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Effects of club size in the provision of public goods. Network and congestion effects in the case of the French municipalities*

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Abstract. The article formalizes and measures the impact of club size on the quality of the public good provided to its members. Under a general framework we describe various functional forms that allow either network or crowding effects. Mechanisms of provision are that of a political process in which both the demand and the supply sides are considered. Estimations use the whole set of French municipalities. The supply model performs better than the demand model in the case of small municipalities, while for large cities the demand model has higher explanatory power. In so far as impact of city size on the quality of club goods is concerned, crowding does appear, but it does so in different patterns. For small towns marginal congestion first decreases then increases with population. Marginal congestion is decreasing for cities of intermediate size. For larger cities no significant effects are observed.

JEL classification: D7, R5, H72

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1 Introduction

The conditions of the provision of public goods depend on the size of the corresponding club. A given club of size N providing a public good Z will deliver a service of quality q to its members. Which are the effects of the size of the club on this service? For a given level of Z, a variation, for instance positive $\Delta^+ N$, of N may induce a variation in quality. If $\Delta q > 0$, a network effect appears. Conversely, if $\Delta q < 0$, congestion affects the provision of the service. To understand

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and measure congestion has become a subject of great interest, particularly with the contributions of Craig (1987), McMillan (1989), Edwards (1990), McGreer and McMillan (1993), Means and Mehay (1995). These authors renew earlier work conducted by Borcherding and Deacon (1972) and Bergstrom and Goodman (1973). More recently, and as the theory of congested public goods was becoming fully established (Reiter and Weichenrieder 1999), debates extended to other topics. Examples include the property tax as a congestion fee (Wilson 1997), the quality of public services when the population is heterogeneous (Glazer and Niskanen 1997), and tax competition in presence of congestion (Matsumoto 2000).

However, focusing on congestion may not allow us to fully understand the effects of club size on the provision of public goods. If we consider for instance the development of cities, they may, at some stages of their development, benefit from network effects derived from the existence of local public goods. Although congestion seems to be dominant in empirical terms, the theoretical analysis cannot afford to not account for possible network effects.Moreover, most congestion functions can be generalized to allow for network effects; this view is also consistent with generalized oligopoly models (see, for instance Kanemoto 2000), which examine the workings of markets with either congested goods or network effects.

We provide here a general microeconomic framework for the definition of the effects of club size on the provision of public goods. We also assess various ways of measuring provision. As in most analyses of this type, the process of club good provision is political. However, we try to describe it more thoroughly by considering a supply model in addition to the usual demand setting. For the first time (to our knowledge) estimations use the whole set of French municipalities, and so offer wide-ranging tests.

We will next proceed to describe the effects of club size on the provision of public goods. Section 3 compares alternative political processes of public good provision; corresponding models are estimated in the subsequent section. Conclusions round out our discussion.

2 Effects of club size on the provision of public goods

For a given club the effects of size can be expressed as:

$$q = f(Z, N) \tag{1}$$

where q reflects the quality of the public goods consumed by members of a community, Z is a composite public good which represents the total quantity of services supplied by the club, and N is the number of simultaneous users. We make the assumption of log-linearity in q in order to avoid non-linearity later in the econometric specifications. This also corresponds to the assumption of proportionality between q and Z (see Reiter and Weichenrieder 1999 on this point) used by Borcherding and Deacon (1972) and Bergstrom and Goodman (1973). Hence:

$$q = g(N)Z \tag{2}$$

The total differentiation of equation (2) amounts to $dq = Zg'(N)dN + g(N)dZ$. Dividing by q or $g(N)Z$ gives:

$$\frac{dq}{q} = \frac{g'(N)dN}{g(N)} + \frac{dZ}{Z} \tag{3}$$

Let us define club-size elasticity $\eta_N = \partial q/\partial N \cdot N/q$ as the measure of the variation in the quality of services if additional users join the club, while simultaneously maintaining the total quantity of public services. This expresses either the absence of any effect ($\eta_N = 0$), a network effect ($\eta_N > 0$) or congestion ($\eta_N < 0$). Since $\partial q/\partial N = g'(N)Z$and $q = g(N)Z$, club-size elasticity can be written:

$$\eta_N = \frac{g'(N)N}{g(N)} \tag{4}$$

Equation (3) thus becomes:

$$\frac{dq}{q} = \eta_N \frac{dN}{N} + \frac{dZ}{Z} \tag{5}$$

Relative variations in quality do depend on the provision of public services, but they also depend on relative variations in club membership and on club-size elasticity.

The specification of club-size elasticity is conditioned by the functional form g. Three alternative functions are usually considered. They are described here under the previous general framework. A widely adopted measure is given by Borcherding and Deacon (1972). In our setting the Borcherding-Deacon function can be expressed through the functional form $g(N) = N^{\gamma}$ as:

$$q = N^{\gamma} Z \tag{6}$$

The function can describe decreasing marginal crowding or alternatively decreasing, constant or increasing marginal network effects (see Fig. 1). Club-size elasticity is constant:

$$\eta_N = \frac{\partial q}{\partial N}\frac{N}{q} = \gamma N^{\gamma-1} Z \frac{N}{N^{\gamma} Z} = \gamma \tag{7}$$

Buchanan (1965) provides another functional form $g(N) = N^{\gamma'} e^{\gamma'' N}$. Up to a certain point an increase in the number of users generates a "friendship" or "camaraderie" effect (Sandler and Tschirhart 1980). After that, crowding erodes benefits to each member of the club (see Fig. 2). The camaraderie function can be written as:

$$q = N^{\gamma'} e^{\gamma'' N} Z \tag{8}$$

where club-size elasticity is:

$$\eta_N = \frac{\partial q}{\partial N}\frac{N}{q} = \left[(\gamma' N^{\gamma'-1} e^{\gamma''} N) + (e^{\gamma'' N} \gamma'' N^{\gamma'})\right] Z \frac{N}{N^{\gamma'} e^{\gamma'' N} Z} = \gamma' + \gamma'' N \tag{9}$$

The Borcherding-Deacon formulation also describes camaraderie if $\gamma > 0$ (see Fig. 1).

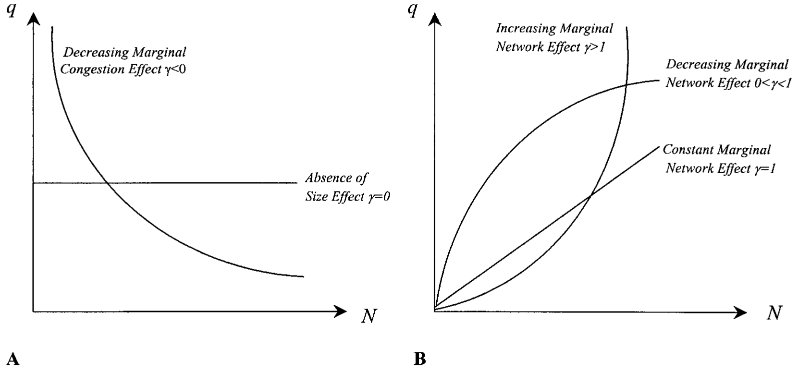

Fig. 1. The Borcherding-Deacon function

$$q = N^{\gamma} Z; \quad \frac{\partial q}{\partial N} = \frac{\gamma}{N} q; \quad \frac{\partial^2 q}{\partial N^2} = \frac{\gamma(\gamma - 1)}{N^2} q$$

The nature of the club-size effect depends on the value of parameter γ

Finally, the flexible form $g(N) = \exp(\gamma' N + \gamma'' N^2 + \gamma''' N^3)$ developed by Edwards (1990) does not impose any *a priori* profile for the effect of club size

$$q = e^{(\gamma' N + \gamma'' N^2 + \gamma''' N^3)} Z \tag{10}$$

with a club-size elasticity of:

$$\eta_N = \frac{\partial q}{\partial N} \frac{N}{q} = (\gamma' + 2\gamma'' N + 3\gamma''' N^2) q \frac{N}{q} = \gamma' N + 2\gamma'' N^2 + 3\gamma''' N^3 \tag{11}$$

Thus, marginal effects can be positive or negative, according to the values of the parameters.

Having described some possible functional forms of the effects of club size on the quality of public goods, we now move on to the formalization of the decision of expenditure.

3 Alternative models of public good provision

In an applied perspective, the clubs considered here are municipalities, but the model can certainly be used in more general cases. The framework is that of a political process, in which the decisive voter delegates power of decision and action to the elected local government. The corresponding contract is incomplete by nature. An alternative mechanism would be the "private" town of the entrepreneurial model, where an urban developer maximizes land value. However, the political process is particularly well adapted to many institutional contexts, for instance the French one. As such, the political process will be our reference model.

In this setting we can proffer two alternative specifications. The first considers the demand side and the choice of public expenditure made by the decisive voter (Sect. 3.1). The second examines the supply side and the decision of public good

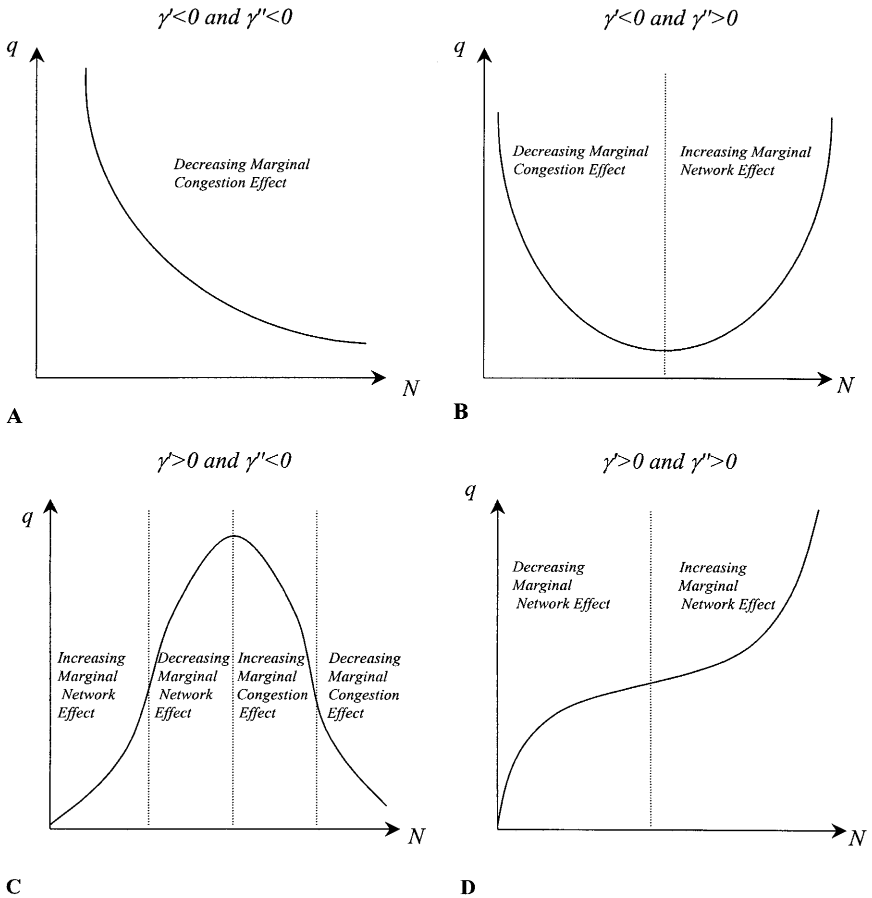

Fig. 2. The *camaraderie* function

$$q = N^{\gamma'} e^{\gamma'' N} Z; \qquad \frac{\partial q}{\partial N} = \frac{\gamma' + \gamma'' N}{N} q;$$

$$\frac{\partial^2 q}{\partial N^2} = [(\gamma'/N + \gamma'')^2 - \gamma'/N^2]q;$$

$$\frac{\partial^2 q}{\partial N^2} = 0 \quad \text{for} \quad N = -\frac{\gamma' \pm \sqrt{\gamma'}}{\gamma''} \text{ and } \gamma' > 0.$$

The nature of the club-size effect depends on the value of parameters γ' and γ''

provision proposed by the local government (Sect. 3.2). The models do not account for possible spillovers from one club to another (see Conley and Dix 1999 on this point). Introducing such spillovers would exceed the scope of our study, which will instead focus on the assessment and measurement of the quality of public services.

3.1 The demand model

The demand model rests on the median voter theorem in a framework of representative democracy. The local government is assumed to abide by a contract, which strictly commits the elected body towards the median voter m, whose program can be written as:

$$\underset{x_m, q}{Max}\ U_m(x_m, q) \tag{12}$$

$$\text{subject to } x_m + tb_m = y_m, \quad C(Z) = tB + S, \quad q = g(N)Z$$

U_m is the preference function of the median voter. He derives utility from the consumption of a *numéraire* x_m and from using a composite public good of quality q. The tax rate is t and the tax base of the median voter is denoted b_m. The total tax base is B. The technology of production is represented by the differentiable cost function $C(Z)$. The local community is granted lump-sum revenues S by higher levels of government. The first constraint is the median voter's budget constraint, where y_m is the income. According to the second constraint, the local government has to balance its budget. Finally, the third constraint expresses the possible mechanism of club-size effects. Combining the three equations yields:

$$x_m + \frac{C(g(N)^{-1}q)}{N}\frac{b_m}{b} = y_m + s\frac{b_m}{b} \tag{13}$$

The average tax base per inhabitant is given by $b = B/N$ and $s = S/N$ denotes *per capita* lump-sum grants. The right side of Eq. (13) measures the overall income of the median voter. The tax price p_m of the composite public good is obtained by solving the previous program (12), where the constraints are combined in Eq. (13):

$$\frac{\partial U_m/\partial q}{\partial U_m/\partial x} = C'_Z\frac{g(N)^{-1}}{N}\frac{b_m}{b} \equiv p_m \tag{14}$$

with C'_Z the marginal cost of production of the local public good. The median voter's tax price is the product of the marginal user cost $C'_Z g(N)^{-1}/N$ and of the tax share b_m/b. The first term describes the conditions of production C'_Z, combined with the characteristics of collective consumption $g(N)^{-1}/N$. The second term gives account of the direct influence of taxation on the choice of the decisive voter. Thus, Eq. (14) broadly delineates the institutional setting in which collective choices are implemented.

Moving on now to the estimation framework, we assume that the demand function is log-linear such that:

$$q = k_1(p_m)^\alpha(y_m)^{\beta_1}\left(s\frac{b_m}{b}\right)^{\beta_2} \tag{15}$$

where p_m is the solution to the previous optimization program (12) and y_m and sb_m/b are variables of this program. This demand function is expressed in terms of q. But only an expenditure function can be observed and estimated. In order to express it, we assume that the average and marginal costs of production are equal and constant within the community ($C(Z)/Z = C'_Z$). Hence, for $q = g(N)Z$,

$q = \frac{g(N)C(Z)}{C'_Z} = k_1(p_m)^{\alpha}(y_m)^{\beta_1}\left(s\frac{b_m}{b}\right)^{\beta_2}$. Moreover, the value of the tax price is given by Eq. (14). The final equation is:

$$\frac{C(Z)}{N} = k_1(C'_Z)^{(1+\alpha)}\left[Ng(N)\right]^{-(1+\alpha)}\left(\frac{b_m}{b}\right)^{(\alpha+\beta_2)}(y_m)^{\beta_1}(s)^{\beta_2} \tag{16}$$

The equation depicts a framework, which is certainly appropriate when the aim is to describe a process of direct democracy. Equation (16) could also suit a situation of representative democracy, whenever the corresponding election contract is relatively complete. In the other cases a supply model would be more relevant.

3.2 The supply model

The supply model considered here rests on a formalization of the behavior of elected representatives who are relatively free to choose the policies they will undertake. However, these policies must be relevant if the local government ever wishes to have its mandate renewed. On the other hand, the median voter would like to ensure that those actions will lead to the desired level of public services, at as low a taxation cost as possible. The incentive associated with the prospect of mandate renewal in this context can be formalized by a popularity function $W(q,t)$ with $\partial W/\partial q > 0$ and $\partial W/\partial t < 0$. The program of the elected representatives can be written as:

$$\underset{q,t}{Max}\ W(q,t) \tag{17}$$

$$\text{subject to } C(Z) = tB + S, \quad q = g(N)Z$$

where the constraints can be combined, using the assumption of equal average and marginal costs of production:

$$\frac{g(N)^{-1}C'_Z}{N}q - bt = s \tag{18}$$

Hence the implicit tax price p_e:

$$\frac{\partial W/\partial q}{-\partial W/\partial t} = C'_Z\frac{g(N)^{-1}}{N}\frac{1}{b} \equiv p_e \tag{19}$$

The user cost $g(N)^{-1}C'_Z/N$ of the local public good is multiplied by a specific tax share $1/b$. Elected representatives do not consider the distribution of individual tax bases, they only take the level into account. Conversely, in the demand model the relative position of the median voter's base is a decisive characteristic.

The discrepancy between tax shares is the main difference between the proposed models. In addition, the introduction of the income of the median voter is no longer necessary in the supply model. The corresponding expenditure function is given by:

$$q = k_2(p_e)^{\alpha}\,(s)^{\beta_2} \tag{20}$$

with α the price elasticity and $\beta_2$the grants elasticity. The final supply equation is:

$$\frac{C(Z)}{N} = k_2(C'_Z)^{(1+\alpha)}\left[Ng(N)\right]^{-(1+\alpha)}\left(\frac{1}{b}\right)^{\alpha}(s)^{\beta_2} \tag{21}$$

Equations (16) and (21) provide the respective specifications of the alternative models of local public good provision. Based on the three congestion functions, the expenditure equations derived from Equations (16) and (21) with the appropriate $g(N)$ are specified as follows:

Demand models:

$$\begin{aligned}&\ln(E) = A_1 + (\alpha+1)\ln(C'_Z) - (\alpha+1)(\gamma+1)\ln(N) + \\ &(\alpha+\beta_2)\ln(b_m/b) + \beta_1\ln(y_m) + \beta_2\ln(s)\end{aligned} \tag{22}$$

(corresponding to the "Borcherding-Deacon" formulation)

$$\begin{aligned}&\ln(E) = A_1 + (\alpha+1)\ln(C'_Z) - (\alpha+1)(\gamma'+1)\ln(N) - (\alpha+1)\gamma''(N) \\ &+(\alpha+\beta_2)\ln(b_m/b) + \beta_1\ln(y_m) + \beta_2\ln(s)\end{aligned} \tag{23}$$

("Camaraderie" specification)

$$\begin{aligned}&\ln(E) = A_1 + (\alpha+1)\ln(C'_Z) - (\alpha+1)\ln(N) - (\alpha+1)\gamma'(N) \\ &-(\alpha+1)\gamma''(N^2) - (\alpha+1)\gamma'''(N^3) \\ &+(\alpha+\beta_2)\ln(b_m/b) + \beta_1\ln(y_m) + \beta_2\ln(s)\end{aligned} \tag{24}$$

("Flexible" form)

Supply models:

$$\ln(E) = A_2 + (\alpha+1)\ln(C'_Z) - (\alpha+1)(\gamma+1)\ln(N) + \alpha\ln(1/b) + \beta_2\ln(s) \tag{25}$$

("Borcherding-Deacon" formulation)

$$\begin{aligned}&\ln(E) = A_2 + (\alpha+1)\ln(C'_Z) - (\alpha+1)(\gamma'+1)\ln(N) \\ &-(\alpha+1)\gamma''(N) + \alpha\ln(1/b) + \beta_2\ln(s)\end{aligned} \tag{26}$$

("Camaraderie" specification)

$$\begin{aligned}&\ln(E) = A_2 + (\alpha+1)\ln(C'_Z) - (\alpha+1)\ln(N) - (\alpha+1)\gamma'(N) \\ &-(\alpha+1)\gamma''(N^2) - (\alpha+1)\gamma'''(N^3) \quad + \alpha\ln(1/b) + \beta_2\ln(s)\end{aligned} \tag{27}$$

("Flexible" form) with $E = C(Z)/N$, $A_1 = (\alpha+1)\ln(k_1)$ and $A_2 = (\alpha+1)\ln(k_2)$. What appears first is that the value of the club-size effect is independent from the specification of behaviors. Moreover, the Borcherding-Deacon specification is a nested version of the camaraderie function, which is in turn a nested version of the "Flexible" form.

4 Estimations

The first step is the description of specifications and data, the latter consisting of the French municipalities for 1995 (Sect. 4.1). We then give estimations for the entire set of these clubs as well as differentiate communities according to size. The first stage provides descriptions and comments on elasticities and cost parameters (Sect. 4.2). In the second stage we discuss the results on marginal congestion and the explanatory power of the models (Sect. 4.3).

4.1 Data and specifications

We begin with a short description of the French local public sector. By decreasing size, the three levels of local government in France are the *régions*, then the *départements*, the lower level being that of the *communes* (municipalities) and their co-operation structures. Municipalities, the object of our analysis, have two thirds of the resources of the local public sector (the *départements* have 25% of these resources, the *régions* less than 10%). They provide collective services physically linked to houses (for instance, water, local roads, sewerage systems, garbage disposal,) as well as amenities provided to their inhabitants (for instance, local schools, sports equipment and playgrounds, recreational or cultural facilities, local transport). When the population of a given municipality grows, the diversity of the proposed services generally increases, particularly in the field of culture and sports.

A specific feature of the French local public sector is the high number of municipalities (more than 36,000). Among them 27,000 have fewer than 1,000 inhabitants, 9,600 have between 1,000 and 10,000 inhabitants, while 874 have more than 10,000 inhabitants. Only one hundred cities have more than 50,000 inhabitants. Resources of municipalities come mainly from local taxes (45% of total resources), then from grants by the central government (30%). User fees account for 15%, while borrowing reaches 10%. Borrowing cannot finance current expenditures. Local taxation mainly relies on taxes on housing or on property, and on local business taxes. These two categories of taxes provide similar revenues. Municipal councils vote the tax rates (without exceeding twice the national average of rates). Moreover, variations in the rates on business and housing must be linked. Hence, the importance of the decisive voter, since the rate applied to his or her base will in turn largely determine the tax policy with regard to the local firms.

An important feature of the French system is the rather unequal distribution of business tax bases: 80% of inequalities in tax resources are explained by this distribution (although grants by the central government correct part of it). The business tax mainly concerns the manufacturing industry and electricity production, which implies that a substantial part is exported. The tax share b_m/b thus varies according to the nature of the municipality. The ratio is near 1 for residential areas, while for industrial areas it tends toward 0. As tax shares vary widely, tax prices are also likely to show a large distribution. Price effects are all the more significant and they may tend to partially overshadow income effects.

Table 1 provides the correspondence between the theoretical variables and the empirical ones. Furthermore, inter-municipal co-operation is taken into account

Table 1. Description of the variables

Variable	Content
$C\,(Z)$	Total cost of local public services (wages of local civil servants, provisions for depreciation, consumption of other inputs). This variable takes account of both strictly municipal costs and contributions to co-operation structures (mainly inter-communal).
N	Local population.
b_m	Tax base of the median voter (since this median base is not available, it is replaced by the average one).
b	Total tax base per inhabitant (property taxes, local business tax, tax on housing).
y_m	Income of the median voter (since the median income is not available, it is replaced by the average one)
s	Grants received by the municipality (mainly from the central government) per inhabitant.
SUR	Surface of the municipality (km^2).
AL	Average altitude of the municipality.

with a dummy variable (anticipating the results, this dummy will always be significant) and in the total cost of public services. We assume that local business taxes are perceived by the median voter to either be exported or shifted fully away. As to the specifications, cross-sectional tests require an estimation of the marginal cost of production. As we have seen earlier, it is assumed constant within a given local community. However, the marginal cost of production is a variable when the entire set of municipalities is considered. First, differences in marginal cost could be explained by the wage policy of the municipalities. In the French case however, municipalities have no degree of freedom since wage rates are chosen at the national level and must be uniformly applied throughout the country. Second, technical efficiency can vary from one community to another; this source of disparity is not considered here due to insufficient data. Third, the spatial allocation of endowments in geographical resources is unequal; this source of disparity is dealt with by the introduction of two geographical variables, namely the surface (denoted *SUR*) and the average altitude (denoted *AL*) of the local territory. Thus:

$$C'_Z = SUR^{\rho_{SUR}} AL^{\rho_{AL}} \tag{28}$$

The use of surface allows us to account for population densities and to therefore capture the unequal distribution of land among the municipalities. Surface also helps to capture that which an important number of small rural communities encounter when their population decreases and the fixed costs of infrastructures do not diminish in proportion. The relative rigidity in the provision of some public services (such as roads) proves to be a budgetary burden for many. The introduction of altitude is more specific to mountain areas and concerns a non-negligible number of municipalities in France. The consideration of altitude accounts for the higher cost of infrastructures due to relief or climate.

4.2 Estimations of elasticities and cost parameters

The results of the estimations are given in Tables 2 and 3. Price elasticities α behave in the usual way in most cases. They are negative and significant. They range from -0.63 to -0.54 in the demand model and from -0.25 to -0.21 in the supply model (in the latter case, the estimation is not significant for cities with more than 50,000 inhabitants). The lower value of these price elasticities in the supply model may be due to the different fiscal share it takes into account. The values obtained here reflect results in other studies, for example McGreer and McMillan (1993) for Canada or Feld (1999) for Switzerland. One must notice that price elasticities are positive but not significant for large municipalities (more than 50,000) in the supply model. Part of the variation in the value of these elasticities from one population category to another may be due to the diversity of the municipalities.

Income elasticities β_1 in the demand model are not conventional for the small municipalities (less than 3,500 inhabitants) and the cities (more than 50,000 inhabitants). They are negative and significant, ranging from -0.25 to -0.04. Although surprising, these results are not unknown (e.g., Gramlich and Rubinfeld 1982; Hayes 1986; Hayes and Slottje 1987; McGreer and McMillan 1993). For municipalities between 3,500 and 10,000 inhabitants, the income elasticity is positive and significant, around 0.07, but not significant for municipalities between 10,000 and 50,000 inhabitants. These ambiguous results may be related to the state of the available statistical data. Indeed, the income is measured at the average rather than at the median level. Grants always have a significant impact on per capita local public expenditures and they appear with the expected positive sign. In fact, grants elasticities β_2 are significantly different from zero, and range from 0.39 to 0.48.

The next step in the interpretation focuses on cost specifications. For municipalities of fewer than 50,000, the estimation of cost parameters is coherent with the previous intuitions. The criterion of surface is indeed significant and does have a positive impact on marginal cost (the coefficient for cities of more than 50,000 is not significant). For instance, a 10% increase in surface (in square kilometres) induces approximately a 1% increase (as measured by $(\alpha + 1)\rho_{SUR}$) in public expenditure per head for the small municipalities. Altitude is also significant, but it takes on different signs according to the size of the cities. The impact on cost is positive for the smaller ones: a 10% increase in altitude implies a 0.3% increase (as measured by $(\alpha + 1)\rho_{AL}$) in expenditures per capita. The negative influence for cities between 3,500 and 50,000 can be explained by the high number of seaside resorts among them. For the latter, it is the low altitude that brings about important costs. For large cities, both cost parameters are not significant. This finding may be explained by the low variance in the distribution of surface and altitude. The allocation of endowments in geographical resources may thus not be a discriminating characteristic for such cities.

We now turn to the interpretation of club size elasticities (see Table 4). They measure the relative variation in the quality q of a given quantity of the local public good Z due to a relative variation in population. For the camaraderie and flexible cases, club size elasticity is calculated at the mean population. For the Borcherding-Deacon and the camaraderie function, whatever the specified model,

Table 2. Estimations of the demand model

		Whole set of municipalities	Less than 3,500 inhabitants	Between 3,500 and 10,000 inhabitants	Between 10,000 and 50,000 inhabitants	More than 50,000 inhabitants
Observations		36143	33820	1478	736	109
Borcherding-Deacon						
Elasticities	α	-0.5669^*	-0.5403^*	-0.6098^*	-0.6333^*	-0.6056^*
	β_1	-0.0489^*	-0.0381^*	0.0711^*	0.0104	-0.2430^*
	β_2	0.4265^*	0.4101^*	0.4129^*	0.4030^*	0.4795^*
Parameters of club size	γ	-1.1211^*	-1.0437^*	-1.2970^*	-1.2006^*	-1.0692
	γ'					
	γ''					
	γ'''					
Geographical parameters	ρ_{SUR}	0.1655^*	0.1984^*	0.0346^*	0.0369^*	-0.0036
	ρ_{AL}	0.0728^*	0.0715^*	-0.0262^*	-0.0447^*	0.0181
	Adjusted R^2	0.6538	0.6374	0.6754	0.6760	0.6894
Camaraderie						
Elasticities	α	-0.5634^*	-0.5226^*	-0.6098^*	-0.6329^*	-0.6072^*
	β_1	-0.0476^*	-0.0476^*	0.0711^*	0.0114	-0.2427^*
	β_2	0.4240^*	0.3986^*	0.4128^*	0.4029^*	0.4807^*
Parameters of club size	γ					
	γ'	-1.1073^*	-0.9051^*	-1.3055	-1.1119	-1.1360
	γ''	$-5.27E-06^*$	$-2.46E-04^*$	0	$-6.27E-06$	0
	γ'''					
Geographical parameters	ρ_{SUR}	0.1670^*	0.1993^*	0.0346^*	0.0362^*	-0.0023
	ρ_{AL}	0.0715^*	0.0682^*	-0.0262^*	-0.0447^*	0.0197
	Adjusted					
R^2	0.6561	0.6467	0.6754	0.6761		0.6911
Flexible form						
Elasticities	α	-0.5540^*	-0.5199^*	-0.6096^*	-0.6336^*	-0.6109^*
	β_1	-0.0443^*	-0.0594^*	0.0713^*	0.0109	-0.2558^*
	β_2	0.4175^*	0.3956^*	0.4127^*	0.4034^*	0.4795^*
Parameters of club size	γ					
	γ'	$-2.07E-05^*$	$-1.29E-03^*$	$-3.14E-03$	$-9.43E-05$	$-1.18E-05$
	γ''	$1.08E-10^*$	$5.32E-07^*$	$2.61E-07$	$1.72E-09$	$1.68E-11$
	γ'''	$-9.52E-17^*$	$-8.39E-11^*$	$-9.31E-12$	$-1.29E-14$	$-8.17E-18$
Geographical parameters	ρ_{SUR}	0.1753^*	0.1963^*	0.0347^*	0.0365^*	-0.0100
	ρ_{AL}	0.0690^*	0.0669^*	-0.0261^*	-0.0449^*	0.0125
	Adjusted R^2	0.6597	0.6502	0.6755	0.6762	0.7068

Note: * Indicates that the estimate is significantly different from 0 at the 5% level.

Table 3. Estimations of the supply model

		Whole set of municipalities	Less than 3,500 inhabitants	Between 3,500 and 10,000 inhabitants	Between 10,000 and 50,000 inhabitants	More than 50,000 inhabitants
Observations		36143	33820	1478	736	109
Borcherding-Deacon						
Elasticities	α	-0.2342^*	-0.2272^*	-0.2547^*	-0.2134^*	0.0380
	β_1					
	β_2	0.3789^*	0.3662^*	0.3493^*	0.3389^*	0.4693^*
Parameters of club size	γ	-1.0359^*	-0.9994^*	-1.1400^*	-1.0681^*	-1.0087
	γ'					
	γ''					
	γ'''					
Geographical parameters	ρ_{SUR}	0.0955^*	0.1155^*	0.0198^*	0.0436^*	0.0146
	ρ_{AL}	0.0318^*	0.0340^*	-0.0255^*	-0.0308^*	0.0041
	Adjusted R^2	0.6940	0.6794	0.7177	0.6490	0.5988
Camaraderie						
Elasticities	α	-0.2337^*	-0.2200^*	-0.2547^*	-0.2127^*	0.0395
	β_1					
	β_2	0.3764^*	0.3571^*	0.3493^*	0.3393^*	0.4713^*
Parameters of club size	γ					
	γ'	-1.0287^*	-0.9291^*	-1.1397	-0.9962	-1.0352
	γ''	$-3.00E-06^*$	$-1.27E-04^*$	0	$-2.92E-06$	0
	γ'''					
Geographical parameters	ρ_{SUR}	0.0969^*	0.1196^*	0.0198^*	0.0428^*	0.0148
	ρ_{AL}	0.0314^*	0.0342^*	-0.0255^*	-0.0308^*	0.0047
	Adjusted R^2	0.6953	0.6860	0.7177	0.6495	0.6007
Flexible form						
Elasticities	α	-0.2308^*	-0.2188^*	-0.2547^*	-0.2128^*	0.0443
	β_1					
	β_2	0.3711^*	0.3543^*	0.3491^*	0.3389^*	0.4718^*
Parameters of club size	γ					
	γ'	$-1.20E-05^*$	$-6.66E-04^*$	$-2.29E-03$	$1.05E-04$	$-4.41E-06$
	γ''	$5.79E-11^*$	$2.77E-07^*$	$1.91E-07$	$-2.20E-09$	$5.60E-12$
	γ'''	$-5.08E-17^*$	$-4.44E-11^*$	$-6.81E-12$	$-1.81E-14$	$-2.93E-18$
Geographical parameters	ρ_{SUR}	0.1024^*	0.1197^*	0.0199^*	0.0424^*	0.0127
	ρ_{AL}	0.0308^*	0.0341^*	-0.0254^*	-0.0308^*	0.0025
	Adjusted R^2	0.6992	0.6883	0.7179	0.6499	0.6091

Note: * Indicates that the estimate is significantly different from 0 at the 5% level.

Table 4. Estimations of club size elasticities

Demand model						
		Whole set of municipalities	Less than 3,500 inhabitants	Between 3,500 and 10,000 inhabitants	Between 10,000 and 50,000 inhabitants	More than 50,000 inhabitants
Average population		1549	590	5653	16810	107014
Elasticities	Borcherding-Deacon	-1.1211^*	-1.0437^*	-1.2970^*	-1.2006^*	-1.0692
	Camaraderie	-1.1155^*	-1.0502^*	-1.3055	-1.2174	-1.1360
	flexible	-0.0315^*	-0.4451^*	-6.0804	-0.7963	-0.9117
Supply model						
		Whole set of municipalities	Less than 3,500 inhabitants	Between 3,500 and 10,000 inhabitants	Between 10,000 and 50,000 inhabitants	More than 50,000 inhabitants
Average population		1549	590	5653	16810	107014
Elasticities	Borcherding-Deacon	-1.0359^*	-0.9994	-1.1400^*	-1.0681^*	-1.0087
	Camaraderie	-1.0334^*	-1.0040^*	-1.1397	-1.0454	-1.0352
	flexible	-0.0183^*	-0.2278^*	-4.4437	0.7850	-0.3545

Note: * Indicates that the estimate is significantly different from 0 at the 5% level.

demand or supply, these elasticities are quite similar; they are all close to –1, although they are not significant for municipalities of more than 50,000 inhabitants for the B-D function, and more than 3,500 for the camaraderie function. These empirical findings are coherent with those obtained in similar studies, which would imply "non-publicness of local public goods", to use the words of Borcherding and Deacon. The particular values obtained with the flexible form come from the computation at the mean population. Take for example, the estimation of club size elasticity for the demand model in the fewer than 3,500 inhabitants case. The calculated value is –0.4451 for an average population of 590. If we consider a population of 3,500 inhabitants, then the club size elasticity amounts to –2.27. Consequently, the range of club size elasticity belongs to the interval $[-2.27, 0]$.

4.3 Statistical comparison of the models and estimations of marginal congestion

To compare the explanatory power of the supply and demand models, we use the method of non-nested hypothesis testing developed in Davidson and MacKinnon (1993). If we consider the two alternative specifications $Y = X_1\mu_1 + \varepsilon$ and

$Y = X_2\mu_2 + \varepsilon$ (where X describes the independent variables and μ is a vector of parameters), the method consists of constructing a convex combination of the competing models. For instance, $Y = (1-w)X_1\mu_1 + wX_2\hat{\mu}_2 + \varepsilon$ (where $X_2\hat{\mu}_2$ is the vector of the estimated values of Y with the second specification) from which we test $w = 0$. Since the models are linear, a simple t-test is adequate. The second step is the test of $w' = 0$ in $Y = w'X_1\hat{\mu}_1 + (1-w')X_2\mu_2 + \varepsilon$. If w is statistically different from 0 while w' is not, then the second model (with the independent variables X_2) has greater explanatory power than the first model. If parameters w and w' are simultaneously either significant or non-significant, then the test is ambiguous and does not give any information on the explanatory power of the models. For the various specifications, the t-values of the corresponding tests are given in Table 5.

Table 5. Comparison of the models (t-test statistics)

Specification (hypothesized/ alternative)	Fewer than 3,500 inhabitants B-D	Cam.	Flex.	Between 3,500 and 10,000 inhabitants B-D	Cam.	Flex.
Demand/Supply	81.75	81.85	82.19	17.78	17.77	17.77
Supply/Demand	−5.69	−3.36	−0.12	1.88	1.88	1.85

Specification (hypothesized/ alternative)	Between 10,000 and 50,000 inhabitants B-D	Cam.	Flex.	More than 50,000 inhabitants B-D	Cam.	Flex.
Demand/Supply	7.50	7.48	7.45	−1.58	−1.50	−1.41
Supply/Demand	9.57	9.51	9.46	5.52	5.49	5.78

For small municipalities with a population of fewer than 3,500 inhabitants, and considering the flexible form, the supply model improves upon the outcomes of the demand model ($t = 82.19$ against $t = -0.12$). As to the Borcherding-Deacon and camaraderie functions, neither model can be rejected outright in preference to the other because the parameters of the Davidson-MacKinnon test are significant in both cases. The test therefore cannot provide any selection of the models. The two models contribute to the explanation of the characteristics of local public expenditures. If we compare alternative congestion functions we have already seen that the Borcherding-Deacon specification is a nested case of the camaraderie model, which in turn is a nested version of the flexible form. Since the parameters of the flexible form are statistically significant, the latter performs better than the other two. All in all, for this range of population, the supply model should be preferred to the demand model, and in this framework the flexible form performs better than the Borcherding-Deacon and camaraderie functions.

Turning to municipalities with a population between 3,500 and 10,000, the supply model is always preferred to the demand model at the 5% level. Inside this supply framework, the Borcherding-Deacon specification is the only function

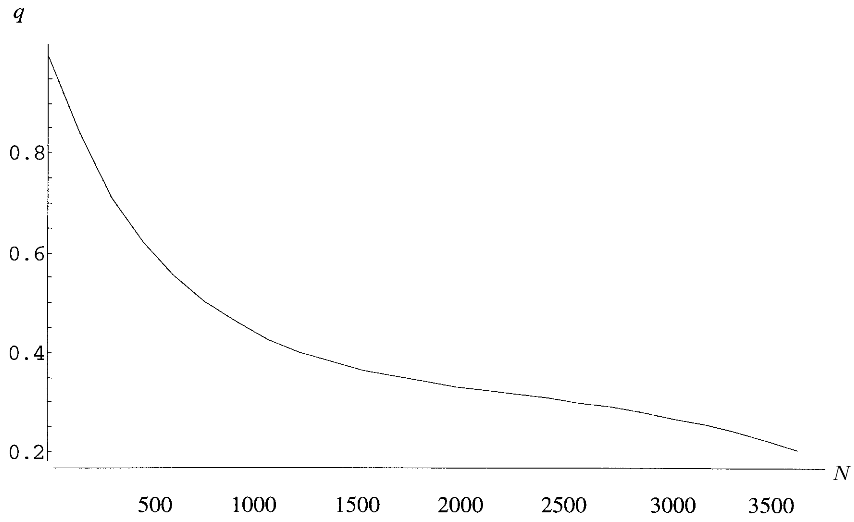

Fig. 3. The flexible function. Numerical simulations (for $Z = 1$) for the values of parameters of the supply model (municipalities of fewer than 3,500)

that provides significant results, in that only γ is statistically different from zero. The next range of population (between 10,000 and 50,000) shows ambiguous results. For all the specifications, the parameters of both tests are significant, which does not allow us to select one of the models. In both settings, however, only the Borcherding-Deacon function performs well. Finally, for large cities of more than 50,000, the demand model performs better than the supply model. However, none of the congestion functions have significant coefficients.

Contrary to most studies on the same subject (for example, Hayes and Slottje 1987; McGreer and McMillan 1993; Edwards 1990), we find results for small municipalities (fewer than 3,500 inhabitants) – giving evidence of decreasing then increasing – marginal congestion (see Fig. 3), which is consistent with club theory. As far as larger municipalities are concerned (from 3,500 to 50,000), our results resemble those usually obtained. They show that the conventional Borcherding-Deacon approach, exhibiting decreasing marginal congestion, is superior to alternative specifications. For cities of over 50,000 inhabitants, no significant results are obtained, as mentioned earlier. What may explain the specificity of our results is the fact that we distinguish between various population ranges, which is not the case with the other studies mentioned here. This distinction may indeed confirm the necessity to consider the population size in the estimation, as suggested by Oates (1988).

At this stage we would like to point out two limitations of the estimations. First, the levels of population thresholds (3,500; 10,000; 50,000) are exogenous in that they correspond to administrative norms. A further step in the research could envisage the use of econometric methods that could make the thresholds endogenous. This step could refine the tests and improve the quality of the estimations. Second, available statistics only provide average income for inhabitants, whereas the application of the median voter model requires the use of median incomes; this data is not yet accessible in the French accounting system. When this occurs estimations should be substantially improved.

5 Conclusion

To some extent the quality of an excludable public good is certainly related to the size of the club that provides it. But this intuition has to be formalized and tested which was the aim of our article. A general theoretical model of network and congestion effects has been put forward while the mechanisms of provision have been described through a political process including demand and supply characteristics. For municipalities between 3,500 and 10,000 inhabitants, the supply model performs better than the demand model. For large cities (more than 50,000 inhabitants), the reverse is observed. The results are ambiguous for the other ranges of population. As far as the impact of the size of the city on the quality of club goods is concerned, crowding does appear, but in different patterns. For small towns of fewer than 3,500, marginal congestion first decreases then increases with population. Marginal congestion decreases for cities of intermediate size (3,500 to 50,000 inhabitants). For larger ones, no significant effects are observed.

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