second equation is a "policy function"

$$z_{it} = \theta_{0t} + \theta_2 L_{it} + \theta_3 e_{it} \tag{17}$$

where regional infrastructure investments per worker z_{it} (the "per-worker" normalization controls for heterogeneous region sizes) are regressed on time effects (θ_{0t}), a measure of lobbying capacity (L_{it}, the number of large firms), and a vector e_{it} of proxies for electoral concerns. The results reported below are based on a linear form for ψ; a log form was tried with similar results. We also estimated (17) with L_{it} replaced by L_{it}/ℓ_{it}, the number of large firms per worker, with similar although slightly less significant results.

3.1   Data and Summary Statistics

We use a panel data set covering 21 of France's 22 regions (we excluded Corsica because of its poor data) over 1985-92. Table 1 provides a brief description of the variables and a list of the relevant regions. All figures are in 1992 Francs. Q (henceforth VAL) is measured as value added at factor cost and has been obtained from the Eurostat database 'New Cronos' (June 1999). Regional employment ℓ (EMP) is also taken from 'New Cronos' and covers all private sectors of the economy. The private capital stock k (CAP) is constructed by the *Laboratoire d'Observation Economique et des Institutions Locales* (OEIL) using national data from INSEE's *Compte de Patrimoine* and allocating the national stock to the regions on the basis of corporate tax rates.

The transportation infrastructure stock X ($INFRAST$) is constructed as follows. As stock data was not available at the regional level, we construct the stock from investment data using the perpetual inventory method (PIM). In order to obtain a benchmark stock level for the initial period, we allocate the national stock, for which data is given by the *Fédération Nationale des Travaux Publics* (FNTP, see also Laguarrigue, 1994) across the

21 regions in proportion to their average investment share over the first three years of the sample period. The relatively slow rate of depreciation of infrastructure capital implies that our stock converges slowly to the true one. In order to reduce possible biases in the calculation of the infrastructure stock we use infrastructure investment data going back to 1975. Aggregating our regional stock data to the national level and comparing it with national data obtained from INSEE yields only marginal differences.

The transportation infrastructure investment data (INV) come from several sources. Railway figures were provided directly by SNCF, the national railway company. Highway figures, which are reported for the year in which the work is done (rather than for the year of budget allocation—there is a delay between the two) have been collected by the OEIL from data generated by the FNTP (see Fritsch and Prud'homme, 1994, for details). The FNTP's data are based on reports by the Federation's member companies. Finally, investment data for waterways was taken directly from the FNTP's statistical yearbook. Although airport construction data, which we had collected from the *Direction Générale de l'Aviation Civile* (DGAC), would have been a natural inclusion in the study, we found that they were not sufficiently reliable and consequently eliminated them from this study.

The number of industrial establishments with more than 500 employees ($LARGE$), our proxy for lobbying forces, is taken from various issues of *L'Industrie dans les Régions,* a yearly statistical publication of the Ministry of Industry.

As for our electoral-concern proxies, the first is $DIFF$, the difference in absolute value between the electoral scores of the left-wing and right-wing coalitions in the 1986 and 1992 regional elections.[7] $DIFF$ is not a proxy for the proportion of swing voters, since it is the outcome of the vote rather than a characteristic of voters. However, inasmuch as it is correctly anticipated, a close race can be taken, somewhat loosely, as conducive to pork-barrel, because it raises the probability of affecting the outcome with any given amount of spending and consequently raises the marginal profitability of spending. Thus, the parameter estimate on $DIFF$ should intuitively be expected to have a negative sign in the policy equation. The second proxy, $LEPEN$, is the combined score of the *Front*

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[7] "Right wing" was defined in the sample as RPR, UDF and "Divers Droite". Given that mainstream right-wing parties refused to form alliances with the far-right Front National, the latter was excluded from the definition of the right wing. "Left wing" was defined as Parti Socialiste, Parti Communiste, Mouvement des Radicaux de Gauche, and Generation Ecologie, a pro-government environmentalist party, but excluded "Les Verts", a more radical one which formed an alliance with the Socialists only later on, and "Divers Gauche". The "Divers Gauche" and "Divers Droite" categories classify independent individuals according to their voting patterns. For instance, *France Unie* is classified as "Divers Droite" before it rallied the Presidential majority in 1988, and "Divers Gauche" thereafter.

National and *Chasse, Pêche, Nature et Tradition.* This is, according to our reasoning about the nature of the *Front National* constituency, a more direct measure of the proportion of at least one type of swing voters. In the presence of a common-pool problem, swing voters want more spending: the $LEPEN$ coefficient estimate should therefore have a positive sign. Finally, $INCUMB$ is the incumbent's margin, which is one possible measure of the parameter ι: as a higher exogenous probability of winning reinforces the power of the lobby's incentive, a higher value of $INCUMB$ should induce more spending, and its parameter estimate should accordingly be positive. Moreover, as ι and R' enter multiplicatively in (13), we expect a positive and significant parameter estimate on the interaction term $INCUMB*$ $LARGE$.

For off-election years, we have tried three different formulations for $DIFF$ and $LEPEN$: a backward-looking one using the *previous* election's score, a forward-looking using the *next* election's score, and a mixture with moving weights, reflecting increasing accuracy and influence of opinion polls as elections approach. All three yielded qualitatively similar results, with slightly better ones for the third approach (mixture), which is the one we report in Table 3. For $INCUMB$, only the forward-looking formulation makes sense. Finally, the dummy variable $PARTY$ is equal to one when the majority in a Regional Council (and hence the affiliation of the region's President) and that of the government are either both right-wing or both left-wing, and zero otherwise. Thus, $PARTY$ picks up specifically that part of spending that is decided upon in Paris and that is targeted at local political allies. As our sample includes two regional elections (in 1986 and 1992) and two national legislative elections (in 1986 and 1988), $PARTY$, which was constructed using press sources, varies both across regions and across time. We have lagged all electoral variables by one year to take account of budget delays.

<div align="center">TABLE 1 HERE</div>

Table 2 shows descriptive statistics for these variables. In 1992 Francs, over the sample period, average infrastructure investment amounted to 1396 Francs per worker, or roughly 0.54 percent of GDP; the infrastructure *stock* amounted to $50,920$ Francs per worker, or 19.8 percent of GDP. The value of the highway infrastructure stock was about 5 times that of the railway stock and 70 times that of the waterways infrastructure stock.

<div align="center">TABLE 2 HERE</div>

<div align="center">13</div>

3.2 Estimates

Slightly rewriting (16) and (17), the system to be estimated is thus:

$$\ln VA_{it}/EMP_{it} = \alpha_t + \alpha_k \ln(CAP_{it}/EMP_{it}) + \alpha_\ell \ln EMP_{it}$$
$$+ \alpha_x \ln\{[(1-\delta_t)*INFRAST_{it-1} + INV_{it}]/EMP_{it}\} + \alpha_p PARIS + \nu_{1it}, \tag{18}$$

$$INV_{it}/EMP_{it} = \theta_t + \theta_1 \alpha_x VA_{it}/INFRAST_{it-1} + \theta_2 LARGE_{it-1}$$
$$+ \theta_3 DIFF_{i,t-1} + \theta_4 LEPEN_{i,t-1} + \theta_5 PARTY_{i,t-1} + \nu_{2it}, \tag{19}$$

where $\nu_{kit} = \rho_k \nu_{ki,t-1} + \varepsilon_{kit}$, $k = 1,2$, and ε_{kit} are i.i.d. normal variables with mean zero and variance σ_k. The term $\alpha_x VA_{it}/INFRAST_{it-1}$ is themarginal product of infrastructure capital and is included to control for an (out-of-model) economic motivation in infrastructure spending decisions. Although this term is not suggested by the theory, its inclusion reduces the scope for omitted-variable bias in the results.

We do not impose constant returns to scale in the production function. As for the infrastructure stock variable, we have decomposed it into the sum of a lagged, depreciated value of the stock ($(1-\delta_t)*INFRAST_{it-1}$) plus gross investment measured at end of period. The endogenous variable is INV_{it}. In the policy function, the term $\theta_1 (\alpha_x VA_{it}/INFRAST_{it-1})$ picks up the effect of the marginal product of the infrastructure stock (with a Cobb-Douglas production function, this is $\alpha_x q/x$).

The estimation procedure is as follows. We estimate (18) and (19) simultaneously by non-linear Full-Information Maximum Likelihood (FIML),[8] using a Prais-Winston transformation which avoids omitting observations for $t = 1$, (Greene 1997, p. 601). We obtain the autocorrelation parameters ρ_k, $k = 1,2$, in a first step by consistent estimates. The results are reported in Table 3.

Endogeneity of the number of large establishments is a potential source of problem. Indeed, regional private capital stocks could be expected to be affected by regional levels of transportation infrastructure if firm location is endogenous (on this, see Aschauer 1989b; see also Combes and Lafourcade (2001) for a recent attempt to estimate the effects of transportation cost declines on the location of economic activity in France). However, we performed a Hausman test and found that endogeneity of the private capital stock and employment were both rejected at the 5% level. The reason may be that the private capital stock includes a substantial fraction of small and medium-sized local companies whose

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[8]Estimations have been carried out using PROC MODEL, SAS 8.02.

inter-regional mobility is limited. It may also be that net investments are too small relative to stocks of existing capital for feedback effects to be felt significantly in the stocks over our relatively short sample period. Having treated explicitly the endogeneity bias on the infrastructure stock and having found it to be nonexistent (more on this below), given also the test's results, we feel reasonably confident that any endogeneity bias on the private capital stock would be small enough to leave our empirical results largely unaffected. We therefore leave for further research the treatment of location-related issues. By contrast, the endogeneity problem cannot be brushed aside so easily for large firms, which are likely to be more mobile than small ones. Short of specifying a full location equation, we have instrumented the number of large establishments with its lagged value (without much change in the results, lending further support to our argumentation above).[9] Similar endogeneity issues arise for election results, which might arguably be sensitive to infrastructure allocation decisions. Of the two regional elections in our sample period (1986 and 1992), only the 1992 is a potential problem, since the 1986 is one year after the beginning of our sample and can accordingly be taken as largely predetermined. Instrumenting 1992 election results with 1986 ones gave disappointing results as 1986 results are a rather poor instrument for 1992 ones. Given that the loss of information appeared to be serious whereas, elections being typically played on broader issues than just kilometers of roads, the endogeneity bias's importance was unclear, we decided to keep 1992 results on the right-hand side.

Several specification tests were performed. In order to test the AR(1) specification against the alternative of an AR(2) specification, we employed the Godfrey Lagrange multiplier test for non-linear regression models (Godfrey 1988, p. 117; White 1992). This test statistic has a critical value of 6.635, which implies acceptance of the AR(1) process at a 1 percent level for all our specifications (see Table 3). We also performed White's test for heteroscedasticity, which is because of its generality also an indicator for functional form misspecification. This statistic is distributed χ^2 with 45 degrees of freedom for the production function and 93 degrees of freedom for the policy equation. Thus, homoscedasticity of errors and functional form specification is not rejected at a 1% level both for the production function and the policy equation. It is also comforting that normality of the

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[9]A full model would allow for firm and household mobility in a spatial equilibrium as in Haughwout and Inman (2000) or Haughwout (2002). However, their model is a complex one while treating policy regimes as control variables. We chose instead to strip down the underlying economy in order to focus on the politics.

error structure is not rejected at a 1% level applying a system test (Henze-Zirkler T). The estimated AR(1) parameters ρ_1 and ρ_2 are about 0.88 and 0.48 respectively.

<div align="center">TABLE 3 HERE</div>

3.3 Discussion

Two preliminary remarks on Table 3's results are in point. First, the proportion of the variability in regional infrastructure investments explained by the policy equation is high (the R^2 is 0.87), given that the equation includes only $DIFF$, $PARTY$ and two regional dummies as out-of-model explanatory variables. Second, the reported parameter estimates turn out to be fairly robust across estimation procedures (OLS and FIML) as well as with respect to changes in the lobbying variable.

All parameter estimates for electoral variables have the expected signs, and all except $PARTY$ are significant at the 1% level, providing strong evidence of pork-barrel and supporting the hypothesis that public goods, even if imperfectly "targetable" (we use here the term coined by Lizzeri and Persico), are used by politicians as redistribution instruments. The parameter estimate on $LARGE$ is also significant at the 1% level, and the positive and highly significant parameter estimate on the interaction term $INCUMB * LARGE$ provides empirical support for (13) since it suggests that, just as predicted, incentives to placate lobbies are stronger for politicians with strong incumbency advantages. Abundant anecdotal evidence[10] suggests that our results capture a phenomenon that is widely perceived as important. A caveat is in point, however. In our last formulation, lobbying comes from *beneficiaries* of transportation infrastructure, whereas in reality, the construction industry itself is an active lobbyist as far as new motorway and high-speed train construction projects are concerned. Although the construction industry as a whole has a fairly low concentration, the lobbies behind large projects include a few large firms for whom location of the work is irrelevant. By contrast, many of the firms that care about where the work is done are small ones, and some are necessarily below our cutoff of 500 employees (a construction lobbyist once boasted that the industry association has "52,000

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[10]See for instance the cover story of the magazine *Capital* (June 18, 1998) entitled "100 lobbies qui font la loi en France"; in particular pp 92–*ff*. According to the magazine, the construction industry is a major political-campaign contributor and a powerful force behind highway construction projects, although lobbying by French firms is expected to decline as a result of a Brussels directive imposing open bidding procedures (and therefore diluting the return to lobbying).

members, practically one in each commune").[11] By contrast, time dummies do not suggest a discernable election-year pattern.

If the positive results concerning lobbying and electoral concerns were to be expected—although perhaps not as clear-cut as they turned out to be—the insignificance of the productivity term, which picks up the government's concern to allocate infrastructure investments to where their marginal product is highest, is more puzzling. Although it is certainly possible (in indeed is suggested by the model) that the government simply doesn't care about the efficient allocation of resources, this conclusion is probably a strong one to draw from such limited evidence and given the scope for misspecification in a simple political-economy model. Moreover, the variety of state-aid schemes aimed at fostering stronger growth in backward regions suggests that European governments, including the French one, do care about convergence—unless, of course, these state-aid schemes are themselves driven by lobbying forces. It is therefore fair to say that, as far as this study is concerned, government objectives in the allocation of transportation infrastructure investment are unclear once political motivations are controlled for. (We tried including regional unemployment rates as a right-hand side variable in the policy equation, but it proved insignificant.)

Quantitative estimates are, of course, sensitive to model specification (although estimates proved remarkably stable) but they nevertheless provide a rough estimate of the orders of magnitude involved, and it is instructive to take a look at them, albeit a very cautious one. *Ceteris paribus*, an additional "representative" large establishment in a region brings that region 8.63 French Francs (FF) of additional infrastructure investment per worker each year; or, with an average of $1,022,000$ workers, a total of 8.819 million FF (the number of large establishments per region varies between 5 in Limousin and 113 in Rhône-Alpes). A one-standard deviation (6.2 percentage points) increase in the Front National and hunters' vote brings a region between 134.54 FF and 160.58 FF of additional infrastructure investment per worker, or 137.5 to 164.11 million FF for the average region (9.6% to 11.5% of average spending).

Production-function estimates are significant and have the expected sign. Constant returns to scale are not rejected, although the test statistic is borderline. The estimated elasticity $\widehat{\alpha}_k$ of private capital is 0.18 and is significant at the 1% level; that of infrastructure $\widehat{\alpha}_x$ is 0.08 and significant at the 5% level. All estimates are remarkably stable across estimation procedures. In particular, the OLS infrastructure elasticity estimate is

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[11]*Capital*, 18 June 1998, p. 92.

very close, suggesting, as noted in the introduction, that the simultaneous-equation bias from OLS estimation of the production function is negligible.[12] Our estimate of the infrastructure share is much lower than Aschauer's (1989) estimate on US aggregate data (0.39) but the two are not directly comparable since Aschauer's infrastructure variable was a broad aggregate of public capital whereas ours is limited to transportation infrastructure. Furthermore, our estimate is unlikely to pick-up spillover effects across regions as Aschauer's aggregate infrastructure estimate does. Munnell's (1990) estimate, which was more directly comparable to ours in that she used state-level data, was 0.14, whereas de la Fuente and Vives' (1995) estimate on Spanish regional data was somewhat higher than ours. Although plausible, our estimate should nevertheless be interpreted cautiously, as $\widehat{\alpha}_x$, in all likelihood, picks up not only the supply-side effects of infrastructure investments (what it is meant to measure) but also their demand-side or Keynesian effects; it is in fact possible that the latter dominates the former. Moreover, as we noted earlier, a common drawback of the production-function approach is that it takes the private capital stock as fixed, which can be a valid approximation of reality only in the short run (see de la Fuente and Vives, 1995, for a discussion and alternative formulation); the same is true of employment.Thus, our estimates are best construed as short-term ones. Finally, we have not included human capital for lack of reliable data; although this is, in general, a potentially serious omission, systematic cross-regional variation in educational levels also may not be a serious a problem given France's relatively egalitarian education system.

As the rates of return on infrastructure capital implied by production-function estimates have been a subject of intense debate in the US (see e.g. CBO, 1988, or Gramlich, 1990), it is instructive to calculate the rates of return implied by our estimates for private and infrastructure capital. Let r_k be the rate of return on private capital; in a competitive environment the unconstrained demand for private capital is given by $r_k = \widehat{\alpha}_k q/k$. Assuming that the stock of private capital is at its long-run equilibrium level and using national aggregates of q and k averaged over our sample period, the implied rate of return is 0.157, which is lower than estimates from US data (see e.g. Munnell, 1990b) but nevertheless plausible. As for infrastructure, the implied rate of return, using again national aggregates averaged time-wise, is $r_x = \widehat{\alpha}_x q/x = 0.44$; this is higher than the upper bound of the

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[12]Note that the mean of the infrastructure stock is 50 times that of the investment, and the standard deviation is about 12 times larger. Considering this, it is less surprising that the estimates do not change very much when one switches from OLS to the structural equation of investment in the FIML estimation.

range of values reported by the US Congressional Budget Office, which vary between 0.35 for highway maintenance projects and 0.05 for new rural highway projects (see Gramlich, 1994, table 4). Thus, the high rate of return on infrastructure capital implied by our elasticity estimate suggests that in France's case there is some ground to the claim that, overall, transportation infrastructure is underprovided, as Aschauer similarly argued for the US; in fact, using our elasticity estimates, the value of the infrastructure stock that would bring its rate of return down to the rate of return on private capital would be $140, 625$ Francs per worker (roughly \$19, 000 at the current exchange rate), or three times the current one. However, the difference in rates of return between private and infrastructure capital should not be overplayed, as rates of return are very sensitive to elasticity estimates, which are themselves fairly imprecise.[13] Moreover, France was, during our sample period, in the middle of a major effort of transportation infrastructure construction, both for highways and for high-speed railway lines. The picture might be different a decade later.

4 Concluding Remarks

The primary interest of our results is that they highlight the importance of the pork-barrel dimension of policy-making. They suggest that modelling explicitly the political processes that drive policy decisions is interesting in its own right, irrespective of whether their omission would or would not introduce a simultaneity bias in regressions where policy variables are treated as exogenous. Commenting on the high rates of return on infrastructure investments estimated by Aschauer, Gramlich (1994) remarked, "If public investment really were as profitable as claimed, would not private investors be clamoring to have the public sector impose taxes or float bonds to build roads, highways, and sewers to generate these high net benefits? [...] Very little such pressure seems to have been observed, even when the implied econometric rates of return were allegedly very high" (p. 1187). We find that, in the absence of a loud clamor, the quiet whisper of lobbies can indeed be heard; but not necessarily because of high rates of return. We also find, and that is perhaps more important, that roads and railways are not built to reduce traffic jams: they are built essentially to get politicians reelected.

As far as policy implications are concerned, our results contain good news and bad news. The bad news is that pork-barrel matters, whereas other governmental objectives, if any,

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[13]In fact, the difference between r_x and r_k is statistically insignificant at a 10 percent level.

are unclear. The good news is that the resulting distortions appear to be relatively small. First, feedback effects on production-function estimates are weak, and the marginal product of infrastructure capital does not vary tremendously across regions, so that departures from the first-best allocation of infrastructure across regions are fairly inconsequential. Second, in rich industrial countries, transportation infrastructure investments are small compared to the level of existing stocks, so that political distortions in the amounts and spatial allocation of investments are unlikely to make themselves felt on GDP before a while. But one should not be excessively optimistic about this. First, if investment decision have *always* been made on the basis of pork-barrel politics, the stock levels should themselves be severely distorted. So our results beg the question: when did things start getting seriously bad? In France's case, the answer seems to be, fairly recently. The conventional wisdom among political scientists is that corruption has vastly expanded in the 1980s, largely as a result of administrative reforms enacted in 1982.[14] Second, if pork barrel is prevalent in infrastructure-investment decisions (although de la Fuente and Vives (1995) found little trace of political influence in Spanish infrastructure investment decisions), developing countries are likely to be less robust to the ensuing distortions simply because the stocks are so much smaller relative to the investments. Under such conditions, political distortions in the allocation mechanisms are unlikely to be innocuous.

If, as our positive analysis suggests, political distortions ought to be taken seriously, at least in the long run, one should be able to offer normative guidance for the design of rules or institutions that could mitigate those distortions. The second interesting aspect of our results is that they provide just such a rule. We showed in Section 2 that the lobbying-free allocation of infrastructure is uniform if its marginal product ($\alpha_x q_{it}/x_{it}$ under a Cobb-Douglas technology) does not vary across regions. Provided that neither productivity levels nor infrastructure stocks per worker vary too much across regions (our data suggests that they don't: the standard deviation of infrastructure's marginal product is 0.067, for a mean of 0.44, a minimum of 0.32 in Provence and a maximum of 0.56 in Alsace), uniform allocation is thus a fairly good rule of thumb. Even if the ratio $\alpha_x q_{it}/x_{it}$ varies, it is not a very difficult one to compute, so the more sophisticated rule is itself not excessively demanding.

Several caveats are in point. First, as pointed out by Haughwout, treating firm and

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[14]See e.g. Mény, 1992; Borraz and Worms, 1996; or SCPC, 1994. We are grateful to Jean-Louis Briquet, from the *Institut d'Etudes Politiques de Paris*, for a useful conversation on this and for attracting our attention to the relevant political-science work.

household location decisions as predetermined may be inappropriate (although perhaps less so in France than in the US). Second, if our allocation rule is clear, how it should be implemented is less so. Delegation to an independent policy-making body may be one answer, whether this body is an independent national agency, like a regulator or a central bank, or an unelected supranational body like the EU Commission. Another answer lies at the opposite extreme of the spectrum: rather than sheltering policymakers, it consists of exposing them. Recent work by Besley and Burgess (2001) on India highlights the power of the press in disciplining politicians. What mixture of sheltering and exposure would best control pork-barrel politics is a question that we leave open; only careful international comparisons will shed light on it. What is clear from our work is that France does not yet seem to have the answer.

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5 Appendix

This appendix extends the "one-road" model of Section 2 to a "two-roads" models à la Blomquist-Christiansen (1999, henceforth BC).

5.1 Set-up

Because a road is to be built in each one of the two regions, the policy vector is now $\mathbf{x} = (x_1, x_2)$. Voter preferences are as before and remain in particular ex-ante identical across regions, but for future use let us label as A1 and A2 respectively two assumptions made about the direct utility function in section 2.1, namely,

A1 $\lim_{x \to \infty} u'(x) = 0$

and

A2 $\lim_{x \to 0} u'(x) = \infty$.

Politician behaviour is as in section 2, that is, A solves

$$\max_{\mathbf{x}} \ \pi^k \left(\mathbf{x}, \mathbf{x}^B\right) \left[\rho + R(\mathbf{x})\right]; \tag{20}$$

as before,

$$\pi_{ij}^A \left(\mathbf{x}^A, \mathbf{x}^B\right) = \begin{cases} 1 & \text{if } \Delta v_j \left(\mathbf{x}^A, \mathbf{x}^B\right) + \iota > \sigma_{ij} \\ 1/2 & \text{if } \Delta v_j \left(\mathbf{x}^A, \mathbf{x}^B\right) + \iota = \sigma_{ij} \\ 0 & \text{otherwise,} \end{cases} \tag{21}$$

where σ_{ij} is an i.i.d. shock distributed uniformly over $[-1/b_j, 1/b_j]$,

$$\pi^A \left(\mathbf{x}^A, \mathbf{x}^B\right) = \frac{1}{2} + \sum_{j=1}^{2} \alpha_j b_j \Delta v_j,$$

but now

$$\Delta v_j = u \left(x_j^A\right) - u \left(x_j^B\right) - \left[\left(x_1^A + x_2^A\right) - \left(x_1^B + x_2^B\right)\right] \frac{y_j}{y}.$$

5.2 Equilibrium

Let $\mathcal{L}$ denote the set of lobby members —which we take for simplicity as a singleton— and $v_L(x)$ the lobby's utility. Let $\mathcal{N}$ be the set of voters and $\mathcal{M} = \mathcal{L} \cup \mathcal{N}$. Let also X^* be the set of Pareto-optimal policies, Pareto-optimality being defined over the set $\mathcal{M}$. From now on, we suppose that $R(\mathbf{x}) = R(\mathbf{x}')$ for any two policies $\mathbf{x}$ abd $\mathbf{x}'$ such that $v_L(\mathbf{x}) = v_L(\mathbf{x}')$.

Proposition A1: *Any policy* $\mathbf{x}^k$ *satisfying (20) belongs to* X^*.

Proof: Suppose not, and without loss of generality let $k = A$. Then there exist two policies $\mathbf{x}^A$ and $\widetilde{\mathbf{x}}^A$ such that $\mathbf{x}^A$ solves (20), and one of the following is true: either $v_1\left(\widetilde{\mathbf{x}}^A\right) > v_1\left(\mathbf{x}^A\right)$ and $v_2\left(\widetilde{\mathbf{x}}^A\right) = v_2\left(\mathbf{x}^A\right)$, or $v_1\left(\widetilde{\mathbf{x}}^A\right) = v_1\left(\mathbf{x}^A\right)$ and $v_2\left(\widetilde{\mathbf{x}}^A\right) > v_2\left(\mathbf{x}^A\right)$. Consider the first case, again without loss of generality. Suppose first that $\mathbf{x}^A$ is pitched in a pairwise vote against an arbitrary $\mathbf{x}^B$, and observe how the probability of voting for A changes when instead $\widetilde{\mathbf{x}}$ is pitched against the same $\mathbf{x}^B$. Clearly $\pi_{i2}^A\left(\mathbf{x}^A, \mathbf{x}^B\right) = \pi_{i2}^A\left(\widetilde{\mathbf{x}}^A, \mathbf{x}^B\right)$; i.e. region two's vote is unaffected since it is by construction indifferent between $\mathbf{x}^A$ and $\widetilde{\mathbf{x}}^A$. By contrast, $\pi_{i1}^A\left(\widetilde{\mathbf{x}}^A, \mathbf{x}^B\right)$ is indeterminate if $\pi_{i1}^A\left(\mathbf{x}^A, \mathbf{x}^B\right) = 0$ and equal to one if $\pi_{i1}^A\left(\mathbf{x}^A, \mathbf{x}^B\right)$ is equal to either one-half or one. That is, the marginal voter in a vote between $\mathbf{x}^A$ and $\mathbf{x}^B$ becomes favorable to A in a vote between $\widetilde{\mathbf{x}}^A$ and $\mathbf{x}^B$. Thus, A's probability of election is never lower under $\widetilde{\mathbf{x}}^A$ than under $\mathbf{x}^A$ and is strictly greater when $\pi_{i1}^A\left(\mathbf{x}^A, \mathbf{x}^B\right) = 1/2$. Moreover, this statement holds irrespective of the relative sizes of regions one and two. It follows that $\mathbf{x}^A$ cannot satisfy (20), a contradiction. The logic of the second case is identical. *Q.E.D.*

As argued in BC, Proposition one reduces the dimensionality of the policy problem from two to one, since all candidate-equilibrium policies lie on the Pareto frontier. We now establish the existence of a policy equilibrium. For this, it suffices to show that reaction functions in the space of Pareto-efficient policies cross at least once. Let us start by defining the set V^* as the set of pairs (v_1, v_2), v_1 being a level of utility for region one's representative individual and v_2 the same thing for region two, attainable by Pareto-optimal policies; and two real-valued functions Ω_v and Ω_v such that the pair $[v_1, \Omega_v\left(v_1\right)]$ belongs to V^* and the pair $[x_1, \Omega_x\left(x_1\right)]$ belongs to X^* We assume that the functions Ω_v and Ω_x are well-defined and invertible everywhere.[15] Let us also define a function

$$\psi : \begin{cases} V^* \to [0, y_1] \\ (v_1, v_2) \to y \end{cases}$$

associating to each Pareto-optimal pair of utilities a scalar y defined on a finite interval $[0, y_1]$. The function ψ formalizes the reduction of the problem's dimensionality. Let $v_1^1 = \max \left\{v_1 \in \mathbb{R}_+ : (v_1, v_2) \in V^*\right\}$ and $v_2^1 = \Omega\left(v_1^1\right)$. In words, v_1^1 is the highest level of utility attainable by region one on the Pareto frontier, and v_2^1 is the corresponding level of utility

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[15]This assumption is convenient but not innocuous. It rules out, in particular, Pareto frontiers bending inward at the extremes as in BC's Figure 2.

for region two. Similarly let $v_2^0 = \max \{v_2 \in \mathbb{R}_+ : (v_1, v_2) \in V^*\}$ and $v_1^0 = \Omega^{-1}(v_2^0)$. In words, v_2^0 is the highest level of utility attainable by region two on the Pareto frontier and v_1^0 is the corresponding level for region one.

By non-satiation (i.e. the assumption that u' is strictly increasing for all finite values of x), v_1^1 defines a unique pair $(x_1^1, 0)$ in which there is no road in region two and v_2^0 defines a unique pair $(0, x_2^0)$ in which there is no road in region one. We construct the function ψ so that $\psi(v_1^0, v_2^0) = 0$, $\psi(v_1^1, v_2^1) = y_1$, and $\psi(v_1, v_2) \in]0, y_1[$ for all other pairs (v_1, v_2) in V^*.

The function ψ makes it possible to establish the existence of a policy equilibrium by observing the properties of reaction functions defined on $[0, y_1]^2$. Candidate A's best response to B in (y^A, y^B) space can be defined as a function

$$R^A : \begin{cases} [0, y_1] \to [0, y_1] \\ y^B \to R^A(y^B), \end{cases}$$

and candidate B's best response, R^B, can be defined similarly.[16]   Following the logic of BC's demonstration, we establish existence by showing that, in (y^A, y^B) space, the graph of $A's$ reaction function is above the 45° line at 0, below at y_1, and conversely for B's.

Proposition A2: *At least one policy equilibrium exists.*

Proof: Let $y^B = 0$, so $x_1^B = 0$ and $x_2^B = x_2^0$. For some $\varepsilon > 0$, consider a policy y^A such that $x_1^A = \varepsilon$ and $x_2^A = x_2^0 - \varepsilon$, and let ε tend to zero. By A1 and A2, u' is finite everywhere except at the origin, so $du_2 = u(x_2^A) - u(x_2^0)$ is of second order of magnitude whereas $du_1 = u(x_1^A) - u(0)$ is not. Thus, policy y^A is better than policy y^B (although it does not guarantee election with probability one). It follows that $y^A = y^B$ cannot be a best response, which must then necessarily lie above the 45° line. A similar argument establishes that if $y^B = y_1$, then $y^A = y_1$ cannot be a best response either. Therefore, by continuity, the graph of R^A must cross the 45° line at least one from above. A similar argument can be used to show that $y^B(0) > 0$ and $y^B(y_1) < y_1$, so that, in (y^A, y^B) space, R^B must cross R^A at least once from below. *Q.E.D.*

Having established the equilibrium's existence, we can now characterize it the same way we did in Section 2. Politician A's maximization problem, once Pareto optimality is introduced as a constraint, becomes

$$\max_{\mathbf{x}} \pi^A(\mathbf{x}, \mathbf{x}^B)[\rho + R(\mathbf{x})]$$

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[16]Written in full, $R_y^A(y^B) = \psi\{\mathbf{v}^A[R_x^A\{\mathbf{v}^{B^{-1}}[\psi^{-1}(y^B)]\}]\}$.

s.t.

$$\mathbf{x} \in X^*,$$

and similarly for party B. Substituting the relevant expressions gives

$$
\begin{aligned}
\pi^A \left(\mathbf{x}^A, \mathbf{x}^B \right) &= \frac{1}{2} + \alpha_1 b_1 \left\{ u \left(x_1^A \right) - u \left(x_1^A \right) - \left[\left(x_1^A - x_1^B \right) + \left(x_2^A - x_2^B \right) \right] \frac{y_1}{y} \right\} \\
&\quad + \alpha_2 b_2 \left\{ u \left(x_2^A \right) - u \left(x_2^A \right) - \left[\left(x_1^A - x_1^B \right) + \left(x_2^A - x_2^B \right) \right] \frac{y_2}{y} \right\}.
\end{aligned}
$$

Using the derivative of the function Ω_x introduced earlier, the FOC for candidate A is then

$$\alpha_1 b_1 u' \left(x_1^A \right) \left[\rho + R \left(\mathbf{x}^A \right) \right] = \left(1 + \Omega_x' \right) \left(\frac{\alpha_1 b_1 y_1 + \alpha_2 b_2 y_2}{y} \right) \left[\rho + R \left(\mathbf{x}^A \right) \right] - \pi^A R' \left(\mathbf{x}^A \right)$$

or

$$u' \left(x_1^A \right) = \frac{1 + \Omega_x'}{y} \left(y_1 + \frac{\alpha_2 b_2}{\alpha_1 b_1} y_2 \right) - \pi^A R' \left(\mathbf{x}^A \right). \tag{22}$$

As the LHS and second term of the RHS are both positive, it follows that in any interior solution, locally $1 + \Omega_x' > 0$. With this caveat the interpretation and properties of (22) are the same as before.

Table 1: Variable Description and Regions

Variable	Description	
VA	Regional GDP, million 1992 Francs	
EMP	Regional employment, million individuals	
CAP	Non-residential private capital stock, million 1992 Francs	
$INFRAST$	Transportation infrastructure stock, million 1992 Francs	
INV	Transportation infrastructure net investments, million 1992 Francs	
$LARGE$	Number of establishments with more than 500 employees	
$PARTY$	Dummy =1 when local/national political congruence	
$DIFF$	Absolute value of RW score minus LW score, in percent. points	
$LEPEN$	*Front National* + hunters' party combined scores, in percent. points	
$INCUMB$	Incumbent's margin, in percent. points	
Regions		
Alsace	Champagne-Ardennes	Midi-Pyrenées
Aquitaine	Franche-Comté	Nord-Pas de Calais
Auvergne	Haute-Normandie	Pays de Loire
Basse-Normandie	Ile-de-France	Picardie
Bourgogne	Languedoc-Roussillon	Poitou-Charentes
Bretagne	Limousin	Provence-Alpes-Côte d'Azur
Centre	Lorraine	Rhône-Alpes

Table 2: Summary Statistics

Variable	Mean	St. Dev.	Minimum	Maximum
VA/EMP	256723	27380.40	195921	357617
CAP/EMP	298142	62624.98	188442	484980
$INFRAST/EMP$	50920	9412.91	35453	70935
$VA/INFRAST$	5.166	0.8416	3.849	7.405
INV/EMP	1396	628.15	412	4934
$LARGE$	35.27	21.66	5	113
$LARGE/\ell$	42.62	17.56	11.90	79.64
$DIFF$	6.94	5.404	0.03	35.10
$INCUMB$	5.42	6.824	-14.50	26.6
$LEPEN$	13.9	6.239	3.40	26.6
$X_{HIGHWAY}/X_{RAIL}$	5.1	2.36	1.74	13.68
$X_{HIGHWAY}/X_{WATER}$	68.8	80.17	2.27	2.90
Total number of observations: 168				

Variable	OLS estimate	t-stat	FIML estimate	t-stat	FIML estimate	t-stat
Production function: *Dependent Variable* $\ln(VA/EMP)$						
85	3.940	21.21	3.905	21.95	3.919	22.04
86	3.969	21.33	3.934	22.07	3.948	22.16
87	3.985	21.34	3.950	22.09	3.964	22.18
88	4.003	21.32	3.967	22.07	3.981	22.15
89	4.021	21.29	3.985	22.04	3.999	22.12
90	4.013	21.19	3.977	21.93	3.991	22.01
91	4.011	21.05	3.975	21.79	3.989	21.87
92	4.027	21.03	3.991	21.77	4.005	21.85
CAP/EMP	0.182	5.26	0.186	5.59	0.182	5.50
EMP	0.029	1.84	0.030	1.96	0.028	1.87
$INFRAST/EMP$	0.080	1.90	0.083	2.06	0.086	2.16
$PARIS$	0.214	4.95	0.217	5.20	0.219	5.27
$AR(1)$	0.888		0.888		0.888	
Godfrey LM Test	1.949		1.999		1.982	
White Test	37.05		36.81		37.14	
R^2	0.9575		0.9577		0.9576	
Policy function: *Dependent Variable* INV/EMP						
Variable						
85	2416.68	6.27	2579.74	7.06	3200.21	9.74
86	2452.16	6.26	2616.15	7.05	3237.91	9.69
87	2437.17	5.94	2599.92	6.71	3239.32	9.18
88	2663.08	6.36	2833.54	7.16	3473.72	9.56
89	2867.94	6.97	3055.73	7.81	3676.67	10.12
90	2701.02	6.49	2892.57	7.31	3508.87	9.48
91	2821.59	6.83	3016.82	7.66	3625.54	9.77
92	2655.02	6.38	2853.97	7.19	3459.01	9.18
$\alpha_x VA/INFRAST$	-1792.84	-1.43	-2107.62	-1.73	-2607.13	-1.95
$PARTY$	117.17	1.50	130.43	1.79	95.31	1.33
$DIFF$	-34.62	-2.55	-32.70	-2.58	-38.83	-3.73
$LEPEN$	29.31	3.26	25.93	3.07	21.72	2.63
$LARGE$	8.25	3.87	8.63	4.39	—	—
$INCUMB$	26.26	2.29	25.65	2.42	—	—
$INCUMB*LARGE$	—	—	—	—	0.91	5.73
$TGVCENTRE$	1096.46	5.42	1139.09	6.03	1172.25	6.23
$TGVNORD$	3112.54	11.21	3124.73	12.06	3230.35	12.75
$PARIS$	-619.28	-1.78	-608.64	-1.89	2.41	0.01
$AR(1)$	0.492		0.486		0.471	
Godfrey LM Test	1.193		2.016		1.764	
White Test	118.6		116.1		107.9	
R^2	0.8753		0.8747		0.8741	
Henze-Zirkler T	2.11		2.04		1.76	