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Public Spending and Quality of Education in Brazil

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Abstract: *We examined whether Brazil's educational spending on public primary schools resulted in better quality of education, 2003-2009. Our hypothesis was municipalities that received higher government spending on primary education had higher students' tests scores. We used a panel analysis with fixed effects, including a simulated instrumental variable to control for endogeneity. Even though the magnitude of all significant estimated coefficients increased, when controlling for endogeneity, they were still very small. Findings proved that the relationship between quality of education and educational spending was not optimal, weakly contributing to the increase in test scores.*

1. Introduction

Quality of education is a key ingredient towards economic growth, so not surprisingly, many countries across the globe are investing in education. Various approaches have demonstrated how education may affect economic growth. First, some scholars empirically showed that education fostered human capital, which increased labour productivity, and as a consequence, moved economic growth to a higher level (Fleisher, Hu, Li, & Kim 2011; Lucas, 1988; Mankiw, Romer, & Weil, 1992; Oketch, 2006; Teixeira & Fortura, 2004). Second, various studies indicated that education boosted both innovation capacity and new knowledge about technology, products, and processes leading to growth (Aghion & Howitt, 1998; Benhabib & Spiegel, 2005; Lucas, 1988; Nelson & Phelps, 1966; Park, Choung, & Min 2008;

Ranis, Stewart & Ramirez 2000; Wolff 2000). Third, the fact that education can facilitate spillovers of knowledge and promote skill based technical changes (Fleisher & Hu Lu Kim, 2011) is well-documented (Acemoglu 1996, 1998; Ciccone & Peri, 2006).

Increasing trends of public investment in education emphasise the need to better understand the relationship between quality of education and public resource allocation for education. Empirical studies have demonstrated mixed results: some studies have indicated a positive relationship between student performance and investments in education (Castelló-Climent & Hidalgo-Cabrillana, 2012; Manuelli & Seshadri 2006); other studies have indicated little impact of investments on performance or no relationship between the two (Hanushek, 2001, 2005; Hanushek & Kimko, 2000).

Investments in education have been a priority in Brazil since the early 2000s. The national public educational and cultural expenditures increased 27 percent from 2006 to 2010 (Ministry of Finance, 2015). Within this context, the main objective of this paper is to examine whether Brazil's educational spending on public primary schools during the period 2003-2009 resulted in better quality of education. *Prova Brasil*, a national test administered by the Brazilian Ministry of Education, is the dependent variable, used as a proxy for measuring quality of education. Higher average scores in *Prova Brasil* indicate better quality of education. The independent variable of interest is the *Fundo de Desenvolvimento do Ensino Fundamental e da Valorização do Magistério* (*Fundef*), a federal fund which had as its aim the redistribution of state and municipal resources back to municipalities according to student enrolment (Koppensteiner, 2014). Our hypothesis is that municipalities that received higher government spending on primary education had higher *Prova Brasil* scores.

We used panel data analysis with school fixed effects to estimate the impact of educational spending on the quality of education; school clusters were also included in the estimations. Two grades and two subjects are used as dependent variables, allowing four different measures of quality of education: 'math grade 4,' 'math grade 8,' 'Portuguese grade 4,' and 'Portuguese grade 8.' Additionally, our panel regression models include a simulated instrumental variable to deal with endogeneity bias due to potential municipal behaviour. The instrumental variable was simulated based on Kosec's (2014) approach, using data prior to *Fundef* to predict municipal revenue in a given year. Only pre law (that is, prior to *Fundef*) municipal responses are included in the instrumental variable. In other words, by using the simulated instrumental variable we are able to capture the impact of public spending on test scores based on exogenous changes in the *Fundef* law, not on municipal behaviour.

The findings of the estimations with the simulated instrumental variable indicate that three out of the four estimated regressions support the hypothesis. In these estimations, the coefficients for the independent variables of interest (that is, educational spending) increase in magnitude when compared to the models that did not control for endogeneity. The magnitude of these coefficients was small, however, showing that education spending has little impact on test scores.

Our contribution to the literature is based on our methodology. We examine an issue already explored by other scholars, but with a more accurate identification strategy, in which fixed effects were combined with a simulated instrumental variable. Even though we follow Kosec (2014), our objective is different from hers. She uses education as an example to understand "what drives governments with similar revenues to publicly provide very different amounts of goods with private sector substitutes"(p. 320); whereas, we sought to examine the relationship between educational spending and quality of education.

The paper is organized as follows. Section two gives a background about the Brazilian socio-economic context. Section three introduces the *Fundef* law. Section four presents a literature review. The fifth section describes the variables used in this study and explains the methodology. The sixth section presents both the estimation results and a discussion about them. The final section contains concluding remarks, limitations of the study, and ideas for future research.

2. BACKGROUND

During the first decade of the 2000s, Brazil was in the headlines of international media because of its high economic growth rate and its investments in social development. In the context of the global economy, Brazil was growing at a faster rate than most other countries. This growth was attracting investors and new businesses to Brazil's territory. Additionally, under President Lula's leadership (2003-2011), social investments were a priority, allowing many Brazilians who were living in poverty to have access to a better quality of life. The poverty rate in Brazil rose to 22.4 per cent in 2004, but has sharply declined since then to 13.3 per cent in 2009 and 8.9 per cent in 2013 (World Bank, 2015). The population earning less than the Purchasing Power Parity of $1.25 per day followed a similar pattern, rising to 11.2 per cent in 2003 but falling to 4.7 per cent in 2009, followed by a very slight decline to 3.8 per cent in 2012 (World Bank, 2015).

When comparing Brazil to the Organisation for Economic Co-operation and Development (OECD) countries, according to OECD (2012), "Brazil [boasted] one of the largest increases in expenditure in education between 2000 and 2009 among the countries for which data was available"(p. 3). Moreover, from 2006 to 2010, the southeast region, the richest region of the country, had an increase of nine per cent of public educational and cultural expenditures (Ministry of Finance, 2015). On the other hand, the northeast region, the poorest region in Brazil, had an increase of 43 per cent, indicating that public resources were being allocated where they needed them the most. In addition to these statistics, the mixed findings reviewed above, bring to light the need to better understand the relationship between quality of education and public resource allocation for education.

It is important to place the Brazilian case in context with other Latin American countries to understand where it stands with regards to economic growth, quality of education, and educational spending. Table 1 compares these factors among five Latin American countries, who were selected because they spent the greatest percentage of GDP on education during the period of study. Economic growth is measured by GDP annual percentage growth, quality of education is measured by the Program for International Student Assessment (PISA), and educational spending is measured by the annual percentage of GDP that is allocated to education.

As Table 1 shows, Brazil had the highest GDP per cent allocated to education in all years. On the other hand, Brazil had the lowest PISA math for 2006, and the second lowest for 2009. Brazil had only average PISA reading values for both years. Since economic growth goes hand in hand with investments in human capital, and these statistics show that public spending on education steadily increased in Brazil, one would expect Brazil to have higher PISA values. However, this does not seem to be the case here, and therefore, attention to ensuring that effective investments are being made for high quality education for students in Brazil is imperative.

[Table 1 about here]

Finally, according to IPEA (2016) the percentage of five and six year old children attending school increased by approximately 15 per cent between 2003 and 2014. These statistics are interpreted as positive signs because more children are attending schools. On the other hand, this increase in attendance may affect quality of education. Knowing that public investment in education is a continuous process in Brazil, it is important to understand whether Brazil's educational spending on public primary schools resulted in better quality of education. This paper sheds new light on the educational quality literature by estimating more accurate econometric models that address endogeneity.

3. FUNDEF

The system that finances education in Brazil is very complex; various funds work together, a large combination of taxes are used to accumulate resources, and resource allocation is based on multiple criteria. Therefore, for the purpose of this paper, a narrowed approach is presented focusing only on *Fundef*, which is only part of the total expenditures on education in Brazil. *Fundef* was chosen because it was the main source of education public spending during the period of study. To illustrate, after calculation based on data from the National Department of Treasury (2016), we found that *Fundef* represented 63 per cent of the total municipal primary education spending in 2005. The 1988 Brazilian Constitution mandated *Fundo de Desenvolvimento do Ensino Fundamental e da Valorização do Magistério* (*Fundef*), which was enacted in December of 1996 (Law number 9.424). Implementation began in 1998, lasting until 2006.

In Brazil, the K-12 system (educação básica) is divided into two levels. The primary school (ensino fundamental) corresponds to grades one to nine, and the high school (ensino médio) corresponds to grades 10 to 12. *Fundef* resources were targeted only to primary schools. In 2007, *Fundef* was replaced by the *Fundo de Manutenção e Desenvolvimento da Educação Básica e de Valorização dos Profissionais da Educação* (*Fundeb*), an expanded version of the former. *Fundeb* is expected to end in 2020, and its resources are being targeted to both primary and high schools.

In 1998, when *Fundef* started to be implemented, every Brazilian state had to gather 15 per cent of the total revenue from each municipality to put in one state fund for education. By doing that, an educational fund for every state in Brazil was created. Each municipality received a quota from the educational state fund, equivalent to the number of students enrolled in their public schools (that is, a per-student basis). The distribution of this educational fund was based on the total number of students enrolled in primary schools in the previous year. Some variations of per student spending occurred, based on rural and urban enrolment, and also based the total number of students enrolled in the first half (that is, grades one to four) and in the second half (that is, grades five to nine) of primary school.

Table 2 shows the weights used by the federal government to allocate resources. Weights were given to each student enrolled in primary school, and varied depending on her/his location (rural or urban) and her/his grade of enrolment. Students enrolled in the second half of primary school and located in rural areas received more funding, as did students enrolled in special education. These weights are included in the simulated instrumental variable.

[Table 2 about here]

In addition, the federal government annually established a minimum amount of funding to be allocated per student. This minimum also varied, depending on location (rural or urban) and grade of enrolment. The federal government contributed to the educational state funds as well, ensuring that a minimum per student spending was reached in every state. Table 3 depicts the minimum amount of spending per student. One can observe that the minimum per student spending had an increase of around 34 per cent from 2003 to 2005; all values were deflated to the year 2005.

[Table 3 about here]

In summary, *Fundef*'s goal was to produce a more equitable and decentralized educational system. As described by Dickovick and Eaton (2013), *Fundef* was an effort "to cut out the state level in favour of direct and unintermediated links between the centre and local institutions or individual citizens" (p. 1458). However, as indicated by Davies (2006), the tax inequality that existed between the different levels of governments in Brazil inhibited the formation of an efficient system of education based on spending with consistent standards and quality.

4. LITERATURE REVIEW

This literature review focuses on work related to educational spending in Brazil, and other studies that also included *Fundef* and *Prova Brasil* in their models.

As Schleicher and Tang (2015) explained, there is a counter intuitive threshold amount for educational spending per student and quality of learning outcomes. In countries that invest less than USD 50,000 per student between the ages of six and 15, a significant positive relationship between spending per student and quality of education can be observed. For countries that invest USD 50,000 or more per student, this relationship cannot be observed. For these countries, the authors explained: increasing quality of education is not about how much to invest, but how to spend the resources (p. 13). For the Brazilian case, taking into account averages in 2007, approximately USD 12,000 were spent per student between the ages of six and 15. This amount increased to USD 21,000 in 2010. These statistics indicate that one should expect a positive relationship between spending per student and quality of education in Brazil. These 2007 and 2010 values were gathered from the Observatório do Plano Nacional de Educação. Annual public spending per student was used for these calculations and required using dollar exchange rates and controlling for inflation.

A few prior studies also examined *Fundef* using regression models, though in different ways from the present study. Focusing on the evolution of public expenditure on education in Brazil during 1991-2002, Mello and Hoppe (2005) tested if *Fundef* had a significant impact on net enrolment rates. They found that primary and lower-secondary education enrolment increased, particularly in small municipalities, proving that *Fundef* improved the supply side of education in Brazil. The authors emphasised the need to place attention on policies to improve the quality of services. However, it should be noted that in their methodology, endogeneity was not addressed.

Moreover, Gordon and Vegas (2005) estimated various regression models, including an instrumental variable to capture mandated spending. They found that increased spending from *Fundef* was associated with smaller class sizes and small gains in enrolment. Conversely, they found no evidence that it improved school performance for most students, except perhaps for low-achieving and non-white students. Finally, in a study using 1998 *Fundef* data, Menezes-Filho and Pazello (2007) found that, overall, increases in teacher salaries due to *Fundef* did little to improve performance in public schools. However, these raises did attract better new teachers to some schools, and students of these teachers did have improved proficiency. In their methodology they did include an instrumental variable, not related to *Fundef*, but to teachers' salary.

Our methodology addresses *Fundef*-related endogeneity by including an instrumental variable in the regression model. This instrumental variable estimated in this study follows Kosec's (2014) methodology. Her regressions were used to examine factors that lead to public and private education provision. Kosec also included both *Prova Brasil* and *Fundef* in her models. Kosec found "no evidence that the quality of public education suffers due to [...] lower propensity to invest" (p. 335).

As explained above, *Prova Brasil* is used as a proxy for quality of education in this study. Hanushek and Wößmann (2007) recommended that quality of education should be measured by standardized test scores. In their literature review, they found that higher performance on tests translated to increased earnings, especially in the developing world. They also suggested that school performance cannot be solely attributed to test scores since factors like family background and living conditions also have an impact. Their main argument is that these scores have significant implications for the economic performance of the students, and for the countries that provided their education.

Finally, Ferraz, Finan and Moreira (2012) also used both *Prova Brasil* and *Fundef* in their models to understand the relationship between corruption and school performance in primary public schools in Brazil. They constructed a variable, "involving educational block grants transferred from the central government to municipalities" (p. 712). By using this variable, the effects of corruption in education became exogenous. The authors found that *Fundef* was being misused by several Mayors, e.g., by stealing teacher salaries. Additionally, they found a significant negative association between corruption and school performance by estimating an OLS and a non-linear Tobit models.

In summary, based on the literature review, we would expect a positive relationship between test scores and educational spending. Moreover, we would expect that the inclusion of the instrumental variable would make our regressions more accurate.

5. DATA AND MODELS

In this section we present the data used in the models, a description of how the simulated variable was estimated, and the models' specifications.

5.1 Data

The data used in this article came from various sources. Table 4 describes all the variables used in the models. Some variables were collected at the school level and others at the municipal level. The dependent variables – average *Prova Brasil* scores – were obtained from the *Insitituto Nacional de Estudos e Pesquisas Educacionais Anisio Texeira* (INEP). *Prova Brasil* started in 2005 and is administered by the Ministry of Education every two years. *Prova Brasil* is a vertically scaled type of test, allowing changes over time to be measured. Tests are designed based on the Item Response Theory, which allows the level of difficulty for questions to change according to the test taker response. Consequently, it is possible to link spending with quality of education over time, when using *Prova Brasil* as a proxy for quality of education. In 2005, the test was administered in public schools located in urban areas that had a minimum of 20 students per grade. In 2007 and 2009, it was administered in public schools located in urban and rural areas that had a minimum of 30 students per grade.

[Table 4 about here]

The objective of *Prova Brasil* is to assess student proficiency in math and Portuguese for grades 4 and 8. Average scores for the four tests were used as dependent variables. It was expected that the four dependent variables would have the same relationships to the independent variables of interest, regardless of the differences subject matter and grade level. The independent variable of interest was the amount of public spending on primary education in a municipality divided by the total number of students enroled in primary schools in that municipality (*Fundef*). Data on public education spending was obtained from the National Department of the Treasury. Natural logarithms were applied to the dependent and independent variables of interest to allow for the measurement of elasticity. By doing that, it was possible to capture how a change of one per cent in the independent variable would affect the dependent variable.

A span of two years was used between the dependent variable and independent variable of interest as an attempt to allow for any time lag necessary for financial resources to start producing results. Specifically, the dependent variable 2005 *Prova Brasil* had the independent variable 2003 *Fundef* in its regression; the 2007 *Prova Brasil* had 2005 *Fundef*; and the 2009 *Prova Brasil* had 2006 *Fundef*, the fund's final year.

Various control variables were also included in the models. These were found based on an extensive literature review examining student proficiency (Hanushek, Lavy & Hitomi, 2006; Kilkenny & Haddad, 2008; Menezes-Filho, 2007; Paes de Barros & Mendonça, 1998). These control variables were divided into four groups: student, school, teacher, and municipality. Characteristics of students who took *Prova Brasil* were obtained from INEP. The School Census was used to get data for the characteristics of schools and teachers in each municipality. Municipal characteristics came from the following sources: GDP per capita came from IBGE; and income and health indices were calculated by the Federation of Industries of the State of Rio de Janeiro. The income index included average wage, and formal employment; and the health index included number of pre-natal and infant deaths.

The number of observations displayed on Table 4 varied within a source, and also from source to source. For instance, the number of schools that participated in the *Prova Brasil* 2005 math test for grade four was 29,072, and in the 2009 test this number was 43,581. It should be noted that all different sources had missing values, varying from variable to variable, and also from year to year. After merging these different data sets, every school was included in the econometric analysis even when having missing values. In other words, the data used in the analysis depicts unbalanced panels. The total number of observations included in the regressions are displayed in tables 7 and 8 below. For the regressions without the instrumental variable, the total number of schools for grade four was 46,514 and the total number of schools for the grade eight was 33,735. For the regressions with the instrumental variable, the total number of schools for grade four was 34,102 and the total number of schools for the grade eight was 25,472.

Table 5 shows the descriptive statistics of the four dependent variables (at the school level), and the independent variable of interest (at the municipal level). There was a consistent increase, from 2005 to 2009, on the average score for math grade four, and Portuguese grades 4 and 8. The average for public spending in education also increased from 2003 to 2006.

[Table 5 about here]

Table 6 depicts a correlation matrix including the dependent variable 'math grade 4,' *Fundef* and all control variables for 104,432 schools (29,072 schools in 2005, 37,483 in 2007, and 43,581 in 2009). In general, variables presented expected signs. For instance, the Pearson coefficient between 'math grade 4' and 'students with internet at home' is 0.54, indicating that higher socio-economic level is correlated with higher test scores. These descriptive results deserve additional examination, motivating our investigation to better understand the causal explanation between quality of education and educational spending in Brazil.

[Table 6 about here]

5.2 The Instrumental Variable

The *Fundef* implementation began in 1998, and the transferring of resources used for that year was based on the 1997 enrolment data from the School Census. Therefore, to simulate the instrumental variable, the 1997 School Census data were used. Additionally, the simulated instrumental variable was constructed by combining the following data: the amount of public spending on primary education in a municipality; and the total enrolment differentiated by location (that is, urban or rural), by grade (that is, from grades one to nine), and by public jurisdiction (that is, municipal or state-based). These data were gathered from the National Department of the Treasury and the School Census, respectively.

The 1997 enrolment data is constant in the 2003, 2005 and 2006 instrumental variables, allowing us to control for possible municipal manipulation in enrolment. As a result, our instrumental variable captured exogenous information excluding municipalities' reaction facing the new *Fundef* rules. In other words, our regressions allowed controlling for any municipal attempt to manipulate enrolment numbers to increase *Fundef* resources to their public schools. Kosec (2014) developed this simulated instrumental variable to overcome the fact that possible municipal manipulation in enrolment could occur.

The exogeneity of the simulated instrument is an important part of our methodology, and a detailed explanation about it follows. Although in Brazil there are mechanism in place to minimize corruption (Sugiyama, 2016), it is still embedded in municipal governments' behaviour (Ferraz & Finan 2011, Ferraz, Finan & Moreira 2012, Timmons & Garfias 2015). For instance, corruption schemes in Brazilian municipalities were examined by Ferraz and Finan (2011). They found that Mayors allocated funds that were supposed to be for education projects "toward the purchase of cars, fuel, apartments, or payment of their friends' salaries" (p. 1281). Knowing that corruption influences the work environment of public employees in Brazil, it would be expected that municipalities could increase their number of students enrolled by, for instance, double counting students, and/or using students' names that do not exist. In other words, public official could take advantage of such situation to get more *Fundef* funding to its municipal budget, trapping the federal allocation system.

As explained above, the federal government used weights to allocate resources. To simulate the instrumental variable, enrolment data per school were divided in three groups: grades one to four, grades five to nine, and special education students. The three school enrolment groups were then separated in sub-groups based on location (rural or urban) and on administrative entity (municipal or state-based). Finally, we aggregated the sub-group school enrolments to obtain the total enrolment by municipality and individual states, both needed to simulate the instrumental variable. Every sub-group had a weight based on *Fundef* rules, as displayed in Table 2.

The federal government allocated resources to each state. In turn, each state redistributed its resources to its municipalities. Because of the federal government's weighting system, municipalities with similar enrolment in primary public schools had different amounts of *Fundef* funds allocated. This situation caused variability in the simulated instrumental variable. This variability is required to identify the effect of *Fundef* funds on quality of education. In the simulation process of the instrumental variable, the estimated public spending on primary education was used. This public spending was estimated using 1997 enrolment data, as a constant across time, to capture municipal pre law behaviour. Afterwards, weights (see Table 2) were applied to the constant enrolment data to obtain the *Fundef* distribution coefficient, which was then multiplied by the 1998 *Fundef* funds.

5.3 Model Specification

The main goal of this econometric approach is to examine the relationship between quality of education and government spending on education in Brazilian public schools during the period 2003-2009. Because the law that dictates government spending on education changed during this period, endogeneity becomes an issue, since the law induced endogenous municipal attempts to manipulate enrolment numbers. As stated above, two panel regression models were estimated: one without the simulated instrumental variable, and the other with the simulated instrumental variable. By estimating both models, it is possible to compare results and to examine how much endogeneity altered those results.

Our panel regression models allow for controlling unobserved school characteristics that were fixed over time, and could have influenced *Prova Brasil* average scores. Examples of these characteristics could be: school programs that motivate reading, community engagement in early childhood education, and the quality of school management.

This study applies the fixed effect panel technique, which includes unobserved school characteristics that are fixed over time, and could influence *Prova Brasil* average scores. This technique can be used to obtain consistent estimators in the presence of omitted variables. Examples of these characteristics could be: public policies that motivate reading, community engagement in early childhood education, the presence of NGOs that have a strong capacity to be engaged in educational debates, the quality of school management, and other social factors that may influence average scores in some way. For instance, an important unobserved characteristic such as quality of school management may or may not be correlated with *Fundef* funds. Assuming that school management is fixed over time, by using this technique, it is possible to control for these managerial characteristics. Therefore, estimated results will be unbiased.

The model specification without the simulated instrumental variable is represented in equation 1.

$$Y_{it} = \beta_0 + \beta_1 Fundef_{it-2} + \beta_2 Student_{it} + \beta_3 School_{it-2} + \beta_4 Teacher_{it-2} + \beta_5 Municipality_{it-2} + C_i + U_{it} \quad (1)$$

where Y_{it} is the natural log of the students' average score in *Prova Brasil* (math grade four, Portuguese grade4, math grade 8, Portuguese grade 8); β_0 is the constant of the model; $Fundef_{it-2}$, is the natural log of the amount spent on primary education divided by total enrolment in primary education, representing the explanatory variable of interest; $Student_{it}$ is the vector of control variables with characteristics of the students who took *Prova Brasil* $School_{it-2}$ is the vector of control variables with characteristics of public schools; $Teacher_{it-2}$ is the vector of control variables with characteristics of public school teachers; $Municipality_{it-2}$ is the vector of control variables with socio-economic characteristics of municipalities; C_i corresponds to the specific (fixed) effects of each municipality; β_1 to β_5 are the unknown parameters to be estimated; and U_{it} is the error term.

The simulation of the instrumental variable had two steps. The first was the computation of *Fundef* distribution coefficient, represented in equation 2:

$$coef_t = \frac{\sum_{j \in FUNDt} d_{tj}^{FUNDt} mat_{m,e,1997,j}}{\sum_{m \in e} \sum_{j \in FUNDt} d_{tj}^{FUNDt} mat_{m,e,1997,j} + \sum_{j \in FUNDt} d_{tj}^{FUNDt} mat_{e,1997,j}} \quad (2)$$

where, $coef_t$ is the *Fundef* distribution coefficient; $FUNDt$ represent all enrolment types (that is., grade one-four urban, grades one to four rural, grades five to nine urban, grades five to nine rural, special education); t is the year; j is the enrolment type; d is the weight based on the enrolment type (see Table 2); $mat_{m,e,1997,j}$ is the total number of students enrolled in 1997, in municipal primary schools in municipality m, in enrolment type j; and $mat_{e,1997,j}$ is the total number of students enrolled in 1997 in state primary schools, in enrolment type j.

The final step was the simulation of the instrumental variable, represented in equation 3:

$$fundef\_total_t = coef_t \times fundef_{1998} \tag{3}$$

where $fundef\_total_t$ is the instrumental variable to be estimated; and $fundef_{1998}$ is the 1998 *Fundef* transfer.

However, if a state did not have revenues for the minimum funding per student, then the federal government would transfer funds to that state in order to achieve that minimum, and the instrumental variable equation follows in equation four:

$$fundef\_total = \sum_{j \in FUNDt} mat_{m,e,1997,j}\, min_{t,j} \tag{4}$$

where $fundef\_total$ is the instrumental variable to be estimated; $min_{t,j}$ é is the minimum value per student in the enrolment type j in year t; and the other is defined as above.

The second panel specification including the instrumental variable *Fundef_IV* (2SLS), the independent variable of interest, is represented in equations five and six, as follow:

$$Fundef_{it-2} = \beta_0 + \beta_1 Fundef\_IV_{it-2} + \beta_2 Student_{it} + \beta_3 School_{it-2} + \beta_4 Teacher_{it-2} + \beta_5 Municipality_{it-2} + C_i + U_{it} \quad \text{First Stage} \tag{5}$$

$$Y_{it} = \beta_0 + \beta_1 \widehat{Fundef}_{it-2} + \beta_2 Student_{it} + \beta_3 School_{it-2} + \beta_4 Teacher_{it-2} + \beta_5 Municipality_{it-2} + C_i + U_{it} \quad \text{Second Stage} \tag{6}$$

where all elements are defined as previously.

The estimations were made using the statistical software Stata 13. The use of fixed effects for the regressions was based on both the Breush and Pagan (1980) and Hausman (1978) tests. The Breush Pagan test indicated that the null hypothesis of non existence of specific effects should be rejected. Instead, there were unobserved fixed effects in the dataset for both panels. Likewise, the Hausman test showed that the fixed effects were better specifications than the random effects for the dataset used in this study (see Table 7).

6. Estimation Results and Discussion

The results for the panel regressions presented in this section were estimated using school fixed effects. In the estimations, clustered robust standard errors and school clusters were used. Table 7 presents results of the estimation without including the simulated instrumental variable, creating a baseline for comparison. *Fundef* is the independent variable of interest. Each column in Table 7 represents a regression for a different dependent variable, i.e. *Prova Brasil* average score for math grade 4, Portuguese grade 4, math grade 8, and Portuguese grade 8. The regression for math grade 4 has 104,432 schools, for Portuguese grade 4 has 105,163 schools, for math grade 8 has 77,741 schools, and for Portuguese grade 8 has 77,740 schools.

[Table 7 here]

Results from this table give weak support to our hypothesis: municipalities that received higher government spending on primary education had higher *Prova Brasil* scores. One can observe that an increase of 1 per cent in public spending on education would produce an increase of 0.04, 0.003 and 0.01 for 'math grade 4,' 'Portuguese grade 4,' and 'Portuguese grade 8,' respectively. These elasticities were statistically significant at 1 per cent, but had very small magnitude, indicating little impact of public spending on student scores. On the other hand, the coefficient for 'Fundef' was not statistically significant for 'math grade 8,' indicating no impact of public spending on student scores.

The four models displayed on Table 7 had control variables for student, school, teachers, and municipal characteristics. When focusing on the student-related control variables, scores were higher in schools with higher proportion of students who had internet at home, for all tests, at 1 per cent level of significance. These findings suggest that the higher the economic status of students, the higher their scores. With regards to working conditions, results suggest that the scores of 'students who were working' were significantly reduced for all tests, at 1 per cent level of significance. 'Mother's education' had a positive significant relationship with all tests, at 1 per cent, suggesting that the higher the level of the mother's education, the higher the chance of children doing better in school.

For school related control variables, the estimated effect of 'computers per school' on test scores was positive and statistically significant for 'math grade 4,' 'Portuguese grade 4,' and 'Portuguese grade 8,' at 1 per cent, and for 'math 8' the level of significance 10 per cent. Proficiency was higher in 'schools with libraries' for the 'math grade4,' 'Portuguese grade 4,' and 'Portuguese grade 8,' at 1 per cent. These results indicate that school resources, such as the existence of libraries, were important for improving scores. The estimated effect of 'students per classroom' on test scores was negative and statistically significant for 'math grade 4,' 'Portuguese grade 4,' and 'math grade 8' at 1 per cent level of significance. This indicates that in the Brazilian context, smaller class sizes lead to improved test scores. Considering teacher related control variables, the estimated coefficient for 'teacher education' was positive and statistically significant at 1 per cent for 'math grade 4,' 'Portuguese grade 4,' and 'Portuguese grade 8' tests, demonstrating that teachers with higher levels of education benefit students.

With regards to the municipality related control variables, the natural log of 'GDP per capita' was statistically significant and positively related to 'math grade 4,' 'Portuguese grade 4,' and 'math grade 8,' at 1 per cent level of significance. The 'health index' was statistically significant and positively associated with all test scores at 1 per cent. The 'income index' was statistically significant and positively associated 'math grade 4,' but was negatively associated with 'Portuguese grade 4,' 'math grade 8' and 'Portuguese grade 8,' all at 1 per cent. In summary, there was consistent significance with the direction of the 'GDP per capita' and 'health index' coefficients. On the other hand, there was no consistent significance with the direction of the 'income index' coefficients.

Knowing that municipalities may have attempted to manipulate enrolment numbers to increase *Fundef* resources to their public schools, a simulated instrumental variable was introduced to the regression analysis. Table 8 presents results of the fixed effects estimation including the simulated instrumental variable. The regression for math grade 4 has 91,918 schools, for Portuguese grade 4 has 92,679 schools, for math grade 8 has 69,390 schools, and for Portuguese grade 8 has 69,398 schools. One can observe that there was a decrease in the number of schools for these regressions. This happened because we used 1997 data to estimate the instrumental variable; in 1997 there were 4,491 municipalities in the country. The number of municipalities increased by 1,018 municipalities in 2000, totalling 5,509 municipalities in the country. This change in the number of municipalities is the reason for the decreased in schools in the instrumental variable regressions. To illustrate, a municipality that did not exist in 1997 could not be included in these regressions because it would not have available enrolment data to estimate the instrumental variable.

In these regressions, endogeneity was controlled, allowing for a more accurate approach to test our hypothesis. The coefficients for '*Fundef*' were positive and significant for 'math grade 4,' and 'Portuguese grade 8' at 1 per cent level of significance, and 'Portuguese grade 4' at 10 per cent of significance. For these three tests there was a coincidence of higher scores and higher spending in education. The magnitude of these coefficients increased by 250 per cent, 320 per cent and 66 per cent respectively, showing that investments in education had some positive effects on test scores. For instance, a 1 per cent increase in *Fundef* allocation would increase score in math grade four by 0.15 per cent and in 'Portuguese grade 4' by 0.005, and grade eight by 0.05 per cent.

In summary, our empirical strategy to examine the exogenous effect of *Fundef* on student performance considered the control of observable variables, school fixed effects, and a simulated instrumental variable for *Fundef*. First, our regressions included control variables, based on the literature, for important characteristics of students, schools, teachers and municipalities. Second, our panel regression models allowed for controlling unobserved school characteristics that were fixed over time, such as public policies that motivate reading, community engagement in early childhood education, and other social factors that may influence average scores in some way. Then, the control observable variables and the control of school fixed effects enable us to capture important information that could bias our instrumental variable if they were omitted. Both play an important part in supporting the exogeneity of our simulated instrumental variable. Our simulated instrumental variable captured exogenous information excluding municipalities' reaction facing new Fundef rules. In other words, this simulated variable overcame the fact that possible municipal manipulation in enrolment could occur.

Based on these findings, the hypothesis about municipalities that received higher government spending on primary education had higher *Prova Brasil* scores was weakly supported. The magnitudes of the coefficients were larger when the instrumental variable was included; however, they were still very small. Concerning the control variables, results displayed in Table 8 were consistent with the results from Table 7. Therefore, the discussion presented above holds for both tables.

[Table 8 about here]

7. Conclusion

The main objective of this study was to examine whether Brazil's educational spending on public primary schools during the period 2003-2009 resulted in better quality of education. Panel data using school fixed effects, including clustered robust standard errors, and controlling for endogeneity was used for the dataset analysed in this study. The dependent variable was average test scores on *Prova Brasil*, which were used as a proxy for quality of education. There was one independent variable of interest: the amount of public spending on primary education in a municipality divided by number of students enrolled in primary education in that municipality. A span of two years was applied between the dependent and independent variable as an attempt to capture any time lag required for financial resources to begin working.

Six regressions indicated that municipalities characterized by higher *Prova Brasil* scores were receiving higher government spending on education, except for the 'math grade 8' regressions. The magnitude of all significant estimated coefficients increased when controlling for endogeneity – using the simulated instrumental variable – but were still very small in magnitude. Our hypothesis, that is, municipalities that received higher government spending on primary education had higher *Prova Brasil* scores was weakly supported by six out of eight regressions.

Even so, these findings proved that the relationship between quality of education and public spending was not optimal, mainly because of the small magnitude of the estimated coefficients. This indicates that public spending in education only weakly contributed to the formation of human capital. This study can illustrate what Hanushek (2013) referred to as "less successful" human capital development because of the "little relationship" found in our estimations (p. 209). Moreover, these results are surprising if one considers Schleicher and Tang's (2015). They state that countries that invest less than USD 50,000 per student between the ages of six and 15, should have a significant positive relationship between spending per student and quality of education. During the period of study Brazil invested less than USD 50,000 per student between the ages of six and 15, putting the country in the optimal range.

The economic growth that Brazil was experiencing from 2003 to 2013 should have been followed by steady human capital formation. Issues such as political factors, corruption, lack of efficiency, and quality of investments could be explanations for the small magnitude of the estimated coefficients. So what should be done to ensure that investments in education contribute to human capital formation? Hanushek (2013) recommended that "slowing the pace of the provision of schools to a rate that also permits the development of quality schools appears to be a good solution" (p. 211), for developing countries. In other words, funding five schools to improve quality before funding additional schools would be better for human capital formation than funding ten schools simultaneously when facing scarce public resources. If Brazilian policy makers had focused funding at the beginning of *Fundef* on a few schools, and had gradually expanded the funds to more schools, then the results might have been more robust.

Moreover, there are various innovative initiatives being implemented and tested in different regions around the world to hasten the 'development of quality schools.' To illustrate, third graders are learning mathematics with songs and games in Paraguay. According to the NGO Innovation for Poverty Action (2013) "results show children in Big Math schools improved their math skills over the five months of the program as much as other accepted education programs" (p. 12). Additionally, in India, children facing lower performance in basic literacy and numerical skills are working together with community assistants to improve the children's performance (Innovation for Poverty Action, 2012). Brazilian policy makers should explore successful initiatives like these to improve the level of efficiency and the quality of educational investments. By doing that, *Fundeb*, the current educational fund, could contribute to the quality of Brazilian public schools, in a more effective and efficient manner.

Some of the potential limitations of this study follow. First, it is important to highlight that the regressions estimated in this paper only captured part of the variation in education spending in Brazil between 2003 and 2009, due to the fact *Fundef* only accounts for part of the total spending. Second, larger time spans between the independent and dependent variables could capture time lags that are required for financial resources to start working more effectively. However, data availability did not allow for larger spans in this study. Third, understating how municipalities spent their *Fundef* resources would help elucidate the complex educational funding system and its effects on test scores. For instance, a municipality could have allocated 50 per cent of *Fundef* resources in buying books for all its libraries;

whereas, another municipality could have allocated the same amount in developing an after school program. However, data availability did not allow for such type of analysis.

Future research should focus on issues related to improving public school quality in Brazil. From a qualitative perspective, for instance, examining how institutional capacity varies between public schools could help better understand the variation on *Prova Brasil* scores. Another research topic could compare public and private schools, focusing on the similarities and differences on how they allocate resources. As Gradin (2009) alerted, in the Brazilian context, public schools “typically provide education of lower quality” (p. 1443), making this comparison an interesting applied study. Additionally, the econometric approach could benefit by developing the Conley, Hansen & Rossi (2012) bounding method for panel data in order to test for plausible exogeneity.

From a quantitative perspective, institutional capacity could be evaluated by building a variable based on educational management characteristics. Another research idea could be a longitudinal study comparing public and private schools, and using data from other sources such as SAEB or Geres Project. In this latter idea, the control of fixed effects should also be included, but an important future step could be the use of data at the individual level. This would make possible to control for school fixed effects and pupil fixed effects simultaneously.

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Table 1: Comparing Economic Growth, Quality of Education, and Educational Spending, 2006-2009.

	Year	**Chile**	**Argentina**	**Colombia**	**Brazil**	**Mexico**
PISA Math	2006	411	381	370	370	406
	2009	496	388	381	386	419
	Change	↑	↑	↑	↑	↑
PISA Reading	2006	442	374	385	393	410
	2009	449	398	413	412	425
	Change	↑	↑	↑	↑	↑
Annual % change in GDP	2006	4.4	8.4	6.7	4.0	5.0
	2007	5.2	8.0	6.9	6.0	3.1
	2008	3.3	3.1	3.5	5.0	1.4
	2009	-1.0	0.1	1.7	-0.2	-4.7
	Change	↓	↓	↓	↓	↓
Public spending on education in % of GDP	2006	3.0	3.7	3.9	5.0	4.7
	2007	3.2	3.9	4.1	5.1	4.7
	2008	3.8	4.3	3.9	5.4	4.9
	2009	4.2	4.9	4.7	5.6	5.2
	Change	↑	↑	↑	↑	↑

Source: OECD and World Bank Indicators.

Table 2. Weights used for FUNDEF allocation based on enrolment type

Enrolment type	**2003**	**2005**	**2006**
1 to 4 grade Urban	1.00	1.00	1.00
1 to 4 grade Rural	1.00	1.02	1.02
5 to 9 grade Urban	1.05	1.05	1.05
5 to 9 grade Rural	1.05	1.07	1.07
Special Education	1.07	1.07	1.07

Table 3. Minimum amount to be allocated per student based on FUNDEF

Minimum amount per student	2003	2005	2006
1 to 4 grade Urban	R$462.00	R$620.56	R$682.60
1 to 4 grade Rural	R$462.00	R$632.97	R$696.25
5 to 9 grade Urban	R$485.10	R$651.59	R$716.73
5 to 9 grade Rural	R$485.10	R$664.00	R$730.38
Special Education	R$485.10	R$664.00	R$730.38

Source: Law number 4,861, October 20, 2003

Table 4: Description of all Variables

Variable	Years	Unit of analysis
Dependent variables		
Log of Prova Brasil Math average score - 4th grade (math grade 4)	2005, 2007, 2009	School
Log of Prova Brasil Portuguese average score - 4th grade (Portuguese grade 4)	2005, 2007, 2009	School
Log of Prova Brasil Math average score - 8th grade (math grade 8)	2005, 2007, 2009	School
Log of Prova Brasil Portuguese average score - 8th grade (Portuguese grade 8)	2005, 2007, 2009	School
Independent variable of interest		
Log of Fundef spending divided by number of enrollment in elementary education (Fundef)	2003, 2005, 2006	Municipality
Student-related control variables		
Proportion of students who took Prova Brasil who lived in a place with internet access (‘students with internet at home)	2005, 2007, 2009	School
Proportion of students who took Prova Brasil and worked (students who were working)	2005, 2007, 2009	School
Proportion of mothers -of students who took Prova Brasil - who attended 4th grade or higher (mother’s education)	2005, 2007, 2009	School
School-related control variables		

Binary variable of public schools that had a computer lab (computers per school)	2003, 2005, 2007	School
Binary variable of public schools that had a library (school with libraries)	2003, 2005, 2007	School
Total number of students divided by number of classes in elementary schools (student per classroom)	2003, 2005, 2007	School
Teacher-related control variables		
Proportion of teachers working in public schools with undergraduate degree (teacher education)	2003, 2005, 2007	School
Municipality-related control variables		
Log of GDP per capita (GDP per capita)	2003, 2005, 2007	Municipality
Health index (health index)	2000, 2005, 2007	Municipality
Income index (income index)	2000, 2005, 2007	Municipality

Table 5: Descriptive Statistics of Dependent Variables and Independent Variables of Interest

Year	Variable (# Obs)	Mean	Std. Dev.	Min	Max
2005	Math grade 4 (29,072)	5.18	0.101	4.73	5.67
	Portuguese grade 4 (30,090)	5.14	0.106	4.67	5.67
	Fundef (45,784)	475.7	205.7	-0.145	2,026
	Math grade 8 (22,017)	5.47	0.074	5.15	5.872
	Portuguese grade 8 (22,017)	5.41	0.072	5.06	5.740
	Fundef (33,618)	478.9	208.2	-0.145	2,027
2007	**Variable (# Obs)**	**Mean**	**Std. Dev.**	**Min**	**Max**
	Math grade 4 (37,483)	5.232	0.107	3.926	5.771
	Portuguese grade 4 (37,483)	5.135	0.109	4.223	5.567
	Fundef (46,970)	595.6	231.6	0.000	1,861
	Math grade 8 (27,381)	5.471	0.080	4.143	5.901
	Portuguese grade 8 (27,381)	5.422	0.077	4.939	5.779
	Fundef (34,152)	600.6	236.3	0.000	1,861
2009	**Variable (# Obs)**	**Mean**	**Std. Dev.**	**Min**	**Max**
	Math grade 4 (43,581)	5.275	0.131	4.611	5.766
	Portuguese grade 4 (43,582)	5.170	0.125	4.531	5.685

	Fundef (47,259)	702.9	265.8	0.000	2,144
	Math grade 8 (31,963)	5.472	0.087	4.931	5.911
	Portuguese grade 8 (31,962)	5.457	0.088	4.874	5.818
	Fundef (34,292)	709.8	272.4	0.000	2,144

Source: INEP and Tesouro Nacional.

Table 6: Correlation Matrix using Math grade 4 as dependent variable

	Math 04	Fundef	Stud. Internet	Stud. Work	Mother edu	Sch. Computer	Sch. Library	Stu. Classroo	Teacher
Math 04	1.000								
Fundef	0.177	1.000							
Stud. Internet	0.543	0.156	1.000						
Stud. Work	-0.431	-0.083	-0.335	1.000					
Mother edu	0.358	-0.012	0.442	-0.287	1.000				
Sch. Computer	0.263	0.096	0.318	-0.168	0.186	1.000			
Sch. Library	0.270	0.030	0.231	-0.170	0.171	0.255	1.000		
Stu. Classroom	-0.109	-0.111	0.122	-0.010	0.102	0.085	-0.040	1.000	
Teacher edu	0.403	0.102	0.381	-0.254	0.266	0.306	0.303	0.005	1.00
GDP	0.224	0.028	0.522	-0.262	0.330	0.262	0.122	0.298	0.33
Health Index	0.539	0.185	0.522	-0.336	0.314	0.309	0.253	-0.099	0.50
Income Index	0.336	0.044	0.529	-0.297	0.323	0.266	0.157	0.177	0.36

Table 7. Results of natural log of average Prova Brasil scores estimated by fixed-effect panel data without simulated instrumental variable

Dependent Variables	(1) Math 4	(2) Portuguese 4	(3) Math 8	(4) Portuguese 8
Independent variable of interest				
Fundef	0.045***	0.003**	-0.001	0.014***
	(0.004)	(0.001)	(0.001)	(0.001)
Student related control variables				
Student with internet at home	0.137***	0.063***	0.044***	0.081***
	(0.004)	(0.004)	(0.003)	(0.003)
Student who were working	-0.173***	-0.179***	-0.064***	-0.117***

	(0.005)	(0.005)	(0.003)	(0.003)
Mother’s education	0.096***	0.112***	0.062***	0.065***
	(0.003)	(0.003)	(0.003)	(0.004)
School related control variables				
Computers per school	0.014***	0.006***	0.001*	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)
Schools with libraries	0.009***	0.014***	-0.001*	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Students per classroom	-0.001***	-0.000***	-0.000***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Teacher related control variables				
Teacher’s education	0.036***	0.016***	-0.003*	0.010***
	(0.002)	(0.001)	(0.001)	(0.002)
Municipality related control variables				
Ln GDP	0.096***	0.086***	0.002	0.067***
	(0.003)	(0.002)	(0.002)	(0.002)
Health Index	0.154***	0.032***	0.019***	0.080***
	(0.007)	(0.006)	(0.004)	(0.005)
Income Index	0.042***	-0.035***	-0.007***	-0.007***
	(0.003)	(0.002)	(0.002)	(0.002)
Constant	3.429***	3.881***	5.394***	4.318***
	(0.026)	(0.023)	(0.018)	(0.022)
Observations	104,432	105,163	77,741	77,740
R-square within	0.4255	0.2292	0.0535	0.3353
R-square between	0.137	0.1643	0.2536	0.1072
R-square overall	0.1233	0.136	0.2234	0.0973
Breusch-Pagan $\chi^2(01)$	8,872	9,163	10,871	7,149
Hausman $\chi^2(11)$	6,611	7,042	7,669	4,082
Number of schools	46,514	46,527	33,735	33,735

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; Breusch-Pagan and Hausman tests were estimated without considering school clusters.

Table 8. Results of natural log of average Prova Brasil scores estimated by fixed-effect panel data with simulated instrumental variable

Dependent Variables	(1) Math 4	(2) Portuguese 4	(3) Math 8	(4) Portuguese 8
Independent variables of interest				
Fundef	0.158***	0.005*	-0.004	0.059***
	(0.004)	(0.003)	(0.003)	(0.003)

Student related control variables				
Stududent with Internet at home	0.115***	0.063***	0.044***	0.075***
	(0.004)	(0.004)	(0.003)	(0.003)
Students who were working	-0.149***	-0.178***	-0.065***	-0.107***
	(0.005)	(0.005)	(0.003)	(0.003)
Mother's education	0.099***	0.112***	0.062***	0.061***
	(0.003)	(0.003)	(0.003)	(0.004)
School related control variables				
Computers per school	0.009***	0.006***	0.001*	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
School with libaries	0.010***	0.014***	-0.001*	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
Students per classroom	-0.000	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Teacher related control variables				
Teach_edu	0.022***	0.016***	-0.002	0.004**
	(0.002)	(0.001)	(0.001)	(0.002)
Municipality related control variables				
Ln GDP	0.041***	0.085***	0.004*	0.047***
	(0.003)	(0.002)	(0.002)	(0.002)
Health Index	0.070***	0.030***	0.021***	0.045***
	(0.007)	(0.006)	(0.004)	(0.005)
Income Index	0.015***	-0.036***	-0.006***	-0.018***
	(0.003)	(0.003)	(0.002)	(0.002)
Observations	91,918	92,679	69,390	69,389
R-square within	0.3741	0.2292	0.0533	0.3141
R-square between	0.1576	0.1644	0.2249	0.1168
R-square overall	0.1739	0.1362	0.196	0.1154
Hausmann $\chi^2(11)$	20,052	8,063	5,918	53,170
Number of schools	34,102	34,145	25,472	25,472

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; Hausman test was estimated without considering school clusters.