No. 2336

A POLITICAL ECONOMY MODEL OF INFRASTRUCTURE ALLOCATION: AN EMPIRICAL ASSESSMENT

Olivier Cadot, Lars-Hendrik Röller
and Andreas Stephan

INDUSTRIAL ORGANIZATION

Centre for Economic Policy Research

ISSN 0265-8003

A POLITICAL ECONOMY MODEL OF INFRASTRUCTURE ALLOCATION: AN EMPIRICAL ASSESSMENT

Olivier Cadot, INSEAD and CEPR
Lars-Hendrik Röller, Wissenschaftszentrum Berlin für Sozialforschung and CEPR
Andreas Stephan, Wissenschaftszentrum Berlin für Sozialforschung

Discussion Paper No. 2336
December 1999

Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: http://www.cepr.org

This Discussion Paper is issued under the auspices of the Centre's research programme in **Industrial Organization**. Any opinions expressed here are those of the author(s) and not those of the Centre for Economic Policy Research. Research disseminated by CEPR may include views on policy, but the Centre itself takes no institutional policy positions.

The Centre for Economic Policy Research was established in 1983 as a private educational charity, to promote independent analysis and public discussion of open economies and the relations among them. It is pluralist and non-partisan, bringing economic research to bear on the analysis of medium- and long-run policy questions. Institutional (core) finance for the Centre has been provided through major grants from the Economic and Social Research Council, under which an ESRC Resource Centre operates within CEPR; the Esmée Fairbairn Charitable Trust; and the Bank of England. These organizations do not give prior review to the Centre's publications, nor do they necessarily endorse the views expressed therein.

These Discussion Papers often represent preliminary or incomplete work, circulated to encourage discussion and comment. Citation and use of such a paper should take account of its provisional character.

Copyright: Olivier Cadot, Lars-Hendrik Röller and Andreas Stephan

CEPR Discussion Paper No. 2336

December 1999

ABSTRACT

A Political Economy Model of Infrastructure Allocation: An Empirical Assessment*

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 investment: 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 1985-91 suggest that influence activities were, indeed, significant determinants of the cross-regional allocation of transportation infrastructure investments. Moreover, we find little evidence of concern for the maximization of economic returns to infrastructure spending, even after controlling for pork-barrel and when imposing an exogenous preference for convergence in regional productivity levels.

JEL Classification: D72, D78, O40
Keywords: growth, infrastructure, political economy, lobbying, France

Olivier Cadot
INSEAD
Department of Economic and
Political Sciences
Boulevard de Constance
77305 Fontainebleu Cedex
FRANCE
Tel. (33 1) 6072 4452
Email: cadot@econ.insead.fr

Lars-Hendrik Röller
Wissenschaftszentrum Berlin
Reichpietschufer 50
10785 Berlin
GERMANY
Tel: (49 30) 25491 440
Email: roeller@medea.wz-berlin.de

Andreas Stephan
Wissenschaftszentrum Berlin
Reichpietschufer 50
10785 Berlin
GERMANY
Tel: (49 30) 25491 440
Email: andrstep@medea.wz-berlin.de

* This research was produced as part of a CEPR research network on The Evolution of Market Structure in Network Industries, funded by the European Commission under the Training and Mobility of Researchers Program (Contract No ERBFMRXCT980203). Financial support from the Deutsche Forschungsgemeinschaft (DFG) for the project ‘Auswirkungen regionaler Infrastrukturunterschiede auf Produktivität und Marktstruktur: Theorie und Evidenz für Deutschland und Frankreich’ is acknowledged. Cadot also gratefully acknowledges financial support from INSEAD under grant 2010-2227R. We would like to thank Patrick Legros and William Bernhard as well as participants at conferences and seminars at CIRANO, Nova University in Lisbon, Universitat Autonoma de Barcelona, Young Economist Meeting in Amsterdam, GAAC Summer Institut at the Center for Advanced Studies in the Behavioural Sciences, ESEM, EEA and EARIE 1999 for helpful comments, and to Bernard Fritsch for kindly supplying the private capital stock data. Special thanks to Pierre Blime for superb research assistance. This paper is produced as part of a CEPR research network on The Evolution of Market Structure in Network Industries, funded by the European Commission under the Training and Mobility of Researchers Programme (Contract No ERBFMRX-CT98-0203).

Submitted 18 October 1999

NON-TECHNICAL SUMMARY

If there is little doubt that investment in public infrastructure capital is a necessary condition for long-run growth in industrial countries and, *a fortiori*, in developing ones*, how much* infrastructure investment actually contributes to growth is still, in spite of a long-standing debate, a largely unsettled question. Disagreement over the magnitudes involved has persisted in spite of a massive amount of research sparked by the influential work of David Alan Aschauer. However, the early studies in this field were fraught with logical and econometric difficulties.

Among the econometric problems, it was pointed out in the literature that the direction of causation was unclear, i.e. whether causation runs from higher infrastructure to higher output or from higher output to higher infrastructure. If the simultaneity of public infrastructure and output is indeed a serious problem, the best way to address it is probably the most direct one, that is, to use simultaneous-equation methods. Therefore our 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. In this perspective, our paper is an attempt to formally bridge the gap between the infrastructure and political-economy literature.

More specifically, we apply a common-agency model to the allocation of infrastructure investment in France. The centralist institutional context in France lends itself towards an analysis under the common-agency setup. To put it differently, an empirical test of the common-agency model in political economy is ideally suited for the French environment. The initial assumption of our model is that firms have sunk investments giving them vested interests in the quality of the infrastructure in regions where they have production units. Thus, we assume that the number of large establishments in a region has a positive influence on the intensity of that region’s lobbying for transportation infrastructure investment. The form of the lobbying is very simple: we suppose that firms offer campaign contributions to incumbent politicians in return for additional spending. At the margin, these contributions reflect the firms’ willingness to pay for additional infrastructure – that is they reflect the infrastructure's marginal contribution to firm value.

The political process is as follows. Local politicians (we focus on regional presidents, whose power of influence has increased after administrative reforms enacted in 1982) act as contribution-collectors, providing their affiliated parties' headquarters with promises of locally-generated campaign

contributions. Their own role is to assemble credible public-works projects for their region and submit them to Paris for approval. Final decisions are made at the national level, either in the Ministry of Transport (for relatively minor projects) or at Cabinet meetings (for larger ones). Thus, *ceteris paribus*, local politicians who share the national executive's political obedience and generate substantial campaign financing, are rewarded with a larger slice of the cake: this is what we call 'pork-barrel politics'. Hence the process can be viewed as an auction whereby incumbent politicians sell infrastructure investments to local lobbies who bid for them through campaign contributions. In order to capture this idea, we approximate lobbying by two variables: the number of large firms in each region and – perhaps more importantly – a dummy variable equal to one when a regional council's majority and the national government are of the same obedience (left-wing or right-wing) and zero otherwise.

Our empirical findings on a panel of France's regions over 1985–91 suggest that influence activities were, indeed, significant determinants of the cross-regional allocation of transportation infrastructure investments. We find both measures of lobbying influence to be significant, statistically and in magnitude. As it turns out, the simultaneity bias from estimating a production function alone is negligible, as single equation elasticity estimates are almost identical to those obtained by simultaneous estimation of both equations. It appears that stocks are too large relative to investments for feedback influences to be a real source of concern over a sample period of less than a decade. We also find that over our sample period (during which left-wing parties were in power for five years and right-wing ones for two), the French government did not seem to be significantly concerned by the maximization of the returns to infrastructure spending. This result, which is robust to changes in the functional form of the government's objective function, reinforces our conclusion that 'pork-barrel' considerations were important – if not primary – policy-drivers in the sample period.

Finally, we carry out an exercise in which we compare the actual allocation of infrastructure investments across regions with a simulated socially optimal value. Interestingly, we find that most of the cross-regional variation in investment levels is attributable to 'pork barrel', suggesting that uniform allocation would be a good rule of thumb to reduce policy capture by lobbies.

1 Introduction

If there is little doubt that investment in public infrastructure capital is a necessary condition for long-run growth in industrial countries and, *a fortiori*, in developing ones, *how much* infrastructure investment actually contributes to growth is still, in spite of a long-standing debate, a largely unsettled question. Disagreement over the magnitudes involved has persisted in spite of a massive amount of research sparked by the influential work of Aschauer (1989). Using aggregate data for the US between 1949 and 1985, Aschauer found that the elasticity of output to a broad measure of public infrastructure capital was significant and quantitatively very large; other studies using aggregate data (Holtz-Eakin, 1988, and Munnell, 1990a) also found public capital to influence productivity significantly. At a time of widespread concern about the slowdown in US productivity growth, these findings suggested that a decline in the rate of public-capital accumulation was "a potential new culprit" (Munnell, 1990a, p. 3).

However, the early studies were fraught with logical and econometric difficulties, the most important of which are discussed in Gramlich's 1994 review essay. Among the econometric problems, it was pointed out 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. Munnell (1990b) and Garcia-Milà (1992) also found positive elasticities of output to public capital using panel data at the state level, 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. Moreover, if the endogeneity of public infrastructure investments is a serious problem, the best way to address it is probably the most direct one, that is, to use simultaneous-equation methods (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 investment decisions should be modelled.

Clearly, the "second equation" should be grounded in a theory of how public infrastructure investment decisions are made, i.e. on some explicit view about what drives policy-making. 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). What Gramlich suggests is to focus explicitly on policy choices and the institutional context in which they are made in order to assess, from a normative perspective, whether they are socially optimal or not. This 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 considerably from social welfare, under constraints that are primarily political (see Dixit, 1996, for a survey). This literature approaches from a positive angle questions that used to be the realm of the normative, taking policy variables to be endogenous rather than control variables. Ultimately, normative considerations are likely to reappear, e.g. in the form of prescriptions in favor of rules or institutions mitigating policy capture by special interests; but the literature's key message is that irrespective of what politicians ought to do, economists need to understand what they actually do and why. For instance, if public infrastructure investment decisions are influenced by pork-barrel politics, pork-barrel politics should be part of the model. We believe that this provides a useful starting point for a discussion of what the "second equation" should be.

In this perspective, the present paper is a first attempt to formally bridge the gap between the infrastructure and political-economy literature. More specifically, we apply a common-agency model to the allocation of infrastructure investment in France. In principle, there exist other political economy mechanisms that may be able to explain how infrastructure investment is allocated in a particular country. However, the centralist institutional context in France lends itself towards an analysis under the common-agency setup. To put it differently, an empirical test of the common-agency model in political economy is ideally suited for the French environment.

The initial assumption is that firms have sunk investments giving them vested interests in the quality of the infrastructure in regions where they have production units (henceforth called "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 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 by 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 assume that the number of large establishments in a region has a positive influence on the intensity of that region's lobbying for transportation infrastructure investment.

The form of the lobbying is very simple: we suppose that firms offer campaign contributions to incumbent politicians in return for additional spending. At the margin, these contributions reflect the firms' willingness to pay for additional infrastructure—that is, they reflect the infrastructure's marginal contribution to firm value, both on the supply side, through the infrastructure's contribution to productivity in all sectors, and on the demand side for the construction industry itself.[1] The political process is as follows. Local politicians (we focus on regional presidents, whose power of influence has increased after administrative reforms enacted in 1982) act as contribution-collectors, providing their affiliated parties' headquarters with promises of locally-generated campaign contributions. Their own role is to assemble credible public-works projects for their region (as per their constituents' demands) and submit them to Paris for approval.

---

[1] Our panel covers a period (1985-91) immediately preceding a new law on political party financing. Ample anecdotal evidence suggests that, prior to that reform, a substantial part of the financing of mainstream parties came from contributions linked to public-works contracts.

Final decisions are made at the national level, either in the Ministry of Transport for relatively minor projects, or at Cabinet meetings for larger ones; *ceteris paribus*, local politicians who *(i)* share the national executive's political obedience and *(ii)* generate substantial campaign financing, are rewarded with a larger slice of the cake; this is what we call "pork-barrel politics". Thus, the process can be viewed as an auction whereby incumbent politicians sell infrastructure investments to local lobbies who bid for them through campaign contributions. Of course, in reality the mechanism through which lobbying pressures are transmitted from the local to the national level is neither as frictionless nor as transparent as it is portrayed here. But the central idea that local politicians are more effective voices for their constituents' demands if they happen to share the national executive's current political obedience is a plausible one and is supported by the data.

In order to capture this idea, we approximate lobbying by two variables: the number of large firms in each region and—perhaps more importantly—a dummy variable equal to one when a regional council's majority and the national government are of the same obedience (left wing or right wing) and zero otherwise. We find both measures of lobbying influence to be significant, statistically and in magnitude. Since lobbying takes place over investment levels (i.e. flows) and output is determined by stocks, one may suspect that the simultaneity bias in the output equation, may not be very large. As it turns out, the simultaneity bias from estimating a production function alone is negligible, as single equation elasticity estimates are almost identical to those obtained by simultaneous estimation of both equations. It appears that stocks are too large relative to investments for feedback influences to be a real source of concern over a sample period of less than a decade. We also find that over our sample period (during which left-wing parties were in power for five years and right-wing ones for two), the French government did not seem to be significantly concerned by the maximization of the *economic* returns to infrastructure spending. This result, which is robust to changes in the functional form of the government's objective function, reinforces our conclusion that pork-barrel considerations were important—if not primary—policy drivers in the sample period. Finally, we carry out an exercise in which we compare the actual allocation of infrastructure investments across regions with a simulated socially optimal value. Interestingly, we find that most of the cross-regional variation in investment levels is attributable to pork barrel, suggesting that uniform allocation would be a good rule of thumb to reduce policy capture by lobbies.

The remainder of this paper is organized as follows. In section 2, we state general conditions for the efficient provision of a public input and derive conditions under which influence activities lead to inefficient provision in a political-economy model. In section 3, we report the results of empirical testing of the model's structural equations on a French data set. Section 4 concludes.

2 Theory

Basic results on the optimal provision of public inputs were derived by Kaizuka (1965), Sandmo (1972), and Negishi (1973). We briefly review these results in the following section in order to provide a benchmark against which inefficiencies arising from influence activities can be assessed.

2.1 Efficient provision of a public input

Consider an economy producing m final goods for consumption, with technologies $Q_i = F^i(K_i, L_i, X)$, for $i = 1, ..., m$, where K_i and L_i are respectively the amounts of capital and labor used up in the production of good i and X is a pure public input. Following Negishi (1973), we take the latter to be of the "unpaid input" type, meaning that the function F^i is linearly homogenous in K_i, L_i and X.[2] When such is the case, owners of capital, which are residual claimants, appropriate the rents generated by the public input if the latter is not priced at the value of its marginal product. This is a source of potential inefficiency in capital-allocation decisions; but for simplicity (and for reasons that will become clear in the empirical part of the paper) we will limit the analysis to a short-run case where capital is fixed; the theory can be easily extended to a long-run case.

Let the public input be produced with labor only according to a technology $G(L_X)$, and let $L = \sum_{i=1}^{m} L_i + L_X$ be the economy's total endowment of labor. For reasons that will become clear later on, we will assume that the social utility function is quasilinear (necessary conditions for the aggregation of individual preferences into a social utility

---

[2] The alternative formulation is to assume that the production function is linearly homogenous in K_i and L_i alone and has increasing returns in all factors including X. This alternative formulation is generally seen as appropriate for publicly-provided R&D, whereas the classical example of the former formulation is, according to Sandmo (1972) and Negishi (1973), transportation infrastructure.

function are assumed to hold); thus, $U(Q_1, ..., Q_m) = Q_1 + \sum_{i=2}^{m} u(Q_i)$ where the function u is increasing and concave.

Given this, the problem of a social planner is:[3]

$$\begin{aligned} & \max_{L_1,...,L_m,L_X} \quad Q_1 + \sum_{i=2}^{m} u(Q_i) \\ & \text{s.t.} \\ Q_i &= F^i(K_i, L_i, X), \quad i = 1, ..., m, \\ X &= G(L_X), \\ L &= \sum_{i=1}^{m} L_i + L_X. \end{aligned} \tag{1}$$

Letting subscripts denote partial derivatives (so $F_L^i = \partial F^i / \partial L_i$ and $F_X^i = \partial F^i / \partial X$), solving (1) and rearranging the resulting first-order conditions gives the basic condition for the efficient provision of X; namely,

$$\sum_{i=1}^{m} \frac{F_X^i}{F_L^i} = \frac{1}{G'}. \tag{2}$$

Condition (2), which closely parallels Samuelson's condition for the optimal provision of public goods, was initially derived by Kaizuka (1965). It states that the sum over industries (firm-level production functions can be aggregated within each industry because the production function is homogenous) of the rates of technical substitution between labor and the public input must be equated to the marginal cost of the public input's provision.

Whereas the maximization of social utility under technology and factor-endowment constraints is the most natural way of deriving (2), this efficiency condition can also be derived from the maximization of firm profits. Let good 1 be the numeraire, p_i the price of good i in terms of good 1, and w the wage rate, and fix all prices and the wage rate at the levels obtained implicitly from the solution of problem (1). Suppose that, at these exogenously given prices and wage, firms make profit-maximizing decisions contingent on X; let also H be the inverse function of G so that $L_X = H(X)$. A government

---

[3] Transportation infrastructure is used as an input not only by firms, but also by households; so a complete statement of the problem should include a household production function. We will abstract from such considerations and treat transportation infrastructure as a "pure input".

maximizing firm profits by choice of X will solve:

$$\begin{aligned} & \max_X \; F^1(K_1, L_1, X) + \textstyle\sum_{i=2}^m p_i F^i(K_i, L_i, X) - w \sum_{i=1}^m L_i - wH(X) \\ & \text{s.t} \\ & F_L^1 = p_2 F_L^2 = ... = p_i F_L^i = w. \end{aligned} \tag{3}$$

It is easily checked that the solution of (3) satisfies first-order condition (2) and consequently yields the same level of provision of X. Although straightforward, this result is very important for our purposes. To see why, consider a simple influence-activity game in which firms offer monetary contributions to an incumbent politician in exchange for the public input's provision, and suppose that the incumbent maximizes the sum of those contributions net of the input's cost. If, at the margin, contributions reflect the willingness of firms to pay for the input, the influence-activity game's unique equilibrium is the solution to (3). In other words, if $C^i(X)$ is industry i's offer of a monetary contribution to the government and $\pi^i = p_i F^i(K_i, L_i, X) - wL_i$ (with $p_i = 1$ when $i = 1$) is its profits, whenever $\partial C^i / \partial X = \partial \pi^i / \partial X$, a government maximizing $\sum_i C^i(X) - wH(X)$ will maximize (3) and consequently provide X according to (2). Thus, influence activities *by themselves* do not imply inefficient provision of the public input.

This result—namely, that the existence of influence activities is not a sufficient condition for an inefficient policy outcome—is simply a restatement of Bernheim and Whinston's (1986a) result according to which, if influence activities can be represented as a "menu auction" and if special-interest groups bid for policy according to their marginal valuation, the resulting "truthful" equilibrium is Pareto-efficient (see also Bernheim and Whinston, 1986b, for parallel efficiency results in a common-agency context). This result also appears in a trade-policy context in Grossman and Helpman (1994) who show that in a small open economy, if all agents are represented in one lobby or another, the resulting equilibrium is free trade. We now turn to conditions under which influence activities do lead to inefficient policy choices.

2.2 Influence activities and inefficient policies

We have established that, in the case of a pure public input, a "policy auctioneer" implements the same policies that a social planner would, provided that all firms have access to the bidding process and bid according to their marginal willingness to pay. It follows that inefficiencies can come from only two sources. First, some firms may not have access to the bidding process, or may choose to free-ride. For instance, small firms may keep out of lobbying because it entails an entry fee that is prohibitive for them. This kind of incomplete coverage of the bidding process may lead to under-provision of the public input, quite like a standard collective-action problem. If infrastructures are specific to geographical entities, like regions or states, and the number of large firms varies across these entities, distortions will also appear in the spatial allocation of the public input.[4] Second, incumbent politicians may pursue an agenda of their own; that is, instead of simply maximizing the sum of the lobbies' transfers as a pure auctioneer would, they may maximize a composite function in which lobbying and non-lobbying arguments enter as substitutes. Non-lobbying arguments—such as priority development of some types of regional infrastructures—may entail choices which, although desirable from the incumbent's perspective, deviate from the first-best allocation of the public input. But they may also reflect economic-efficiency considerations, as opposed to pork barrel (this is the case considered by Grossman and Helpman, 1994, in which the government maximizes a linear combination of social welfare and contributions from lobbies).

For instance, suppose that the incumbent government maximizes a convex combination of social utility $U(.)$ and a monetary contribution $C^k(X)$ from some non-numeraire industry k. Again, the economy is in a competitive equilibrium as far as consumption and the allocation of labor across industries are concerned, the government's only problem being the provision of public input X.

Suppose that the government now maximizes a linear combination of industry k's contribution and social utility, the resource constraint being represented as in problem (3) by the term $wH(X)$. Although we are aggregating money and "utils", this poses no particular problem as long as preferences are quasilinear. Letting a be the weight on

---

[4] Note that the existence of lobbying implies that collective-action problems are at least partially overcome. If collective-action problems were so severe as to hamper *any* lobbying, there would be no distortion in the state's provision of the public input.

social utility the government now solves

$$\begin{aligned}
&\max_X \ (1-a)C^k(X) + a\ [Q_1 + \textstyle\sum_{i=2}^m u(Q_i)] - wH(X) \\
&\text{s.t.} \\
&Q_i \ = \ F^i(K_i, L_i, X), \ \ i = 1, ..., m, \\
&F_L^1 = p_2 F_L^2 = ... = p_m F_L^m = w, \\
&u' = p_i \quad \forall\, i = 2, ..., m, \\
&C^{k\prime}(X) = \partial \pi^k / \partial X = p_k F_X^k,
\end{aligned} \tag{4}$$

with first-order condition

$$(1-a)p_k F_X^k + a \left(F_X^1 + u' \sum_{i=2}^m F_X^i \right) - wH' = 0,$$

after substitution of the relevant constraints, this becomes

$$\frac{F_X^k}{F_L^k} + a \sum_{i \neq k} \frac{F_X^i}{F_L^i} = H'. \tag{5}$$

Thus, efficiency condition (2) is now violated; as the left-hand side of (5) is a decreasing function of X whereas its right-hand side is an increasing one, the public input is underprovided in (5) compared to (2). However, underprovision follows from the choice of a convex combination of social utility and industry k's contribution in the objective function; non-convex linear combinations could yield overprovision. In the empirical part of this paper, we will not impose convexity.

Given that (5)'s departure from optimality comes from the fact that sector k and only sector k lobbies, it can be eliminated in two ways. First, the distortion shrinks as a increases; in the limit, when $a = 1$, (5) reduces to (2). That is, the departure from optimality disappears if the government's valuation of sector k's contribution goes to zero. Second, if all industries lobby, (5) reduces to (2) irrespective of the value of a in $[0, 1]$, because by maximizing a convex combination of social utility and the profits of competitive firms, the government in effect maximizes twice the same thing.

Although simple, this theoretical framework provides a useful starting point for our empirical exploration of the effect of lobbying on the allocation of transportation infrastructure investments. Whether or not there is underprovision of the public input as implied by (5) is a very important question because under-investment in infrastructure is a subject of recurrent concern, in particular in the US.[5] A second important implication of (5) is that if the intensity or effectiveness of influence activities varies across states or regions, distortions in the overall level of infrastructure investments will be compounded by distortions in their spatial allocation. We now turn to an estimable model of regional infrastructure allocation building on these foundations.

2.3 A model of regional infrastructure allocation

2.3.1 Production function

Let Q_{it} be the aggregate output of region i at time t, L_{it} the level of regional employment, K_{it} the region's aggregate (non-infrastructure) capital stock, and X_{it} its stock of transportation infrastructure.[6] All regions have identical aggregate Cobb-Douglas production functions F:

$$Q_{it} = F(A_{it}, L_{it}, K_{it}, X_{it}) = A_t \, L_{it}^{\alpha_L} K_{it}^{\alpha_K} X_{it}^{\alpha_X}, \tag{6}$$

where A_t is a technical-change parameter common to all regions. Note that this formulation rules out cross-regional externalities in the productivity of transportation infrastructure; while this assumption is obviously an oversimplification, Gramlich (1990) and Holtz-Eakin (1994) argued on the basis of US data that such externalities are unlikely to be a major problem, as most traffic, even on interstate highways, is local. Moreover, relaxing it would require the estimation of a large number of parameters relative to our sample size. Dividing through by L_{it}, (6) becomes

$$q_{it} = A_t k_{it}^{\alpha_K} x_{it}^{\alpha_X} L_{it}^{\tilde{\alpha}_L}, \tag{7}$$

where q_{it} is labor productivity, k_{it} is the capital-labor ratio and x_{it} is the stock of transportation infrastructure per worker (we will henceforth use lower-case letters to desig-

---

[5] It should be noted, however, that the political model implicit in (4) is a representative-democracy one, whereas in the US about 20% of new state and local construction must be approved by referendum (see Gramlich, 1994). Peterson (1991) showed that under this partial direct-democracy mechanism the political economy of infrastructure construction is also likely to lead to underprovision of the infrastructure, as risk-averse politicians undertake projects only when assured of an overwhelming majority (the average approval percentage in referenda was close to 70% over 1948-90).

[6] We abstract from non-transportation infrastructure like schools, hospitals, and so on.

nate per-worker variables),[7] and $\tilde{\alpha}_L = \alpha_L + \alpha_K + \alpha_X - 1$. Note that $\tilde{\alpha}_L = 0$ if returns to scale are constant.

As policy decisions are concerned with infrastructure investments rather than stocks, for future purposes we need to establish the formal link between the two. The law of motion of region i's real transportation infrastructure stock X_{it} is given as

$$X_{it} = \gamma X_{i,t-1} + Z_{it}, \tag{8}$$

where Z_{it} denotes real gross investment in transportation infrastructure and $1 - \gamma$ is the rate of depreciation of the infrastructure stock, so that

$$\frac{\partial X_{it}}{\partial Z_{it}} = 1. \tag{9}$$

2.3.2 Policy function

We model lobbying as a common agency game. Although the problem should formally be treated in an explicit intertemporal context (see Bergemann and Valimaki, 1998), for the sake of simplicity we will reduce it to a succession of static games. In each period, region-specific lobbies indexed by $i = 1, ..., n$ (the principals) simultaneously face the government with monetary transfer offers $C_{it}(\mathbf{Z}_t)$ conditioned on the vector of transportation infrastructure investments $\mathbf{Z}_t = (Z_{1t}, ..., Z_{nt})$. These transfers can be interpreted, depending on the context, as political campaign contributions or outright bribes. The government then chooses a value $\mathbf{Z}_t^*$ of the policy vector $\mathbf{Z}_t$ that maximizes a suitably defined objective function $\mathcal{V}[\mathbf{Z}_t, \sum_i C_{it}(\mathbf{Z}_t)]$. Finally, lobbies make transfers $C_i(\mathbf{Z}_t^*)$ as promised. In order to be consistent with the framework of the previous section, keeping the same notation let $\mathcal{V}[\mathbf{Z}_t, \sum_i C_{it}(\mathbf{Z}_t)] = au(\mathbf{Z}_t) + (1-a)\sum_i C_{it}(\mathbf{Z}_t) - H(\mathbf{Z}_t)$; the nature of the functions u and H will be explained later on. Let also $\Pi_{it}(\mathbf{Z}_t)$ be the value of $\mathbf{Z}_t$ to lobby i. The game's unique "truthful" equilibrium is characterized by the following

---

[7] Using per-worker variables reduces heteroscedasticity due to unequal region sizes.

equations:

$$\left.\frac{\partial C_{jt}(\mathbf{Z}_t)}{\partial Z_{it}}\right|_{\mathbf{Z}_t^*} - \left.\frac{\partial \Pi_{jt}(\mathbf{Z}_t)}{\partial Z_{it}}\right|_{\mathbf{Z}_t^*} = 0, \qquad i, j = 1, ...n; \tag{10}$$

$$a\frac{\partial u}{\partial Z_{it}} + (1-a)\sum_{j=1}^{n}\frac{\partial C_{jt}}{\partial Z_{it}} - \frac{\partial H}{\partial Z_{it}} = 0, \qquad i = 1, ...n. \tag{11}$$

Equations (10) are "truthfulness" conditions whereas (11) is the government's first-order condition. Bernheim and Whinston (1986b, Theorem 2) state a number of sufficient conditions under which the common-agency game's unique equilibrium maximizes the joint surplus of the agent and principals, i.e. under which it collapses to a single principal-agent problem which, in the absence of hidden action, generates no inefficiency. These conditions do not apply here, because small firms do not lobby, whence transfer functions are distorted. Thus, efficiency does not hold.

The first step in taking (10) and (11) to the data consists of parameterizing the u and H functions. We define u as a nested function of $\mathbf{Z}_t$; i.e. u is a function of productivities q_{it}, themselves functions of $\mathbf{Z}_t$ through (7). Specifically, let $u(\mathbf{Z}_t) = 2\sum_i L_{it} q_{it}(\mathbf{Z}_t)^{1/2}$. This formulation reflects the twin assumptions that the government values convergence in per-capita incomes (hence the concave form),[8] and that a given departure from optimal productivity levels receives more weight, *ceteris paribus*, if it affects a more populous region (hence the multiplicative term L_{it}).

The costs of these investments are captured by the function H. Some of the spending is financed by corporate taxes whose impact is reflected in the firms' willingness to lobby (see details below). The rest is financed by other taxes which, although they do not directly affect the profits of local firms, affect local welfare and are therefore of concern to the government. Accordingly, let $H(\mathbf{Z}_t) = \sum_i L_{it} z_{it}^2/2$. The quadratic form reflects a rising marginal distortion cost of individual tax burdens;[9] in general, convexity (quadratic or other) of infrastructure investments costs can reflect non-financial considerations as well as financial ones. For instance, in a pork-barrel context, it may be politically important for the incumbent government to appear even-handed in the distribution of favors. Using these functional forms and differentiating the non-lobbying terms of (11) with

---

[8] Other functional forms, e.g. logarithmic, were tried in the estimation and found to yield similar estimates.

[9] The tax burden can alternatively be expressed as a percentage of regional GDP; however, such a formulation turns out to yield awkward functional forms with difficult-to-interpret parameters.

respect to Z_{it} gives

$$a\frac{\partial u}{\partial Z_{it}} - \frac{\partial H}{\partial Z_{it}} = aL_{it}q_{it}^{-1/2}\frac{1}{L_{it}}\frac{\partial Q_{it}}{\partial X_{it}}\frac{\partial X_{it}}{\partial Z_{it}} - z_{it},$$

where $z_{it} = Z_{it}/L_{it}$. Using (6) and (9), this simplifies to

$$a\frac{\partial u}{\partial Z_{it}} - \frac{\partial H}{\partial Z_{it}} = aF_X q_{it}^{-1/2} - z_{it}, \tag{12}$$

where $F_X = \partial F/\partial X_{it}$.

We now turn to the lobbying term. In a transportation-infrastructure allocation problem, it is natural to suppose that lobbying is organized along regional lines, with industrial firms playing an important role in the process. As already discussed, we will treat transportation infrastructure as a pure input, so that only firms lobby for it, and we will assume, in addition, that firms do not lobby in regions where they have only small production units (this is the "small-firms-out" assumption). In the absence of cross-regional externalities (discussed in section 2.3.1), firms having establishments in multiple regions make separate lobbying decisions for each one of their establishments, so we can treat the latter, without loss of generality, as separate firms. Accordingly, suppose that in any region i, N_{it} identical, large "firms" are active in lobbying. Although large, these firms are price-takers, and we will assume that they all produce a single manufactured good priced at p_{it}; as all variables are measured in constant 1992 francs in the empirical part, we set $p_{it} = 1$ for all i and t. As transportation infrastructure investments, in particular on highway maintenance and construction, are typically financed out of composite packages combining local and national budgets, we model their impact on local taxes through a tax function $\mathcal{T}_{it}^{\ell}(Z_{it})$. On the other hand, we assume that the *use* of transportation infrastructure is free. In order to include regional employment and private capital stocks as right-hand side variables in the production function, we assume that they are taken by the representative firm as fixed; finally, we denote by F^{ℓ} the production function of a representative large firm. The profit of a representative large firm in region i at time t is then

$$\pi_{it}^{\ell} = p_{it}F^{\ell}(A_t, K_{it}^{\ell}, L_{it}^{\ell}, X_{it}) - w_{it}L_{it}^{\ell} - r_{it}K_{it}^{\ell} - \mathcal{T}_{it}^{\ell}(Z_{it}), \tag{13}$$

where w_{it} and r_{it} are the wage rate and the rental rate of capital in region i at time t.

Suppose that firms pay local taxes in proportion to their employment in the region;[10] then, letting L^{ℓ}_{it} be the total number of employees in large establishments in region i at time t, the tax function facing a representative large firm in region i is

$$\mathcal{T}^{\ell}_{it}(Z_{it}) = \lambda \frac{Z_{it}}{N_{it}} \frac{L^{\ell}_{it}}{L_{it}}, \tag{14}$$

for some (unknown) parameter λ. Substituting (14) into (13), aggregating over N_{it} identical large firms (i.e. multiplying by N_{it}) and differentiating with respect to Z_{it} gives

$$\frac{\partial \Pi_{it}}{\partial Z_{it}} = N_{it} \frac{\partial \pi^{\ell}_{it}}{\partial Z_{it}} = N_{it} \left[F^{\ell}_{X} - \mathcal{T}^{\ell\prime}_{it}(Z_{it}) \right] = N_{it} \left(F^{\ell}_{X} - \lambda \frac{l^{\ell}_{it}}{N_{it}} \right), \tag{15}$$

where $F^{\ell}_{X} \equiv \partial F^{\ell} / \partial X_{it}$ and $l^{\ell}_{it} = L^{\ell}_{it} / L_{it}$. We will henceforth assume that (15) is positive; that is, that the marginal local-tax burden does not swamp the marginal benefit of infrastructure investments (since otherwise there would be no lobbying). Finally, using (10) and making use of the no-externality assumption,

$$\frac{\partial C_{jt}}{\partial Z_{it}} = \frac{\partial \Pi_{jt}}{\partial Z_{it}} = \begin{cases} F^{\ell}_{X} N_{it} - \lambda l^{\ell}_{it} & \text{if } j = i \\ 0 & \text{otherwise.} \end{cases} \tag{16}$$

The government's first-order condition (11) is found by adding (16) to (12) and setting their sum equal to zero. Finally, solving for z_{it} yields

$$z_{it} = a F_{X} q_{it}^{-1/2} + (1 - a)(F^{\ell}_{X} N_{it} - \lambda l^{\ell}_{it}). \tag{17}$$

Together, (7) and (17) form a system of two equations which we will estimate simultaneously, yielding consistent estimates of the contribution of transportation infrastructure investments to GDP and of the extent of political interference with these investment decisions.

---

[10] The largest local tax in France is the *taxe professionnelle* which is proportional to employment. As a robustness check, we also tried empirically an alternative formulation whereby the tax burden on local companies was proportional to their sales; it gave similar results.

3 Empirical Implementation

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) from 1985-91. Table 1 provides a brief description of the variables and a list of the relevant regions. All figures are in 1992 Francs. Output Q is measured as value added at factor cost and has been obtained from the Eurostat database 'New Cronos' (June 1999). Regional employment L is also taken from 'New Cronos' and covers all private sectors of the economy. The private capital stock K 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 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 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 (N_{it}) is taken from various issues of *L'Industrie dans les Régions,* a yearly statistical publication of the Ministry of Industry. From our model it is natural to suppose that the region Paris plays a specific role in lobbying process for infrastructure investment, therefore we defined two new variables as $N_{it}(1 - D_{Paris})$ and $N_{it}D_{Paris}$, i.e. for the former the observations from Paris are excluded whereas for latter all other observations except from Paris are excluded. Finally, the partisan dummy variable (D_{it}) is equal to 1 when the majority in a Regional Council (and hence the affiliation of the region's President) and that of the national parliament (and hence of the current government) are either both right-wing or both left-wing, and zero otherwise.[11] As our sample includes one regional election (in 1986) and two national legislative elections (in 1986 and 1988 respectively), D_it, which was constructed using press sources, varies both across regions and across time. We lagged it by one year to take account of budget delays.

TABLE 1 HERE

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.

TABLE 2 HERE

3.2 Baseline estimates

Several further adjustments are needed before (6) and (17) can be taken to the data. First, we drop the assumption that the weights on lobbying and non-lobbying terms in the government's objective function ($1 - a$ and a respectively) add up to one. As these weights are arbitrary, we will simply call them a_1 and a_2. Second, we approximate the marginal product of infrastructure capital for the representative large firm in one

---

[11] "Right wing" was defined in the sample as RPR, UDF, Front National, and "Divers Droite". "Left wing" was defined as Parti Socialiste, Parti Communiste, Mouvement des Radicaux de Gauche, various environmentalist parties, and "Divers Gauche". The "Divers Gauche" and "Divers Droite" categories classify independent individuals according to their voting patterns.

region by its aggregate value in that region; using the fact that, under technology (6), $F_X^\ell \approx \alpha_X Q_{it}/X_{it} = \alpha_X q_{it}/x_{it}$ and simplifying, (17) becomes

$$\begin{aligned} z_{it} &= a_1 \alpha_X (q_{it}/x_{it}) q_{it}^{-1/2} + a_2 \left[\alpha_X (q_{it}/x_{it}) N_{it} - \lambda l_{it}^\ell\right] \\ &= \theta_{PROD}\, q_{it}^{1/2}/x_{it} + \theta_{LOBBY}\, q_{it} N_{it}/x_{it} + \theta_{TAX}\, l_{it}^\ell, \end{aligned} \tag{18}$$

where $\theta_{PROD} = \alpha_X a_1$, $\theta_{LOBBY} = \alpha_X a_2$, and $\theta_{TAX} = \lambda a_2$. Third, as (18) is nonlinear in x_{it}, using (8) to substitute for x_{it} does not yield a closed form for z_{it}. Therefore we take care of the endogeneity of x_{it} by instrumenting it with its lagged value. Fourth, we include time dummies[12] and regional dummies (for Ile-de-France in the production function, and for Ile de France, Nord-Pas-de-Calais in 1991, and Centre between 1986 and 1990 in the policy function; the first because it contains Paris and the last two because of large-scale Eurotunnel and TGV construction). Fifth, in the policy function we include as a separate regressor the "partisan" dummy $D_{i,t-1}$. Finally, we assume an AR(1) structure for the error term of both equations. Denoting fixed time-effects by α_t and β_t, $t = 1 \ldots T$, the system to be estimated is thus:

$$\ln q_{it} = \alpha_t + \alpha_K \ln k_{it} + \alpha_X \ln(x_{i,t-1} + z_{it}) + \tilde{\alpha}_L \ln(L_{it}) + \alpha_{PARIS}\, D_{Paris} + \nu_{1it}, \tag{19}$$

$$\begin{aligned} z_{it} = {} & \beta_t + \theta_{PROD} q_{it}^{1/2}/x_{i,t-1} + \theta_{LOBBY}\, q_{it} N_{it}/x_{i,t-1}(1 - D_{Paris}) \\ & + \theta_{LOBBY\_PARIS}\, q_{it} N_{it}/x_{i,t-1} D_{Paris} + \theta_{TAX} l_{it}^\ell + \theta_{PARTY}\, D_{i,t-1} \\ & + \beta_{NORD}\, D_{Nord} + \beta_{PARIS}\, D_{Paris} + \beta_{CENTRE}\, D_{Centre} + \nu_{2it}, \end{aligned} \tag{20}$$

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 estimation procedure is as follows. We estimate (19) and (20) simultaneously by non-linear Full-Information Maximum Likelihood (FIML),[13] using a Prais-Winston transformation which avoids omitting observations for $t = 1$, (Greene 1997, p. 601). For the non-linear OLS estimation we obtain the autocorrelation parameters ρ_k, $k = 1, 2$, by minimizing the Sums of Squares Errors (SSE) for each equation, whereas for the non-linear FIML the autocorrelation parameters ρ_k are jointly estimated with the other parameters. The results are reported in Table 3.

---

[12] Instead of fixed time effects we could also use linear time trends both for the policy equation and the production function, as supposed in (6). While estimating the model with linear time trends does not change the main results, using time dummies stresses also the cross-sectional variation between regions.

[13] Estimations have been carried out using PROC MODEL, SAS 6.12.

Several specification tests are performed. In order to test the AR(1) specification against the alternative of an AR(2) specification, we employ the Godfrey Lagrange multiplier tests for non-linear regression models (Godfrey 1988, p. 117; White 1992). The test statistic has a critical value of 3.84 at a 5 percent level, which implies acceptance of the AR(1) process for all our specifications (see Table 3). It is also comforting that normality of the error structure is accepted for both single equation tests (Shapiro-Wilk) as well as for a system test (Henze-Zirkler) for all specifications.

Table 3 reports three different specifications of the policy function, labeled respectively *(b)*, *(c)* and *(d)*, depending on which lobbying variable is used. In *(b)* both N_{it} and $D_{i,t-1}$ are included together; in *(c)*, only N_{it}, the number of large establishments, is included; in *(d)*, only $D_{i,t-1}$, the partisan dummy, is included. The estimated AR(1) parameters ρ_1 and ρ_2 are about 0.90 and 0.72 respectively.

TABLE 3 - 6 HERE

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 about 0.86), given that the equation includes only $D_{i,t-1}$ and three 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. This remarkably good fit of the policy equation can also be seen by a comparison of the actual values of transportation infrastructure investment from Table 4 with the predicted values from Table 5.

The results reported in Table 3 suggest that lobbying, as we proxy it, exerts a statistically significant and quantitatively non-negligible influence on the allocation of infrastructure investment across regions. Their primary interest is qualitative—namely, that lobbying matters.[14] Quantitative estimates are, of course, sensitive to model specification (although the estimate of $\widehat{\theta}_{LOBBY}$ 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 1.46 Francs of additional

---

[14] We do not directly interpret θ_{LOBBY}, but the weight of lobbying by firms defined as $a_2 = \theta_{LOBBY}/\alpha_X$. Statistical tests of the null hypothesis that a_2 equals zero yield the following results: Likelihood Ratio (LR) 5.86, Wald 2.90 and Lagrange Multiplier (LM) 4.90. These tests are distributed as $\chi^2(1)$, thus at a 10 percent level the null hypothesis is rejected by all tests.

infrastructure investment per worker each year; or, with an average of $1,022,000$ workers, a total of 1.5 million francs for the representative region, a relatively small amount (the number of large establishments per region varies between 6 in Limousin and 113 in Rhône-Alpes). A region with a president sharing the current national executive's political obedience will attract 123.8 Francs more of infrastructure investment per worker than one having a president of the 'wrong' obedience; for the average region, this means an additional 126.5 million Francs, or 8.8 percent of average infrastructure investment. Moreover, lobbying by firms having large establishments in the region and the political orientation of the region's president slightly reinforce each other, as expected from our two-stage lobbying model whereby firms first approach local politicians, who then take up their demands to the relevant Ministry. Abundant anecdotal evidence[15] suggests that our results do capture a phenomenon widely perceived as important. Several caveats are in point, however. First, in the model of section 2, lobbying comes from *users* of transportation infrastructure, whereas in reality, the construction industry itself is one of the most active lobbyists as far as new highway construction projects are concerned. But the construction industry is composed of a few giants such as Bouygues for whom location across regions is irrelevant, and a host of small firms many of which are below our cutoff of 500 employees (a construction lobbyist recently boasted that the industry association has "52,000 members, practically one in each commune").[16] This type of lobbying activity is not or only imperfectly picked up in our framework. Second, region presidents are not the only local politicians involved; members of parliament are also important relays of local lobbying pressure.

If the positive results concerning lobbying activity 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 (and to foster regional convergence, since the postulated functional form is concave), is more puzzling.[17] Although it is certainly

---

[15] 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).

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

[17] As before, we do not directly interpret θ_{PROD}, but the weight of productivity concerns by the governments defined as $a_1 = \theta_{PROD}/\alpha_X$. Statistical tests of the null hypothesis that a_1 equals zero are not rejected at a 10 percent level by the Likelihood Ratio, Wald and Lagrange Multiplier tests.

possible 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. An obvious alternative for the square-root form used in the first term of the function U, namely a log form, gave very similar results. A convex form, being implausible since implying preference for divergence, was also tried with inconclusive results. 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 lobbying is controlled for.

Production-function estimates are significant and have the expected sign. Constant returns to scale are not rejected. The estimated elasticity $\widehat{\alpha}_K$ of private capital is 0.181 and that of infrastructure $\widehat{\alpha}_X$ is 0.101; both estimates are significant at the 5 percent level, and remarkably stable across estimation procedures: the OLS infrastructure elasticity estimate is about 0.099, suggesting, as noted in the introduction, that the simultaneous-equation bias from OLS estimation of the production function is negligible. 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. 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, 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, although inter-regional labor mobility is arguably a lesser problem than interregional capital mobility. 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 short-run 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 0.156, 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 $r_X = \widehat{\alpha}_X Q/X = 0.522$; this is slightly higher than the upper bound of the 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; 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 $115,221$ Francs per worker, or 2.3 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.[18] 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.

Pork barrel (of which we found evidence) distorts not only the overall level of infrastructure investments, but also their spatial allocation. In order to assess the size of these distortions, we perform two experiments. In the first, we calculate predicted optimal values of infrastructure investments, $\hat{z}'_{it}$, using the estimated coefficients of the policy function's "non-lobbying" terms. That is,

$$\hat{z}'_{it} = \hat{\beta}_t + \hat{\theta}_{PROD} q_{it}^{1/2} / x_{i,t-1} + \hat{\beta}_{NORD}\, D_{Nord} + \hat{\beta}_{PARIS}\, D_{Paris} + \hat{\beta}_{CENTRE}\, D_{Centre}. \tag{21}$$

---

[18] In fact, the difference between r_X and r_K is statistically not significant at a 10 percent level.

The resulting values of $\hat{z}'_{it}$ are reported in the second column of Table 6. The major drawback of this approach is that $\hat{\theta}_{PROD}$ is a very imprecise estimate (indeed, not significantly different from zero). Thus, in the second experiment, using the fact that the infrastructure stock is 0.43 times what it would take to bring its rate of return down to the rate of return on private capital (15.6 percent), we simply assume that the aggregate (nationwide) level of predicted investment is also 0.43 times its optimal value when averaged over the sample period; i.e. $\sum_t \sum_i \hat{z}_{it} = 0.43 \sum_t \sum_i z^*_{it}$, and solve the equation

$$\begin{aligned}2.3 \sum_t \sum_i \hat{z}_{it} = n \sum_t \hat{\beta}_t + \theta \sum_t \sum_i (q_{it}^{1/2} / x_{i,t-1}) \\ + \sum_t (\hat{\beta}_{NORD}\, D_{Nord} + \hat{\beta}_{PARIS}\, D_{Paris} + \hat{\beta}_{CENTRE}\, D_{Centre}),\end{aligned} \tag{22}$$

for the unknown parameter θ. The solution $\tilde{\theta}$ of (22) is then used in place of $\hat{\theta}_{PROD}$ in (21) to recalculate optimal regional investments. The resulting values are reported in the third column of Table 6.

Whereas the coefficient of variation of actual investments (averaged over time) is 45 percent , the coefficient of variation of optimal investments is 45.2 percent according to method 1 but only 33.8 percent according to method 2. Thus, our experiment suggests that a least a part of the observed cross-regional variability in infrastructure investments comes from pork-barrel terms. The reason for this is apparent: the optimal investment rule calls for equalization of the term $\alpha_X q_{it}^{1/2} / x_{it}$(after adjustment with regional dummies); as long as output per head (q_{it}) and the infrastructure stock per head (x_{it}) do not vary too much, the optimal allocation is nearly uniform. This result has an important practical consequence: whenever political distortions to the allocation of infrastructure are a source of concern—as they are in our sample—the uniform rule, which is simple to administer and monitor, is a good rule of thumb. Of course, there is a caveat; namely that if the ratio $q_{it}^{1/2} / x_{it}$ does not vary excessively in an industrial country with a large existing infrastructure stock, the same is not necessarily true in developing countries with patchy infrastructure stocks, where the uniform rule could be misleading.

4 Concluding Remarks

The primary interest of our results is that they highlight the importance of the pork-barrel dimension of policy-making, suggesting that explicit modelling of the political-economy processes driving economic-policy decisions is interesting in its own right, irrespective of whether its 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. The interest of our political-economy approach is that it can provide indications—however rough—both on the departure of policy from the social optimum and on the extent of special-interest influence. As far as policy implications are concerned, our results contain good news and bad news. The bad news is that influence activities appear to be significant drivers of infrastructure-investment decisions, whereas non-lobbying governmental objectives, if any, are unclear. The good news, however, is that the resulting distortions appear to be relatively minor. 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 the 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 (see e.g. Mény, 1992; Borraz and Worms, 1996; or SCPC, 1994).[19] 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

---

[19] 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.

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. Given our functional forms (alternative ones give similar rules) the first-best allocation of infrastructure equalizes the term $\alpha_X q_{it}^{1/2}/x_{it}$ across regions. Provided that neither productivity levels (q_{it}) nor infrastructure stocks per worker (x_{it}) vary too much across regions (our data suggests that they don't), uniform allocation is a good enough rule of thumb. Even if the ratio varies, it is not a very difficult one to compute, so the more sophisticated rule is itself not excessively demanding. Of course, if the rule is clear, how it should be implemented is not as clear, since rational politicians are unlikely to abide by a rule. What mixture of centralized vs. decentralized decision-making is least conducive to pork barrel 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.

References

[1] Aschauer, David A. (1989), "Is Public Expenditure Productive?", *Journal of Monetary Economics* **23**, 177-200.

[2] — (1995), "Infrastructure and Macroeconomic Performance: Direct and Indirect Effects", 85-101, in: *The OECD Jobs Study: Investment, Productivity and Employment*, OECD, Paris.

[3] Bergemann, Dirk, and Juuso Valimaki (1998), "Dynamic Com-mon Agency"; mimeo.

[4] Bernheim, Douglas, and Michael Whinston (1986a), "Menu Auctions, Resource Allocation, and Economic Influence", *The Quarterly Journal of Economics* **101**, 1-31.

[5] — (1986b), "Common Agency", *Econometrica* **54**, 923-942.

[6] Borraz, Olivier, and Jean-Pierre Worms (1996), "Dysfonctionnement du Pouvoir Local", *Projet* **245**.

[7] Dixit, Avinash (1996), *The Making of Economic Policy: A Transaction-Cost Politics Perspective*, MIT press.

[8] Dixit, Avinash, Gene Grossman and Elhanan Helpman (1997), *Journal of Political Economy* **105**, 752-769..

[9] Duffy-Deno, K.T., and Eberts, Randall W. (1991), "Public Infrastructure and Regional Economic Development: A Simultaneous Equation Approach", *Journal of Urban Ecocomics,* **30**, 329-343.

[10] Eberts, Randall W. (1990), "Public Infrastructure and Regional Economic Development", *Federal Reserve Bank of Cleveland Economic Review* **26**, 15-27.

[11] Eisner, R. (1991), "Infrastructure and Regional Economic Performance"; *New England Economic Review*, Federal Res. Bank of Boston, Sept./ Oct., 47-58.

[12] de la Fuente, A., and X. Vives (1995), "Education, Infrastructure and Regional Inequality: Evidence from Spain "; *Economic Policy* **20**, 13-51.

[13] Flores de Frutos, R. and Pereira, A. M. M. (1993), "Public Capital and Aggregate Growth in the United States: Is Public Capital Productive?", W 562 (93, 31), University of California Discussion Paper.

[14] Fritsch, B., and R. Prud'homme (1994), "Measuring the Contribution of Road Infrastructure to Economic Development in France", Université Paris XII, working paper 94-02.

[15] Godfrey, L. G. (1988), *Misspecification tests in econometrics: the Lagrange multiplier principle and other approaches*, Cambridge University Press.

[16] Gramlich, E. M. (1990), *A Guide to Benefit-Cost Analysis*, 2nd ed., Prentice-Hall.

[17] — (1994), "Infrastructure Investment: A Review Essay", *Journal of Economic Literature* **32**, 1176-1196.

[18] Greene, William H. (1997), *Econometric Analysis*, 3rd ed., New York, Macmillian.

[19] Grossman, Gene M. and Elhanan Helpman (1994), "Protection for Sale", *The American Economic Review* **84**, 833-850.

[20] Henze, N. and Zirkler, B. (1990), "A Class of Invariant Consistent Tests for Multivariate Normality", *Comm.Statist.-Theory Meth.* **19**, 3595-3617.

[21] Holtz-Eakin, Douglas (1988), "Private Output, Government Capital, and the Infrastructure 'Crisis'; Columbia University Discussion paper 394.

[22] — (1994), "Public-sector Capital and the Productivity Puzzle"; *Review of Economics and Statistics* **76**, 12-21.

[23] Hulten, C. (1995), "Infrastructure Spending: Where Do We Go from Here?", Proceedings of the National Tax Association conference, 1995.

[24] Kaizuka, K. (1965), "Public Goods and Decentralization of Production"; *Review of Economics and Statistics* **30**, 118-120.

[25] Laguarrigue, F., (1994), "Infrastructures de Transport et Croissance Endogène", mimeo, OEST, Ministère de l'Equipement, des Transports et du Tourisme.

[26] Martin, Philippe, and Carol A. Rogers (1995), "Industrial Location and Public Infrastructure"; *Journal of International Economics* **39**, 335-351.

[27] — (1999), "Public Policies, Regional Inequalities and Growth"; *Journal of Public Economics* **73**, 85-105.

[28] Mény, Yves (1992), *La Corruption de la République*; Fayard.

[29] Munnell, Alicia H. (1990a), "Why has Productivity Growth Declined? Productivity and Public Investment", *New England Economic Review,* Jan / Feb, 3-22.

[30] — (1990b), "How Does Public Infrastructure Affect Regional Economic performance?" in A. Munnell, ed., *Is There a Shortfall in Public Capital Investment?* Boston: Federal Reserve Bank of Boston.

[31] Negishi, Takashi (1973), "The Excess of Public Expenditures on Industries"; *Journal of Public Economics* **2**, 231-240.

[32] Peterson, G. E. (1991), "Historical Perspective on Infrastructure Investment: How Did We Get Where We Are?", American Enterprise Institute Discussion Paper.

[33] Sandmo, Agnar (1972), "Optimality Rules for the Provision of Collective Factors of Production"; *Journal of Public Economics* **1**, 149-157.

[34] Service Central de Prevention de la Corruption (1994), *Rapport Annuel 1993/94*, Paris.

[35] Tatom, J. A. (1993), "Paved with Good Intentions: The Mythical National Infrastructure Crisis", Washington, DC: Cato Institute.

[36] US Congressional Budget Office (1988), *New Directions for the nation's public works*, Washington, DC: US GPO, 1988.

[37] White, Kenneth J. (1992), "The Durbin-Watson Test for Autocorrelation in Non-Linear Models", *The Review of Economics and Statistics*, **74**, 370-373.

Table 1: Variable Description and Regions

Variable	**Description**	
Q	Regional GDP, million 1992 Francs	
L	Regional employment, million individuals	
K	Non-residential private capital stock, million 1992 Francs	
X	Transportation infrastructure stock, million 1992 Francs	
Z	Transportation infrastructure net investments, million 1992 Francs	
N	Number of establishments with more than 500 employees	
D_{it}	Dummy variable equal to 1 when regional council and national parliament have same political majority.	
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**	**Std.Dev.**	**C.V.**	**Minimum**	**Maximum**
Q/L	256723	27380.40	0.106	195921	357617
K/L	298142	62624.98	0.210	188442	484980
X/L	50920	9412.91	0.185	35453	70935
Q/X	5.166	0.8416	0.163	3.849	7.405
Z/L	1396	628.15	0.450	412	4934
$N * (1 - D_{\text{Paris}})$	35.27	21.66	0.614	5	113
$N * D_{\text{Paris}}$	7.19	32.42	4.505	0	170
D_{it}	0.435	0.50	1.143	0	1
$X_{HIGHWAY}/X_{RAIL}$	5.18	2.36	0.456	1.74	13.68
$X_{HIGHWAY}/X_{WATER}$	68.8	80.17	1.165	2.27	290

Total number of observations: 147

Table 3: Estimation Results

	(a) **OLS**		**(b)** **FIML**		**(c)** **FIML**		**(d)** **FIML**	
Production Function	Dependent Variable: $\ln q_{it}$							
α_{85}	11.24	(23.50)	11.18	(20.91)	11.19	(20.94)	11.18	(20.89)
α_{86}	11.27	(23.52)	11.21	(20.93)	11.22	(20.96)	11.21	(20.92)
α_{87}	11.28	(23.53)	11.22	(20.94)	11.23	(20.96)	11.23	(20.92)
α_{88}	11.30	(23.54)	11.24	(20.95)	11.25	(20.98)	11.24	(20.94)
α_{89}	11.32	(23.58)	11.26	(20.99)	11.27	(21.01)	11.26	(20.97)
α_{90}	11.31	(23.55)	11.25	(20.95)	11.26	(20.98)	11.25	(20.94)
α_{91}	11.31	(23.52)	11.25	(20.93)	11.26	(20.95)	11.25	(20.91)
α_K	0.189	(5.44)	0.181	(4.77)	0.182	(4.80)	0.182	(4.82)
$\widetilde{\alpha}_L$	0.025	(1.60)	0.025	(1.43)	0.025	(1.44)	0.025	(1.44)
α_X	0.097	(2.30)	0.101	(2.14)	0.100	(2.12)	0.101	(2.15)
α_{Paris}	0.218	(5.20)	0.219	(4.27)	0.219	(4.57)	0.219	(4.58)
AR(1) ρ_1	0.867		0.904		0.904		0.904	
Godfrey LM	1.764		3.366		3.293		3.278	
Shapiro-Wilk W	0.979		0.985		0.985		0.985	
R^2	0.9539		0.9537		0.9537		0.9537	
Policy Function	Dependent Variable: z_{it}							
β_{85}	848.7	(2.59)	879.8	(2.52)	997.2	(2.85)	1043.6	(2.57)
β_{86}	1159.8	(2.92)	1186.8	(3.40)	1304.4	(3.71)	1362.6	(3.36)
β_{87}	1199.4	(3.02)	1226.1	(3.58)	1340.8	(3.90)	1392.8	(3.50)
β_{88}	1539.4	(3.03)	1564.0	(4.56)	1730.1	(5.09)	1734.0	(4.37)
β_{89}	1433.3	(3.64)	1457.2	(4.28)	1622.6	(4.82)	1632.5	(4.15)
β_{90}	1949.9	(4.34)	1975.9	(6.03)	2039.6	(6.13)	2145.9	(5.61)
β_{91}	1767.7	(4.36)	1794.6	(5.67)	1853.3	(5.77)	1955.9	(5.28)
θ_{Prod}	-28165	(-0.79)	-31545	(-1.08)	-33253	(-1.12)	-31319	(-0.89)
θ_{Lobby}	1.334	(2.07)	1.456	(2.79)	1.388	(2.61)	—	(—)
$\theta_{\text{Lobby\_Paris}}$	-1.775	(-0.89)	-1.762	(-0.96)	-1.914	(-1.03)	—	(—)
θ_{Party}	120.5	(1.98)	123.8	(2.11)	—	(—)	117.9	(2.01)
θ_{Tax}	-1126.8	(-0.44)	-1473.5	(-0.71)	-1906.4	(-0.91)	376.1	(0.16)
β_{Paris}	1971.0	(0.99)	1993.9	(1.07)	2100.6	(1.11)	-30.7	(-0.11)
$\beta_{\text{Nord}_{91}}$	2373.3	(9.85)	2422.1	(10.23)	2457.3	(10.19)	2373.3	(9.98)
$\beta_{\text{Centre}_{86-90}}$	708.5	(3.97)	779.1	(4.53)	771.4	(4.43)	636.9	(3.92)
AR(1) ρ_2	0.783		0.718		0.720		0.785	
Godfrey LM	1.250		0.661		0.647		0.985	
Shapiro-Wilk W	0.982		0.980		0.974		0.983	
R^2	0.8593		0.8586		0.8546		0.8483	
System								
Henze-Zirkler T	1.198		0.817		1.112		0.899	

Estimated asymptotic t-values are given in parentheses

Table 4: Infrastructure Investment Allocation Across Regions and Years

Actual Values of Transportation Infrastructure Net Investment Per Worker, 1985-1991, in 1992 Francs	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*
Alsace	1085	1454	1306	1708	1291	1685	1723
Aquitaine	688	1106	1090	1598	1533	1984	1496
Auvergne	613	1297	1543	2026	1949	2334	1358
Basse-Normandie	526	873	620	938	878	1402	1250
Bourgogne	529	944	1115	1665	1235	1697	1424
Bretagne	412	818	871	1432	1527	1904	1449
Centre	1357	2106	2613	3003	3492	3343	2373
Champagne-Ardenne	552	965	868	1281	1128	1892	2158
Charentes Franche-Comte	542	675	580	1052	836	1451	1074
Haute-Normandie	416	617	635	865	1127	1575	1662
Ile de France	455	834	1148	1621	1532	1730	1747
Languedoc-Roussilon	630	685	822	1391	1439	1735	1574
Limousin	981	1408	1515	1288	1407	1592	1432
Lorraine	1096	1086	860	1398	1232	1693	1681
Midi-Pyrenées	811	1074	1127	1342	1402	1864	1608
Nord-pas de Calais	863	1766	1367	1983	1790	2936	4934
Pays de la Loire	868	1017	1111	1560	1255	1243	995
Picardie	1504	1625	1896	1732	1433	1586	1499
Poitou	888	1294	1095	1500	1186	1693	1276
Provence-Alpes-Côte d'Azur	505	836	739	1189	1312	2077	2240
Rhône-Alpes	1086	1338	1602	2218	1739	2142	2486

Table 5: Predicted Values

Predicted Values of Transportation Infrastructure Allocation from Table 3 (b), in 1992 Francs

	1985	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*
Alsace	772	1318	1410	1726	1549	1766	1566
Aquitaine	847	1042	1142	1451	1471	1886	1750
Auvergne	676	941	1254	1752	1743	2165	1987
Basse-Normandie	572	864	916	1182	981	1402	1317
Bourgogne	848	945	1030	1470	1537	1705	1551
Bretagne	595	791	867	1358	1343	1870	1676
Centre	808	2306	2073	2876	2757	3548	2188
Champagne-Ardenne	725	910	1026	1376	1246	1614	1684
Charentes Franche-Comte	471	839	756	1115	1033	1335	1320
Haute-Normandie	796	835	784	1223	953	1636	1461
Ile de France	504	810	930	1588	1521	1926	1754
Languedoc-Roussilon	770	971	828	1244	1292	1811	1552
Limousin	651	1201	1328	1592	1168	1979	1465
Lorraine	818	1333	1132	1426	1367	1706	1567
Midi-Pyrenées	784	1105	1133	1483	1261	1787	1645
Nord-pas de Calais	1116	1225	1702	1582	1762	2350	4934
Pays de la Loire	821	1188	1055	1593	1485	1735	1232
Picardie	935	1639	1550	2055	1586	1813	1487
Poitou	807	1171	1278	1453	1396	1620	1536
Provence-Alpes-Côte d'Azur	878	908	976	1210	1171	1740	1823
Rhône-Alpes	1216	1474	1354	2039	2101	2165	1944

Table 6: Simulated Solution Values

Actual, Predicted & Optimal Values of Transportation Infrastructure Net Investment Allocation, Averages of Years 1985-1991, in 1992 Francs	Actual	Predicted	Method I	Method II
Alsace	1465	1444	1299	2077
Aquitaine	1356	1370	1275	2492
Auvergne	1589	1503	1464	2783
Basse-Normandie	927	1034	983	2586
Bourgogne	1230	1298	1205	2535
Bretagne	1202	1214	1150	2831
Centre	2613	2365	2266	3564
Champagne-Ardenne	1264	1226	1168	2542
Charentes Franche-Comte	887	982	982	2688
Haute-Normandie	985	1098	1020	2354
Ile de France	1295	1290	1968	3744
Languedoc-Roussilon	1183	1210	1169	2587
Limousin	1375	1341	1299	3005
Lorraine	1292	1336	1244	2575
Midi-Pyrenées	1318	1314	1214	3269
Nord-pas de Calais	2234	2096	1933	3261
Pays de la Loire	1150	1301	1171	3088
Picardie	1611	1581	1480	2991
Poitou	1276	1323	1241	3045
Provence-Alpes-Côte d'Azur	1271	1244	1179	2452
Rhône-Alpes	1802	1756	1524	2949