Locally Provided Public Schooling in Brazilian Municipalities

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Abstract

The objective of this paper is to assess the demand for public schooling in the Brazilian municipalities within a median voter framework. The quantile regression and spatial techniques proved to be useful to account for the spatial and marginal effects associated with educational services. The coefficients attached to the main variables – price, income and population – were significant and had the expected sign. The relatively high values for those parameters attest the status for these merit goods as "luxuries". Last, but no least, the municipal school system in Brazil seems to present increasing returns to scale both, at the school and the municipality level.

Keywords: Public Schooling, Demand, Brazilian municipalities, Median voter

JEL Classification: H72, H75, C31

Resumo

O objetivo deste estudo é estimar a demanda por serviços educacionais nos municípios brasileiros dentro de uma abordagem do eleitor mediano. Técnicas de regressão quantílica e de econometria espacial provaram ser úteis para captar efeitos espaciais diferenciados e de transbordamento na demanda municipal por educação. Os coeficientes estimados das principais variáveis – preço, renda e população – foram significantes e apresentaram os sinais esperados. Os valores relativamente altos desses parâmetros atestam esses bens meritórios como 'de luxo'. Por fim, nossos resultados sugerem que o sistema educacional no Brasil apresenta retornos de escala tanto em nível da escola quanto do município.

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1. Introduction

Education policies represent a decisive contribution to a nation's progress as it fosters productivity and reduces poverty. Recent studies have consistently found that additional years or levels of schooling are translated into a large labor market premium. Also, there is by now a growing consensus that education is a critical determinant of income distribution. Indeed, current research point outs to education as the single most important determinant of inequality.[1] This point is particularly relevant for Brazil, a country characterized by extreme inequalities, and a correspondingly social debt, that seriously jeopardize the long run growth prospects of the economy. Hence, the urge to improve public education offered at earlier stages and to promote a wider access to secondary education is crucial to Brazil as it may help to reduce the strong political demands for redistributive measures and contributes to a sustainable and equitable growth.

To achieve these goals Brazilian governments at different levels devote a considerable amount of resources to fund public schooling. Local government efforts as well as a substantial share of their revenues – augmented by state and federal grants – are allocated to increase the much required educational standards, making schooling expenses one of the largest items of municipal budgets. In order to reduce regional educational disparities and increase teachers' wages, earmarked transfers such as FUNDEF (Fund for Maintenance and Development of the Fundamental Education and Valorization of Teaching), injected a considerable amount of resources into the basic educational system. In this context, the analysis of local public expenditures with education in Brazil is highly pertinent.

School expenditures may be analyzed from a number of perspectives. Among them we find studies which emphasize the role played by demand on the provision of public education. Following the seminal work of Bergstrom et al. (1982), many empirical studies used survey data to estimate the demand for educational expenditures (Rubinfeld et al. 1987; Rubinfeld and Shapiro 1989; Shapiro and Papadakis 1993). An alternative way of modeling education demand is the well known median voter model (Lovell 1978; Inman 1978; Holcombe 1980). If preferences are single-peaked, this model predicts that voting by majority rule over a single-dimensional public good will result in the provision of the median voter's desired level of public schooling.

The median voter as a model of demand aggregation under majority rule has proven to be quite robust as attested by many empirical studies (Holcombe 1989). Besides the knowledge of demand functions, this hypothesis takes into account the existence of economies of scale and congestion in the provision of school services and permits to identify the effects of changes in demographic and economic variables on the amount of the educational services demanded. Here, we will adhere to this tradition to investigate the determinants of local education expenditures on basic

[1] See Barros (1992).

education in Brazilian municipalities.

Although many studies have used the median voter approach, only a few incorporated inter-jurisdictional spillovers into the median voter's demand function for public goods (Murdoch et al. 1993). This point is especially meaningful when we are dealing with municipalities. The existence of multiple interactions among neighbor towns makes decisions in a given commune dependent on the ones adopted by the other communes in a close area. The relevance and direction of such interactions are an empirical matter that should be investigated. One might think, for example, that in close areas, schools in a given commune may be a substitute for the ones located in its neighborhood, thus, reflecting a free riding behavior by the median voter. Alternatively, a higher demand for education in one community may increase the demand for this service in neighbor's towns. This complementarity may be explained by competition among municipalities or by the fact that education in nearby communes is a joint product and thus enhance each other's value through a better neighborhood quality. To account for that dependence here we will use spatial models along the lines proposed by Anselin (1988).

Moreover, most of the previous studies on local educational expenditures used classical linear regression to estimate models for conditional mean function. However, when municipalities are highly heterogeneous, as is the case in Brazil, results produced by the classical model may be misleading because they fail to account for this diversity. Quantile regression methods, that offer a mechanism to estimate models for the conditional median and other conditional quantile functions, are more appropriate to grasp differences among communes. This approach could be useful when estimating the median voter model for schooling because it allows the impacts of the conditioning variables to differ across the expenditures distribution and permits to examine the marginal effects of the exogenous variables across educational spending levels.

The objective of this paper is to assess the demand for public schooling in the Brazilian municipalities within a median voter framework. Our model differs from previous work in the specification of the spatial structure and the use of quantile regression techniques to account for the above mentioned spatial and marginal effects associated with the demand for educational services.

This paper unfolds as follows. Section 2 describes the theoretical model for demand for schooling based in the median voter framework. Section 3 describes the data and variables. Section 4 describes the econometric model. Section 5 presents the results. Finally, Section 6 summarizes the main conclusions.

2. Demand for Schooling within a Median Voter Model

Let $i = 1, \dots, M$ denote municipalities. The median voter preferences are represented by a quasi-concave utility function on private goods (C_i) and publicly provided education (e):

$$u = u(C_i, e) \tag{1}$$

Due to the presence of congestion in consumption, the quality of the public service depends on the size of the community's population (N). Using the proportional metric proposed by Bocherding and Deacon (1972), the congestion function may be written as:

$$E = N^{\gamma} e \tag{2}$$

Where E is the total education and γ measures the crowding effect. If γ is one, the public good is private and there is no benefit from scale economies for the community: the individual consumption is equal to $1/N$. On the other hand, if γ is zero, the good is a purely public good. Notice that if γ is higher than one the good is marginally over congested (Reiter and Weichenrieder 1999). Every additional user requires an increase in the supply of E so as to keep e constant. Values of γ between 0 and 1 allow for the possibility of goods that have partly private and partly public characteristics, where crowding effects are presents but there are still economies of scale in consumption.

The median voter maximizes its utility function subject to its budget constraint:

$$Y_i = C_i + tb_i \tag{3}$$

The price of the private good (C) has been normalized to be equal to 1. All individuals within the jurisdiction consume the same level of education, herein denoted by e, whose price is p. The income of the median voter is given by Y_i; b_i represents its tax base and t is the municipality tax rate. The individual's demand functions depend also on the government's budget constraint, given by:

$$cE_i = G_i + tB_i \tag{4}$$

where c is the constant marginal and average cost of production of public service;[2] B_i stands for the tax base, tB_i corresponds to total tax revenues and G represents the intergovernmental grants received by the i-th municipality. Rearranging (4) for t and using it together with (2) in the median voter's budget constraint gives:

$$Y_{ai} = Y_i + g(b_i/b) = C_i + (b_i/b)cN^{\gamma-1}e \tag{5}$$

Y_{ai} corresponds to the revenue of the median voter increased by its share of *per capita* intergovernmental grants, $g = G/N$, and $b = B/N$., where B stands for the total tax base. The median voter's income plus its share of the *per capita* intergovernmental transfer must finance its private expenses as well as its cost share on education $(b_m/b)cN_i^{\gamma-1}e$. Rewriting (5) we have

[2] Bergstrom and Goodman (1973, p. 280) showed that this will be possible even if communities produce public goods using some local inputs whose prices may differ from place to place, so long as all municipalities have identical, homothetic production functions and face horizontal supply curves for inputs.

$$C_i = Y_i + (b_i/b)\left[g - cN^{\gamma-1}e\right] \tag{6}$$

Replacing (6) in (1) yields the following maximization problem:

$$\max u = u\left[\left(Y_i + (b_i/b)[g - cN^{\gamma-1}e]\right), e\right] \tag{7}$$

Assuming that the maximization of [7] yields the median voter's demand function for education, e, we have:

$$e = e\left[Y_a, (b_i/b), N\right] \tag{8}$$

Defining the tax price of schooling as the individual cost of purchase one additional monetary unit of education it can be derived by differentiating Y_a with respect to e. The tax price is therefore:

$$\partial Y_a/\partial e = p = (b_i/b)cN^{\gamma-1} \tag{9}$$

Each consumer knows his own tax price and is able to determinate the amount of commodity [3] which his choose for the community. Supposing that the demand function defined by (8) is characterized by constant price and income elasticity, it can be written as:

$$e = \alpha p^{\beta_1} Y_a^{\beta_2} \tag{10}$$

Using [9], rearranging the terms, and writing [10] in terms of E, by means of [2] we have:

$$E = eN^{\gamma} = \alpha c^{\beta_1}(b_i/b)^{\beta_1} Y_a^{\beta_2} N^{[(\gamma-1)\beta_1+\gamma]} \tag{11}$$

Finally, adding a vector Ω of socio-economic characteristics, which are expected to influence demand, and multiplying (11) by p leads to an estimable function of local educational expenditures, $\check{E}$:

$$\check{E} = pE = peN^{\gamma} = \alpha c^{1+\beta_1}(b_i/b)^{1+\beta_1} Y_a^{\beta_2} N^{[(\gamma-1)\beta_1+2\gamma]}\Pi_k \Omega_k^{\beta_k} \tag{12}$$

Rewriting (12) in log terms, yields the standard estimation equation for analyzing the demand for locally supplied public goods:

$$\ln \check{E} = \ln k + (1+\beta_1)\ln c + (1+\beta_1)\ln(b_m/b) + \beta_2 \ln Y_a + \beta_3 \ln N_i + \sum \beta_k \ln \Omega_k + \varepsilon_i \tag{13}$$

where $k = \alpha c^{1+\beta_1}$ and $(1+\beta_1)$ is the price elasticity of the demand for public schooling. The population elasticity, β_3, satisfies the following equation:

$$1 + \beta_1 + \beta_3 = \gamma(2 + \beta_1) \tag{14}$$

[3] Reiter and Weichenrieder (1997, p. 21) showed three reasons why electors may misperceive the costs of public services: "fiscal illusion"; "flypaper effect" and "revenue-complexity".

3. Data and Variables

The data used in this study were obtained from the Census 2000 and the Base de Informações Municipais (BIM) of IBGE (Instituto Brasileiro de Geografia e Estatística – Brazilian Institute of Geography and Statistics). To complement the required information we used data from the Instituto de Pesquisa Econômica Aplicada (IPEA – Institute for Applied Economic Research), Ministry of Education, particularly those referring to the FUNDEF (Fundo de Manutenção e Desenvolvimento do Ensino Fundamental e de Valorização do Magistério – Fund for Maintenance and Development of the Fundamental Education and Valorization of Teaching) as well as two others municipal database: the one built by the Secretaria do Tesouro Nacional (STN – National Treasure Secretariat) and the Base de Finanças Municipais do Brasil (FINBRA). The sample consists of 3,426 municipalities, out of a total of 5,507 Brazilian municipalities. The communes for whom some information was missing were excluded of the data set. Data on local tax revenues was obtained from STN. Table 1 provides the complete list of variables.

4. Spatial Estimators

As previously stated, since the cross-sections in this study are municipalities, spatial dependence may occur due to the existence of interactions among neighbor towns. To consider these interactions we will use the spatial autoregressive model (Anselin 1988) and the Conley correction for spatial dependence (Conley 1999). Below we will briefly describe those models.

4.1. *The Anselin model*

Let n be the number of observations, $y = (y_1, \ldots, y_n)'$ the vector of dependent variable, X a matrix of dimension $n \times p$, containing the explaining variables, β a p-dimensional vector of unknown parameters and u an n-dimensional vector of random errors.

$$y = \rho W y + X\beta + u; \qquad u = \lambda W u + \varepsilon; \qquad \text{with} \qquad \varepsilon \sim N(0, \sigma^2 \ln) \tag{15}$$

where W is an $n \times n$ matrix that controls for the existence of neighborhood effects. Here, a spatially explicit variable takes the form of a "spatial lag" or spatially lagged dependent variable, which consists of a weighted average of the neighboring values. This model is also known as the Spatial Autoregressive Model.

The interpretation of the parameter ρ is straightforward: for our application, if different from zero, the value for ρ gives the extent to which education expenditures, for a given municipality, are influenced by the expenses of its neighbors. The sign of this effect, as previously stated, depends on the relationship between expenses among communes. If they act as complement, we should expect a positive;

Table 1
Dependent and explanatory variables: a brief description

Dependent variable	Description
Municipal Spending on Education – E	The value of municipal spending with education
Explanatory Variables	**Description**
Tax share – b_m/b	The tax share of the citizen with the median income, based on the ratio between the median and the average income.
Median Income – y_m	Median earnings, median income plus tax share × *per capita* intergovernmental grants.
Total Population – N	Number of citizens in a municipality (total population).
% Population > 15 years old literate	Demographic variable. Population above 15 years old that is illiterate.
% Population < 15 years old	Demographic variable. Population below15 years old.
% Population > 60 years old	Citizens older than 60 in percent of total population.
Demographic Density	Population/area of the community (scale variable).
Urbanization rate	Ration between the urban population and total population.
Enrollment	Education scale variable. Data refers to primary and secondary enrollment in municipal schools.
Enrollment per school	Education scale variable. Data refers to primary and secondary enrollment in municipal schools.
Enrollment in private schools	Education variable. Data refers to enrollment in municipal private schools.
% of Households whose Head Earns up to 1 Minimum Wage	Poverty proxy.
Dummy variables	**Description**
Participation in Inter-Municipal Consortia	Proxy to administrative coordination and organization among municipalities.
Council power	Power yielded to municipal councils. Proxy to effectiveness in resource utilization.
Alvorada program	Special development program that includes municipalities whose IHD (Index of Human Development) is inferior to 0.5. Municipalities participating in this program take 1; zero otherwise.
North, Northeast, Southeast and Center-West Regions	Proxies to evaluate for regional and geographic influence. Municipalities located in these regions take 1; zero otherwise
Colligation 1	Colligation formed by the political parties that support the Federal government. When the mayor belongs to this colligation, it takes 1; zero otherwise.
Colligation 2	Colligation formed by the political parties that oppose the Federal government. When the mayor belongs to this colligation, it takes 1; zero otherwise.

otherwise, a negative relationship indicates substitution among spending levels. The parameter λ captures the spatial correlation between the errors and ε is a new error term.

The contiguity matrix W plays a key role in spatial modeling by quantifying the notion of location similarity. This matrix, crucial to test statistics, may be defined in a number of ways. For instance it may assume a binary form, based on shared borders. Then, the element (i, j) from W is one if municipalities i and j are neighbors and zero otherwise, neighborhood being defined as geographical distance that does not exceed a certain distance. Alternative ways to this binary form for the W matrix includes defining weights as an inverse function of distance or even general "social" distance. [4]

The spatial simultaneity shown by (15) violates OLS assumptions. Hence, this method will yield inconsistent and biased estimates making its inference flawed. Consequently, estimation methods that account for this simultaneity should be used such as maximum likelihood (ML) principle and instrumental variable (IV) estimation in a spatial two-stage, least-squares approach (Anselin 1988). However, these spatial techniques are highly sensitive to the specification of the neighborhood matrix (W). Below we will present an alternative way to correct for spatial dependence.

4.2. *The Conley correction*

Conley (1999) used nonparametric methods to build up a consistent estimator for the GMM (Generalized Methods of Moments) moment conditions covariance matrix, corrected for spatial dependence. His approach is a variant of the well known Newey and West (1987) estimator for the spatial dependence covariance matrix in presence of heteroskedasticity and autocorrelation. As the GMM estimator does not assume a parametric form, it is robust to model specification, distance measurement errors and missing values. Inferences from this model are therefore robust to more general spatial error structures.

Notice that in absence of endogeneity problems, the Conley estimator coincide with the one produced by the OLS method; therefore, its use do not alter the estimated values for the β parameters, modifying only the statistical inference referent to these estimations.

5. Results

Firstly, we will present OLS and GMM spatial results. Table 2 shows estimates for the β parameters as well as the standard error and the p-values, for both OLS and spatial GMM. The cut off criteria adopted here for the GMM correction is 0.5 that corresponds to an influence area of roughly 50 kilometers. Remember that the GMM estimator does not make any assumption about the parametric form of the spatial dependence and does not interfere with the estimation of the OLS parameter. However, although the point parameter estimates for OLS and spatial GMM coincide, the standard errors can be different, implying different hypothesis test results because the latter corrects the covariance matrix for spatial correlation.

Our results show that, for most coefficients, the OLS procedure underestimated the standard errors; consequently, the distributions of the p-values appear more concentrated in the region close to zero. However, most variables, in spite of higher standard errors, remain significant at the 1% and 5% level. The exception is the

[4] For technical details, see Anselin (1988).

variable urbanization that looses its significance when we account for the spatial dependence. Below, we discuss these results in detail.

Table 2
Estimated demand for education expenditures in Brazilian municipalities – GMM Spatial Results – 2000

Independent variables	Dependent variable: municipality educational expenditures				
	Coefficients	OLS		Spatial GMM (cutoff =0,5)	
		Standard-error	p-value	Standard-error	p-value
Intercept	-1,8666	0,2288	0	0,2864	0
Tax price	-0,7486	0,0319	0	0,04	0
Median income	1,1914	0,0227	0	0,0286	0
Population	0,9318	0,0105	0	0,0152	0
Urbanization rate	0,0543	0,0138	0,0001	0,0289	0,0599
Demographic density	-0,0296	0,0051	0	0,006	0
% Households earning up to 1minimum wage	0,0602	0,0087	0	0,012	0
Program Alvorada	0,0624	0,0184	0,0007	0,0198	0,0016
% Population < 15 years old	0,0782	0,0158	0	0,0214	0,0003
% Population > 60 years old	-0,0654	0,0151	0	0,0183	0,0003
% Population > 15 years old literate	-0,429	0,0668	0	0,0718	0
Enrollment in private schools	-0,0381	0,0067	0	0,0079	0
Enrollment	-0,9631	0,007	0	0,0066	0
Pupil per school	-0,2074	0,0581	0,0004	0,0666	0,0018
Municipal Consortia	-0,0294	0,0107	0,0058	0,0128	0,0212
Council power	-0,0154	0,009	0,0862	0,0092	0,0919
Colligation 1	-0,0274	0,0145	0,0586	0,0132	0,0373
Colligation 2	-0,0421	0,0168	0,0122	0,0182	0,0206
North	-0,2294	0,0296	0	0,0416	0
Northeast	0,1207	0,0242	0	0,0309	0,0001
Southeast	-0,0665	0,0228	0,0036	0,0242	0,0061
Center-west	0,2095	0,0129	0	0,0161	0

Number of observations: 3426; Number of covariates: 22; Number of instruments: 22;
Horizontal cutoff value: 0.5; Vertical cutoff value: 0.5; J-statistics: 3.2893e-019;
J-statistics p-value: 1.

Concerning the core variables of the median voter model – price, income and population – the computed demand elasticities are, respectively, -0.7486, 1.1914 and 0.9318.[5] These relatively high values – even when we control for neighborhood characteristics and socio-demographic variables – should not be attributed to aggregation problems[6] but to the underlying preferences of the community. The estimated income elasticity higher than one confirm previous results for the median voter's theory and attest the status of merit goods such as education, as "luxuries" (Newhouse 1987; Gerdtham 1992; Falch and Rattso 1997). As for the price coefficients, although its value is higher than the ones found in the literature, our findings confirm previous results showing that educational expenditures are

[5] Price-elasticities computed by Rubinfeld and Shapiro (1989) range from -0.43 to -0.719 whereas the income elasticities found by those authors are between 0.695 and 0.931.
[6] See **?**.

rather inelastic, (Rubinfeld and Shapiro 1989; Ahlin and Johansson 2001). The estimated coefficient for population reflects the economies of scale that characterizes the provision of educational services in Brazilian municipalities.

As expected, a younger population (a higher share of people below 15 years old) contributes to increase the demand for educational services; on the other hand, a larger share of elder citizens leads to lower municipal education expenses suggesting the existence of a potential competition between the elderly and younger segments of the population for public resources (Poterba 1997; Ladd and Murray 2001). Elderly people may prefer to spend on other public services such as health care that benefit them more directly. Also, they demand less education because they do not have children at schools. Lastly, as elderly people tend to be better off than the younger, even when they are head of family (phenomenon quite widespread in the poorest Brazilian communes) their relatives can afford to use private schools. Corroborating previous studies, our estimates suggest that private schools are substitutes for municipal public schools. A higher enrollment in private schools reduces the demand for public schooling.

To account for the scale of operation in schools, we include two variables: total enrollment and pupils per schools. Both variables were relevant for explaining educational expenditures. Due to scale effects, municipal education expenditures grow slower than enrollment. The negative coefficient for the variable pupils per school support the existence of scale economies in teacher salary costs, supply costs, and total educational costs. [7] Consequently, larger schools are cheaper because the fixed costs are diluted among a higher number of students.

Turning now to the municipality size, our results show that cities with very high-density rates spend less on education, even when we control for population and other relevant variables. This is likely due to the presence of local increasing returns to scale prevalent among small municipalities. They fail to optimally use their resources, because the scattered populations on those cities raise the average costs of educational services, thus preventing them from exploiting the economies of scale that characterizes the production of those services. Hence, the municipal school system in Brazil seems to present increasing returns to scale both, at the school and the municipality level. Finally, when we account for spatial effects, the positive effect of the urbanization rate on educational expenses, found by using the OLS model, is no longer significant.

Let us now turn to impact of the socioeconomic characteristics of the communes on their educational spending pattern. Poverty incidence, measured here by the share of population whose household head earns up to one minimum wage, raises educational expenses as the poor have no private substitute for public schools. This positive effect may also reflect the fact that the poor do not pay property taxes and hence do not share the costs of financing schools. Furthermore, among the very poor municipalities, those taking part in the Alvorada Program tend to spend more. This is probably due to the additional resources brought about by this program,

[7] See Hanushek (1986), Sampaio de Souza and Stosic (2005).

designed to improve the socio economic conditions of these poor areas. Finally, a higher percentage of literates in a municipality leads to a reduced demand for local public schooling.

The inverse relationship between educational expenses and participation in inter-municipal consortia may be due to the fact that, *ceteris paribus*, the coordination among neighbor municipalities to provide educational services contributes to optimize the scale of operations and cut costs. One would also expect that the more power yielded to municipal councils, the better the effectiveness in resource utilization and hence, the lower the expenditures required for a given service because these councils would increase the transparency of the budgeting process and contribute to more effective control of corruption and misuse of local funds. However, we only found weak evidence in both OLS and GMM models for that hypothesis.

As for the political variables, municipalities where the mayor opposes the central government (colligation 2) have smaller expenses than the ones where the mayor stands for the ruling parties in Brasília (colligation 1). This also means that the so called left parties that represent the main opposition, do not have a particularly higher demand for public education – at least, their demand are not high enough to counterbalance their more restrict access to public funds.

We also found that municipalities located in the Northeast region tend to spend more on education when compared with the South region (the omitted region); this result is reinforced by the positive coefficient attached to the municipalities participating to the Alvorada Program, where most of the cities are located in this region. The same apply for the Center West region. Such a result is consistent with the idea that, for different reasons, both regions have, indeed, a greater demand for public educational services. In the poor Northeast, public schools are, frequently, the only ones available for many families as they cannot afford its private substitutes. In the relatively rich Center West, the highest expenses per student may reflect the presence of the Brazilian Capital, which has one of the best and expensive schooling systems in Brazil.

Finally, regarding the crowding out effect, its computed value is 0.9455, below the values found by previous studies (Reiter and Weichenrieder 1997), where this parameter tends to be higher than one, thus implying a strong congestion effect. This result is hardly surprising. This comparatively large public ness of government-supplied goods may be explained by the small size of the typical Brazilian municipalities. We should expect a lower congestion effect in presence of significant economies of scale that makes most of the municipality's facilities oversized, as is the case, for example, with the relatively small Brazilian schools. Indeed, an increase in the number of students would lower the tax price of the publicly provided schools as their cost is shared by a larger group. Of course the value of this parameter depends on the definition of the tax rate. However, even when we use a different definition, our estimates were kept below the unity.

5.1. *Quantile regression estimates*

To complement the econometric analysis carried out in the previous sub-section, we proceed to a more detailed investigation using quantile regression methods, as introduced by Koenker and Bassett (1978). Just as classical linear regression allows one to estimate models for conditional mean functions, quantile regression methods offer a mechanism for estimating models for the conditional median function, and also for other conditional quantile functions. The OLS estimate considers only the effect of one variable in the medium point of the conditional distribution of another dependent variable. Quantile regression permits to analyze the impact of explanatory variables on different points of the conditional distribution of the dependent variable. The basic idea is to estimate the τ-th quantile of efficiency conditional on the different explanatory variables, assuming that this quantile may be expressed as a linear predictor based on these variables. [8]

We thus re-estimate the OLS models by using the techniques of quantile regression. In order to do that, we considered the following conditional quantiles: 0.10 (percentile 10%), 0.25 (lower quartile), 0.50 (median), 0.75 (upper quartile) e 0.90 (percentile 90%), that is (τ= 0.10; 0.25; 0.50; 0.75; 0.90). We used the estimation method "BR", proposed by Barrodale-Roberts, adequate for the case where the sample size has around 3,500 observations and the only one that allows for the "rank test". The errors were considered not i.i.d, thus allowing for the presence of heteroskedasticity. Notice also that this method satisfy the criterion of "goodness-of-fit" (the "pseudo-R^2") for model selection (see Koenker and Machado 1999).

To explicitly consider the spatial dependency, the Anselin Model, presented in Section 4, was used. The contiguity matrix, W, used here considers that the element (i, j) from W will be equal to the distance between municipalities i and j divided by the maximum distance encountered; hence, we have a measure between zero and one for all pairs of localities and not only a binary measure of neighborhood.

We turn now to the analysis of quantile estimations. Results shown in Table 3 qualify those previously obtained with the OLS and GMM models, as new and useful information is added by using quantile regression. Firstly, the spatial effects become much evident. The estimates for ρ (coefficients on *spillover* (equation (15)) are positive indicating that, for the median voter, neighborhood schools function as complements to the ones located in their own municipality. Moreover, this effect decreases across quantiles. However, for the big cities, located on the last quantile, this effect is insignificant and changes its sign providing a weak evidence of the existence of free riding behavior involving metropolitan areas that should be better investigated.

The impact of the tax price increases along the expenditure classes. The higher price elasticities for public education in cities with higher expenses are probably

[8] For further details on the method see Koenker and Bassett (1978); Koenker and Basset (1982), Koenker and Machado (1999).

due to the fact that these cities have a large tax base and support a larger share of their school system. So, they are more sensitive to its costs. Small cities, relying basically on grants from the central government to fund their educational system, are less sensitive to modifications in their tax price. Quantilic results reinforces the fact that education is a normal (luxury) good, i.e. income elasticities increases with income showing that higher levels of development bring about increased pressures for education. Also, the well to-do voters concentrated in those areas are more likely to vote for more public financial support for schools, even if they send their children to private school, because they place a greater priority on education.

As for population, except for the lowest quantile, the elasticity is fairly stable across quantiles. The reduced coefficient for the lowest quantile suggests that the positive impact of population on expenditures, for small cities, is negligible. Consistent with this result, the coefficient attached to the demographic density variable decreases along expenditure classes. This is rather expected as the economies of scale in Brazil affect mostly the small cities, unable to wipe off the high fixed costs of educational services. Once cities reach a certain level of size, the agglomeration benefits begin to peter out, while diseconomies rise rapidly.

Table 4 shows that the computed congestion parameter is reduced along total spending classes showing that the degree of public ness for educational services is higher for cities in the higher classes of expenses. This is apparently contradictory as we expect big cities to be more congested when compared to small ones. Yet, a careful look shows the drawbacks of such interpretation. Indeed, here we have two distinct effects acting simultaneously.

Firstly, in Brazil, institutional rigidities – such as the set up of maximum number of students per class, far below the required by cost efficiency standards – prevent even large cities to exploit the economies of scale that are present in educational services. Secondly, larger cities offer a more diversified range of educational services – such as the extended journey at schools as well as sports and arts programs – that are unavailable in small towns and contributes to increase spending along the lines of the so called "zoo-effect" pointed out by Oates (1988). So, in Brazil, contrary to the traditional results, the reduced congestion effect along the spending classes reflects the predominance of the scale elements measured by the population elasticities over the price effects. Hence, the higher expenditures of larger towns show not only a crowding cost but also the fact that these cities offer a wide range of services when compared to the small ones.

The positive effect of the urbanization rate on educational expenses is significant only for the lowest quantile, a rather surprising result, as one would expect that the higher costs brought about by urbanization would be more expressive for the largest cities. Increased educational costs resulting from poverty incidence diminishes across the quantile classes As previously mentioned, the poor inhabitants of small towns have no private substitute for public schools and/or do not pay property taxes. Also, the analysis of the socio economic characteristics points out to the fact that for the smallest – and, probably, poorest – municipalities, the participation in the Alvorada Program does not guarantee additional funds for education.

Table 3
Determinants of the demand for educational services in Brazilian municipalities – Quantile regression results – 2000

Explaining variables	Dependent variable: municipality educational expenditures				
	$\tau = 0,10$	$\tau = 0,25$	$\tau = 0,50$	$\tau = 0,75$	$\tau = 0,90$
Intercept	-2.2028***	-2.2681***	-1.9343***	-1.9276***	-1.5016***
	(0.3883)	(0.2468)	(0.2496)	(0.2509)	(0.2645)
Spillovers(W.education expenditure)	0.0179***	0.0129***	0.0081*	0.0081**	-0.0008
	(0.0060)	(0.0040)	(0.0043)	(0.0040)	(0.0046)
Tax price	-0.6150***	-0.7411***	-0.7806***	-0.8175***	-0.8579***
	(0.0492)	(0.0310)	(0.0331)	(0.0333)	(0.0346)
Median income	1.1291***	1.1921***	1.1876***	1.2054***	1.2333***
	(0.0356)	(0.0238)	(0.0223)	(0.0228)	(0.0270)
Population	0.9110***	0.9372***	0.9312***	0.9395***	0.9302***
	(0.0152)	(0.0099)	(0.0107)	(0.0105)	(0.0099)
Urbanization rate	0.0287**	0.0242**	0.0125	-0.0064	-0.0043
	(0.0145)	(0.0108)	(0.0141)	(0.0162)	(0.0121)
Demographic density	-0.0499***	-0.0383***	-0.0315***	-0.0306***	-0.0240***
	(0.0090)	(0.0053)	(0.0057)	(0.0054)	(0.0065)
	0.1022***	0.0792***	0.0613***	0.0509***	0.0534***
% Households earning up to 1minimum wage	(0.0133)	(0.0087)	(0.0088)	(0.0088)	(0.0092)
Program Alvorada	0.0101	0.0564***	0.0757***	0.0954***	0.0637***
	(0.0238)	(0.0163)	(0.0193)	(0.0190)	(0.0159)
% Population < 15 years old	0.0359	0.0656***	0.0609***	0.0671***	0.1369***
	(0.0231)	(0.0153)	(0.0164)	(0.0160)	(0.0183)
	-0.0132	-0.0532***	-0.0524***	-0.0647***	-0.1210***
% Population > 60 years old	(0.0240)	(0.0147)	(0.0158)	(0.0154)	(0.0180)
% Population > 15 years old literate	-0.4735***	-0.3246***	-0.3045***	-0.3087***	-0.2500***
	(0.0879)	(0.0566)	(0.0662)	(0.0581)	(0.0500)
Enrollment in private schools	-0.0293***	-0.0418***	-0.0353***	-0.0381***	-0.0360***
	(0.0092)	(0.0062)	(0.0067)	(0.0063)	(0.0050)
Enrollment	-0.9724***	-0.9678***	-0.9655***	-0.9749***	-0.9613***
	(0.0113)	(0.0063)	(0.0067)	(0.0069)	(0.0084)
Pupils by schools	-0.0044	-0.1479***	-0.1784***	-0.1019*	-0.1808***
	(0.0872)	(0.0545)	(0.0569)	(0.0585)	(0.0675)
Colligation 1	-0.0452*	-0.0266**	-0.0204*	-0.0176	-0.0337***
	(0.0258)	(0.0126)	(0.0123)	(0.0133)	(0.0091)
Colligation 2	-0.0670**	-0.0377**	-0.0255*	-0.0138	0.0013
	(0.0290)	(0.0155)	(0.0147)	(0.0176)	(0.0117)
	-0.0234	-0.0303***	-0.0381***	-0.0289***	-0.0298**
Municipal Consortia	(0.0157)	(0.0109)	(0.0107)	(0.0107)	(0.0120)
	-0.0024	-0.0016	-0.0156*	-0.0189**	-0.0228**
Council power	(0.0136)	(0.0083)	(0.0089)	(0.0089)	(0.0101)
North	-0.2150***	-0.2198***	-0.2003***	-0.1881***	-0.1232***
	(0.0383)	(0.0293)	(0.0334)	(0.0433)	(0.0405)

Table 3
Determinants of the demand for educational services in Brazilian municipalities
Quantile regression results – 2000 – cont.

Explaining variables	Dependent variable: municipality educational expenditures				
	$\tau = 0,10$	$\tau = 0,25$	$\tau = 0,50$	$\tau = 0,75$	$\tau = 0,90$
Northeast	0.1108***	0.1657***	0.1730***	0.1406***	0.1509***
	(0.0343)	(0.0219)	(0.0254)	(0.0242)	(0.0234)
Southeast	-0.0936***	-0.0306	-0.0153	-0.0404*	-0.0765**
	(0.0347)	(0.0267)	(0.0266)	(0.0222)	(0.0338)
Center-West	0.2431***	0.2411***	0.2430***	0.1924***	0.1951***
	(0.0187)	(0.0136)	(0.0128)	(0.0137)	(0.0170)

Obs: a) in brackets: standard errors; b) *** – significant in 1%; ** – significant in 5%; * – significant in 10%.
Elaborated by the authors.

Table 4
Congestion parameter across quantiles

	Expenditure classes				
Quantiles	0.10	0.25	0.50	0.75	0.90
Congestion parameter	0,9357	0,9501	0,9436	0,9488	0,9389

Source: Authors' results.

Concerning the school-related variables, the reduced coefficient for enrollment in private schools, for the lowest quantile, fit in with the absence of private schools in the small cities that predominates in this quantile. As for enrollment, the coefficient is quite stable across quantiles and significantly different only for the two superior quantile. Cost reduction, induced by a higher number of pupils per school, is the highest in the last quantile, where the big cities – and their larger schools – are to be found. Notice that for the lowest quantile, the coefficient, although negative, is not significant reflecting the existence small and dispersed schools situated in this quantile.

Except for the first class of spending, the participation in inter-municipal consortia contributes to reduce school expenditures. This result is hardly surprising as the smallest cities, concentrated in the lowest quantile, usually lack the administrative organization required to implementing these consortia. Hence, they are unable to exploit the gains from joining such associations. From the efficiency aspect, this is a quite important result as it builds up a much-required coordination among municipal administrations. On the other hand, the smaller coefficients for the highest quantiles show that the largest cities' overcrowded schools have no need to join consortia to reach the scale required to minimize costs. Lastly, empowered municipal councils enhance the efficient use of resources by reducing expenditure only for the highest quantile, a rather expected result as those councils, frequently, are not set up in very small cities.

Results involving the political variables are quite changed when disaggregated into quantile classes. Now, for the larger municipalities situated in the last quantile, the fact that their mayor belongs to the opposition is no longer a liability as suggested by previous results. This is consistent with the fact that those cities have alternative channels to finance their school system. Accordingly, supporting the national majority (colligation 1) does not prevent the municipalities from having lower expenses when compared to the ones outside these two coalitions.

Concerning the location variables, the quantile results qualify the aggregated ones. Thus, even if municipal expenses are higher for the Northeast and Center-East regions, their spending behavior across expenditure classes is quite distinct for these regions: in the latter, expenses are higher for the lowest quantile suggesting that scale effects predominate over the so called "zoo effect". Northeast towns present an opposite result: spending is lower for the municipalities situated on the lowest quantile, reflecting probably the less diversified educational services offered by these small cities.

6. Concluding Remarks

In this paper we estimated the demand for education expenditures for the Brazilian municipalities within a median voter's framework. Results obtained are consistent with the theoretical background thus suggesting that this hypothesis might be useful to describe the demand for public schooling in Brazil. The use of quantile regression and spatial techniques to investigate the spillovers and the marginal effects of the exogenous variables in the various spending levels proved to be very useful in qualifying these effects as the OLS results, in some cases, could be quite misleading.

Confirming previous studies we found out that the coefficients attached to the main variables in this model – price, income and population – were significant and had the expected sign. The relatively high values for those parameters suggest non essential characteristic for educational services and attest the status of such merit goods as "luxuries".

Our results also suggest that the impact of the city size on the quality of club goods shows crowding effects as γ is between zero and one. However, in quantilic model, marginal congestion slightly decreases with expenditure. This is rather surprising as one is tempted to conclude that the congestion effect should be higher on big cities. Yet, a more careful look shows the drawbacks of such interpretation. The indivisibilities that preclude the provision of certain services in small towns, concentrate their provision on larger cities. Hence, the higher expenditures of those big cities reflect not only a crowding cost but also the fact that these towns offer a wide range of services when compared to the small ones. This is consistent with our findings showing that the municipal school system in Brazil seems to present increasing returns to scale both, at the school and the municipality level.

Last, but not least, our analysis suggests that, in the future, we may expect a reduced pressure for educational spending in Brazil. Indeed, as shown by the analysis of the demographic variables, the aging of the Brazilian population will reduce the demand for schooling. Moreover, the fact that the municipal school system in Brazil presents increasing returns to scale both, at the school and the municipality level, demonstrates that it is possible to expand schooling, without an equivalent increase in costs, just by exploiting the economies of scale that characterizes the production of these services.

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