The quality of public education and private school enrollment: an assessment using Brazilian data*

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Abstract

In this paper, we test the hypothesis that private school enrollment is the households' response to the low quality of public schools. In order to deal with the simultaneity issue, we explore variations in public school funding caused by the FUNDEF reform that occurred in Brazil in 1998. Using data from the Brazilian School Census, we show that a positive impact of the reform is associated with an immediate reduction in the share of private enrollment for the first grade of primary school at the municipality level. The same effect is not observed for the subsequent primary school years. This confirms the intuition that the parents may be reluctant to switch schools after the beginning of their child's schooling track. Our estimation results are robust to variations in the school participation and changes in the income distribution. Thus, the improvement in the quality of public schools originated by the FUNDEF reform has attracted households that would otherwise enroll in private institutions. The same mechanism seems to explain the increase in the net attendance rate during the same period.

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1 Introduction

The question of whether public expenditure in education crowds out private investments is central for policy purposes. The overall effect of a public policy on education cannot be correctly assessed without taking into account the changes in the private investment made by the households.

A prominent way by which such crowding out may take place is on the option of public versus private schooling. The household's choice of private education when schools are publicly available is generally assumed to be quality-driven. However, the school's inputs are only one component of its perceived quality. The parents take also into account the characteristics of the student body in opting for private versus public schools (O'Shaughnessy, 2007). Therefore, an increase in the public school resources would not necessarily lead them to modify their enrollment decision, unless it causes a sufficiently high number of private school pupils to switch to public schools.

Thus, a policy aimed at improving the quality of public schools may attract or not pupils that would otherwise enroll at private schools. The number of switchers may be quite small or even absent whenever there is a large difference in school composition between public and private schools or the parents attach a lot of importance to the school's student body.

Previous attempts to analyze the impact of the quality of public schools on the demand for private education pointed out the difficulties arising from the endogeneity of public expenditures in education (Glick and Sahn, 2006). The main concern is related to the simultaneity of the enrollment and public expenditure decisions. Indeed, enrollment in private schools itself may cause a low level of public expenditure in education resulting in a poor quality of public schools. This is a consequence of the decrease in political support for public expenditures on education caused by a high proportion of households opting out of public education.[1]

In this paper, we analyze how a variation in the quality of public schools affects the share of private school enrollment in a given municipality. A negative impact of an increase in public school quality on the share of private enrollment will be interpreted as evidence of a crowding out effect. In order to cope with the simultaneity issue, this paper explores the effect of the FUNDEF[2] reform held in Brazil in 1998.

[1] The literature investigating the political economy of public school expenditures when private schools are available includes Stiglitz (1974), Epple and Romano (1996b), Glomm and Ravikumar (1998), Blomquist and Christiansen (1999), and, more recently, de la Croix and Doepke (2009).

[2] *Fundo de Manutenção e Desenvolvimento do Ensino Fundamental e de Valorização do Magistério- Fund for the Maintenance and Development of the Fundamental Education and Valuing of Teaching.* The fundamental education corresponds to the four years of primary school and the subsequent four years of the so-called low secondary.

We argue that FUNDEF constitutes an interesting natural experiment for our purpose, since it renders public investment in education exogenous at the municipality level.

We will focus on primary education (grades 1 to 4), corresponding to children aged 7 to 10. This has at least two advantages. The first is that we can be quite confident that public schools are available all over the country for these educational levels and so that the absence of public schools will not be driving the demand for private education.[3] The second is that parents may be reluctant to switch schools after the beginning of the child's schooling track. The focus on the first years should minimize this issue.

This paper is organized as follows. In Section 2 we discuss the related literature and some empirical works that focus on the FUNDEF reform. In Section 3 we solve a simple model that helps us determine some of the effects we expect to find in the data. In Section 4 we outline the Brazilian educational system and the FUNDEF reform. In Section 5 we present some descriptive statistics and in Section 6 we describe our empirical strategy. We present the main estimation results in Section 7, some robustness checks in Section 8, and our conclusions in Section 9. In Appendix A, we describe the data.

2 Review of the literature

The relation between the quality of public education and public/private school enrollment has been investigated from several angles.

One strand of the literature concentrates on the impact that the quality of education has on both public and private school enrollment. Using household surveys and community data, Glick and Sahn (2006) have estimated demand functions for public and private schools using data from rural Madagascar.[4] The distinguishing feature of Glick and Sahn (2006) with respect to previous studies is that they consider that not all individuals have the same number of schooling options from which to choose. They also explicitly control for endogeneity of school characteristics by including the average education of household heads, median village household expenditures per capita, and an indicator of urban location. They find that public school quality indicators (such as distance to school, lack of teachers, multigrade classes, and fa-

[3] In theory, the public schools in Brazil cannot refuse a student who has no other option in the same municipality. For this reason, some public schools work with large groups or operate in several periods, reducing the number of hours of classes per group.

[4] The estimation of the demand functions was not the ultimate objective of this study. Their main purpose was to simulate policy alternatives such as improvements in the quality of schools financed by tuition fees.

cilities condition) have negative effects on public school enrollment. In the case of private schools, none of the school characteristics have significant effects on demand.

Alderman et al. (2001) collected data on Pakistan's households and schools. They first explicitly consider the option of attending school and subsequently analyze the choice between public and private schools. In their model, the decision to enroll or not relies on household characteristics such as income, sex, and parents' education. The choice of school depends exclusively on the school characteristics such as school distance, instructional expenditure, and pupil-teacher ratio. They obtain that all these variables are significant in driving the parents' choice between school alternatives.

A related strand of the literature considers a two-way causality in the interaction between public school quality and public/private enrollment. Goldhaber (1999) allows for a decrease in the support for public school expenditures due to increased private enrollment, but also for the fact that private enrollment may be an answer to low quality of public education caused by low school expenditure.[5] He obtains strong evidence of the crowding out effect. He shows that increases in public school expenditure per pupil have a significant and negative effect on the private school enrollment rate. His results also suggest that private school enrollment does not cause a great loss in tax support for public schools.

An alternative view postulates that private school enrollment may increase the quality of public schools since it brings about competition. Therefore, even if private schools may cause a decrease in the public budget for education, public school administrators and teachers may respond to stronger competition by increasing the quality of the instruction.

Couch et al. (1993) test this prediction using county level data from North Carolina. Among other results, their regressions suggest that the parents choose private school to avoid classmates that are black or come from low-income households. Their findings also indicate the existence of the crowding out effect: private school enrollment is lower, the higher the spending per student in the public system. Finally, they argue that there is a significant competition effect since increments in private school enrollment improve the performance of public students in test scores. Hoxby (1994) also find evidence for the United States that private school competition increases the attainment of public school students.

One of the merits of this strand of the literature is that it calls into question

[5]He also considers another source of endogeneity, the so-called Tiebout endogeneity: the choice of location by the parents may already reflect their taste for public education. This will be specially true in cases in which education is financed by local taxes, but may also arise when the parents chose to enroll in public schools and thus decide to live in a community taking into account the quality of public schools available.

the relation between expenditures and quality of education. It suggests that increased expenditures on public schools constitute only one component of the quality of schools.

To the best of our knowledge, the impact of public school expenditures on private school enrollment has not yet been investigated using Brazilian data. In a related topic, e Souza and do Valle Silva (1996) analyze the household's characteristics that determine enrollment in a private school. They use data from the 1982 Brazilian Household Survey.[6] Restricting their analysis to the state of Sao Paulo, they find that the probability that a child is in a private school raises with the education of the household head. Family income also explains private school enrollment, though to a lower extent. Also, the larger the family, the lower the chance that a children will be enrolled in a private institution.

The effects of the FUNDEF reform have been analyzed by Menezes-Filho and Pazello (2007) and Gordon and Vegas (2005), among others. We next briefly review the results they obtain, since they constitute interesting guidelines for our analysis.

Menezes-Filho and Pazello (2007) investigate the impact of the increase in wages brought about by the FUNDEF reform on the students' performance. They use data from the SAEB[7] for 1997 and 1999 for students at grade 8. They explore the fact that wages in the public schools are set by law in the municipal level and were changed exogenously by the FUNDEF reform across municipalities to identify the impact of teachers' wages on the students' outcomes.[8] Using an OLS regression with fixed effects for year, municipality and system, and the three-way interaction, they show that the effect of the teachers' wages is significant and increases students' performance by about half standard error.

Gordon and Vegas (2005) estimate the effect of the FUNDEF reform on enrollment, school spending, age-by-grade distortion and achievement of the students. They use the School Census from 1996 to 2002. The data on student's achievement

[6]PNAD, *Pesquisa Nacional de Amostra de Domicilios* is collected by IBGE, *Instituto Brasileiro de Geografia e Estatistica*, Brazilian Institute of Geography and Statistics, www.ibge.gov.br. The 1982 wave included a special supplement on education.

[7]SAEB, *Sistema de Avaliação do Ensino Básico* means System of Evaluation of Basic Education. This database contains a variety of information on the student's background and performance on a mathematics and language test for students at grade 4, 8 and 11. It also includes detailed data on the school, teacher and director's background. This survey is conducted every two years by the Brazilian Ministry of Education in a sample of schools that change in every edition.

[8]The schools in the database typically do not coincide in the two successive editions of the survey. This is not an issue in the case of public schools since the wages are established at the municipality level and they exclude every municipality not present in both waves. However, this prevents them from using data on private schools, since in this case, the teachers' wages are defined at the school level.

is obtained from SAEB. They obtain that FUNDEF slightly increased enrollment in the higher grades of basic education (grades 5-8) in the states most affected by the reform. Reduction in the class size and improvement in the qualification of teachers can also be attributed to FUNDEF, even if the second was also the effect of other legislation. These two effects, however, seem to have contributed to a lower age-by-grade distortion. Finally, the FUNDEF reform also seems to contribute to narrow the gap between high and low achievers.

3 The theoretical model

In this section, we present a simple theoretical model that illustrates the crowding out effect. We assume that the economy is composed of individuals that are identical with respect to their preferences. These preferences are defined over private consumption, c_i, and human capital, h, and are represented by the utility function $U(c_i, h)$. The utility function is assumed to be increasing, strictly concave, and twice continuously differentiable. Individuals are heterogeneous with respect to their income y_i. There are three income groups denoted poor, middle and rich, i.e, $i = P, M, R$, with $y_P < y_M < y_R$. Their proportions in the population are λ_P, λ_M, and λ_R, with $\lambda_P + \lambda_M + \lambda_R = 1$.[9]

All individuals' incomes are taxed at the constant rate t. The government uses the tax revenues to finance the public education system. The technology available in this economy is such that e units of private consumption can be transformed into one unit of education quality, e (i.e. the price of public education quality is normalized to one). The government provides public education at quality e per student. The equilibrium condition of the government's budget constraint requires that:

$$t\overline{y} = e\theta, \tag{1}$$

where $\overline{y} = \lambda_P y_P + \lambda_M y_M + \lambda_R y_R$ is average income and θ is the proportion of students enrolled at public schools.

Public education is freely available at quality e to all households. However, not all children go to public school. This happens for two reasons. First, there is an opportunity cost related to schooling denoted by w. Second, private education may exist in the community at quality $s > e$.[10] We set the tuition price to 1.

Human capital, h, is a function of the quality of the school and of the student's body composition. While the students are assumed to have the same innate ability,

[9] Considering a continuous income distribution would not change our main results.

[10] For simplicity, we assume that there is an unique level of private provision available. In reality, several quality levels of private provision may coexist.

we assume that the parents attach value to the average income level of the pupils in a given school. This may reflect concerns for peer effects that may improve learning during the educational process or social network formation that may affect the child's earnings later on.[11] The human capital function is given by:

$$h = h(q, \mu_q), \tag{2}$$

where $q = \{e(\theta), s\}$ for a public and private school, respectively, and μ_q is the average household income in school q.[12] We discuss the implications of different assumptions on the human capital technology below.

We start by assuming the existence of a private school. The utility functions of a household at private school, public school and out of school are given by, respectively:

$$U(c_i, h(s, \mu_s)) \qquad \text{where} \qquad c_i = (1-t)y_i - w - s \tag{3}$$

$$U(c_i, h(e(\theta), \mu_e)) \qquad \text{where} \qquad c_i = (1-t)y_i - w \tag{4}$$

$$U(c_i, 0) \qquad \text{where} \qquad c_i = (1-t)y_i. \tag{5}$$

We assume that the middle income group always go to a public school, i.e., $\forall\theta$,

$$\begin{aligned} U((1-t)y_M - w, h(e(\theta), \mu_e)) &> U\left((1-t)y_M - w - s, h\left(s, \mu_s\right)\right) \\ U((1-t)y_M - w, h(e(\theta), \mu_e)) &> U((1-t)y_M - w, 0). \end{aligned} \tag{6}$$

Thus, the rich households are the ones that may opt for private education if:

$$U((1-t)y_R - w - s, h(s, \mu_s)) > U\left((1-t)y_R - w, h\left(e(\theta), \mu_e\right)\right). \tag{7}$$

Likewise, the poorer households may be at a public school or out of school. They will be out of school if:

$$U((1-t)y_P, 0) > U((1-t)y_R - w, h(e(\theta), \mu_e)). \tag{8}$$

Thus, the proportion of public school users, θ, will vary depending on whether equations (7) and/or (8) hold or not. The four possibilities are $\theta = \{\lambda_M, \lambda_P + \lambda_M, \lambda_M + \lambda_R, 1\}$.

Similarly, the proportion of private school users, ϕ equals λ_R if (7) holds and 0 otherwise.[13] Now consider the problem of the private provider of education. Assuming that there is a fixed cost F to set a school and no variable cost, its profit function is given by:

$$\pi = s\phi - F. \tag{9}$$

[11] An extension would be the inclusion of different ability levels and an analysis of sorting between public and private schools. These issues have been analyzed in Epple and Romano (1996a) among others.

[12] For simplicity, we use the subscript q to denote the school type.

[13] In general, $\theta + \phi < 1$ due to the presence of children out of school.

The private provider chooses s in order to maximize (9). Since opting for private education does not reduce one's tax liability, its choice is restricted to $s > e$. Denote φ the quality level that the private producer of education chooses to offer. It is given by:

$$\varphi = \begin{cases} s^* = \text{argmax} \quad \pi & \text{if } \pi = s^*\phi - F > 0 \text{ and } s^* > e \\ 0 & \text{if } \pi = s^*\phi - F < 0 \text{ or } s^* < e \end{cases}$$

Thus, a private school may not exist in a community if the number of potential users is low. This may be caused by a small population of high income households or by a high quality of public education.

We next derive our main prediction to be tested empirically. We concentrate on the case where both public and private schools are available. We assume that the tax rate, t, is unchanged.[14] This assumption is in line with the FUNDEF reform that implied a redistribution of resources across the state and its municipalities instead of an increase in public funds.

The main prediction of the model is that if the quality of public schools and the composition of the student body are considered to be substitutes at least to some extent by the households, an increase in the quality of school inputs should attract students that would otherwise enrol at private schools. Let Υ be the utility differential between public and private school for a rich household. It is given by:

$$\Upsilon = U((1-t)y_R - w - s, h(s, \mu_s)) - U\left((1-t)y_R - w, h\left(e(\theta), \mu_e\right)\right). \tag{10}$$

For a household going to a private school, $\Upsilon > 0$. Note that the effect of an increase in e for a given t will mainly depend on the human capital technology. Clearly, if e and μ are substitutes, an increase in e may lead rich households to switch to public schools. Indeed, for a given tax rate, Υ is decreasing in e. This phenomenon corresponds to the crowding out effect. However, in the extreme case in which e and μ are perfect complements, the share of private enrollment may not react to an increase in quality, unless a sufficient number of rich households switch to a public school.[15]

[14] In general, an improvement in the quality of public education requires an increase in the tax rate.

[15] Note that this will be the case if one considers that the rich households are unable to coordinate and switch together to the public sector.

4 The Brazilian Educational System and the FUNDEF Reform

In this section, we provide a description of the features of the Brazilian educational system that are relevant to our analysis.

Primary education lasts for 4 years and is offered by private and public schools. In 1997, 9% of the more than 20 million students enrolled in primary education were attending private institutions. Figure 1 illustrates the share of private enrollment in primary education at the 26 Brazilian states. There are significant differences in the size of the private sector in primary education among states. In 1997, 2,120 municipalities had at least one private school (38% of the 5,507 municipalities). Private schools do not receive public funds and are mainly financed by tuition fees. Therefore, they were not directly affected by the FUNDEF reform.

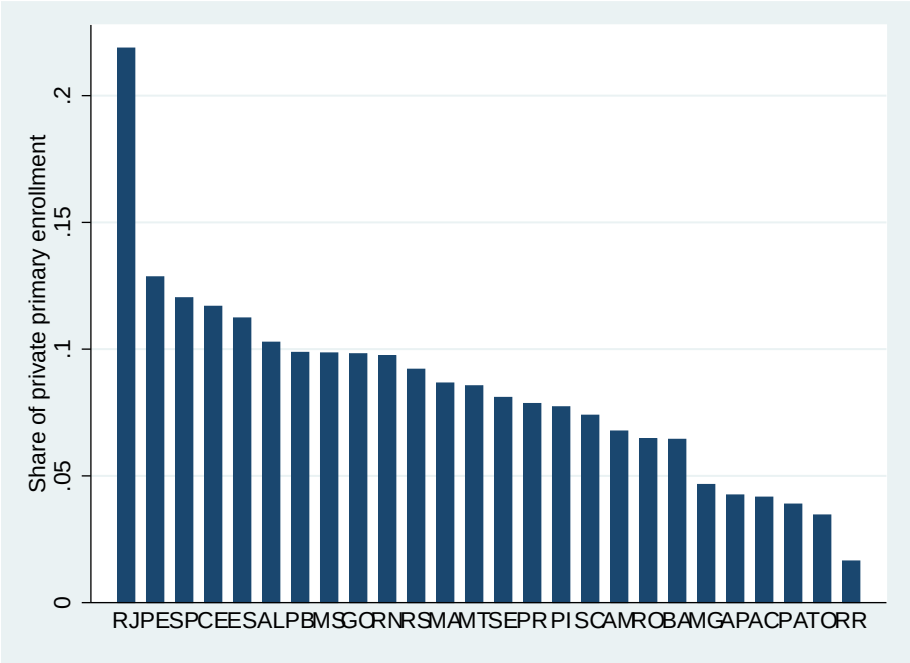

Figure 1: Share of private primary school enrollment per state in 1997.
Source: School Census 1997.

The great majority of primary school pupils are enrolled in public schools. In the public system, primary education is provided by the states and municipalities

independently.[16] Accordingly, public schools are classified as *state* or *municipal*.[17]

Under the 1988 Brazilian Constitution, the states and municipalities have to invest at least 25% of their tax and transfers revenues in the public education system. Theoretically, this principle should provide a significant amount of resources for the public schools. However, this rule reproduced the country's economic disparities in the educational system. Wealthier municipalities could count on a much larger amount of resources to education than poorer ones. Moreover, there was no correspondence between the amount of resources allocated to education and the number of students attended by a given system. In addition, there was a relative flexibility in the use of resources that were often diverted from education into other uses.

In this context, the FUNDEF reform aimed to improve the distribution and use of resources inside each state for primary and low secondary public education. The level of 25% of all taxes and transfers to be spent on education by the states and municipalities was maintained. However, 15% of the four main taxes and transfers (roughly 60% of all taxes and transfers) is gathered by a fund created inside each state. The amount collected is then redistributed back to the state and municipalities according to the number of students in primary and low secondary education enrolled in the previous year in their respective systems. Accordingly, the resources originated by the fund have to be spent exclusively in primary and low secondary education. It is also established that 60% of the resources received from the fund have to be used for teachers' wages and, in the first five years of implementation, could also be employed to increase the teachers' qualification. Finally, the federal government provides additional funds for those states whose value per student (considering only the resources arising from the fund) fall behind with some established minimum level.[18]

Table 1 provides the distribution of public enrollment by system in each of the states. The proportion of schools belonging to each system varies significantly from one region to the other mostly due to historical reasons. It also summarizes the impact of the FUNDEF reform by system (municipal and state). In most of the cases, the balances of the municipal and state system sum to zero, since the reform was meant to redistribute resources inside the state.

The final balance is positive in those states that received supplementary federal

[16] Brazil is composed of 27 federation units (26 states and the federal district) that are grouped in 5 regions. The states are divided in municipalities. In 1997, there were 5,507 municipalities in the whole country.

[17] A negligible number of *federal* schools offer primary education. Most of them are concentrated in the capital Brasilia. Since federal schools were not affected by the FUNDEF reform, we exclude them from the analysis.

[18] The minimum level defined for 1998 was R$315.00.

Table 1: Percentage of public enrollment and impact of FUNDEF by system and state in 1998

			State level			Municipal level		
State/ Region	**Public enrollments (%) State**	**Municipal**	**Annual contribution to FUNDEF (a)**	**Annual revenue received from FUNDEF (b)**	**Increase/ Decrease (b-a)**	**Annual contribution to FUNDEF (a)**	**Annual revenue received from FUNDEF (b)**	**Increase/ Decrease (b-a)**
AC	67	33	65.3	52.5	(12.8)	12.8	25.5	12.7
AM	63	37	166.2	144.7	(21.5)	64.9	86.4	21.5
AP	84	16	64.7	63.1	(1.6)	10.1	11.7	1.6
PA	59	41	217.8	255.5	37.7	105.8	180.6	74.8
RO	66	34	79.9	70.7	(9.2)	26.8	36.1	9.3
RR	96	4	48.5	53.9	5.4	7.7	2.3	(5.4)
TO	66	34	89.3	81.2	(8.1)	34.4	42.5	8.1
AL	27	73	117.9	47.4	(70.5)	58.9	129.5	70.6
BA	48	52	471.7	422.8	(48.9)	270.4	463.2	192.8
CE	36	64	272.8	177.1	(95.7)	147.1	289.3	142.2
MA	32	68	165.8	132.1	(33.7)	91.3	278.5	187.2
PB	47	53	139.2	103.7	(35.5)	80.1	115.6	35.5
PE	48	52	305.5	224.9	(80.6)	158.2	245.0	86.8
PI	40	60	105.3	74.6	(30.7)	57.4	112.1	54.7
RN	52	48	124.5	98.1	(26.4)	63.9	90.3	26.4
SE	55	45	107.9	80.4	(27.5)	38.8	66.4	27.6
GO	67	33	221.0	232.9	11.9	126.3	114.3	(12.0)
MS	57	43	92.1	82.2	(9.9)	51.7	61.6	9.9
MT	63	37	138.9	131.2	(7.7)	69.0	76.6	7.6
ES	70	30	166.8	172.3	5.5	80.2	74.7	(5.5)
MG	74	26	758.8	905.5	146.7	470.3	323.3	(147.0)
RJ	35	65	765.9	375.6	(390.3)	303.8	694.3	390.5
SP	81	19	2,635.5	3,046.8	411.3	1,119.0	707.6	(411.4)
PR	53	47	434.5	364.1	(70.4)	256.4	326.8	70.4
RS	59	41	579.6	524.4	(55.2)	306.4	361.6	55.2
SC	62	38	269.3	264.0	(5.3)	154.4	159.7	5.3
Brazil	**59**	**41**	**8,604.7**	**8,181.7**	**(423.0)**	**4,166.1**	**5,075.5**	**909.4**

Parentheses stand for negative numbers.

funds. Only six out of the 26 states (PA, BA, CE, MA, PE, PI) received additional resources from the federal government, since they were below the minimum level per student. In most states, FUNDEF caused a transfer of resources from the state system to the municipal system of education. This is consistent with the fact that in the majority of the states, primary and low secondary education schools are subordinated to municipalities that generally have insufficient resources to invest in education. The transfer went the other way round only in five states (RR, GO, ES, MG, SP), the last three belonging to region SE.

It is worth noting that the FUNDEF fund represents only a fraction of the resources spent in education (roughly 15% of taxes and transfers). The municipalities and states have to invest approximately 10% of their taxes and transfers directly in the educational system. Moreover, the states and municipalities always have the possibility to invest more than the amount established by the law. For instance, the municipalities and states that lost resources with the FUNDEF reform can supplement their educational budgets with their own resources. Gordon and Vegas (2005) show that wealthy states that should have lost resources with the FUNDEF reform were unable to reduce educational expenditures (meaning that they have partially compensated the losses with additional resources).

For our purposes, the FUNDEF reform provides an exogenous change in the amount of resources available to the municipal and state schools. Since the redistribution mechanism was defined at the federal level and was uniform across the country, we can fairly assume that the level of spending in public education is independent of the preferences of the states and municipalities. Moreover, it is unrelated to the proportion of students enrolled in private schools at least to the extent that this may reduce political support for public education.

5 Descriptive Statistics

In this section, we present some descriptive statistics based on the School Census mostly for the years 1997 and 1999, which correspond to the years before and after the FUNDEF reform. We first describe some basic facts about the public and private schools that were active during this period.[19] Then, we analyze more in details some quality indicators to investigate the impact of the FUNDEF reform.

Table 2 shows that the total number of schools offering primary education has declined between 1997 and 1999. Even if the number of private schools has raised,

[19]Henceforth, the denomination *public* corresponds to municipal or state schools. We exclude the few federal schools offering primary education (67 in 1997 and 28 in 1999), since they were not directly affected by the FUNDEF reform.

this increase was not large enough to compensate for the decrease in the number of public schools.

Table 2: Number of schools offering primary education.

	Before FUNDEF 1997	After FUNDEF 1999
Public	172,355	156,993
Private	16,554	17,258
Total	188,909	174,251

Nevertheless, the public school enrollment has increased between 1997 and 1999 (but declined since 1999). The number of students at private schools decreased over all the period 1996-2000. The result is that the share of private primary education decreased, as shown in Table 3.

Table 3: Total enrollment in primary school.

	Before FUNDEF		FUNDEF	After FUNDEF	
Year	1996	1997	1998	1999	2000
Private	1,987,652	1,961,939	1,803,036	1,718,092	1,658,510
Public	18,039,588	18,606,189	19,530,294	19,220,984	18,552,996
Total	20,027,240	20,568,128	21,333,330	20,939,076	20,211,506
Share of private	9,92%	9,54%	8,45%	8,21%	8,21%

Consequently, the private school average size decreased from 118,5 to 99,6 students and the public school average size increased from 107,9 to 122,4 students between 1997 and 1999. Not surprisingly, the average class size decreased in private schools while it has slightly increased at public institutions (Table 4).

Table 5 shows that the number of children enrolled in primary school is much larger than the population at primary school age. Moreover, the gross enrollment rate has substantially increased in the period coinciding with the FUNDEF reform.

The reform may have affected the gross enrollment rate in at least two different ways. An improvement in the quality of public schools may have attracted children that were previously out of school to the public system. We test this hypothesis in Section 7 and show that indeed this seems to be the case. However, there is a second possibility that also may explain some of the increase in the gross enrollment rate.

Table 4: Average class size at primary schools.

	Before FUNDEF 1997	After FUNDEF 1999
Public	26.41	27.03
Private	18.91	17.77

Note: The average class size can only be calculated for the schools not using multigrade groups. The average class size is calculated using the totality of public and private schools in both periods. Considering only the schools that were operating in both periods, we observe a very similar trend.

It is related to the fact that the design of the reform may have provided incentives to the municipalities and states to inflate the number of students enrolled in their schools. While we are unable to verify this hypothesis, we think that its impact should be limited in the first year after the reform under consideration. In any case, we will design our empirical strategy to minimize any impact that an inflated public enrollment rate would have on our results. We discuss further this issue in Section 6.

Table 5: Gross enrollment rate in primary school.

	Before FUNDEF		FUNDEF	After FUNDEF	
Year	1996	1997	1998	1999	2000
Total enrollment in primary school	20,027,240	20,568,128	21,333,330	20,939,076	20,211,506
Population at primary school age	13,980,867	13,787,236	13,556,124	13,276,987	13,143,842
Gross enrollment rate	143.25	149.18	157.37	157.71	153.77

Source: 1996-2000 School Census and 2000 Population Census.

We next compare some features of public and private schools before and after the reform.[20] As shown in Table 6, multigrade groups are pervasive in public schools, while a small fraction of private schools makes use of them. In addition, the percentage of public schools using multigrade groups has only slightly declined over the

[20]It is worth noting that although most schools coincide in 1997 and 1999, some appear only in one of the editions of the School Census. This happens, for example, if a school shut down in 1998 or if a new school was installed in 1998.

period.

Table 6: Percentage of schools with multigrade groups.

	Before FUNDEF 1997	After FUNDEF 1999
Public	0.64	0.62
Private	0.05	0.06

Note: The proportion of schools using multigrade classes is calculated using the totality of public and private schools in both periods. Considering only the schools that were operating in both periods, we observe an increase in the use of multigrade groups in public schools from 0.61 in 1997 to 0.63 in 1999.

Table 7 shows the increase in the percentage of public and private schools considering several infrastructure items between 1997 and 1999. There are at least two important information that can be extracted from this table. First, the differences between the private and public sector with respect to the schools' facilities are striking. In 1997, only 13% of public schools had a library, while 66% of private schools were equipped with one. Similar conclusions can be drawn with respect to science laboratory and sports facilities, even if the figures are different. Second, public school access to electricity, water, library, and sports facilities have increased in 1999 as compared to 1997.

Table 7: Percentage of schools by infrastructure item.

	Public schools		Private schools	
	Before FUNDEF 1997	After FUNDEF 1999	Before FUNDEF 1997	After FUNDEF 1999
Electricity	0.53	0.60	0.99	1.00
Water	0.85	0.92	0.99	1.00
Library	0.13	0.15	0.70	0.76
Science laboratory	0.03	0.03	0.31	0.33
Sports facility	0.11	0.12	0.50	0.53

Note: The proportion of schools with these facilities is calculated using the totality of public and private schools in both periods. The restriction to schools that were operating both in 1997 and 1999 yields very similar results.

Thus, there were several improvements in the public schools' infrastructure, especially regarding electricity, water, library, and sports facilities coinciding with the

period of the FUNDEF reform. In addition, there was a slight decrease in the use of multigrade groups.

6 The impact of FUNDEF reform on the share of private enrollment: a test

6.1 Empirical Model

Our purpose is to estimate whether the propensity of the households at municipality i to choose private education was affected by changes in the quality of public schools originated by the FUNDEF reform. Our hypothesis is that increments in the municipalities' educational budget caused by the FUNDEF reform should be associated with a reduction in the propensity to go to a private school (*crowding out* effect).

The data on the financial impact of the FUNDEF reform is available at the municipality and state level. This corresponds to having information on a *representative* household per municipality. Thus, we have to make sure that the representative household did not change before and after the reform.

In this respect, there are two issues to be taken into consideration. The first is that the choice of the school type is preceded by a decision of going to school or not in Brazil. Therefore, the total school enrollment does not coincide with the number of children at school age for at least two reasons. First, some children at school age are not at school. Second, some children not at school age are at school. Note that the latter is a consequence of two different phenomena: late entry and high repetition rates. In our analysis, we have to be concerned with the fact that these two groups of households may have changed before and after the reform. If this happened, the representative household enrolled at school in each municipality will be different in both periods.

The second is that private school is only accessible for those households that can pay for it. Therefore, it does not constitute a real choice for all households. If the proportion of children living in wealthy households has changed over the period, then our representative household is not the same before and after the reform.

Let $T_{i,t}$ be the total number of students enrolled at school in municipality i at time t and $C_{i,t}$ be the total population at primary school age in municipality i at time t. The following identities can be defined:

$$T_{i,t} = P_{i,t} + G_{i,t} \tag{11}$$

$$T_{i,t} = C_{i,t} - O_{i,t} + N_{i,t} \tag{12}$$

$$C_{i,t} = H_{i,t} + L_{i,t} \tag{13}$$

where $P_{i,t}$ and $G_{i,t}$ are the number of students enrolled at private and public school in municipality i at time t, respectively, $O_{i,t}$ gives the total number of children at school age that are out of school in municipality i at time t, $N_{i,t}$ is the total number of children not at school age that are at school in municipality i at time t, and $H_{i,t}$ and $L_{i,t}$ are total number of children at school age living in high and low income households in municipality i at time t, respectively.

Equation (11) shows that total enrollment is given by the sum of private and public enrollment. Equation (12) illustrates that the difference between the primary school enrollment and the total population at primary school age is given by the households out of school at school age and those at school that are not at the school age. Finally, equation (13) highlights that the data on the number of children by household income refers to the total population at school age.

Using the data on school enrollment, the *crowding out* assumption can be evaluated using:

$$\frac{P_{i,t}}{T_{i,t}} = \theta_i + \tau_t + \gamma F_{i,t} + \beta X_{i,t} + \varepsilon_{i,t}, \tag{14}$$

where θ_i accounts for the time-invariant propensity to go to a private school in municipality i, τ_t measures the propensity to choose private education at time t that is common to all municipalities, $F_{i,t}$ is an indicator of the impact of the FUNDEF reform in municipality i at time t, and $X_{i,t}$ stands for the control variables available at municipality i at time t. The parameter of interest is γ that measures the *crowding out* effect.

Alternatively, the share of private enrollment can be calculated over the total population at primary school age:

$$\frac{P_{i,t}}{C_{i,t}} = \theta_i + \tau_t + \gamma F_{i,t} + \beta X_{i,t} + \varepsilon_{i,t}. \tag{15}$$

Suppose that all the children at school age were at school and no child not at school age was at school, i.e., $O_{i,t} = 0$ and $N_{i,t} = 0$. Clearly, estimating the model (14) or (15) would be equivalent in this case, since $T_{i,t} = C_{i,t}$. However, the school enrollment does not coincide with total population at school age in Brazil. Moreover, there is evidence that these two groups may have changed over the period under consideration (Table 5). Therefore, we have to use a model that provides a consistent estimation of the propensity to go to private school and is not affected by variations in school enrollment.

It turns out that the choice of the correct model depends heavily on the assumption on the propensity to choose private education of the different groups. First, assume that if the children that are out of school would enter the school system, they

would have the same propensity to choose private education than those currently enrolled at school. Suppose that the same applies for the children not at school age at school. In this case, (14) would estimate the propensity to opt for private education consistently, while (15) would yield misleading estimates.

To see why, consider that the size of the population at school age is identical in 1997 and 1999. Suppose that there is an increase in enrollment between the two years caused by the fact that some children out of school at school age or not gain access to the school system. If the propensity to go to private school for any children (either at school or not) is the same, model (14) would be unaffected by this increase in enrollment while model (15) would indicate an increase in the propensity that in reality did not occur.

However, the assumption of identical propensity is certainly not realistic. The children out of school or entering the school late typically come from low income households and therefore have very limited access to private schools. Throughout, we assume that the propensity of households out of school to join the private school system is zero. In this situation, the estimation of model (15) yields consistent results, while (14) does not. Indeed, the increase in school enrollment of these groups is not reflected in (15).

Finally, a change in the income distribution may affect the number of children having access to private schools. Suppose that the fertility rate of high income households is decreasing at a faster rate than the fertility rate of poor households. In this case, the proportion of children that may choose to go to a private school will decrease over time, but such reduction is unrelated to a lower propensity to go to private school. Ideally, we would like to replace $C_{i,t}$ by $H_{i,t}$. The problem is that we do not have data on the number of children per income level before and after the reform. However, we are able to calculate the share of children living in rich households in 1997 and 1999, as explained in Appendix A, and use it as a control variable.

6.2 Empirical Strategy

In this Subsection, we briefly describe our strategy to estimate model (15). In the estimation, we will use data for 1997 and 1999 that correspond to the pre- and post-reform years. For 1999, model (15) can be written as:

$$\frac{P_{i,99}}{C_{i,99}} = \theta_i + \tau_{99} + \gamma F_{i,99} + \beta X_{i,99} + \varepsilon_{i,99}. \quad (16)$$

Likewise, for 1997 we have:

$$\frac{P_{i,97}}{C_{i,97}} = \theta_i + \beta X_{i,97} + \varepsilon_{i,97}, \quad (17)$$

since $\tau_{97} = 0$ and $F_{i,97} = 0$ in all municipalities before the FUNDEF reform. The key identifying assumptions are that θ_i does not vary across 1997 and 1999 and that $E[F_{i,99}\varepsilon_{i,t}] = 0 \quad \text{for} \quad t = 97, 99$. This means that whatever the source of correlation between the reform and the unobservable, it is captured by the time invariant covariate θ_i.

Our estimation strategy is to subtract (17) from (18) in order to eliminate θ_i. We obtain:

$$\Delta\frac{P_{i,99}}{C_{i,99}} = \tau_{99} + \gamma F_{i,99} + \beta\Delta X_{i,99} + \Delta\varepsilon_{i,99}, \quad (18)$$

where $\Delta\frac{P_{i,99}}{C_{i,99}} = \frac{P_{i,99}}{C_{i,99}} - \frac{P_{i,97}}{C_{i,97}}$, $\Delta X_{i,99} = \Delta X_{i,99} - \Delta X_{i,97}$ and, $\Delta\varepsilon_{i,99} = \varepsilon_{i,99} - \varepsilon_{i,97}$.

6.3 Measuring the impact of the FUNDEF reform

We now turn to the question of how to measure the impact of the FUNDEF reform in a given municipality, that is, how to calculate $F_{i,t}$.

Potentially, the FUNDEF reform has affected all the municipalities and states. They have all contributed to the fund with 15% of their tax and transfer revenue and all received a transfer from the fund based on the number of students enrolled in the previous year in their system.

Nevertheless, the impact of the FUNDEF reform varied depending on the difference between what they have paid to and received from the fund. Intuitively, if a municipality's contribution is very similar to the revenue received from FUNDEF, the impact of the reform on this municipality is close to zero. On the contrary, if a municipality receives a substantial amount from the fund compared to its contribution, the impact of the FUNDEF reform is large. Thus, rather than having a zero-one variable for the effect of the reform, we build an indicator measuring the intensity of the impact of the reform at each municipality.

A first possibility would be to use the difference between contribution and revenue from the fund as an indicator. However, the absolute difference does not give a precise information on the impact. The same net balance would have a completely different impact depending on the size of the municipality's educational system. Another possibility would be to divide the FUNDEF balance by the number of students enrolled in the municipality's public schools. However, this is not a solution neither since the variation in terms of budget per student is substantial in the different states.

Therefore, we opt for a measure that considers the net balance with respect to the contribution made to FUNDEF. This indicator shows how many times the budget of that municipality was increased by the reform with respect to its contribution to the fund. Moreover, since many municipalities have both municipal and state primary schools, we have to consider the effect of FUNDEF in both systems. We start by considering the municipal system. The impact of the reform is calculated by:

$$\begin{aligned} \text{IMPACTFUNDEF}^{M}_{ij,t} &= \frac{\text{Received from FUNDEF}^{M}_{i,t} - \text{Contributed to FUNDEF}^{M}_{i,t}}{\text{Contributed to FUNDEF}^{M}_{i,t}} \\ &= \frac{\frac{E^{M}_{i,t-1}}{\sum_{i\in j} E^{M}_{i,t-1}+E^{S}_{j,t-1}}(\text{FUNDEF}_{j,t} + \text{FEDERAL}_{j,t}) - 15\%\ \text{taxes}_{i,t}}{15\%\ \text{taxes}_{i,t}} \end{aligned} \tag{19}$$

where the subscript i identifies a municipality located in state j in period t and the superscript M and S stand for the municipal and state system, respectively. E represents enrollment, FUNDEF_j is the total amount in the fund in state j (sum of contributions by the state and municipalities), and FEDERAL_j is the federal complements to those states below the minimum value. This formula highlights that the amount a municipality received from FUNDEF depends on the share of students it had in the previous year with respect to all students enrolled in the municipal and state system in state j. The contribution to FUNDEF is equal to 15% of all its taxes and transfers.

A similar formula is used to compute the impact of the FUNDEF reform on the state system.

$$\begin{aligned} \text{IMPACTFUNDEF}^{S}_{j,t} &= \frac{\text{Received from FUNDEF}^{S}_{j,t} - \text{Contributed to FUNDEF}^{S}_{j,t}}{\text{Contributed to FUNDEF}^{S}_{j,t}} \\ &= \frac{\frac{E^{S}_{j,t-1}}{\sum_{i\in j} E^{M}_{i,t-1}+E^{S}_{j,t-1}}(\text{FUNDEF}_{j,t} + \text{FEDERAL}_{j,t}) - 15\%\ \text{taxes}_{j,t}}{15\%\ \text{taxes}_{j,t}} \end{aligned} \tag{20}$$

Now consider the case of a municipality i located in state j that has both municipal and state schools. We define the total impact of the reform as the weighted average of $\text{IMPACTFUNDEF}^{M}_{ij}$ and $\text{IMPACTFUNDEF}^{S}_{j}$, where the weights are given by the proportion of public students enrolled in each system in municipality i at $t-1$.

$$\text{TOTIMPACT}_{i,t} = \frac{E^{M}_{i,t-1}}{E^{M}_{i,t-1}+E^{S}_{i,t-1}}\text{IMPACTFUNDEF}^{M}_{ij,t} + \frac{E^{S}_{i,t-1}}{E^{M}_{i,t-1}+E^{S}_{i,t-1}}\text{IMPACTFUNDEF}^{S}_{j,t} \tag{21}$$

Note that the implicit assumption in (21) is that the FUNDEF resources received by the state were uniformly distributed among the state schools. Since this assumption is somewhat extreme, we perform some robustness checks in Section 8.

Figure 2 illustrates the density of municipalities with at least one private school by impact of the FUNDEF reform given by (21). It shows that few municipalities lost resources with the FUNDEF reform. The mode is around zero, so that the most frequent group comprises the municipalities whose contribution was very similar to the amount they received from FUNDEF. Finally, it is worth noting that the positive impact of the FUNDEF reform has been quite significant for some of them. Indeed, some of the municipalities received up to six times the amount of their contribution.

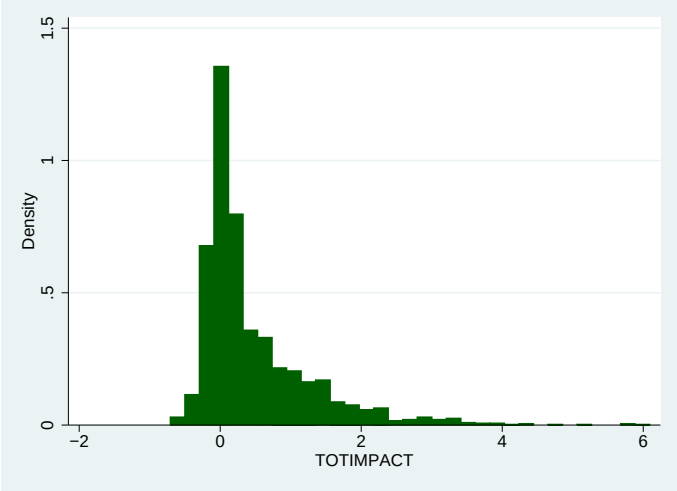

Figure 2: Total impact of FUNDEF reform in municipalities with a private school.

7 Estimation results

7.1 The impact of the FUNDEF reform on the quality of public education

We start by investigating whether the FUNDEF reform had an impact on the quality of public schools using the indicators available in the School Census.[21] Our unit of observation is the school and the impact of the reform depends on the system j (state or municipality) it belongs and on the geographical unit it is located.[22]

In Table 8, we present the impact of the FUNDEF reform on the class size and teachers' qualification. In average, the class size in public schools has decreased over

[21] Note that the results in this subsection are not restricted to municipalities with a private school, since our main goal is to present the overall impact of the reform.

[22] Thus, the implicit assumption is that the impact of the reform was uniformly distributed among all the schools belonging to a certain system and located in a given geographical unit. While this assumption can be regarded as extreme, we are limited by the lack of availability of financial data at the school level.

the period.[23] However, the opposite has happened in the schools that were mostly affected by the FUNDEF reform. This result is consistent with a positive impact of the FUNDEF reform on the enrollment rate, an hypothesis that will be confirmed in Subsection 7.4.

The remaining columns analyze the impact of the FUNDEF reform on the teacher's qualification. It appears that the teachers' level of qualification has increased in 1999 with respect to 1998. This improvement is a consequence of a larger proportion of teachers with secondary education instead of primary education. Moreover, this effect is much more pronounced in the municipalities that were mostly affected by the reform.[24]

Table 8: Impact of FUNDEF on the Public Schools' Class Size and Teachers' Qualification

Dependent variable:	Δ Class size	Δ Proportion of teachers per education level		
		Primary	Secondary	Higher
ΔIMPACT$_j$	0.117*	-0.020***	0.024***	-0.004***
	(0.070)	(0.003)	(0.003)	(0.000)
Dummy 1999	-0.427***	-0.038***	0.026***	0.012***
	(0.052)	(0.002)	(0.003)	(0.001)
Observations	42,385	137,195	137,195	137,195
R-squared	0.001	0.006	0.007	0.001

Notes: Robust standard errors clustered at the municipality level are in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. *Class size:* the analysis is restricted to schools that were not using multigrade groups in primary education in neither 1997 and 1999 since for the others there is no information on class size available in the School Census. *Teachers' qualification:* the data is not available for 1997, so we used the data from the 1998 School Census. Therefore, these results can be seen as conservative estimates of the real impact of the FUNDEF reform.

The results in Table 9 indicate that the FUNDEF reform has had a significant impact on the proportion of schools with electricity, water, and science laboratory. However, the FUNDEF reform does not seem to have affected the prevalence of library and sports facilities in public schools.

[23] In all the regressions, the standard errors are robust and clustered at the appropriate level of aggregation following Bertrand et al. (2004).

[24] However, the proportion of teachers with higher education has raised over the period, but not in the municipalities most affected by the reform, where it has slightly decreased.

Table 9: Impact of FUNDEF on the Public Schools' Infrastructure

Dep. var.:	Δ Electricity	Δ Water	Δ Library	Δ Sports facility	Δ Science lab
ΔIMPACT$_j$	0.007***	0.024***	-0.005***	-0.003***	0.001*
	(0.002)	(0.005)	(0.001)	(0.000)	(0.000)
Dummy 1999	0.050***	0.047***	0.018***	0.012***	-0.003***
	(0.003)	(0.004)	(0.002)	(0.001)	(0.001)
Observations	130,630	130,630	130,630	130,630	130,630
R-squared	0.001	0.006	0.001	0.000	0.000

Notes: Robust standard errors clustered at the municipality level are in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. The dependent variable takes the value 1 if the school has the infrastructure facility and 0 otherwise. The schools are located in 5,379 municipalities (out of 5,507), even if in some of them only financial data of the state system is available.

7.2 The impact of the FUNDEF reform on the share of private enrollment: Using the financial impact

We start by estimating model (15) for the sample of municipalities that have at least one private school.[25] We perform the exercise for different grades and we use the financial impact of the FUNDEF reform calculated by (21) as the explanatory variable. The estimation results for Grade 1 and Grades 2 to 4 using data for 1997 and 1999 are presented in Table 10.

If a municipality receives from the FUNDEF twice its contribution, its share of private enrollment in Grade 1 decreases by 1.0%.[26] Note that this is a significant reduction since the share of private enrollment in Grade 1 is on average equal to 7% for the municipalities that have private schools.

The decrease is not significant for Grades 2 to 4. This confirms our intuition that the reform should affect mainly the enrollment in Grade 1 as the parents may be reluctant to switch schools in the middle of their child's schooling path. Thus, there is evidence of the crowding out effect in the first grade of primary education. The municipalities that have experienced a large positive impact of the FUNDEF reform saw a reduction in their share of private education.

In columns (2) and (4), we control for the share of children living in rich households. This is convenient to account for the fact that only high income households have access to private education, as discussed in Section 6. The results are kept al-

[25] In the case of municipalities without a private school, the schooling choice model does not apply.

[26] Note that if a municipality receives twice its contribution, the indicator of the impact of the FUNDEF reform indicator is equal to 1.

Table 10: Impact of FUNDEF on the Share of Private Education

Dependent variable:	Δ Share of private enrollment in the population at school age between 1997 and 1999			
	Grade 1		Grades 2 to 4	
TOTIMPACT	-0.010*	-0.011**	-0.003	-0.003
	(0.005)	(0.005)	(0.003)	(0.003)
Dummy 1999	-0.008	-0.007	-0.006	-0.005
	(0.006)	(0.006)	(0.005)	(0.005)
Δ Share of rich children		0.101		0.103
		(0.083)		(0.079)
Observations	2109	2109	2081	2081
R-squared	0.027	0.028	0.016	0.019

Notes: Robust standard errors clustered at the state level are in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. Among the 5,507 municipalities in Brazil, 2,379 had at least one grade of primary education offered by a private institution in either 1997 or 1999. The lower number of observations in these regressions is due to unavailability of financial data for some municipalities. Note that the slight decrease in the number of observations of Grades 2 to 4 in comparison with Grade 1 is due to the fact that the sample is restricted to municipalities with private education in the grade under consideration.

most unchanged, except that the inclusion of this variable allows for a more precise estimation of the main variable of interest, TOTIMPACT.

7.3 The impact of the FUNDEF reform on the share of private enrollment: Using the quality indicators

In the regressions presented in Table 10, the impact of the FUNDEF reform was measured by (21). However, it may be questioned whether this indicator captures the impact of the FUNDEF reform that is relevant to our analysis. In particular, if the increase in the municipalities' financial resources was not followed by an improvement in the quality of public schools, there is no reason to believe that the parents would react by changing their enrollment decision. In Tables (8) and (9), we have shown that the FUNDEF reform has improved the quality of public schools. We now verify whether this improvement in quality is related to the decrease in the share of private education in Grade 1.

In this subsection, we will estimate the model (15) by replacing the variable $F_{i,t}$ by some quality indicators. The purpose is to verify whether changes in quality of public schools were responsible for the decrease in the share of private enrollment.

However, if these quality variations are endogenous, we will not be identifying the true causal impact of quality of schools on the share of private enrollment. Our strategy is to use the financial impact of the FUNDEF reform, TOTIMPACT, as an instrument. The underlying assumption is that the FUNDEF reform has no direct impact on the share of private education apart from its impact on the quality of public schools.

The first step consists of defining three different public school quality measures that are aggregated at the municipality level.[27]These are:

$$\text{QUAL1} = \text{Sec} + \text{Electricity} + \text{Water} + \text{Science lab} \quad (22)$$

$$\text{QUAL2} = \text{Sec} + \text{Electricity} + \text{Water} + \text{Library} + \text{Sports} + \text{Science lab} \quad (23)$$

$$\text{QUAL3} = \text{Sec} + \text{Electricity} + \text{Water} + \text{Library} + \text{Sports} + \text{Science lab} + \text{Size} \quad (24)$$

where Sec stands for the proportion of teachers with secondary education and Size is an indicator calculated as:

$$\text{Size} = 1 - \frac{\text{Class size} - 30}{30}. \quad (25)$$

Note that Size is larger (smaller) than 1 if class size is smaller (larger) than 30.[28]

We start by presenting the results for the instrumental equation in Table 11. It shows that there is a positive correlation between the financial impact of the FUNDEF reform and the improvement in the quality indicators. This result is unambiguous and significant.[29]

We now turn to the second stage regression where we analyze the impact of the variation in the quality of public schools instrumented by the FUNDEF reform on the share of private enrollment for Grade 1 and Grades 2 to 4. The results obtained in Table 12 parallel those obtained in the regressions using the financial impact of the FUNDEF reform. The larger the positive impact of the FUNDEF reform, the lower the share of private education in the municipality. This effect is strong for Grade 1 and not significant for Grades 2 to 4.

Thus, the FUNDEF reform has improved the quality indicators of the public schools located in the municipalities that have benefited the most from the reform.

[27]The explanation of how these measures were aggregated at the municipality level are contained in the Appendix A.

[28]The class size equal to 30 is fixed arbitrarily as the maximum acceptable.

[29]Not surprisingly, the results are very similar for the two grades. Indeed, the only difference between these two estimations is that the sample of municipalities changes since we consider only the municipalities having a private school for that specific grade. Note that we have to perform the two regressions since they are the first stage regressions for the IV estimation.

Table 11: Impact of FUNDEF on Quality Indicators: Instrumental Equation

	Grade 1			Grades 2 to 4		
Dep. var.:	ΔQUAL1	ΔQUAL2	ΔQUAL3	ΔQUAL1	ΔQUAL2	ΔQUAL3
	(1)	(2)	(3)	(4)	(5)	(6)
TOTIMPACT	0.077***	0.077***	0.088***	0.074***	0.073***	0.084***
	(0.013)	(0.019)	(0.018)	(0.012)	(0.018)	(0.017)
Dummy 1999	0.012	0.038	0.044	0.013	0.041	0.046
	(0.020)	(0.036)	(0.034)	(0.020)	(0.036)	(0.034)
Observations	2109	2109	2078	2081	2081	2052
R-squared	0.135	0.087	0.110	0.133	0.086	0.108

Notes: Robust standard errors are in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. Among the 5,507 municipalities in Brazil, 2,379 had at least one grade of primary education offered by a private institution in either 1997 or 1999. The lower number of observations in these regressions is due to unavailability of financial data for some municipalities.

The improvement in the quality of public schools seems to explain the decrease in the share of private enrollment observed in these municipalities.

7.4 The impact of the FUNDEF reform on school attendance

Our results suggest that some students that would enroll in a private school have chosen instead a public school attracted by the quality improvements caused by the FUNDEF reform. In this section, we investigate whether these improvements have also brought children that were previously out of school to the public schools.

As discussed in Section 5, one difficulty related to investigating this issue is that the FUNDEF reform may have given incentives for municipalities to inflate their enrollment levels.[30] Indeed, the resources received by a municipality from the fund depend on the number of students enrolled in the public schools. Moreover, it would be difficult to distinguish the students coming from private schools from those previously out of school using data on school enrollment.

The 1996 Population Count and 2000 Population Census provide information on school attendance for children aged 7 to 9 at the municipality level. This allows us to measure the extent to which the FUNDEF reform attracted children that were

[30]Note that even if this was the case, it would not have significantly affected our previous estimations results for the crowding out effect. Indeed, we have relied on total population at school age and not on enrollment data.

Table 12: Impact of Quality Indicators on the Share of Private Education

Dep. var.: Δ Share of private enrollment in the population at school age 1997 and 1999 *Instrumental variable*: TOTIMPACT						
	Grade 1			Grades 2 to 4		
	(1)	(2)	(3)	(4)	(5)	(6)
Δ QUAL1	-0.147*			-0.046		
	(0.079)			(0.041)		
ΔQUAL2		-0.148*			-0.047	
		(0.079)			(0.040)	
ΔQUAL3			-0.122**			-0.037
			(0.056)			(0.032)
Dummy 1999	-0.004	0.000	-0.001	-0.004	-0.002	-0.003
	(0.006)	(0.008)	(0.005)	(0.005)	(0.005)	(0.005)
Δ Share of rich children	0.164*	0.185**	0.151**	0.124	0.130*	0.120*
	(0.085)	(0.078)	(0.071)	(0.073)	(0.064)	(0.069)
Observations	2109	2109	2078	2081	2081	2052

Notes: Robust standard errors clustered at the state level are in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. Among the 5,507 municipalities in Brazil, 2,379 had at least one grade of primary education offered by a private institution in either 1997 or 1999. The lower number of observations in these regressions is due to unavailability of financial data for some municipalities.

out of school to the school system. The dependent variable is the net attendance rate and the regression is performed for all the municipalities with public finance data available. The estimation results are presented in Table 13.

Table 13: Impact of FUNDEF on the Net Attendance Rate

Dependent variable:	Δ Net attendance rate for children aged 7 to 9 1996 and 2000
TOTIMPACT	0.028***
	(0.003)
Dummy 1999	0.024***
	(0.004)
Observations	4061
R-squared	0.330

Notes: Robust standard errors clustered at the state level are in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. These regressions are performed for all the municipalities with data available on school attendance and the financial impact of the reform.

These results indicate that the FUNDEF reform had a positive impact on the net school attendance rate. If the municipality received twice its contribution, the net attendance rate increased by 2.8%. Since the resources originated by FUNDEF had to be invested in the schools and teachers, our hypothesis is that the improvement in quality was responsible for this increase in attendance rate. Therefore, we expect that the increase in school attendance was caused by an improvement in quality originated by the FUNDEF reform. In order to verify this hypothesis, we perform an instrumental variable regression using the financial impact of the reform as the instrument. We present the results for the first and second stage regressions in Tables 14 and 15, respectively.

The results in Table 14 show that a positive financial impact of the FUNDEF reform is associated with an improvement in the three quality indicators. Table 15 confirms that these quality improvements were responsible for the increase in the net attendance rate of children aged 7 to 9.

Table 14: Impact of FUNDEF on Quality Indicators: Instrumental Equation

Dependent variable:	ΔQUAL1	ΔQUAL2	ΔQUAL3
	(1)	(2)	(3)
TOTIMPACT	0.092***	0.094***	0.098***
	(0.006)	(0.011)	(0.011)
Dummy 1999	0.016***	0.037***	0.046***
	(0.004)	(0.008)	(0.008)
Observations	4061	4061	3792
R-squared	0.074	0.037	0.048

Notes: Robust standard errors are in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. These regressions are performed for all the municipalities with data available on school attendance, quality indicators and the financial impact of the reform.

Table 15: Impact of Quality Indicators on the Net Attendance Rate

Dependent variable:	Δ Net attendance rate for children aged 7 to 9 1996 and 2000 *Instrumental variable*: TOTIMPACT		
	(1)	(2)	(3)
ΔQUAL1	0.305***		
	(0.037)		
ΔQUAL2		0.299***	
		(0.054)	
ΔQUAL3			0.286***
			(0.061)
Dummy 1999	0.019***	0.013	0.011
	(0.005)	(0.011)	(0.014)
Observations	4061	4061	3792

Notes: Robust standard errors clustered at the state level are in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. These regressions are performed for all the municipalities with data available on school attendance, quality indicators and the financial impact of the reform.

8 Robustness Checks

8.1 Testing for the composition of municipal and state impact of FUNDEF reform

The variable that measures the financial impact of the FUNDEF reform defined by (21) combines the financial impact of the reform in the municipal and state system.

This may be problematic for at least two reasons. First, it assumes that the states distributed the resources received from the FUNDEF reform uniformly across all state schools located in the different municipalities. Second, it may be the case that the weighted average of the state and municipal impact does not reflect the true impact of the FUNDEF reform in a given municipality.

In this section, we perform several robustness checks to verify whether our results are robust in light of this composition effect. We do so by first restricting the sample to the municipalities with a predominance of municipal schools while still considering the impact on both systems. Then, we investigate the same sample of municipalities by taking into account exclusively the impact of the FUNDEF reform on the municipal school system.

The results of these robustness checks are presented for Grade 1 and Grades 2 to 4 in Table 16. The results confirm that our previous estimations were robust. There is no significant change in the results by restricting the sample to municipalities having a majority of municipal schools or not accounting for the impact of the FUNDEF reform in the state system. However, the results for some of the subsamples lose power of estimation and are no longer significant.

8.2 Eliminating states without state data

In the Appendix A, we discuss the fact that we are using two types of database to compute the impact of the FUNDEF reform. These two sources present different degrees of reliability. Since this may certainly affect our results, in this section we run the same regressions by restricting our sample to those municipalities for which we have reliable data, i.e. data collected by the State Treasuries.

These results confirm the existence of a crowding out effect that is stronger for Grade 1, but still exists for Grades 2 to 4. Interestingly, the estimation of the effect is much more precise than in the previous regressions.

Table 16: Testing for the composition of municipal and state impact of FUNDEF

Dependent variable : Share of private enrollment in the population at school age 1997 and 1999										
Grade 1										
	Percentage of public schools that are municipal									
	All sample		> 70%		> 80%		> 90%		100%	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
TOTIMPACT	-0.011**		-0.010*		-0.009		-0.012*		-0.009	
	(0.005)		(0.006)		(0.006)		(0.006)		(0.011)	
IMPACT^M		-0.010**		-0.010*		-0.009*		-0.011**		-0.010
		(0.004)		(0.005)		(0.005)		(0.005)		(0.008)
Dummy 1999	-0.007	-0.007	-0.009	-0.007	-0.010	-0.009	-0.003	-0.003	-0.000	-0.001
	(0.006)	(0.005)	(0.008)	(0.007)	(0.009)	(0.009)	(0.010)	(0.009)	(0.011)	(0.009)
Δ Share of rich children	0.101	0.124	0.266	0.291	0.134	0.158	0.184	0.205*	0.181	0.198*
	(0.083)	(0.080)	(0.186)	(0.182)	(0.134)	(0.132)	(0.115)	(0.113)	(0.114)	(0.111)
Observations	2109	2109	1083	1083	794	794	504	504	309	309
R-squared	0.028	0.032	0.039	0.043	0.048	0.052	0.045	0.050	0.018	0.022
Grades 2 to 4										
	Percentage of public schools that are municipal									
	All sample		> 70%		> 80%		> 90%		100%	
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
TOTIMPACT	-0.003		-0.003		-0.003		-0.004		-0.003	
	(0.003)		(0.003)		(0.004)		(0.004)		(0.008)	
TOTIMPACTm		-0.005		-0.003		-0.004		-0.005		-0.004
		(0.003)		(0.003)		(0.003)		(0.003)		(0.006)
Dummy 1999	-0.005	-0.004	-0.006	-0.005	-0.005	-0.004	-0.001	-0.001	0.001	0.001
	(0.005)	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)	(0.007)	(0.006)	(0.009)	(0.007)
Δ Share of rich children	0.103	0.123*	0.306	0.319	0.170*	0.184**	0.157**	0.168**	0.129*	0.137*
	(0.079)	(0.071)	(0.199)	(0.193)	(0.091)	(0.086)	(0.071)	(0.069)	(0.070)	(0.067)
Observations	2081	2081	1063	1063	778	778	493	493	299	299
R-squared	0.019	0.024	0.032	0.034	0.028	0.032	0.020	0.024	0.006	0.008

Notes: Robust standard errors clustered at the state level are in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. Among the 5,507 municipalities in Brazil, 2,379 had at least one grade of primary education offered by a private institution in either 1997 or 1999. The lower number of observations in the two first columns is due to unavailability of financial data for some municipalities.

Table 17: Testing for the Reliability of Data

Dependent variable:	Δ Share of private enrollment in the population at school age 1997 and 1999	
	Grade 1	Grades 2 to 4
	(1)	(2)
TOTIMPACT	-0.018***	-0.007**
	(0.005)	(0.003)
Dummy 1999	0.003	0.002
	(0.006)	(0.005)
Δ Share of rich children	0.129***	0.043
	(0.035)	(0.030)
Observations	1375	1349
R-squared	0.033	0.013

Notes: Robust standard errors clustered at the state level are in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. Among the 5,507 municipalities in Brazil, 2,379 had at least one grade of primary education offered by a private institution in either 1997 or 1999. This regressions include only the municipalities that had financial data available at the State Treasuries.

9 Conclusion

The assumption that the parents' decision to enroll their children in private schools is related to the quality of public schools has been extensively used in the theoretical literature. The main difficulty associated with testing this hypothesis is the simultaneity of public school expenditures and private enrollment decisions. A large number of households opting out of public schools may decrease the support for public education expenditures and therefore cause a decrease in the quality of public schools.

In this paper, we test this assumption by exploring the effect of the FUNDEF reform that took place in Brazil in 1998. This reform implied a redistribution of financial resources between the state and the municipalities inside each of the 26 states that constitute Brazil. Since the reform was defined by the federal government and was uniform across the country, we argue that its impact can be considered exogenous at the municipality level.

We present evidence that the municipalities that had a positive impact of the FUNDEF reform saw their share of private primary school enrollment decrease. This was especially the case for Grade 1, confirming our intuition that the parents may be

reluctant to switch schools after their child has already started school. Importantly, our estimation results are robust to any changes in the gross enrollment rate that may have occurred in these municipalities during this period. We also rule out alternative explanations to the decrease in the share of private enrollment such as possible changes in the income distribution.

Since the FUNDEF reform funds have to be used exclusively at schools, the parents' reaction has to be necessarily associated with visible quality improvements. We show that the FUNDEF reform has indeed improved several quality indicators at the school level, such as class size, teachers' qualification, and infrastructure. Using the financial impact of the FUNDEF reform as an instrument, we show that these quality improvements may explain the decrease in the share of private primary enrollment. Finally, we show that the improvements in quality originated by the FUNDEF reform also caused an increase in the net enrollment rate.

Thus, a policy aimed at increasing the quality of public schools may attract students that would otherwise enroll in private institutions. If this phenomenon is not taken into account by policymakers, they may underestimate the amount of resources needed to improve the public education system. Moreover, improving quality also seems to attract additional students to the school system. These conclusions are derived by analyzing the period immediately after the implementation of the reform. It would be convenient to extend this analysis to more periods to verify whether these short term effects persist over the long term.

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A The Data

A.1 School Census

The Brazilian School Census contains information for all public and private schools at the school level. The information is provided by each school director by means of a questionnaire and is collected by INEP.[31] The School Census provides information on enrollment per grade. It also allows us to calculate the following quality indicators at the school level: class size, proportion of teachers per education level, and infrastructure (electricity, water, library, sport facilities, science laboratory). The infrastructure indicator equals 1 if the item is present in a school and 0 otherwise.

We aggregate the public and private enrollment data at the municipality level. We also compute quality indicators for the public schools at the municipality level. They are calculated as a weighted average of the public schools' quality indicators by using the number of students in each school as weights. For instance, suppose that a municipality has two public schools with 40 and 60 students in primary education, respectively. If only the former has a library, the library indicator equals 0.4 for this municipality.

A.2 Financial data

In order to compute the impact of the FUNDEF reform by municipality, we compute the amount each municipality and state has received and contributed to FUNDEF. The amount each municipality or state received from FUNDEF and the state's contribution to FUNDEF are available on the Treasury website.[32]

For the municipalities, the contribution to FUNDEF can be calculated by using data on their tax and transfer revenues. FUNDEF is composed by 15% of four taxes and the information on three of them (FPM/FPE, IPIExp and LC87/96) has been obtained from the Treasury. This data corresponds to the amounts that have effectively been paid in the municipalities' and states' bank account.

The fourth source of revenue is the value-added tax, ICMS. It is collected by the states, but 25% of it is redistributed back to their municipalities. The Treasury also provides information on this tax redistribution to the municipalities in a database called FINBRA. However, it is based on self-report by the municipalities. Since the Treasury collects this information, but does not audit the municipalities, it has

[31] *Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira* - National Institute of Educational Research Anísio Teixeira, www.inep.gov.br. INEP is a federal institution related to the Minister of Education and responsible for designing and performing studies, surveys, and evaluation on the Brazilian Educational System.

[32] STN, *Secretaria do Tesouro Nacional*, www.tesouro.fazenda.gov.br.

been shown not to be very reliable. Moreover, during the implementation of the FUNDEF reform, it was not very clear whether the municipalities should report the gross or net value (including or not the 15% destined for the FUNDEF). A simple comparison with more reliable data indicates that nearly half has reported the net value and the other half the gross value. In addition, 25% of the municipalities did not sent the information to this database, leaving us with a substantial amount of missing data. The more reliable alternative consists of collecting data directly with the State Treasuries for this specific tax. The difficulty is that very few of the 26 State Treasuries make this data readily available. Until the moment, we have data on 12 states amounting to about 60% of the municipalities. For the remaining states, we have used the data on FINBRA while waiting that the corresponding state treasuries send us additional information. In Section 8, we do some robustness checks by eliminating the municipalities for which data from the state treasury was not obtained.

A.3 Demographic data

Our main sources of demographic data are the 1996 Population Count and the 2000 Population Census that are collected by IBGE.

The 2000 Population Census contains information on the number of children by age group at the municipality level. This allows us to calculate the total population at primary school age in 1997 and 1999. This exercise relies on the assumption that there were no significant changes in the population at these age groups between 1997 and 2000. Thus, it rules out variations that can be due to migration or mortality. As an illustration, to compute the number of children that should be at Grade 1 in 1997, i.e. aged 7, we use the number of children who were 10 in 2000 in each municipality. Similar exercises are done for the remaining grades and 1999. This figure allows us to calculate an alternative measure for the share of private enrollment that is not influenced by possible changes that may have affected the enrollment in public schools.

In order to control for social mobility and differential mortality across income groups, we use data from the 2000 Census on the number of children per household income level. We consider a household to be rich if its per capita income is higher than 2 minimum wages. Our group for 1999 corresponds to the group aged 7 to 9 in 2000 and the group for 1997 is composed of the group aged 10 to 14 in 2000. We calculate the share of children living in rich households by dividing the number of children in a rich household over the total number of children in that age range per municipality.

In both the 1996 Population Count and the 2000 Population Census, we have

information on the number of children that were attending school or not. We use this information for the age range 7 to 9 years corresponding to the three first grades of primary school. We calculate a measure of net attendance rate by dividing those at school by the total number of children at the same age group in households reporting their schooling status.