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THREE ESSAYS ON EDUCATION FROM THE PERSPECTIVE OF THE ECONOMICS OF PUBLIC SECTOR

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Advisor: Prof. Paulo Roberto Arvate

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ABSTRACT

This work consists of three essays organized into chapters that seek to answer questions at first sight unrelated, but with one common denominator, which is the scarcity of public resources devoted to education, overall, especially in lower education. .

The first chapter deals with the scarcity of resources devoted to education in a context of population aging. Two hypotheses were tested for Brazilian municipalities on the relationship between the aging of the population and educational expenditure. The first, already proven in the literature, is that there is an intergenerational conflict for resources and the increase of the share of elderly in the population reduces the educational expenditure. The second, proposed here for the first time, is that there should be reduction of competition for resources if there is a relationship of co-residence between young and old. The results indicated that an increase in the share of elderly reduces the educational expenditure per youth. But the results also illustrate that an increase in the share of elderly co-residing with youth (family arrangement more common in Latin American countries) raises the educational expenditure, which reflects a reduction of competition for resources between generations.

The second chapter assesses the allocative efficiency of investments in Higher Education. Using the difference between first-year and last-year students' scores from Enade aggregated by HEI as a product in the Stochastic Production Function, is possible to contribute with a new element in the literature aimed at estimating the production function of education. The results show that characteristics of institutions are the variables that best explain the performance of students, and that public institutions are more inefficient than the private ones.

Finally, the third chapter presents evidence that the allocation of public resources in early childhood education is important for a better future school performance. In this chapter was calculated the effects of early childhood education on literacy scores of children attending the 2nd grade of elementary school. The results using OLS and propensity score matching show that students who started school at the ages to 5, 4, and 3 years had literacy scores between 12.22 and 19.54 points higher than the scores of those who began school at the ages 6 years or late. The results also suggest that the returns in terms of literacy scores diminish in relation to the number of years of early childhood education.

Key Words: Educational Expenditures, Population Aging, Intergenerational Competition, Co-residence, Aggregate Value, Higher Education, Stochastic Frontier, Production Functions, Early Childhood Education, Literacy Scores, Propensity Score Matching.

RESUMO

Este trabalho é composto por três ensaios organizados em capítulos que buscam responder questões a uma primeira vista independentes, mas com um denominador comum, que é a escassez de recursos públicos destinados à educação.

O primeiro ensaio trata da escassez de recursos voltados à educação em um contexto de envelhecimento populacional. Foram testadas duas hipóteses sobre a relação entre o envelhecimento populacional e os gastos em educação. A primeira, já presente comprovada na literatura, é a de que há uma disputa intergeracional por recursos e o aumento na proporção de idosos reduz os gastos em educação. A segunda, proposta aqui pela primeira vez, é a de que deve haver redução dessa disputa por recursos se houver uma relação de co-residência entre jovens e idosos. Os resultados indicaram que um aumento no percentual de idosos, de fato, reduz os gastos por jovem em educação. Mas também foram encontradas evidências de que conforme aumenta a proporção de jovens e idosos co-residindo (arranjo familiar mais comum em países lationo-americanos), aumentam os gastos em educação, o que reflete uma atenuação da disputa intergeracional por recursos.

O segundo capítulo avalia a eficiência alocativa dos investimentos realizados no Ensino Superior. Utilizando a diferença entre os escores de alunos ingressantes e concluintes do Enade agregados por IES como produto na Função de Produção Estocástica, foi possível contribuir com um elemento novo na literatura voltada à estimação de Função de Produção de Educação. Os resultados mostraram que as características das instituições são as variáveis que melhor explicam o desempenho. Adicionalmente, as instituições públicas são mais ineficientes que as privadas.

Por fim, o terceiro capítulo apresenta evidências de que a alocação de recursos públicos na Educação Infantil é importante para um melhor desempenho escolar futuro. Nesse capítulo foram calculados os efeitos da educação infantil sobre os escores de alfabetização das crianças do 2º ano do Ensino Fundamental. Os resultados encontrados com o uso de OLS e de *Propensity Score Matching* mostram que alunos que ingressaram com 5, 4, e 3 ou menos anos de idade, obtiveram escores de alfabetização entre 12,22 e 19,54 pontos a mais do que os que ingressaram na escola com 6 anos ou mais. Os resultados também sugerem que os retornos são decrescentes em relação ao tempo de Educação Infantil.

Palavras-Chaves: Gastos em Educação, Envelhecimento Populacional, Competição Intergeracional, Co-residência, Valor Agregado, Ensino Superior, Fronteira Estocástica, Função de Produção, Educação Infantil, Escores de Alfabetização, Propensity Score Matching.

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1 Introduction

Admittedly the provision of quality education depends, in large part, on the family background of students, and little can be done to reverse a consolidated situation in which the family background is disadvantaged. Moreover, most of these families do not have the resources to invest in the education of their children, and there is not an appropriate credit system which facilitates this investment. According to Stiglitz (1999), this characteristic of the capital market represents a failure or an imperfection of the market, and by itself, would justify public intervention through investments in public education.

However, the situation of education in Brazil cannot be resolved simply by increasing spending. Resources are scarce, i.e., there is an overall budget constraint, and various interest groups compete for these resources. Therefore, it is interesting to try to better understand the competition for public resources and how to take maximum advantage of available resources to education. In other words, maximize educational outcomes for a given level of expenditure, identifying where the spending is more productive and if the private sector is actually more efficient than the public sector to provide education. Given this background, this paper seeks to examine three issues related to the scarcity of public resources for education in the form of three essays.

The first essay deals with the allocation of resources in education in the context of population aging, where there is a greater demand for resources targeted to the elderly and there is not a decrease in demand for resources for education.[1] Consequently, the relevant question, facing these demographic changes and government constraint, is to which group should public resources be directed. This question reflects an intergenerational conflict. To this end, two hypotheses were tested for Brazilian municipalities on the relationship between the aging of the population and educational expenditure. The first hypothesis is that the increase of the share of elderly in the population reduces the educational expenditure, according to consensus of the recent empirical literature. The second hypothesis is that there should be reduction of competition for resources if there is a relationship of cohabitation (co-

[1] Considering the need to increase both the average schooling and the quality of education, the demand for resources to education should increase rather than diminish, even with the decrease in the proportion of young population.

residence) between young and old, which is a common arrangement in Latin American countries. Thus, a greater share of elderly and youth living together should increase the expenditure in education. This last hypothesis is a new element that this essay tries to introduce to current literature. To test the hypothesis of this essay, a panel of data from Population Census (Brazilian Institute of Geography and Statistics) and from Finbra (National Treasury Office) was used to the years 1991 and 2000. The possibility of endogeneity was considered due to the Tiebout mechanism for individual's location.[2] To correct this problem the Fixed Effects method was used with instrumental variables. The econometric results indicated that an increase in the share of elderly in the population reduces the educational expenditure per youth, which supports the results of the main studies of the current literature. In addition, the results in this essay illustrate the reduction of intergenerational conflict in Brazil due family arrangement, i.e., an increase in the share of elderly co-residing with youth in the population raises the educational expenditure. Therefore, the results confirm the hypotheses of this essay and also emphasize the importance of family arrangements with elderly in determining the educational expenditure.

The second essay highlights the disparity of investments in different levels of education, especially in favor of higher education. Accordingly, high levels of investment realized at this level of education, compared to other levels, creates concerns regarding the allocative efficiency. [3]An improvement in allocative efficiency would free resources to be used more productively by all levels of education. Thus, the second essay assesses the effectiveness of investments in higher education, comparing the results of performance on the National Student Achievement Assessment Test (ENADE) obtained from public and private universities. In this case, a Stochastic Production Function of Education for the Brazilian Higher Education Institutions (HEIs) is estimated based on information from the 2006 Census (Higher Education Census) and the 2007 ENADE. Using the difference between first-year and last-year students' scores from Enade aggregated by HEI as a product in the Stochastic

[2] The citizens choose to reside in a municipality based on the supply of public goods (Tiebout effect, 1956).

[3] According to a study conducted by the National Institute of Educational Studies AnísioTeixeira (INEP / MEC), Institute of Applied Economic Research (IPEA) and National Fund for Educational Development (ENDF), the ideal amount of spending per student in higher education should be three times the amount spent per pupil in basic education based on similar proportions and ratios observed in developed countries. The study showed that in 2002 Brazil spend 11 times more per student in higher education than basic education. In 2006, this proportion dropped to 6.7 due to increased investments made in basic education and increased enrollment in higher education.

(Accessed July 21, 2009. http://www.inep.gov.br/imprensa/noticias/outras/news08_26.htm).

Production Function, is possible to contribute with a new element in the literature aimed at estimating the production function of education. The results show that characteristics of institutions are the variables that best explain the performance of students, and that public institutions are more inefficient than the private ones.

Finally, the third essay examines the importance of resource allocation in Early Childhood Education (ECE) for best results at other levels of education. According to the literature, the investment in this level of education increases the efficiency of investments in education levels later. In the case of Brazil, it is emphasized that this investment should be made by increasing attendance, and improving the quality of education. To indicate how early childhood education is important for a better future school performance, the effects of early childhood education on literacy scores of children attending the 2nd grade of elementary school were calculated. To do that, the *Provinha Brasil* was administered in a Brazilian municipality (Sertãozinho in State of São Paulo) in conjunction with a socioeconomic questionnaire answered by children's parents. Despite external validity problems, the assessing the effect of ECE in one municipality is advantageous, since it is estimated one kind of treatment. Several studies ignore this fact. Often, the other studies estimate an average effect of various treatment effect and not just one. They use data from different municipalities where the ECE have different levels of quality. The results using OLS and Propensity Score Matching show that students who started school at the ages of 5, 4, and 3 years had literacy scores between 12.22 and 19.54 points higher than the scores of those who began school at the ages of 6 years or later. The results suggest that the returns in terms of literacy scores diminish in relation to the number of years of early childhood education. Tests were also run to validate the matching quality and to improve the reliability of results.

2 Intergenerational conflict and public education expenditure when there is co-residence between the elderly and young (1st Essay)

Although Brazil's population pyramid shows that its citizens are predominantly young, the number of elderly has been growing as a result of higher life expectancy and a lower birth rate.[4] [5] [6] This distribution places Brazil in a peculiar situation regarding the intergenerational issue and has consequences for the budgets of subnational governments, given that the population still has too few years of schooling (median of four years; 2000 census data) and the elderly require more healthcare resources.[7]

As a consequence, an aging population can put pressure on the need for more public expenditure on health and it can change public budget allocations as well, leading to an intergenerational electoral competition for funds.[8] If this competition exists in Brazil, it is still quite mild compared to that found in the United States, considering the differences in the population pyramids of these two nations, as shown in the table below:

The share of young people in the Brazilian population in the year 2000 (last census) is about seven times that of the elderly, while in the United States this ratio was about two and a half. However, population forecasts suggest narrowing of the age distributions in these two countries. In 2050, both nations should have one elderly for every young. Thus, if an aging population has a negative effect on education expenditure (Poterba,1997; Ladd & Murray, 2001), Brazil's situation in the future may be much more worrisome than that of the United States.

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[4] According to the United Nations population forecasts (2005), Brazil ranks among the 10 countries with the largest elderly population in the world.

[5] Berquó & Cavenaghi (2004) discussed the role of women's insertion in the Brazilian job market and the effect of the increase in years of schooling on birth rate reduction.

[6] The declining Brazilian birth rate should be observed more carefully, because it is not uniform for all income groups and consequently it does not reduce the availability of resources intended for the education of youth as one would expect (the birth rate is still high among the poor, as shown by Rios-Neto, 2005 and Berquó & Cavenagui, 2004).

[7] Generally, the elderly have more health problems and lower income than they used to at other moments of their lives (Buttons, 1992).

[8] Button (1992) has pointed out that, although individuals aged over 65 are the minority in Florida, they account for 50% of the individuals who vote in elections. Logan & Spitze (1995) stated that the elderly are a more effective political group when they fight for services that meet their specific needs. Although there is no study on the weight and involvement of the elderly in the Brazilian elections, we believe they are a strong political group that can interfere with the local government budget.

Table 2.1: Percentage of young and elderly in relation to the total population in the United States and Brazil

Aging				
	Under 18		Over 65	
Year	USA	Brazil	USA	Brazil
2000	28.5	40.2	12.4	5.4
2030[a]	26.2	28.6	19.6	12.1
2050[a]	26	24.1	20.7	18.8

Source: Census Bureau and IBGE. Note: [a]: projected

Although the existing literature has come to differing conclusions about intergenerational disputes regarding public education expenditure (Bergstrom, Rubinfeld & Shapiro, 1982; Richman & Stagner, 1986; Ladd & Murray, 1999; Harris, Evans & Schwab, 2000; and Brunner & Balsdon, 2004), we cannot ignore that the intergenerational conflict in the United States is at least exacerbated by a family arrangement in which the elderly live apart from their young. [9]

Considering this possibility, the main objective of this study is to verify how the elderly population affects public education expenditures in different family arrangements. The current study was conducted with 2,054 Brazilian municipalities because the co-residence of the elderly with the young in Brazil (Camarano & Ghaouri, 2002) is higher than in the United States.

However, an investigation into this issue is not easy considering that there is the possibility of endogeneity bias between education expenditure and the elderly's choice of their municipality of residence based on the supply of public goods (Tiebout effect, 1956). To correct this bias, it is necessary to estimate two-stage least squares (2SLS) models using instrumental variables (IV) in order to obtain consistent estimations (see Ladd & Murray, 1999 and Borge & Rattso, 2007). Following this recommendation, we employ three different variables as instruments for the elderly: the share of people aged 55 to 64 in the previous census (10 years before), the share of women aged 55 to 64 in the previous census (10 years before), and the share of women aged over 65 who had more daughters than sons. The first

[9] The share of elderly living with the youth in the United States is quite small in comparison to Latin American and Asian countries (De Vos & Holden , 1988).

instrumental variable was used by Ladd & Murray (1999), while the other ones are introduced in this study.

Our results show that an increase in the share of elderly reduces local public education expenditure, confirming the results found in previous studies (see Button, 1992; Poterba, 1997; Ladd & Murray, 1999; Brunner & Balsdon, 2004 and Borge & Rattso, 2007). Depending on the instrument used to correct the Tiebout effect, the increase of one point in the percentage of elderly in the total population reduces the per young education expenditure between -0.267 and -0.193 points. [10] However, we find evidence that the increase in the share of elderly living with the young also augments local public education expenditures. Depending on the instruments used to correct the Tiebout effect, the increase of one point in the percentage of elderly in the total population living with young people under 18 increases the per young education expenditure between 0.767 and 0.516 points.[11] This second result shows the importance of family arrangements for the definition of public expenditure. Moreover, this contribution was not considered by the existing literature.

This essay is organized into four subsections, in addition to this introduction. Subsection 1 introduces the model used for the estimation and discusses the instrumental variables employed to correct the bias produced by the Tiebout effect. Subsection 2 shows the budgeting process for municipalities, resources for the education area, data sources, and key variables used in the estimations, while subsection 3 presents the empirical estimates. Finally, subsection 5 includes a summary of the main results.

2.1 The model

The specification used in the empirical part of this study follows the work of Poterba (1997), Ladd & Murray (1999), and Harris, Evans & Schwab (2000), who investigated the impact of the aging population on public education expenditure in the United States. We included only the possibility of individuals aged over 65 who co-reside with young

[10] We considered the coefficients of the elderly variable in Table 2.5 (columns 5 and 7). These numbers in terms of elasticity are between -0.012 and -0.017.
[11] These numbers in terms of elasticity are between 0.011 and 0.020.

(under 18) in the specification to verify whether intergenerational conflict is attenuated by a different family arrangement. The main equation is:

$$exp_{it} = \beta_0 + \beta_1 elderly_{it} + \beta_2 elderly\_young_{it} + W_{it}\Theta + c_i + \tau_t + u_{it}, \quad (2.1)$$

where exp_{it} is the logarithm of per young education expenditure (under 18) in municipality *i* in year *t*; $elderly_{it}$ is the share of people aged over 65 in municipality *i* in year *t*; $elderly\_young_{it}$ is the share of people aged over 65 co-residing with young under 18 in municipality *i* in year *t*; W_{it} is a line vector of covariates of municipality *i* in year *t*; Θ is a column vector of parameters; c_i is the fixed effect of municipalities; τ_t is a time dummy to control for the census years (1991 and 2000); and u_{it} is the random term with zero mean and a normal distribution.

Considering that Ladd & Murray (1999) and Borge & Rattso (2007) have shown the possibility of people over 65 choosing their place of residence according to the local supply of public goods (Tiebout effect, 1956), we use instrumental variables that enable us to estimate consistent coefficients for equation (2.1), i.e., those neither correlated with u_{it} nor with errors of the first-stage equations.

2.2 Instrumental variables

If we really had a bias caused by the Tiebout effect (groups of different ages choose their municipality of residence according to the bundle of public goods supplied by the local government), we would have three endogenous variables to correct this effect: the elderly, the elderly co-residing with young and the young (over 18).

Considering that one of the main assumptions of Tiebout's model (1956) is that "restrictions due to employment opportunities are not considered" and it "(…) may be assumed that all persons are living on dividend income" (p. 419), we believe that this

assumption is very strong for all workers in Brazil. However, this assumption is suitable for the elderly population, which, in general, lives on retirement income.

In our understanding, the elderly people choose to live in municipalities where public spending meets their preferences. Moreover, the mobility of the young is linked to their parents' employment opportunities.[12] This implies that only the variables ($elderly$) and ($elderly\_young$) are endogenous in model (2.1).

To avoid the bias of the variables associated with the elderly, we employ three different instrumental variables: the share of people aged 55 to 64 in the previous census (10 years before), the share of women aged 55 to 64 in the previous census (10 years before), and the share of women aged over 65 who had more daughters than sons.

Ladd & Murray (1999) used the share of people aged 55 to 64 from the previous census (10 years before), arguing that this variable is a suitable instrument because it is correlated with the current share of elderly (in *t*), but their preferences for public spending refer back to the previous census (*t-10*). Camarano & Pasinato (2007) pointed out that Brazilian women predominate in the elderly population because they have a higher life expectancy than men. The use of this variable as an instrument of the variables associated with the elderly can help us in the current study because if women live longer than men, they have more chances to co-reside with young. Living longer, they will probably require special care. In this case, we also have a higher probability of these women co-residing with their grandchildren. Thus, the choice of "share of women aged 55 to 64 in the previous census (10 years before)" can represent an interesting instrument. This variable can be used as an instrument both for the share of people aged over 65 as well as for the share of people aged over 65 who co-reside with those under 18. Since this variable is highly correlated with the variable used by Ladd and Murray (1999) - the share of people aged 55 to 64 in the previous census (10 years before) - we should not use these two variables together in the same first-stage equation to avoid collinearity problems. Bongaarts & Zimmer (2002) have shown that it is usual to see more daughters than sons living with elderly parents in Latin American countries. This observation produces our third instrument: the share of women aged over 65 who have more daughters than sons.[13] In this case, the choice of having children took place in the past. Therefore, the choice is not affected by the bundle of public goods offered during

[12] It is reasonable to assume that these parents are economically active and integrate the workforce. Thus, their mobility between municipalities is linked to employment opportunities rather than to higher local expenditure on education.

[13] This variable was restricted to women who had liveborn daughters and sons and whose number of daughters exceeded the number of sons.

period *t*. Moreover, the gender of their children and the ratio of daughters and sons are totally random.

Considering that we have two endogenous variables, we need two instrumental variables, and as the two possible variables ("share of people aged 55 to 64 in the previous census" and "share of women aged 55 to 64 in the previous census") are highly correlated, we decided to use two types of instruments:

$$elderly_{it} = \gamma_0 + \gamma_1 between55\_64_{it-10} + \gamma_2 women\_only\_daughter_{it} + W_{it}\Gamma + \eta_i + \tau_t + \nu_{it} \quad (2.2)$$

and

$$elderly\_young_{it} = \delta_0 + \delta_1 between55_{64\,it-10} + \delta_2 women\_only\_daughter_{it} + W_{it}\Gamma + \eta_i + \tau_t + \varepsilon_{it} \quad (2.3)$$

where $elderly_{it}$ is the share of people aged over 65 in municipality *i* in year *t*; $elderly\_young_{it}$ is the share of people aged over 65 who co-reside with young under 18 in municipality *i* in year *t*; $between55\_64_{it-10}$ can be the share of people aged 55 to 64 or the share of women aged 55 to 64 in municipality *i* in the previous census (10 years before) *t-10*; W_{it} represents a line vector of covariates of each municipality *i* in year *t*; Γ is the column vector of these parameters; η_i is the fixed effect of municipality *i*; τ_t is a time dummy to control for the census years (1991 and 2000); and ν_{it} and ε_{it} are random terms.

2.3 Budgeting process for municipalities, resources for the education area, data sources and key variables

The 1988 New Brazilian Constitution established that municipalities are an independent level of government like states and the federal government. Thus, each municipality has local executive and legislative members elected simultaneously for a four-year term. The local executive is elected based on the majority rule and each member of the legislative is elected by an open-list proportional system (voters can choose their candidates freely). Municipalities with over 200,000 inhabitants elect their executive members in two rounds if a candidate does not receive the majority of the votes in the first round (50% plus one). Legislative members represent the most important interest groups from a municipality (teachers, farmers, owners of private transportation companies, and groups with interest in different areas - public order and health – such as the elderly population, etc) which dispute budget resources. The municipalities have the transfers from state and federal government as their main source of revenue. They are regular (constitutional transfers) and their distribution is defined by law.[14] Basically, the tax revenue is a small share of the total revenue budget representing 6.80% in 1991 and 5.17% in 2000 of total transfers received by the average of municipalities.

In this situation, the local budget (including the education budget) is formulated annually by the executive and submitted to the legislative for approval in year before its execution. In the case of education budget, it must respect a specific federal legislation. The main rule determined by the 1988 Constitution (article 212) imposes that each municipality must spend a minimum of 25% of their revenues on education (tax revenue and transfers from federal and state governments). Besides, these resources are targeted at specific policies: half of this amount must be used to eliminate adult illiteracy and the other half must be used to ensure access to education for the young ("universal policy").

After 8 years (1996), the evaluation of federal government was that the allocated resources did not achieve the targets of universal policy because the realized expenditure did not help improve young people's access to education (the legislation allows for different

[14] The 1988 Constitution established a rule of transfers because the taxes were centralized in the federal government during the authoritarian period. In general terms, the rule of distribution of regular transfers depends on local per capita income and population.

interpretations of what type of expenditure should be used).[15] Thus, although the federal government has maintained the limits of minimum revenue established by the 1988 Constitution, it imposes a set of legal changes to assure that new and existing resources from state and federal governments for educational purposes will be used effectively in the area.[16] As a result of these changes, the Fund for the Maintenance and Development of Elementary Education and Valuation of Teaching - FUNDEF (law 9424)[17] was created, and it was determined that 2/3 of the resources from the National Fund for the Development of Education – FNDE (referred to as education salary) must be distributed directly to municipalities (obeying the same law which created the FUNDEF).[18] [19]

So, considering the legal aspects of the education area, the final budgetary education expenditure is defined by the relationship between the executive and legislative branches. Table 2.2 shows the share of local education expenditure according to the established legislation.

[15] Training of education administrative workers and payment of retired teachers are some cases mentioned as expenditure used for fulfill universalization. See Mendes (2004).

[16] During political negotiation in the Brazilian Congress, it was clear that after eight years a share of the resources sent to comply with the universal policy was committed to expenditures that would not achieve this goal. Thus, the federal government established a new set of rules to guarantee that additional resources and the share of resources already committed to the policy would not be deviated from their purpose. Basically, the set of actions of universal policy was directed towards elementary education.

[17] FUNDEF was created with 15% of resources from federal and state governments (specifically, resources from ICMS, IPI, FPE, and FPM – consumption taxes and funds). As a share of ICMS, FPM, and a share of IPI (resources from IPI are sending for FPM) was already transferred to municipalities, all municipalities had an accounting reduction of these resources because they started to receive the same resources under FUNDEF's name. As the distribution of FUNDEF resources depends on the number of enrollments in each municipality, the final resources received by each municipality (considering the resources from FUNDEF) could be higher, lower than or the same as before. The law established also that if the revenue of FUNDEF divided by the number of enrollments in the state (local and state enrollments) did not achieve a minimum value, the federal government would have to complement this value with its own budget resources until this minimum could be reached. FUNDEF resources represented 34.5% of education expenditure in 2000 for the average of municipalities. Moreover, the resources from FUNDEF were directed towards elementary education and it was established that 60% of the resources received through this fund must be spent on teachers' wages while the remaining share must be spent in the education area.

[18] The education salary consists of resources from FNDE. The resources from FNDE are collected from the total payroll paid by firms (2.5%). Initially, the distribution of FNDE resources depended on individual projects approved by the government's education area. After the legislation changed (1996), 2/3 of the resources were sent directly to municipalities for expenditures with school transportation, food, and teaching material. The remaining 1/3 was maintained by FNDE and could be requested through individual projects. The education salary represented 3.08% of education expenditure in 2000 for the average of municipalities.

[19] Following the Accounting Plan published by the National Treasury (2000), municipalities consider the FUNDEF, education salary, and FNDE resources as transfers.

Table 2. 2: Local Education Expenditure on Tax Revenue + Total Transfers

Years	Observations	Percentage
1991	2882	0.36
2000	3721	0.36

Source: FINBRA (IPEADATA)

The first column shows the years used in our sample (1991 and 2000). The second column presents the number of observations used.[20] The third column shows the average education expenditure on tax revenue plus total transfers received by municipalities. It is possible to ascertain that the average of municipalities spend more than the minimum established by the Constitution (25%): 36% for both years. The difference between the values established by law and the real ones makes it clear that the education area disputes local resources with other areas (transfers received and not related directly by law to education expenditure and tax revenue). Furthermore, it is important to observe that there are situations in which not even the minimum level of expenditure is obeyed: 11% of the municipalities in 1991 (325) are below the minimum level established by law. In 2000, this number fell to 7% (261 municipalities). [21]

With specific regard to the primary databases, we used the demographic census conducted by the Brazilian Institute of Geography and Statistics (IBGE). In addition to the years of 1991 and 2000, we also employed data from the 1980 census to build the instrumental variables. Information relative to local public education expenditures for 1991 and 2000 was provided by the Brazil Finances (FINBRA), a database of the Brazilian National Treasury Department (STN).[22] Fiscal variables were deflated using the IGP-DI index.[23] However, it is necessary to describe the limitations imposed by the available data on longitudinal studies. It is especially important to point out that, from 1970 to 2000, the number of Brazilian municipalities grew considerably (1,556 new municipalities). Thus, to prevent an inconsistent intertemporal analysis, we use aggregated information according to

[20] The number of observations used here is higher than that used in the econometric exercise. Our exercise has 2,054 observations in 1991 and 3,656 in 2000.

[21] The city of São Paulo in 1996 did not use the minimum resources established by law. The judicial power accepted that this difference will be incorporated in the subsequent years. It is likely that other municipalities will follow in the same path (see municipal law 12.340/1997 in São Paulo).

[22] In the FINBRA database, public education expenditures for 1991 and 2000 are aggregated with cultural expenditures. However, looking at the same database after 2002, we see that cultural expenditures represent a small share of this total and should not greatly influence our analysis.

[23] This index was provided by Getúlio Vargas Foundation and stands for General Price Index on Internal Availability.

minimum comparable areas (MCA).[24] In addition, we considered only MCAs about which all municipalities had information, for a total of 2,054 MCAs in a universe of 3,659 MCAs existing from 1970 to 2000 (56.13 percent of the total). Whenever we refer to municipalities in this study, we are in fact referring to MCAs, which is the same thing in most cases, because municipalities that did not secede between 1970 and 2000 represent a single MCA.

The public education expenditure measure used in our estimations is per young expenditure considering individuals up to 18 years old. This age bracket is suitable for our study for two reasons. First, no data are available for different education levels. The second reason is less evident, though. Since education outlays in Brazilian municipalities focus on elementary schools, we should consider a fitting age bracket: 0 to 14 years. However, what we see in Brazil, especially during the period in question, is a considerably high rate of grade repetition.[25] Thus, by considering the young aged up to 18, we minimize the overestimation of expenditures in municipalities where the share of grade repeaters is higher.

Looking at the descriptive statistics in Table 2.3, we observe that per young expenditure increased more than 400 percent between 1991 and 2000.

As the share of young aged under 18 in relation to the total population decreased by nearly six percentage points, this result is conditioned by institutional changes that occurred in 1996, as described previously (especially regarding transfers: FUNDEF and education salary). Per pupil expenditure is also very important in our study.[26] Table 2.3 shows that this figure rose by 63.2 percent during the period in question. This increase is modest compared to per young expenditure, but it captures the actual change. The change in per pupil expenditure captures the changes in transfers received by municipalities and the overall increase in enrollment in local schools. However, per pupil expenditure should be viewed with caution in an econometric test in which this figure appears as a dependent variable. Poterba (1997) has pointed out that per pupil public expenditure could affect decisions on whether a student should attend public or private schools, and an econometric model that uses

[24] Minimum comparable areas (MCA) consist of geographical areas built by the Brazilian Institute of Geography and Statistics (IBGE) that are not subject to the division and aggregation of municipalities. The municipality definition of MCA is the same and is constant over time.

[25] The mean expected age for concluding elementary school (eight initial years of official study) was 16 years in 2000, while the ideal age would be 14. In several northern and northeastern Brazilian states, the mean age is even higher. Consequently, the use of the 0-18 age bracket seems quite reasonable in the case of Brazil.

[26] Data on student enrollment in local schools for 1991 and 2000 were provided by the Anísio Teixeira National Institute of Educational Studies and Research (INEP).

this as a dependent variable could have endogeneity.[27] Therefore, our estimations are based on a model whose dependent variable is per young expenditure, which does not lead to this problem.

Table 2. 3 – Averages and standard errors from aggregate variables by municipality

Variables/Year	1991	2000
Per young local education expenditure (under 18) (2000 R$)	89.64 (72.24)	460.87 (733.72)
Per pupil local education expenditure (2000 R$)	1440.4 (6995.66)	2350.49 (6609.67)
Elderly over 65 (share of population)	5.7 (1.50)	6.99 (1.74)
Elderly over 65 who co-reside with young under 18 (share of population)	2.27 (0.82)	2.4 (0.85)
Young under 18 (share of population)	45.58 (6.04)	39.93 (5.70)
Per capita income (2000 R$)	91.02 (60.92)	164.36 (101.40)
Non-white (share of population)	53.67 (26.26)	50.30 (22.66)
Urban population (share of population)	57.13 (22.71)	62.83 (22.27)
Individual who migrated less than 5 years ago (share of population)	11.99 (6.94)	11.6 (5.48)
Elderly who migrated less than 5 years ago (share of population)	0.36 (0.31)	0.45 (0.33)
Young black (share of black population) - Elderly black (share of black population)	0.042 (0.074)	0.044 (0.071)
Demographic density (number of inhabitants per square kilometer)	139.10 (702.27)	164.90 (811.28)
Population (number of inhabitants)	3941 (266108)	4496 (290823)
Elderly women over 65 (share of population)	2.94 (0.85)	3.66 (0.99)
Population between 55 and 64 years in previous census (share of population)	4.95 (1.04)	5.67 (1.31)
Population of women between 55 and 64 years in previous census (share of population)	2.40 (0.58)	2.91 (0.72)
Elderly women with more daughters than sons (share of population)	0.380 (0.103)	0.440 (0.114)

Source: The 1991 and 2000 Population Census (IBGE), and the 1991 and 2000 FINBRA (National Treasury). Standard errors are in parentheses.

[27] Appendix 1 shows the econometric results using per pupil expenditure as the dependent variable (Table A2). These results are not the focus of analysis in this study, because they could present endogeneity. However, they are interesting because of the information they provide if the endogeneity potential is null. We could justify that endogeneity is non-existing, because most of the municipalities in Brazil do not even have a private school, and therefore their citizens are not faced with the decision of whether to attend a public or private school. However, for the sake of precaution, the results of Table A2 in the Appendix 1 should be considered with caution.

It is somewhat difficult to build a variable which represents the proximity between the young and the elderly (Poterba, 1998). Brunner & Balsdon (2004) used the standard variables employed in population aging and education spending studies, and also employed a "voter having children in a public school" variable. Another way to build a proximity variable between the young and the elderly would be co-residence between these two groups. This variable is normally employed in studies that analyze new trends in family arrangements. According to De Vos & Holden (1988), when individuals co-reside they have a higher chance of sharing their incomes. However, this co-residence variable does have its limitations. It would probably not yield significant results in the United States because the share of elderly living with their children is quite small in comparison to Latin American and Asian countries (De Vos, op. cit). On the other hand, it is common to find family arrangements in which the elderly and the young co-reside in Brazil (Camarano & Ghaouri, 2002).[28]

We employ the following control variables that are expressed as a share of the total population: "young aged less than 18", "non-white", "individuals living in urban areas", "individuals who migrated less than five years ago", and "elderly who migrated less than five years ago". Another variable employed is the "difference in the young black to elderly black ratio", which shows the difference in the ratio of each group to the total number of individuals in a given age bracket and tries to capture any reductions in the intergenerational competition according to race. The other variables (in logarithm) considered are "per capita income", "population", and "demographic density."[29]

2.4 Empirical estimates

As discussed above, Equation (2.1) cannot be estimated directly without dealing with the endogeneity observed in the key variables of our investigation. According to the specifications of Equations (2.2) and (2.3), we estimated the first stage using pooled ordinary

[28] These social, economic, and demographic differences between countries are of crucial importance in developing applied research to a specific nation. Therefore, we must consider the possibility that something valid in one country might not be valid in another with distinct characteristics.

[29] Considering that the most important fund transfers (FPM) to the municipalities were set in Brazil's 1988 Constitution (a rule based on the municipality's population and the inverse of its per capita income), including this resource (transfers) would determine collinearity with per capita income and the population already used as controls.

least squares (POLS) and fixed effects (FE) to verify the robustness of the results. Table 2.4 shows the results of the first stage considering two groups of instruments, since we cannot use the instruments together.

I. The share of people aged 55 to 64 in the previous census (10 years before) and the share of women aged over 65 who have more daughters than sons.
II. The share of women aged 55 to 64 in the previous census (10 years before) and the share of women aged over 65 who have more daughters than sons (same instrument used in Group I).

The results for Group I presented in Table 2.4 show that the "share of individuals aged 55 to 64 in the previous census (10 years before)" explains the "share of individuals aged over 65". The signs were also as expected. The "share of women aged over 65 who have more daughters than sons" also showed significant and positive coefficients in the estimations using POLS and FE.[30]

In this same group, the results show that the "share of individuals aged 55 to 64 in the previous census (10 years before)" does not present any significance at any level in explaining the "share of individuals aged over 65 who co-reside with young under 18". Only the "share of women aged over 65 who have more daughters than sons" is significant in explaining this variable, with a result quite similar to that of Bongaarts & Zimmer (2002): the greater the share of women aged over 65 who have more daughters than sons, the greater the share of individuals aged over 65 who co-reside with young under 18.

The results for Group II are similar, with the exception of the (negative) result for the "share of women aged 55 to 64 in the previous census (10 years before)". If this share increases, we can expect a decrease in the percentage of elderly who co-reside with young.

[30] The results of the first stage with all control variables can be obtained from the authors upon request.

Table 2. 4: First-Stage Regression (IV)

	Endogenous Variables	Instrumental Variables (IV)	POLS	FE
First-Stage Regression (IV-Group I)	$elderly_{it}$	People between 55 and 64 years in previous census (10 years before)	0.188***	0.279***
			(0.012)	(0.021)
		Women with more daughters than sons	1.212***	0.340***
			(0.131)	(0.014)
		Control Variables	*Yes*	*Yes*
		Observations	4106	4104
		R^2	0.92	0.89
		F-statistic	3197.53***	1002.38***
	$elderly\_young_{it}$	People between 55 and 64 years in previous census (10 years before)	-0.017	0.022
			(0.012)	(0.014)
		Women with more daughters than sons	0.466***	0.142***
			(0.014)	(0.012)
		Control Variables	*Yes*	*Yes*
		Observations	4106	4104
		R^2	0.62	0.21
		F-statistic	575.10***	29.47***
First-Stage Regression (IV-Group II)	$elderly_{it}$	Women between 55 and 64 years in previous census (10 years before)	0.358***	0.251***
			(0.020)	(0.024)
		Women with more daughters than sons	1.207***	0.954***
			(0.012)	(0.023)
		Control Variables	*Yes*	*Yes*
		Observations	4106	4104
		R^2	0.92	0.89
		F-statistic	3391.40***	1012.48***
	$elderly\_young_{it}$	Women between 55 and 64 years in previous census (10 years before)	-0.003	-0.041*
			(0.021)	(0.024)
		Women with more daughters than sons	0.457***	0.301***
			(0.014)	(0.023)
		Control Variables	*Yes*	*Yes*
		Observations	4106	4104
		R^2	0.62	0.21
		F-statistic	574.59***	29.75***

Note: Robust standard deviations in parentheses. * Significance at 10%; ** Significance at 5%; *** Significance at 1%.

Table 2.5 shows the results of the second stage, seeking to answer whether there are elements that support the notion that a different family arrangement (co-residence of the elderly with the young) determines different public spending on education.

The estimations based on the first stages shown in Table 2.4 correspond to the term IV highlighted in different columns of Table 2.5. To compare the results, we initially

presented (FE - Poterba column) the same specification employed by Poterba (1997), using more disaggregated data.[31] Our results were similar to those found by that author. The coefficient equal to -0.056 [32] shows that an increase in the share of individuals aged over 65 (elderly) reduces public education expenditure. This result confirms the result shown in the literature: an aging population reduces per young public spending.

The results of the specifications in Table 2.5 help confirm the results of family arrangement by co-residence. As we can see, the estimation using POLS (second column), not using instruments, also has a negative coefficient (equal to –0.045), significant at the 1 percent level for the $elderly_{it}$ variable. This result shows that an increase in the share of elderly reduces per young public spending. However, these estimations are inconsistent because they fail to consider the endogeneity resulting from the fixed effect correlated with the covariates and the possibility of the Tiebout bias. On the other hand, the $elderly\_young_{it}$ variable has a non-significant coefficient.

The estimation with fixed effects without the use of instruments (third column) presented significant coefficients at the 1 percent level, with greater magnitude and the expected signs. The fixed effect estimator is consistent, even when endogeneity is not considered and the covariates are not correlated. Therefore, when correcting endogeneity, which we can understand as being caused by omitted variables, we obtained more significant coefficients. The coefficients equal to –0.071 and 0.067, respectively, for the $elderly_{it}$ and $elderly\_young_{it}$ variables also support the notion that an increase in the ratio of elderly reduces expenditures with the young, but an increase in the frequency of co-residence between the elderly and the young leads to higher expenditures.

Instrumentalizing the endogenous variables with the "share of people aged 55 to 64 in the previous census (10 years before)" ($between55_{64\,it-10}$) and the "share of women aged over 65 who have more daughters than sons" ($women\_only\_daughter_{it}$), we hope to correct the Tiebout bias. The POLS-IV estimations shown in the fourth column of Table 2.5 do not consider the unobserved heterogeneity, but present a significant leap in magnitude. The coefficient of the $elderly_{it}$ variable, equal to -0.194, shows that the negative impact of the ratio of elderly on per young public education expenditure is even more intense. Similarly, the

[31] Poterba (1997) did not employ instruments to deal with endogeneity and worked with data from the United States. The fact that Poterba (op. cit) worked with data from states and not from municipalities partially justifies the fact that that author did not consider the issue of the Tiebout bias, which is more intense in smaller locations.
[32] The explanatory variables in terms of proportion are not in logarithmic form because this would imply loss of information if the variables assume a value equal to zero

$elderly\_young_{it}$ coefficient, equal to 0.427, also suggests a greater effect. Additionally, the tests for underidentification of instruments and weak identification validate our instruments at the strictest level.

Table 2.5: Per young expenditure estimations considering as instrument (IV) two variables: population aged between 55 and 64 years in previous census and the difference between daughters and sons

Dependent Variable	**Per young local education expenditure**						
Exogenous Variables	**FE –Poterba**	**POLS**	**FE**	**POLS-IV (Group I)**	**FE-IV (Group I)**	**POLS-IV (Group II)**	**FE-IV (Group II)**
	[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**
$elderly_{it}$	-0.056***	-0.045***	-0.071***	-0.194***	-0.267***	-0.238***	-0.193***
	(0.010)	(0.007)	(0.0103)	(0.048)	(0.083)	(0.057)	(0.058)
$elderly\_young_{it}$		-0.006	0.067***	0.427***	0.767***	0.553***	0.516***
		(0.014)	(00172)	(0.1385)	(0.289)	(0.167)	(0.19)
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	4106	4106	4106	4106	4104	4106	4104
R^2	0.92	0.82	0.92	0.78	0.74	0.75	0.80
Weak identification test (Kleibergen-Paap rk LM statistic):	..	..	..	18.40[a]	5.81[b]	16.28[a]	10.41[a]
IV-Underidentification Test (Kleibergen-Paap rk Wald F statistic):	..	..	..	37.67[c]	11.88[c]	32.62[c]	20.40[c]

a- Instruments are not weak at a more rigorous level (*10% maximal IV size*).
b- Instruments are not weak at a less rigorous level (*15% maximal IV size*).
c- Instruments are not overidentified at 1% level of significance.
Note**:** Robust standard deviations in parentheses. * Significance at 10%; ** Significance at 5%; *** Significance at 1%.

The estimations with the same instruments (Group I) using fixed effects (FE-IV) also presented the expected coefficients. The magnitude of these coefficients was even greater than in the method of instrumental variables using pooling data (POLS-IV, Group 1). The coefficient of the share of people aged over 65 ($elderly_{it}$) leaps to –0.267 and that of people aged over 65 who co-reside with the young under 18 ($elderly\_young_{it}$) to 0.767. The instrument tests show that no under - or weak identification problem exists and, therefore, the instruments are qualified to identify the equation. This method is the most suitable to test the hypothesis of this paper, because the coefficients of (1) are consistently estimated, enabling a random correlation between the fixed effect and the covariates, and also the endogeneity caused by the Tiebout effect.

Last, the estimations using as instruments the "share of women aged 55 to 64 in the previous census (10 years before)" ($\text{between55\_64}_{\text{it-10}}$), and the "share of women aged over 65 who have more daughters than sons" ($\text{women\_only\_daughter}_{\text{it}}$), which comprise Group II, were all significant and featured the expected signs. In the sixth column, we see that the coefficients estimated for POLS show that an increase in the share of elderly reduces per young public education expenditure, while the ratio of elderly co-residing with the young increases this expenditure.

The estimations using these same instruments, but considering the panel characteristic (FE-IV, Group II) in the last column of Table 2.5, also show that the coefficients were significant and matched our expectations. The $elderly_{it}$ variable presented a coefficient equal to –0.193, while the $elderly\_young_{it}$ variable presented a coefficient of 0.516. Moreover, the under - weak identification tests corroborated the validity of our instruments. Of all specifications presented in this study, the fixed effects with instrumental variables model (estimated in 2SLS) are the most suitable ones in the presence of the Tiebout bias and unobserved heterogeneity correlated with the covariates. Therefore, we should trust the results obtained by FE-IV (Group I) in the fifth column of Table 2.5, and by FE-IV (Group II) in the last column.

The results of Table 2.5 confirm that, to the extent that we employ consistent methods in the presence of endogeneity resulting from the correlation between fixed effects and the covariates, and use instruments for the endogenous variables given by the Tiebout effect, the coefficients become more significant and have a greater magnitude, further supporting our investigation. Finally, we dare say that our study was successful because the results of our estimations were validated by co-residence: co-residence between the young and the elderly results in higher demand for public education expenditure. Table A.2 of Appendix 1 shows the results of the estimations using "per pupil expenditure" as the dependent variable. Generally, the results also validate our main idea, but as we mentioned above, these results should be interpreted with some caution.

The full estimations of equation 2.1, including the control variables, are shown in Table A.1 of Appendix 1. We see that the results are in line with those obtained in the studies cited in this work. Two variables are especially noteworthy because they recurrently appear in the literature: the "ratio of young" and the "difference between the ratio of young black and the ratio of elderly black." Indeed, Poterba (1997) has highlighted this last variable. The

purpose of this variable to him is to check the presence of altruism among the elderly in relation to the young of the same origin (race) regarding public education expenditure. The author captures the effects that support the existence of altruism when young black and elderly black are in similar ratios within their age bracket. However, we found no evidence of this (Table A1 of Appendix 1). Regarding the ratio of young up to 18, we found that this ratio reduces per young expenditure. This result corroborates those of Poterba (op. cit), who argued that this effect is attributable to the size of the cohort phenomenon. Another argument in favor of this result is the fact that, among the young, it is more common to find those with a weaker socioeconomic situation and less political power. This means that their interests are underrepresented, which in part explains the fact that the higher the ratio of young in the municipality, the lower the expenditure (Poterba, 1998 and Preston, 1984). In regard to the other covariates presenting significant results, we see that an increase in the share of non-whites reduces per young expenditure. We also see this in relation to the increase in the population share. Finally, the ratio of individuals who have lived less than five years in their municipality has a positive effect on per young expenditure.

2.5 Final Remarks

This paper has shown how a group of elderly can choose not to reduce public spending on education provided that they co-reside with the young. This element is an innovation we have attempted to introduce in the literature dealing with the relation between the elderly and public education expenditure. Poterba (1997) and others have only shown that an increase in the share of elderly persons reduces per young public education expenditure.

In relation to the United States, for instance, these results may not be very significant because the share of elderly living with their children is much lower than in Latin American countries. On the other hand, in Brazil, it is common to find family arrangements where the elderly and young co-reside (Camarano & Ghaouri, 2002). Moreover, the social arrangement conditions the results.

It is important to point out that the economic situation in these countries could condition the existing family arrangement, regardless of the existing demographic structure.

Although the current study investigates this behavior over a period of two decades, future and systematic studies should investigate this type of result. At any rate, family arrangements should be more stable than demographic changes, which is a point that could be investigated in future studies.

3 Production Efficiency in Education: Evidence from the Brazilian Universities (2nd Essay)

The objective of this essay is to assess the determinants of performance from institutions of higher education in Brazil, taking particularly into account the relative efficiency of public and private institutions on the application of its resources. There has been a remarkable increase in the demand for Higher Education in Brazil in the past two decades. This reflects the response of the labor market demand for better qualified professionals, and also the requirement that candidates for public office must have Higher Education to sit for competition exams. In addition, in this same period, the percentage of individuals who finished High School education has increased, which eventually boosted the demand for Higher Education. [33] Moreover, the Federal Government influenced the supply of vacancies in two ways. The first concerns the Federal Government's policy for the sector, which was apparently based on the supply of a larger number of vacancies through expansion of private organizations (PINTO, 2004). The second one is related to the "University Education for All" (ProUni), a program devised by the Brazilian Ministry of Education in 2004. This program grants low-income students from private Higher Education Institutions (HEI) full-tuition or half-tuition scholarships. [34]

According to data of the 1987 and the 2007 Higher Education Census, the number of students enrolled in HEI more than tripled (a 231.9% increase). However, one should underscore that enrollments in private HEI were virtually three times greater than those in public institutions during the same period, increasing their share in the overall enrollment rate from 60.2 to 74.6% between 1987 and 2007. Regarding to the total HEI, the change observed in this period was 167.41%. Additionally, the number of public HEI rose only 3.75% between 1987 and 2007, compared to 231.48% in private HEI.

The empirical literature estimates production functions of K-12 and Higher Education developed independently from literature concerning the efficiency in the education provision. The methodology of Ordinary Least Squares (or any variant) was commonly used

[33] The comparison of the Brazilian National Household Survey (PNAD) data for 1987 and 2007 shows that 4.66% of the Brazilian population aged 18 to 25 years attended Higher Education in 1987. In 2007, however, this rate amounted to 12.60%. Regarding high school education, according to PNAD data for 1987, 14.81% of Brazilian individuals had completed High School education by the age of 19. In 2007, this rate rose to 42.95%.

[34] Charnes and Cooper (2002) analyze different aspects regarding knowledge production by U.S. HEI, and one of their goals is to check the relative efficiency of public and private universities in the conferral of doctoral degrees.

to delineate a function through a series of points, and the waste did not receive special treatment. The concern was how the production structure parameters and not with individual deviations of estimated function. This shows that the average was considered more important than the best practice.

The availability of scores in standardized tests (ENADE – National Examination of Performance Evaluation of Student) for brazilian universities that provide a measure of output widely accepted and the possibility of direct estimation of education production function. Even qualitative indicators as occupation and remuneration in the long term could obtain better contribution of education for human capital, an intermediary result as the score in a standardized examination can be seen as basic elements in the accumulation of human capital[35].

Thus, in this article estimates a production of stochastic function of education, in each university is confronted with its own production frontier, being this randomly frontier dependent of the full set from stochastic elements that are important but are out of universities control.

The empirical literature available on efficiency of higher education use largely DEA (date envelopment analysis) structure, being applied usually to the estimation of functions cost for universities in an individual country in which the dependent variable generally captures the number of students registered or its level (master, doctorate, receives financing, etc.). [36] Some recent references are Avkiran (2001) and Abbott and Doucouliagos (2003) for Australia, Salerno (2002) and Calhoun (2003) for the United States, Afonso and Santos (2004) for Portugal, Warning (2004) for Germany, Johnes (2005) for England, Jongbloed and Salerno (2003) and Chercye and Abeele (2005) for Holland and Castano and Cabanda (2007) for Philippines. Joumady and Ris (2004) represent an exception for working with a number of countries (Austria, Finland, France, Germany, Italy, Holland, Spain and the United Kingdom) .[37] They also innovate to use as a measure of the output the competence

[35] Sutherland, Price, Jourmad e Nicq (2007) follow to some extent the same direction, using as an intermediary result, the scores of PISA in four academic disciplines, to evaluate the provision efficiency of basic education in OECD countries.

[36] Johnes, Oskrochi e Crouchley (2002) are an exception since using the Stochastic Frontier method to estimate a function cost to the higher education institutions of the United Kingdom.

[37] Agastini (2008) also investigates several countries (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Great Britain, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Slovakia, Spain, Sweden, and Switzerland), and three outputs in order to calculate the frontier: rate of undergraduate students; rate of employability and of undergraduate students from abroad.

gained during the graduation and competence required by current work, both obtained from a survey done with students from college[38].

Ferrari and Laureti (2004) and Laureti (2008) estimate an output function of higher education in which the student is considered as the basic unit of production, using respectively a model of homocedastic (no explanation for the error terms) and heteroscedastic (some of the error terms are explained through other variables) Stochastic Frontier. As such work assesses a single university, average score in the exam gives the measure of output. However, as known the examinations made for the application in the classroom by professors are not standardized tests. A standardized test is a test, which is administered, which is corrected (given a score) and interpreted in a standardized way. The objective of standardization is to ensure that the test conditions are approximately the same for all individuals who are being submitted to the test. If this happens any student who was examined will have an advantage over others that can be attributed to the variance the administration procedures and so the results of evaluations shall be comparable. Therefore, considers that the ENADE consists of a better output measure because it consists of a standardized test.

This essay is organized in the following way. The first subsection discusses the output measure. As it is not aware of the standardized exams existence for higher education in other countries, presents carefully the evaluation system of brazilian universities since its implementation until today. The second subsection discusses briefly the inputs used. The third subsection presents the obtained results. The last subsection summarizes the main conclusions.

[38] Asked for undergraduate students to indicate a scale of 1 (not at all) up to 5 (to a very high extent), to what extent they had acquired competence during the graduation and to what extent this competence was required at work that they were at that time.

3.1 Measuring The Performance of Higher Education Institutions: Output Definitions

Once higher education institutions produce a series of outputs, is not easy to measure the universities result. As illustrated by Salerno (2008) let's suppose two institutions that attend the same number of students. However, one provides an excellent education while the other offers a reasonable education. If it was used to output measure the number of registered students, the institution with the largest number of students per professor would probably be considered more efficient, which does not imply that this is in true fact.

Although researchers suggest that an ideal output measure of education must be accompanied by an institutional "weight quality" to the number of students that it educates (NELSON and HEVERT, 1992), the difficulties of measurement make the task virtually impossible. Therefore, are adopted proxies in which the education output is almost exclusively measured by registrations or number of awarded diplomas, even though the limitations of the non consideration of quality are explicitly recognized.[39]

Large-scale evaluations of Higher Education in Brazil have considerably improved in the past few years. To our knowledge, no other country uses an evaluation that is applied to students both at the beginning and at the end of their Higher Education courses. This allowed us to measure a product that takes into account the effort put into education of students and therefore may be more appropriate in an efficiency evaluation.

In 1995 started the assessment procedure of higher education in Brazil with the law 9.131, which established the National Examination of Courses (ENC), which should be applied to all graduating students in certain areas of knowledge previously chosen, and it was subsequently known as "Provão".

The "Provão" consisted of a written examination applied annually and throughout national territory,. The participation of students was compulsory, and students who did not make the exam would be prevented from obtaining the diploma of graduate courses. The Ordinance 2.026/96 lays down as additional measures for the assessment of higher education: i) the analysis of general indicators performance, by state and by region, in accordance with the area of knowledge and the type of education institution, based on the data of Higher

[39] For studies that use input variables related to Research see Table A.3 in Appendix 2.

Education Census[40]; ii) the institutional assessment, based on information in the Census but also in its report from experts which would tour the academic institutions in a search of information to assess the administration, education, social integration and the technological, cultural and scientific products. The Ordinance maintained Coordination of Improvement of Higher Education (CAPES) as the responsible to assessment of post-graduation, as occurred since 1976.

In 2001, the Ordinance 3.860 established officially the aspect high stakes of evaluations ("significant consequences for who is being evaluated"), that should be used to guide decisions concerning the re-accreditation of the institutions and the recognition and renew and recognition of courses.[41]

The courses were classified as on the basis of "Provão" scores, that is, was compared the average performance of their students with the average performance of students of other courses in the same area of knowledge. As it was not determined a minimum score that indicate considered appropriate proficiency in the course, the results have not being used directly as a measure of teaching quality. It was indicated only if, on average, a course had more or less prepared students than others in the same area of knowledge. Adding the aspect of criterion, the fact that the tests are not equivalent didn't enable that were compared the results of different areas and not the same area over time. To complicate, as the test was applied only to graduating student, "Provão" was not able to identify the programs that in fact contributed to increase the level of students' knowledge. Thus, the institutions with entry procedures more rigorous, in general, were those with the best performance in "Provão". The highlights were public universities that tend to attract the best students by the fact of having excellent academic reputation, besides being free of charge, even if there is a belief that the quality of these institutions has fallen in the recent past by the combination of budget problems and successive strikes[42].

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[40] It were identified the following indicators identified by the Ordinance 2.026/96: Gross and net rates of registration, availability of posts for new students, rate of evasion and approval, average time of course conclusion, levels of docent qualification, reason student/professor, average size of classes, cost per student, percentage of costs for higher education in the total of public spending on education and percentage of GDP spent on higher education.

[41] In fact, only in extremely bad cases institutions have lost the accreditation. The Ministry of Education came to intervene in some private institutions, but attempts to close courses and institutions with performance very inexpressive were not carried forward through appeals to the judiciary, to the National Council of Education or by means of political pressure. The Ministry of Education was never to intervene in any public institution. The process of periodical re-accreditation also did not apply.

[42] Other criticisms to "Provão" were the use by some institutions of the "Provão" results for marketing; the possible imposition of an unified curriculum, as a single exam and common to all courses of the country, with

Despite the growth of "Provão" (from 3 areas tested in 1995 rose to 26 in 2003[43]) and from breaking resistance to assessment of higher education when its implementation, during the 2002 presidential campaign were discussed various aspects of the exam. Immediately after the take office of the President Luiz Inacio Lula da Silva, was formed a Special Commission for the Evaluation of Higher Education (CEA) which had as objective suggest changes in the system of assessment for Higher Education centered in "Provão". In August 2003, the Commission suggested a new system, which was formally established by Federal Law N°10.861 approved in April 2004. The National Evaluation System of Higher Education (SINAES) included a new approach for the examination of courses of Higher Education, called ENADE.

The ENADE upheld the approach of "Provão" as regards to test the courses individually and not the areas[44]. However, was to assess both the freshmen students as the graduating students with the goal of capturing the contribution of the course to learning, including the results in an approximation of the aggregate value concept. This was subsequently called Performance Difference Indicator (IDD). The IDD, theoretically, would allow that two comparisons were made. The first would be a comparison in the same year between the averages obtained by graduating students and the averages obtained by freshmen students. The problem is that the profile of students from a course or institution may have been amended over the course, as well as may occur a selection by means of approval/failing of the students that tends to impact positively the IDD.

The second would be the comparison between the results of freshmen students in the first year of the 3 years of evaluation cycle with those graduating students in the third year of this same cycle. In this case, could be adopted procedures that resulted in good

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possible negative results on efforts to diversify the higher education in a large country and geographically and demographically heterogeneous; the emphasis on content and at the expense of specific competencies and abilities; the high cost of implementation. In the text will be seconded only the aspects related to suitability as measure of performance (quality) of education as we need a measure to assess the result of higher education.

[43] In 1995 were evaluated the students of Law, Medicine and Civil Engineering. In 2003 were evaluated the courses of Accountancy, Administration, Agronomy, Architecture, Biology, Chemistry, Dentistry, Economy, Civil Engineering, Electrical Engineering, Mechanical Engineering, Chemical Engineering, Geography, History, Journalism,, Law, Letters, Mathematics, Medicine, Nursing, Pedagogy, Pharmacy, Logopaedics, Physics, Psychology and Veterinary Medicine.

[44] When the Lula government took office in 2003, despite the prospect of "Provão" extinguishment, the CEA chose to maintain an assessment through test. The proposal was called "Paidéia" (Process of integrated assessment of Educational Development and Area Innovation) and consisted of a test program for a sample of courses with a view to capture the trends of performance by area of knowledge. Several members of Congress, however, have supported the "Provão" and rejected "Paidéia". The argument is that Paidéia was contrary to what the population was accustomed in terms of Higher Education evaluation and had a demand for this type of information despite of initials resistance.

performance indicators. It could, for example, encourage freshmen students to show a poor performance, increase the rigor of the evaluations during the course in order to retain the students with worse performance and undergo only the students who were not compromise the results of the institution in ENADE. If the same students were evaluated in the first and last year these problems would obviously be solved. Outside the difficulties associated with obtaining a panel of this type, other problems could appear as the provision of benefits for the bad performance were improved.

Differentiate also the "Provão" and the ENADE, the proposal of ENADE to establish minimum standards in the different areas of knowledge, the dissipation of the character high stakes of "Provão" since the ENADE takes into account other indicators and only from the consideration that all of them may be taken any regulatory decision and focusing in general training in addition to the specific content. Finally, the ENADE incorporated the sampling procedure. A criticism that has been commonly submitted to sample approach was that it could encourage distortions since the institutions could list only candidates more prepared for the exam. The score at ENADE is part of the student historical school grade.

The test is composed by 40 questions in total, being 10 general issues (25% of the score) and 30 related to specific training of the area (75% of the score), containing in the two parts discursive and multiple choice issues. Are eligible to make the test students considered graduating (last year) and freshmen (first year) being selected by drawing lots only one sample. Once selected the student, this must appear to the exam otherwise will have problems when taking the diploma having to present supporting at the Ministry of Education.

Table 3.1 below shows the score average of Enade 2007 general and specific test, for freshmen and graduating students, for the institutions of public and private Higher Education, by region of the country.

Notes that the scores of freshmen and graduating students are higher in the public education than in private education, regardless the region of the country. Thus, the better prepared students are accepted in the public education of Higher Education (freshmen with highest scores) and leave its institutions best prepared (highest graduating scores).

Whereas the aggregate value of knowledge, measured by the difference between the scores of graduating students and freshmen students, notes that as expected the courses

aggregate to students more precise knowledge of that general knowledge. To Enade 2007, there is an improvement, on average of 11% in the general score and 50% in specific score.

Table 3. 1– Average score in Enade 2007 for Freshman students and for Graduating student of Public and Private Education

		General		***Public***		***Private***	
		Freshman	Graduating	Freshman	Graduating	Freshman	Graduating
Brazil	General Studying	44,67 (21,96)	49,59 (21,78)	47,41 (24,21)	54,61 (25,14)	42,53 (20,32)	46,48 (18,96)
	Specific Studying	31,35 (16,29)	47,21 (20,11)	32,61 (17,26)	50,94 (22,72)	30,17 (15,68)	44,70 (18,13)
	General and Specific Studying	34,69 (16,12)	47,81 (19,26)	36,33 (17,45)	51,87 (22,25)	33,27 (15,18)	45,16 (16,88)
North	General Studying	42,06 (19,25)	50,68 (22,71)	42,07 (19,26)	51,90 (23,55)	40,20 (19,00)	44,73 (18,56)
	Specific Studying	31,12 (14,08)	44,94 (20,46)	31,19 (14,06)	45,13 (21,28)	27,88 (14,69)	43,68 (17,34)
	General and Specific Studying	33,87 (13,90)	46,38 (19,71)	33,92 (13,89)	46,84 (20,61)	30,98 (14,05)	43,95 (15,91)
Northeast	General Studying	45,49 (26,09)	49,24 (24,98)	47,18 (28,04)	50,36 (25,81)	41,55 (21,22)	45,84 (21,17)
	Specific Studying	29,88 (18,41)	47,13 (22,50)	30,13 (19,58)	47,30 (23,14)	28,59 (15,54)	46,26 (19,57)
	General and Specific Studying	33,80 (18,86)	47,67 (22,02)	34,40 (20,28)	48,07 (22,76)	31,84 (15,31)	46,16 (18,65)
Southeast	General Studying	44,52 (21,87)	48,54 (21,31)	54,99 (26,80)	57,37 (26,43)	42,16 (20,34)	46,09 (19,08)
	Specific Studying	30,68 (16,47)	45,85 (19,81)	35,22 (18,97)	52,99 (23,59)	29,44 (15,92)	43,67 (18,29)
	General and Specific Studying	34,15 (16,21)	46,54 (18,88)	40,17 (19,33)	54,10 (23,28)	32,63 (15,37)	44,29 (17,04)
South	General Studying	45,45 (22,03)	51,00 (20,73)	50,62 (25,38)	55,03 (23,98)	43,13 (20,37)	47,96 (17,88)
	Specific Studying	33,42 (16,55)	50,14 (19,10)	35,62 (19,22)	53,01 (21,98)	32,25 (15,43)	47,94 (16,91)
	General and Specific Studying	36,44 (16,30)	50,37 (18,20)	39,38 (19,19)	53,53 (21,39)	34,98 (14,99)	47,96 (15,61)
Middle West	General Studying	47,45 (20,93)	52,18 (21,08)	53,14 (22,78)	58,99 (21,43)	44,06 (19,39)	46,53 (19,13)
	Specific Studying	31,62 (15,37)	49,01 (19,44)	33,99 (16,92)	54,79 (19,63)	30,03 (14,44)	43,92 (18,04)
	General and Specific Studying	35,59 (15,03)	49,82 (18,62)	38,79 (16,41)	55,85 (18,89)	33,55 (14,06)	44,58 (16,97

Source: Own formulation with the data from Microdata of the Enade 2007. In parenthesis are the standard deviations.

As regards the added value at specific and general knowledge, it is possible to notice that the numbers vary a lot by region and nature of the institution.

For example, for the North and Northeast regions of Brazil, the aggregate value of the specific knowledge for private institutions exceeds the equivalent in public institutions (56% and 61% of private against 44% and 56% of the public respectively). The Southeast and South regions of Brazil there are no difference in the improvement rate of specific knowledge for public or private HEI. Only in the Middle West region of Brazil, the percentage gain observed is higher in public IES for the specific knowledge.

In addition, in the Northeast, Southeast and South, the private HEI added, percentage, more in general knowledge than in public HEI. In general terms, the region that had the greatest increase in percentage terms in aggregate value of knowledge was the Northeastern region (44%) followed by North (41%) and South (37%). These data suggest that, in terms of aggregate value, we must take into account: 1) the nature of the institutions, that is, whether public or private; 2) the regions of the HEI, and 3) the different components of the test (general or specific), since they may influence the results when seeking to estimate the determinants of the performance of the HEI.

Thus, as a output measure is possible to use the difference between the score of general knowledge of graduating and freshman students [45], this allows an analysis of the inputs effects on the knowledge of the students that changed during the course of graduation.

The information used in this work was obtained from Microdata of the Higher Education Census 2006 and the Enade 2007.

[45] The inputs derivatives of Enade questionnaire were aggregated by IES for graduating and freshmen students.

3.2 Measuring the Performance of Higher Education Institutions (HEI): Defining the inputs

How inputs were used the following variables of the HEI obtained from microdata of Higher Education Census:

a) Total of professors per registered students as a measure of input work; [46]
b) Total computers per registered students as a measure of capital input; [47]
c) The existence of a complete teaching plan as proxy for the technology [48].
d) Expenditure incurred with professors (without inactive) per student; [49]
e) Expenditure incurred with capital per pupil;
f) Expenditure incurred with other factors (maintenance, cleaning etc) per student[50].

In addition, were included explanatory variables that catch the family background and the inherent characteristics of the students. Such information are in percentage terms by HEI and are the following:

a) If the student works more than 20 hours per week;
b) Dummy equal to 1 if the student isn't white, and 0, otherwise;
c) The maternal education. It has appeared as a fundamental factor for the performance of students in the work that assess the determinants of K-12 education[51], which suggests that it can occur with higher education[52]. Therefore, the option to use this variable as input on the Stochastic Frontier of production.

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[46] For studies that use professor as input variables see Table A.3 in Appendix 2.
[47] For studies that use computers as input variables see Table A.3 in Appendix 2.
[48] A complete teaching plan refers to the description of the tasks to be performed during the course, and generally covers the following aspects: objectives, teaching and evaluation procedures, content and bibliography of discipline.
[49] For studies that use expenditure as input variables see Table A.3 in Appendix 2.
[50] The costs are established in R$1.000,00.
[51] Barros (2001), Fernandes (2005), Menezes-Filho (2001), among other authors, indicate the family as the primary determinant of children educational results, mainly by means of parents' education.
[52] Diaz (2005) found no empirical evidence that the highest parents' education generates best scores in higher education. In the meantime, it argues that it is expected that the IES with higher percentage of students whose parents present higher education tend to have better performance.

Table 3.2 presents some descriptive statistics of inputs, classified according to the HEI type (public and private) and whereas the five regions of the country.

Table 3.2 – Inputs based on declared information by students and separated by public and private institutions

Region	**North**		**Northeast**		**Southeast**		**South**		**Middle West**	
Education	*Private*	*Public*	*Private*	*Public*	*Private*	*Public*	*Private*	*Public*	*Private*	*Public*
Professor by student	0,0225	0,0306	0,0218	0,0391	0,0293	0,0602	0,0126	0,0042	0,0318	0,0378
Total computer by students	0,0759	0,0346	0,0425	0,0619	0,0549	0,2503	0,073	0,131	0,0636	0,0754
Complete teaching plan of the IES (%)	61,89	40,28	63,47	47,54	61,02	49,64	63,3	52,43	63,02	48,12
Expenditure with professor per student	1.374	2.385	1.381	4.750	1.775	7.902	1.679	3.125	1.719	2.945
Capital expenditure per student	200	408	350	1.365	300	825	357	412	432	413
Other expenditure per student	2.028	2,059	1.885	6.641	2.551	10.519	2.284	4.099	1.518	2.341
Student working 20 hours or more (%)	28,49	28,5	28,2	23,64	49,21	21,97	45,7	29,44	37,71	25,65
Maternal high schooling (%)	21,91	17,15	28,87	27,19	21,99	31,98	21,84	32,18	23,19	29,86
Not white student(%)	44,16	37,03	36,51	36,22	21,26	20,28	9,03	7,59	28,54	23,98

Source: Own formulation with the data from Microdata of the Higher Education Census 2006 (the banks of institutions and witnessed graduation) and the Enade 2007 (bank of microdata).

It is clear that the public HEI present a bigger number of professors per student than the private HEI, except for southern region. With relation to the variable used as proxy for capital, which is, a total of computers per student, note a higher value for the public HEI in four of the five regions. In fact, in the Southeastern Region, there is a value approximately five times greater than that found in private IES. However, verify a contrary situation in the Northern Region, in which the private HEI registered a total of computers per student bigger than the public HEI.

In relation to the variable "full teaching plan", notes that a higher percentage of private institutions students comparatively to public institutions, replied positive to this issue. As regards the expenditure by registered students carried out by the HEI, notes that they are higher among the public HEI. Both the expenditure with professors as the capital and the other public institutions expenses may be up to four times higher than those carried out by the private HEI. However, this difference varies between regions.

On the students characteristics, notes that the percentage of students who work 20 hours or more per week is bigger in private institutions. In the south and southeast regions, this percentage reaches be two times higher than in public institutions.

Among the public HEI of the Southeast, South and Middle West Regions, the percentage of students whose mothers attended Higher Education is bigger in public institutions. But in the North and Northeast region, this characteristic is higher among the private HEI [53].

Finally, there are a higher percentage of not-whites students in private institutions than in public. The statistics shows a perverse feature of Brazilian Higher Education System, in which the students in a more vulnerable socioeconomic situation that wish to attend Higher Education are forced to pay for this.

3.3 Result

As previously mentioned, using the method of Stochastic Production Frontier to estimate the degree of inefficiency of HEI. Thus, the general specification for data on cross-section is as follows:

$$lny_i = \beta_0 + f(\beta_k, x_i^k) + v_i - u_i, \ i = 1, \dots, I; k = 1, \dots, n \qquad (3.1)$$

that lny_i is the logarithm of the quantity produced by the firm (HEI) *i*; β_0 is the intercept of the equation; $f(\beta_k, x_i^k)$ is the appropriate functional; β_k is the vector of technology coefficients; x_i^k is the vector of inputs used in the production by the firm (HEI) *i*; v_i is the random clash (idiosyncratic) not correlated with x_i^k and u_i, with distribution $N(0, \sigma_v^2)$; and u_i is the term of inefficiency nonnegative of the firm *i* also not correlated with x_i^k.

For the coefficients technological estimation of Stochastic Production Frontier are employees the estimators of maximum likelihood[54]. It is necessary to take distributive

[53] Calculating separately for freshmen and graduating students, the percentage of students whose mothers attended Higher Education, notes an increase in the past 5 years in public IES. This is possible to verify when compare this percentage between graduating students (that had been attending for 4 or 5 years ago) and freshmen students. Among the private IES, note a contrary trend, that is, a reduction in the percentage over time, which shows an increase in demand for Higher Education among the students with worse family background.

[54] Other estimators may be used for the coefficients calculation. Opted here for maximum likelihood because this is a consolidated literature methodology on inefficiency technique, in addition to possess properties on the other interesting estimators. As it is not the scope of this work dissertate on various possible methodologies for the estimation of Stochastic Frontier, suggests the concerned reader to check Kumbhakar and Lovell (2000).

hypotheses on the term of inefficiency u_i. Various asymmetric distributions may be used for the term u_i, and this work assumes that the component of inefficiency of the model error presents exponential distribution[55].

One of the main disadvantages of the Stochastic Frontier method is the need to make an arbitrary choice of the efficiency distribution. However, there is evidence that the relative position of the decision taken units in the ranking of efficiencies is not very sensitive to distributive form assumed by those units, as shows Greene (1990). Thus, we believe that the obtained results can be considered reliable.

Although the analysis unit is the Higher Education Institution, only universities are considered. The other academic organizations (University Center, Integrated Faculty, Faculty, Institute / School, Center for Technological Education) were not part of the sample. The reason for including only universities in the estimation is that this academic organization has a larger number of courses than other institutions.[56] As our analysis aggregates a set of courses for each institution, we needed a more homogeneous sample with respect to the total number of courses offered by each HEI, and a sample that could represent the highest number of courses evaluated by Enade. Thus be assessed 164 universities.

Opted to evaluate the efficiency of IES using as output variable the difference between the note of general knowledge of graduating and freshman students [57], which allowed an analysis of the inputs effects on how the IES added knowledge to students. Another reason for use as output the difference between the scores of graduating and freshmen students is the observation that the private IES, in general, combines proportionally more in general knowledge that the public IES (Table 3.2). However, the last ones with greater proficiency, which makes this analysis highly attractive.

In Table 3.3 are presented the results of the Stochastic Frontier estimates. For each model are made two estimates. The first specification identifies inefficiency component of the model (u_i) is different of zero, it is necessary because otherwise the model could be

[55] When choosing an econometric method, shall evaluate the existing advantages between the choice made and the possible alternatives. The first question that arises is why does not use ordinary least squares (OLS). As facing Kumbhakar and Lovell (2000), the estimator of least squares, despite of not being biased to the coefficients technological vector is biased to intercept the equation to be estimated. Furthermore, this methodology does not allow the existence of inefficiency technique, giving all variation in production that can be explained by varying the inputs to random shocks. In this situation, if there is no presence of inefficiency, OLS is the most appropriate estimator for the production function. Thus, OLS assumes states fully efficient, while the Stochastic Frontier methodology does not assume this hypothesis.

[56] According to the statistical synopses of the 2007 Higher Education Census, universities have, on average, seven times more courses than other types of academic organization.

[57] The inputs derivatives of the Enade questionnaire were aggregated by IES for graduating and freshmen students.

estimated by ordinary least squares. The second specification includes additional information to explain the inefficiency of the model, if the component is different of zero. According to Siegel, Waldman and Link (2003), the variables that explain the deviations associated with the relative inefficiency of the production function are a function of environmental and institutional characteristics that are beyond the control of production units.

In model 1 are considered as input traditional variables, which are, the capital and labor. The total of professors per registered students were used as a measure of labor input and the total of computers per registered student as a measure of capital input. Furthermore, a variable was used to identify if the higher education institution presents complete teaching plan attempting to capture the "quality" of the institution and its effect on productivity [58].

In model 2 input variables that were previously physically measures, are replaced by their monetary compensation. Thus, as inputs are used the expenditure incurred with professors (without inactive) per student, expenditure incurred with capital per student and expenditure incurred on other factors per student.

In model 1 notes that as bigger is the total of professors per student less is the difference between the scores of graduating and freshmen students in two specifications (1.1 and 1.2, approximately elasticity -1). This result shows that this type of input is not a decisive determinant knowledge aggregation.

As regards the total of micro-computers per student, there is a positive and statistically effect significant in the difference between the scores (elasticity 0.4). This shows that by investing in capital, the HEI can aggregate more knowledge.

In relation to the variable “complete teaching plan”, note that the greater the percentage of students which replied that the course presented this characteristic, smaller is the difference between the scores of graduating and freshmen students (elasticity -1.73). It is worth that this characteristic presented greater percentage between the private institutions (Table 3.2).

The negative signal associated to the coefficients of the variable professor and teaching plan surprising, since would expect a positive effect of both variables on the output. Were estimated two new models of Stochastic Frontier, one with only the score of freshman

[58] A complete teaching plan covers the following aspects: objectives, teaching and evaluation procedures, content and discipline bibliography.

students as an output and another with only the score of graduating student as output[59]. The score model of freshman students both the coefficient of variable professor as the coefficient of variable teaching plan is positive, the same doesn't happening with the model with the score of graduating students. In this way, it seems that the best faculties already attract beforehand the best students, their characteristics appear positively correlated with the note of freshmen students.

In this first model to explain the inefficiency (specification 1.2) uses a dummy indicating whether the institution is public or private[60]. The positive coefficient indicates that the public institution is more inefficient than the private institution. In model 2 that the labor and capital variables are measured in monetary units, the coefficients of the three expenses variables were not statistically significant. Notwithstanding, Winston (2000) underscores that the information on expenditures shows comparison problems across different HEI. HEI tend to fail to make a proper distinction of each expenditure category, which may lead to the overestimation of certain types of expenditures. In addition, to explain the inefficiency with information referring to public or private HEI, note that the coefficient of the variable despite been positive was not statistically significant.

These results reinforce the review literature beforehand, that physical inputs catch the contribution of teaching institution for the production and/or aggregation of knowledge. However, another literature branch argues that the results of standardized exams as ENADE reflect mainly the socio-economic status of the students, more than the value added by the schools (MIZALA et al.,2007; CHAY, MCEWAN AND URQUIOLA,2005).

In order to verify if the obtained results were not contaminated by the effect of variables related to the students and their families, were included in the production function three variables that characterize the students: that is a dummy variable indicating whether the student works more than 20 hours per week; maternal schooling and a dummy variable of race[61].

In model 3 are included only the characteristics of the students to explain the output. In model 4 are included the characteristics of students and inputs of measured

[59] The results may be obtained directly with the authors.
[60] Charnes and Cooper (1998) conducted a similar analysis in order to identify which HEI is more efficient, the public or the private ones. However, their results rely on the set of data analyzed. For instance, when medical schools are included in the sample, public institutions are more efficient, but if these schools are left out of the sample, private institutions are more efficient.
[61] Dummy equal to 1 if the student is not white, and 0, otherwise.

university in physical units. Finally in model 5 are included the characteristics of students and the expenditure of universities.

Table 3.3 – Stochastic Frontier esteem with the score difference of graduating and freshmen students (inputs: characteristics of the HEI)

	Model 1		Model 2	
	Model.1	Model.2	Model.1	Model.2
professor by student	-99.30***	-87.88***		
	(31.92)	(32.44)		
total computer by student	16.55***	16.80***		
	(4.69)	(4.82)		
Complete teaching plan of the IES	-8.43***	-10.05***		
	(3.19)	(3.25)		
Expenditure with professor per student			-0.17	-0.13
			(0.00)	(0.00)
Capital expenditure per student			0.28	0.29
			(0.00)	(0.00)
Other expenditure per student			0.06	0.06
			(0.00)	(0.00)
Student working 20 hours or more				
Not white student				
Maternal high schooling				
Constant	14.75***	14.74***	7.61***	7.25***
	(2.51)	(2.53)	(1.04)	(1.05)
Explaining the inefficiency				
Public IES		1.51*		0.99
		(0.81)		(0.67)
Constant	2.10***	1.05	2.12***	1.52**
	(0.42)	(0.91)	(0.52)	(0.76)
N	164	164	155	155
Dummies of Regions	yes	yes	yes	yes
LR test for null inefficiency component ($p>\chi^2$)	6,88	-	3,13	-

Source: Own formulation with the data in INEP. Paren are the robust standard deviations. *p<0.10, ** p<0.05, *** p<0.01.

In model 3 only maternal schooling appears as statistically significant and negative. Thus, the higher the percentage of students in HEI whose mothers attended higher education, the smaller is the difference between the scores of graduating and freshmen students. This result seems to indicate that the HEI combines less knowledge when better is the family background.

In model 4 (Table 3.4), in both the specifications (4.1 and 4.2), none of the information about the students appears as statistically significant. But the institutions characteristics presents, in general, signs and magnitudes similar to those found in model 1.

In addition, in the specification 4.1 rejects the null hypothesis that there is no technical inefficiency in the model by means of Wald and Likelihood Ratio Test. To explain this inefficiency with the information if the HEI is public or private (specification 4.2), note that the fact of HEI be public increases inefficiency in similar magnitude verified in model 1.

Table 3.4 – Stochastic Frontier esteem with the score difference of graduating and freshmen students (inputs: characteristics of the IES)

	Model 3		Model 4		Model 5	
	Model3.1	Model3.2	Model4.1	Model4.2	Model5.1	Model5.2
professor by student			-92.99***	-90.99***		
			(34.63)	(34.92)		
total computer by student			16.41***	17.03***		
			(4.75)	(4.87)		
Complete teaching plan of the IES			-6.70	-9.22*		
			(4.69)	(4.71)		
Expenditure with professor per student					-0.17	-0.15
					(0.00)	(0.00)
Capital expenditure per student					0.20	0.22
					(0.00)	(0.00)
Other expenditure per student					0.08	0.09
					(0.00)	(0.00)
Student working 20 hours or more	-3.37	-5.46	-1.30	-2.19	-4.37	-6.05*
	(3.47)	(3.50)	(4.35)	(4.26)	(3.56)	(3.56)
Not white student	-2.65	-1.47	0.36	2.16	0.35	1.10
	(4.96)	(4.91)	(4.95)	(4.88)	(5.29)	(5.14)
Maternal high schooling	-7.66*	-6.86	-3.98	-1.47	-7.20	-6.79
	(4.43)	(4.44)	(5.55)	(5.63)	(4.76)	(4.75)
Constant	11.12***	11.30***	15.00***	15.41***	11.34***	11.46***
	(2.38)	(2.34)	(2.75)	(2.77)	(2.42)	(2.37)
Explaining the inefficiency						
Public IES		1.18*		1.54*		1.10*
		(0.70)		(0.85)		(0.65)
Constant	2.16***	1.41*	2.11***	1.05	2.28***	1.61**
	(0.48)	(0.79)	(0.42)	(0.94)	(0.46)	(0.70)
N	164	164	164	164	155	155
Dummies of Regions	yes	yes	yes	yes	yes	yes
LR test for null inefficiency component ($p>\chi^2$)	3,61	-	6,66	-	3,99	-

Source: Own formulation with the data in INEP. Paren are the robust standard deviations. *p<0.10, ** p<0.05, *** p<0.01.

In the model 5 (Table 3.4) notes that the expenditure continue with the coefficients not statistically significant and which only the variable "student working 20 hours

or more" presents negative and significant. In addition, the fact that the institution be public or private is important to explain the inefficiency.

3.4 Final Remarks

The objective of this work is to assess the determinants of performance from institutions of higher education in Brazil, taking into account the relative efficiency of public and private institutions on the application of its resources. To measure performance uses the difference between the graduating and freshmen students score in ENADE.

The main results indicate that:

a) the input work (professor per student) affects negatively the difference in the score in ENADE, that the principle would be counter-intuitive. The separate estimation, however, using the score of freshman students and score of graduating students as output indicates that the input work affects the first but not the second. This indicates that higher education institutions attract the best students, which explains the impact on the score of freshmen students, but precisely because attract the best students ended aggregating little value, which reflects the negative impact of the professor on the score of graduating students and on the difference in the score.
b) the input capital affects positively the difference in the score in ENADE, as would be expected.
c) the existence of the search plan negatively affects the difference in the score in ENADE and the reasons for this are the same associated with the negative effect of professor per student.
d) the fact that the university being public increases the inefficiency.
e) the socio-economic characteristics of the students aren't important to explain the result, except in some cases in which the maternal schooling and the fact that the student work, or do not affect negatively in the difference in the score in ENADE.

Seek to advance in respect of the existing literature estimating in fact production functions of education since it controls for the inputs. The availability of scores in

standardized tests for Brazilian universities help in this task since it provides an output measure, which is widely accepted. In the absence of qualitative indicators as occupation and remuneration in the long term that catch more adequately the education contribution for human capital, an intermediary result s the score in a standardized exam can be seen as a good approximation. In addition, replaces the traditional use of DEA by Stochastic Frontier method.

If other studies confirm more firmly the result that the public higher education institutions are more inefficient, a politics suggestion would be to link the resources transference of the Government to the performance of the same. In this way, only public universities to submit a score above a certain threshold and/or to improve their performance over the time would have its resources guaranteed.

4 The Effects of Early Childhood Education on Literacy Scores Using Data from a New Brazilian Assessment Tool (3rd Essay)

With the advent of the Human Capital Theory – especially with the work conducted by Becker (1964) – we observe the consolidation of a theoretical framework where education played a major role in the determination of poverty, of long-term growth, of per capita income, and of income inequality within and between countries. Nevertheless, the identification of this relationship between education and income per se was not enough for the implementation of public policies targeted at the improvement of people's living conditions. In this respect, we have the Economics of Education literature, whose main goal is to identify the most important factors for the development of people's skills.[62] Among these factors, family background plays a crucial role. According to these studies, the influence of family on the development of their children's skills is so important that the room for public sector action seems quite restricted. This perspective is particularly problematic for Brazil, since most adults have a low educational level and live in precarious conditions, which hinders their children's skill development and perpetuates the cycle of poverty.

Despite the limited scope of public policies aimed at improving education (in terms of quality and quantity), some factors indirectly related to family are important, as evinced by empirical studies. Improvement of school infrastructure, qualification of teachers and principals, accountability, in addition to other activities offered at schools, are some examples.[63][64][65] But another specific factorhas been given special attention in the literature: the Early Childhood Education.

In the last two decades, there has been a debate about the effects of Early Childhood Education on future educational outcomes. A considerable number of scientific studies find evidence that educational intervention early on during childhood yields significant and long-lasting results on future school performance, and even on adult life successes. Based on this literature, Cunha *et al.* (2005) introduce a model for skill development that reflects the necessity that investments in education be made in early childhood. The model also considers that later investments are important to maintain the skill

[62] Coleman *et al.* (1966), have conducted a seminal work on the determinants of school success.
[63] For educational accountability results, see Jacob (2005) and Carnoy & Loeb (2002).
[64] For further information about the effects of teachers' characteristics on school success, see Rivkin, Hanushek & Kain (2005).
[65] For the effects of some variables related to school infrastructure on students' performance in standardized exams, see Albernaz, Ferreira & Franco (2002) and Felício & Fernandes (2005).

level developed in early childhood, but if investments are not made in early childhood, the ability to acquire knowledge in the future will be impaired, and this cannot be offset by further investments in the future. Therefore, the authors refer to early childhood as the *Critical Period.*

Low scores in standardized assessments obtained by Brazilian students in national exams (Prova Brasil and SAEB –National Basic Education Assessment System) and also in international exams (Programme for International Student Assessment – PISA), high repetition rates and high dropout rates before accomplishing High School education, underscore the need for urgent action by the public sector, and Intervention in Early Childhood is an important alternative for Brazilian public education.

Some measures have been taken by the Brazilian federal government. To improve children's educational level and to encourage early school admission, the minimum period for accomplishment of Elementary Education has recently been extended from 8 to 9 years, which decreased the mandatory age for school admission to 6 years. Moreover, an attempt has been made to boost the supply of vacancies at day care centers and at pre-schools and to stimulate the school admission of children aged 0 to 5 years with inclusion of Early Childhood Education in FUNDEB (Fund for the Maintenance and Development of Basic Education and Teaching Improvement).[66] This implies the guarantee of a minimum common grant value in all states and municipalities for every child enrolled from the Early Childhood Education program to High School. Also, there is a congress bill in discussion that, if enacted, will make these two stages mandatory, as occurs with Elementary Education.

Another measure that is important for the improvement of the education system is to warrant that children can be taught to read and write at the appropriate age so that they will be ready to develop the skills that are required throughout their school life. In this regard, the Brazilian Ministry of Education developed *Provinha Brasil* in 2007, an exam that assesses the literacy of children aged 6 to 8 years.

This exam is an innovative tool used to measure the development of children's reading and writing skills, when it is still possible to correct learning deficiencies in a more

[66] Before Fundeb, the federal fund for the transfer of grants for education was FUNDEF (Fund for the Maintenance and Development of Elementary Education and Teaching Improvement – implemented by Amendment no. 14, enacted in September 1996), which guaranteed minimum resources for students enrolled in Elementary School. Early Childhood Education (for children aged 0 to 6 years at the time) and High School (for teenagers aged 15 to 17 years) were financially supported only by states and municipalities. Given the evidence of the efficiency of investments in Early Childhood Education, this strategy of heavily investing in Elementary Education, with support from FUNDEF, has been deemed to be mistaken.

effective way (at least if we compare it with the possibilities of educational intervention for older children) and to adjust, whenever necessary, the process that precedes the assessment. It can also be used to assess the effects of public policies adopted in response to deficiencies revealed by the exam results.

As *Provinha Brasil* assesses students at the very beginning of Elementary Education, the main goals of educational policies targeted at the improvement of literacy levels diagnosed by the exam should concern Early Childhood Education and the first years of Elementary Education. This is consistent with the model put forward by Cunha et al. Students with low literacy scores in *Provinha Brasil* might not be able to achieve the potential they would be able to if they had been properly taught to read and write. Therefore, interventions should occur when children are still young, i.e., during Early Childhood Education, so that students in the subsequent cohorts can be better prepared when they are assessed.

The aim of this essay is to empirically determine the relationship between age at school admission (which also reflects the fact that a student attended or did not attend Early Childhood Education) and children's literacy score based on the results obtained in *Provinha Brasil*. However, this exam differs from other tests applied by the Ministry of Education. Its application and correction requires active participation of the local school systems. As a matter of fact, the Ministry of Education makes the test and the manuals for its application and correction and provides the public school systems all over Brazil with the exam and respective manuals in digital format, but the exam is applied and corrected by the local school systems.

There is neither a database with the exam results (as the application is decentralized), nor a socioeconomic questionnaire to be answered by the children, as occurs in SAEB, since the children who take this exam are too young to answer such a questionnaire in an accurate way. Thus, the solution we found to use the exam results in an econometric analysis was to closely follow the application of *Provinha Brasil* in a Brazilian municipality where Early Childhood Education was well structured and where we could also apply socioeconomic questionnaires directly to the parents. This way, we chose Sertãozinho, a municipality located in the state of São Paulo.

As this is a medium-sized town (with a projection of 109,565 inhabitants according to Brazilian Institute of Geography and Statistics – IBGE – 2008 and 2,081 students attending the 2nd grade of Elementary School in 2007), it was possible to standardize

and inspect universal application properly. This means that it was also possible to apply the exam in private schools, which allowed us to draw generalized conclusions about the econometric results we obtained. Note that the cooperative attitude of private and public schools was important for the selection of this municipality.

The assessment of a single municipality, even though it has some problems relative to the external validity of the results, is desirable in an analysis using Propensity Score Matching, as the one we carried out in this study. Friedlander & Robins (1995) and Michalopoulos et al. (2004) find evidence that when treatment and control groups belong to the same place, the matching procedure yields better results. Indeed, if we consider Early Childhood Education an intervention, one cannot use treatment units from various localities because each place has one quality of education and thus we have a number of different treatments instead of just one.

Finally, this essay is important because it verifies the effectiveness of incentive policies for the expansion of Early Childhood Education as a way to increase students' learning. To achieve that, we sought to identify the relationship between the attendance of Early Childhood Education and the literacy score attained in the 2nd grade of Elementary School, using a new assessment tool that measures an especially important set of skills, as it interferes directly with learning capacity in any area of knowledge.

This essay is organized into six subsections. Subsection 1 reviews the literature on the effects of Early Childhood Education on children's skill development. Subsection 2 describes the *Provinha Brasil* in more detail, as well as the application of this exam and of the questionnaire to the selected municipality, and also presents some descriptive statistics. Subsection 3 explains the whys and wherefores of using the Propensity Score Matching as estimation method. Subsection 4 describes the estimation results. Subsection 5 presents the tests used to check whether the matching was properly performed and, finally, subsection 6 brings the concluding remarks.

4.1 Literature Review

The literature dealing with the effects of Early Childhood Education on children's skill development is quite rich and comprehensive. Most of the reported results are based on random experiments, but important studies that use non-experimental methods are also included. Some experiments conducted in the United States, which are especially noteworthy in the literature, include the following: the High/Scope Perry PreSchool Project, the Carolina Abecedarian Project and the Early Training Project (CURRIE, 2001).

The High/Scope Perry PreSchool Project was an experiment undertaken between 1962 and 1967 which assessed 123 children aged 3 to 4 years (all of the children had a vulnerable socioeconomic background). The treatment consisted of pre-school attendance for one shift (morning or afternoon) every day plus a 90-minute weekly home visit for eight months a year during two years. Students usually left the program at the age of 5 years. All of the teachers had a Master's degree and the teacher-to-student ratio was 1:6. According to Schweinhart et al. (1993), the results obtained with this program were quite positive: better performance on skill tests (at 9 and 14 years), better performance in High School, higher rates of High School accomplishment, lower rates of imprisonment (at 27 years), higher salaries (at 27 years) and lesser use of government support (at 27 years).

The Carolina Abecedarian Project was an experiment targeted at children with a vulnerable socioeconomic background and with risk for mental retardation due to the precarious situation in living (CURRIE, 2001). Admission to the experiment occurred at 6 to 13 weeks of age. The treatment consisted of an intensive child care and language development program for eight hours a day, 5 days a week, 50 weeks a year, from birth to the age of 5 years. After admission to school, the treatment group was randomized into two groups, one with a tutor who provided additional instructions at home, and another one that did not have any additional intervention. The program was concluded up to the age of 8 years. The teacher-to-student ratio was initially 1:3, rising to 1:6 as children grew older. The results were also quite positive. The treatment group had better results on proficiency tests, higher averages of school performance in High School, lower incidence of repetition (at 15 years) and lower dropout rates (at 21 years), in addition to lesser need for special education (at 15 years), and higher probability of attending college (at 21 years).

The Early Training Project was a less intensive program, targeted at children aged 4 to 5 years. It consisted of weekly home visits for 1 year, in addition to a single-shift 10-week course for two or three summers for the treatment groups. The treatment was concluded at the age of 6 years. According to Gray et al. (1983), the results showed a reduction in the need for special education for children in the treatment group.

These three experiments share a common feature: they are all small-scale projects. This may have important implications, since it is impossible to determine the external validity of these experiments. The results of these experiments if they were to be carried out on a large scale cannot be predicted. An important and more comprehensive experiment is the Head Start program, adopted by the U.S. government in 1964, and whose target public was composed of children aged 3 to 5 years. Intervention consists in providing health care, meals, snacks and child care with a higher quality standard than that which low-income parents can provide for their children. Currie & Thomas (1995) conducted a quasi-experimental study of the effects of this program on the performance obtained on the Peabody Picture Vocabulary Test (PPVT) and on the probability of never having to repeat a grade. The authors found positive effects on the performance of white children who participated of this program, whereas the results for Afro-American children, who participated in the program, were not statistically different between those who took part in the program and those who did not. After controlling for participants' ages, the authors found a positive and statistically significant effect on the performance on the PPVT and on the probability of never having to repeat a grade, also among Afro-American children. According to the authors, this may be linked to the possibility of children from this ethnic group facing more hostile environments or opportunities after they finish the program. Thus, in order for the benefits to last longer, as occurs among white children, investments, even after the program has finished, should be made in those children enrolled in the program.

Recently, important experiments and quasi-experimental studies have been conducted in Latin America. Schady (2006) carried out a literature survey on assessment of the impact of investment programs in childhood on cognitive and non-cognitive development. Gertler & Fernald (2004, apud SCHADY, 2006), for instance, found evidence that transfers made by Mexico's Opportunities Program had a positive impact on motor skills and socioemotional problems. Behrman, Parker & Todd (2004, apud SCHADY, 2006), on the other hand, gathered evidence that these transfers had a positive impact on the probability of children enrolled in the program (aged 0 to 6 years) starting school at an earlier age. They also

found evidence of higher promotion rates and higher expected schooling years among children of the treatment group.

Behrman, Cheng & Todd (2004) analyzed the results of a Bolivian pre-school program called *Proyecto Integral de Desarollo Infantil* (PIDI) using Propensity Score Matching. The program consists of intensive child care, such as full-time day care center and nutritional and educational services for children aged between 6 months and 6 years from low-income families. The authors encountered evidence of improved motor and psychosocial skills and of improved language acquisition. These results were more significant among children older than 3 years and among those who attended the program for a longer period.

Berlinski et al. (2009) assess the effects of an exogenous variation in the supply of pre-school vacancies due to a program for the construction of schools in Argentina on students' performance. The authors collected evidence that the performance in the Spanish language and in mathematics of cohorts and regions subjected to the treatment (construction of schools) was significantly higher than that obtained by children who were not exposed to this exogenous variation. They also found evidence of positive impacts on non-cognitive skills such as attention, participation and discipline in the classroom.

In Brazil, some studies were developed to assess the effects of an intervention (Early Childhood Education) in early childhood. Curi & Menezes-Filho (2006), for instance, demonstrate that students who attended pre-school and a day care center are more likely to finish primary education (1st to 4th grade of Elementary School), Middle School (5th to 8th grade), High School and College. The authors also observed that because individuals attended a day care center or pre-school, they have a higher average of schooling years (measured from the first year of primary education) and higher salaries as well. Finally, the authors found evidence that early school admission has positive effects on math proficiency.

This result about the effects of Early Childhood Education in Brazil on performance is corroborated by Felicio & Vasconcellos (2007). The authors use methods for the correction of endogeneity and self-selection bias and find positive and statistically significant effects of pre-school attendance on the performance of fourth-graders on SAEB. Depending on the region, these effects ranged from 9 to 19%.

Given the evidence of these studies and the model proposed by Cunha et al. (2005) described in the introduction of the present study, it is fundamental to address the problem of liquidity constraints faced by socioeconomically underprivileged families. Following this line of research, the simulations of a general equilibrium model run by

Restuccia & Urrutia (2004) confirm the existence of intergenerational persistence of earnings and schooling. According to the authors, this problem arises mainly from low investments in the earliest stages combined with liquidity constraints by poorer parents. Therefore, children whose parents cannot afford to invest in this initial stage will be condemned to have poor skills in the subsequent stage and, consequently, to have lower earnings in adult life.

This is particularly worrying as children with the worst family background are exactly those who take most advantage of these programs in early childhood (CURRIE, 2001). These programs would be useful to minimize adverse family conditions. This way, there is room for the government to act in order to provide equal opportunities to the children, i.e., to lessen the large disparities observed between the initial skills of economically privileged and underprivileged groups.

4.2 Dataset

The database used in this study was built using the results obtained from the first application of *Provinha Brasil* in Sertãozinho,[67] in the state of São Paulo, in May 2008. The exam was applied universally (to public and private education networks) with the aim of assessing literacy measured as the reading and writing skills of students attending the 2nd grade of nine-year-long Elementary School education. The choice of Sertãozinho was based on the fact that this town had a not so large number of children enrolled in this grade (2,081 students according to the 2007 School Census), thus allowing us to follow up the application of the exam and of the socioeconomic questionnaires in an appropriate fashion. The presence of a well-structured Early Childhood Education system is another highlight of this municipality.[68] Finally, the availability of public and private schools to participate in the study was also decisive for the selection of this municipality.

[67] Sertãozinho is a countryside town in the State of São Paulo whose major economic activity is the sugarcane industry.

[68] By comparing pre-school attendance between public and private schools (using data from the Basic Education Census), we noted that the average rate between the total number of enrollments in public and private schools of Sertãozinho was 6.29 between 2005 and 2006. When we made the same calculation for Brazil, the average rate was 2.69. In terms of municipal expenditures with Early Childhood Education per student (based on data from the National Treasury Department), we perceived that Sertãozinho spent on average R$1,761 between 2005 and 2006, while the average expenditure at the national level was R$1,196.

It should be underscored that *Provinha Brasil* differs from other Brazilian exams in some important aspects, besides the fact that it also assesses literacy. The first aspect concerns the responsibilities attributed to each phase of the exam. In other Brazilian exams developed by the Ministry of Education (Prova Brasil and SAEB), an external institution is hired to apply the exams, organize the data and hand the database over to the Ministry of Education. In the case of *Provinha Brasil*, the National Institute for Educational Studies and Research (INEP) is in charge of devising the material and making it available online so that schools can print it. The use of *Provinha Brasil* by Municipal Departments of Education is optional. Therefore, the application, correction and publication of results are locally assigned responsibilities[69].

Another difference lies in the assessment method. The score of *Provinha Brasil* ranges from 217.4 to 665.0 points, as opposed to the scores of Prova Brasil and SAEB, which range from 0 to 500 points. As previously mentioned, *Provinha Brasil* aims to assess children's literacy. Thus, its maximum score (665.0), can be achieved by children only when they are totally literate. The other exams, however, focus on determining the skill levels developed by each student during K-12 education, and in practice this means that students hardly achieve the maximum score. Nevertheless, *Provinha Brasil*, SAEB and Prova Brasil are all based on the Item Response Theory, which allows the results to be placed on the same scale and comparing the results between assessments, between the grades of the same exam, and over time. Therefore the results of these exams permit monitoring education quality.

As stated in the first section of the present study, another aspect that distinguishes *Provinha Brasil* from other Brazilian exams is the absence of questionnaires for the collection of relevant information to explain student performance. Children who take part in *Provinha Brasil* are very young, which does not allow them to answer a questionnaire in a consistent manner.

For the application of *Provinha Brasil* to public schools, the Municipal Departments of Education offer examiners a training course. To carry out this study in Sertãozinho, this was no different. We only followed up the process to guarantee that both application and correction were standardized.

However, in private schools, we endeavored to reproduce the same standard adopted for public schools. In order to set the schools ready, we relied on the help from the Board of Education, of the State Department of Education. We held a meeting with the

[69] Actually, some well known state level exams (e.g. SARESP, of the State of São Paulo) are applied and corrected by the teachers themselves, instead of an external institution.

coordinators of each school to explain the objective and importance of the study and then we trained the teachers in charge of applying the exam. The training also included instructions on how to apply the socioeconomic questionnaires to be answered by students' parents or surrogates, the same guidelines public schools were provided with.

Altogether, 14 public schools and 9 private schools were assessed in Sertãozinho. Among those students enrolled in the 2nd grade of Elementary School, 1,986 took *Provinha Brasil* exam, which is a significant share considering the estimate of approximately 2,100 students enrolled in 2008. The exam was applied on the same day in both public and private schools. With regard to the questionnaires, they were applied in order to collect information about the socioeconomic characteristics and school history of students.[70] Parents were asked to fill out the questionnaires at teacher-parent meetings, or the questionnaires were sent to those parents who did not turn up for the meetings so that they could answer and return them later.

The information obtained this way was more reliable than that obtained on SAEB and on Prova Brasil from fourth-graders. Out of the 1,986 students who participated in *Provinha Brasil* in Sertãozinho, 1,850 questionnaires were returned. This represents a loss of only 6.85%, which is much lower than that of Prova Brasil questionnaires in 2007, in which 18.71% of fourth-graders did not answer any of the questions. Regarding the question about mother's level of education, for example, only 1% of the questionnaires filled out by the parents had "I don't know" as the answer. Conversely, in the questionnaires related to Prova Brasil in 2007, this rate was as high as 30.43%.

According to the descriptive statistics of the variables used in the estimations in the present study (Table 4.1), the average score on *Provinha Brasil* 2008 in Sertãozinho amounted to 547.9 points. According to the Brazilian Ministry of Education, this score is lower than what is desirable in terms of literacy (563.9 points or more). When we assess the results considering children's age at school admission, we note that the younger the children start attending school, the higher their literacy score. Recall that after the implementation of the nine-year Elementary School education, the age for school admission is 6 years. However, we verified that 84.2% of the students from Sertãozinho started attending school at the age of 5 years or less, allowing us to conclude that a significant share of the students had attended Early Childhood Education.

[70] With respect to school history, we collected information about the age at which children entered school and about which school they attended at each age. The questions on socioeconomic characteristics were based on the questionnaire of Prova Brasil 2005. The questionnaire applied in this study may be obtained from the authors upon request.

Table 4. 1 – Literacy Scores and characteristics of the 2nd grade students of Sertãozinho-São Paulo

	Variable	Obs	% within category	Mean Score	Std. Dev.	Min	Max
1	Literacy Scores (all students)	1986	100.0	547,9	77,1	272,1	665,0
2	Entered school at ages 7 or more	22	1.2	523,1	86,6	272,1	621,8
	Entered school at age 6	258	14.6	525,3	76,3	328,6	665,0
	Entered school at age 5	344	19.6	547,1	74,6	358,5	665,0
	Entered school at age 4	535	30.6	558,6	72,5	272,1	665,0
	Entered school at ages 3 or less	597	34.0	560,3	77,0	293,3	665,0
3	lives with mother and father	1358	73.5	554,2	75,5	272,1	665,0
	doesn't live with mother and father	486	26.5	540,2	78,1	272,1	665,0
4	Mother with College Education	101	5.6	590,0	69,2	385,6	665,0
	Mother with High School Education	373	20.3	580,0	69,4	328,6	665,0
	Mother with 8th grade completed	372	20.4	556,2	72,4	358,5	665,0
	Mother with 4th grade completed	682	37.2	542,4	75,8	328,6	665,0
	Mother without schooling	286	15.5	512,0	73,6	272,1	665,0
	Don't know mother's educational attainment	19	1.0	518,6	91,3	311,9	665,0
5	Parents don't go to school meeting	87	4.7	511,0	74,1	358,52	665,04
	Parents go to school meeting	1736	95.3	552,8	76,2	272,09	665,04
6	More than three rooms in the house	537	29.2	566,6	73,6	293,29	665,04
	Less than three rooms in the house	1309	70.8	543,7	76,8	272,09	665,04
7	Lives with 5 or more persons	818	44.3	538,8	77,8	272,09	665,04
	Lives with 4 or less persons	1026	55.7	559,5	74,4	272,09	665,04
8	Child study less than one day a week	140	7.8	512,0	79,4	272,09	665,04
	Child study one day or more a week	1642	92.2	555,2	75,0	272,09	665,04
9	Parents see children reading 3/4 days a week	727	40.3	566,5	73,4	358,52	665,04
	Parents see it less than 3 days a week	1078	59.7	540,5	77,2	272,09	665,04
10	Parents see their children playing 3/4 days a week	1523	85.3	551,7	77,2	272,09	665,04
	Parents see their children playing < 3 days a week	265	14.7	545,8	75,5	358,52	665,04
11	Male student	989	52.4	542,6	76,2	272,09	665,04
	Female student	897	47.6	556,6	77,0	293,29	665,04
12	White	999	54.5	558,6	77,0	272,09	665,04
	Brown	729	39.8	542,6	76,0	272,09	665,04
	Asian	12	0.7	557,9	73,6	491,32	665,04
	Indian	9	0.5	562,4	78,7	423,96	665,04
	Black	84	4.6	516,1	68,4	293,29	665,04
13	There is a quiet place for studying in the house	1576	86.2	555,0	76,2	272,09	665,04
	There isn't a quiet place for studying in the house	251	13.8	522,5	74,3	293,29	665,04
14	There is a computer with access to the internet	381	20.9	586,0	67,1	358,52	665,04
	There isn't a computer with access to the internet	1461	79.1	541,3	76,1	272,09	665,04
15	There are one or more DVD devices in the house	1554	84.9	554,4	76,0	272,09	665,04
	There aren't DVD devices in the house	278	15.1	527,8	77,7	272,09	665,04
16	Family has one or more automobiles	954	53.1	562,5	74,1	311,87	665,04
	Family has n't automobiles	839	46.9	537,1	77,6	272,09	665,04

Source: Questionnaire and Literacy Test (Provinha Brazil) applied to 2nd grade students (K-12 education) of Sertãozinho-São Paulo (and their parents).

In regard to family arrangement, those children who live with their father and mother achieved an average score of 554.2 points. Among those who did not have such a family arrangement, the average score corresponded to 540.2 points. Family size was also

important. Children from big families (5 people or more) had a lower average than those from smaller families (4 people or less), with an average difference of 20.7 points on literacy scores. As for the participation of parents in their children's school life, we found a difference of 41.9 points between students whose parents attended the school meetings and those whose parents did not do so. Finally, as expected, the higher the mother's level of education, the higher the student's score.

Another interesting information concerns the time children devoted to studying and reading. Those who spend more time studying or reading had better scores than those who study or read less often. The differences in scores corresponded to 43.2 and 26.0 points, respectively.

As far as the households where children live are concerned, we perceived that higher scores are associated with better socioeconomic conditions. Thus, students who live in a house with a larger number of bedrooms, with Internet access, a DVD player, and a car, had better scores than those students from socioeconomically underprivileged families. In addition, children whose households have a quiet place for studying had on average a score of 32.5 points higher than those who do not have it.

4.3 Estimation Strategy on the Presence of Self-Selections Bias

Average performance (in terms of literacy scores of *Provinha Brasil*) of students who started school at an earlier age is certainly higher than that of those who entered school later (Table 4.1). Notwithstanding, there is a consensus agreement in the literature that children with a better family background tend to start school earlier than those with less favorable social conditions. They self-select to receive treatment *S*, which in this case refers to earlier school admission.

Therefore, to obtain consistent estimates of earlier school admission on the literacy scores of *Provinha Brasil* from children aged 7 to 8 years, it is necessary to find an estimation strategy that corrects the self-selection bias inherent to the difference in averages between treatment and control groups.

Ideally, the real average effect of treatment on literacy could be known if it were possible to observe the same children in two distinct situations, one in which they had been enrolled at age *s* (treatment designated by S), and another one in which they had started school when they were *l* years old (control designated by L), where $s < l$. Thus, the average treatment effect (ATE) could be obtained by:

$$E\left[Y_i^S - Y_i^L\right] \tag{4.1}$$

where Y_i^S is the potential result of child *i* on *Provinha Brasil* if she belongs to treatment *S*, and Y_i^L is the potential result of this same child if she belongs to control group L.[71]

Nonetheless, it is not possible to observe the same individual in these two states simultaneously. But one can observe:

$$E\left[Y_i^S|S\right] - E[Y_i^L|L] \tag{4.2}$$

Adding and subtracting counterfactual $E[Y_i^L|S]$ in this equation, we have

$$E\left[Y_i^S|S\right] - E[Y_i^L|L] + E[Y_i^L|S] - E[Y_i^L|S] \tag{4.3}$$

rearranging

$$E\left[Y_i^S - Y_i^L|S\right] + E[Y_i^L|S] - E[Y_i^L|L] \tag{4.4}$$

The first term in (4) is the average treatment effect on treated subjects (ATT), and the two subsequent terms stand for the self-selection bias. The interest lies in ATT, but to

[71] The result observed can be denoted as $Y_i = Y_i^L(1 - D) + Y_i^S D$, where D is a variable that assumes value equal to 1 if individual *i* was submitted to treatment, and 0 otherwise.

estimate it, it is necessary to use an estimation method that rules out the self-selection bias. A very frequent solution described in the literature consists of social experiments based on treatment randomization for a selected set of individuals, resulting in a group of treated and untreated (control) subjects. By obtaining a perfect randomization of treated individuals, potential outcomes will be independent from the treatment status, and the self-selection bias will be null, i.e., $E[Y_i^L|S] - E[Y_i^L|L] = 0$. This way, equation 4 can be rewritten as

$$E\left[Y_i^S - Y_i^L|S\right] = E\left[Y_i^S|S\right] - E[Y_i^L|L] = E\left[Y_i^S - Y_i^L\right]^{72} \qquad (4.5)$$

Therefore, with a perfect randomization, it is possible to estimate the ATT by comparing the average outcomes of treated and untreated groups. However, in many cases, it is the individuals' interest to receive treatment, then it might be difficult to prevent them from self-selecting to participate in the treatment, especially in social experiments. In the case proposed in the present study, this difficulty is even more evident, as the age at which children are enrolled in school is determined by the characteristics (or preferences) of their families. Additionally, besides other difficulties related to the conduct of experiments,[73] follow-up time of observation units is also a hindrance. For example, if treatment refers to school admission at the age of 3 years, while control refers to school admission at a later age, it would take us about 4 years before we could assess the effects of treatment on literacy. This time period is too long, considering the lack of Brazilian studies on the topic and also the urgent necessity for novel studies that may contribute to the recent debate about the mandatory requirement of Early Childhood Education in Brazil.

In view of these arguments, a more appealing alternative for estimating the effects of Early Childhood Education on *Provinha Brasil* literacy scores is the use of non-experimental methods based on the hypothesis of selection according to observable characteristics. This can be done if the following assumption holds true: in a given set of observable characteristics X that determine the selection for treatment, potential outcomes do not depend on treatment status (RUBIN, 1977), that is

[72] This last equality requires the *Stable Unit Treatment Value Assumption* (SUTVA) to be true. This means that the potential outcome of one unit can not be related to the treatment status of another units.

[73] Duflo, Glennerster & Kremer (2006) describe several setbacks related to the conduct of random social experiments. They highlight the difficulty in avoiding the contamination of the control sample by possible treatment externalities and by social interactions. They also mention that costs may be remarkably high depending on the study design.

$$\{Y_i^S, Y_i^L \perp S_i\}|X_i \text{ (Unconfoundness Assumption)}^{74} \qquad (4.6)$$

In fact, this is a strong assumption, but we regard it as valid for the present study.

Nevertheless, note that if there are many covariates, it might be difficult to obtain cells with treatment and control groups in a sufficient amount to estimate the treatment effect.[75] An alternative proposed by Rosenbaum & Rubin (1983) to circumvent the dimensionality problem was the use of the propensity score ($p(X_i)$), which consists of a measure that combines individual characteristics into a single indicator with the same independence property between potential outcomes and treatment assignment

$$\{Y_i^T, Y_i^C \perp T_i\}|p(X_i) \text{ (Propensity Score Unconfoundness Assumption)}, \qquad (4.7)$$

where $p(X_i)$ gives each individual i the probability of receiving treatment based on her characteristics X_i and allows treated and untreated individuals with similar indicators to be compared. Another requirement is that observable characteristics should not fully determine treatment status, that is

$$0 < P(S_i = 1|X_i) < 1 \qquad (4.8)$$

In this study, the propensity score was obtained using a probit regression where the dependent variable S_i is equal to 1 if the individual is treated, i.e., if she started school at age s, and 0 if she started school at age l. Explanatory variables X_i that determine treatment were chosen based on two procedures: i) statistical significance; and ii) the "hit or miss"

[74] The notation used in (6) – *S* for treatment and *L* for control – is not the same one used by Rubin (1977), as it seeks to maintain the notation that was previously employed in this study.
[75] See Angrist (1998) for an application of a non-parametric matching.

method.[76] The first procedure consists in selecting covariates from a larger set whose coefficients are statistically significant. The second one consists in developing an indicator equal to 1 if $\hat{p}(X_i) > p$, and 0 otherwise, where $\hat{p}(X_i)$ is the estimated probability of receiving treatment and p is the percentage of treated individuals. The larger the number of correct predictions obtained with the indicator developed in relation to dependent variable S_i which designates treatment, the better the model.

The subsequent step consisted in choosing a matching algorithm based on the predicted propensity score matching (PSM) to estimate the effect of treatment on treated subjects (ATT_X). In line with Heckman, Ichimura & Todd. (1997),[77] the method used as benchmark among the different options available was the Kernel Matching (with a bandwidth of 0.06 and Epanechnikov weighting function). Using PSM has an advantage comparing to OLS conditioned on covariates, it does not suppose a linear additive functional form. For the sake of comparison and robustness check of the results, ATT_X were also estimated by: 1) Ordinary Least Squares (OLS) with covariates, 2) OLS with the reciprocal of the Propensity Score as weights;[78] 3) OLS with the Propensity Score as covariate;[79] 4) Nearest Neighbor PSM with replacement; 5) Nearest Neighbor PSM without replacement; 6) Nearest 10 Neighbors PSM with replacement; 7) Radius PSM with caliper of 0.1; 8) Radius PSM with caliper of 0.001; 9) Radius PSM with caliper of 0.0001[80]; 10) PSM within Strata with five strata; 11) PSM within Strata with 10 strata.[81]

Concomitantly with the PSM estimations, we ran tests to check whether the covariates were balanced between the treatment and control groups (i.e., to check whether both groups were alike). Two tests proposed by Rosenbaum and Rubin (1985) have such purpose. The first one consists of a *t* test to determine the differences between the averages of treatment and control groups for each covariate before and after the matching. The second test is based on the calculation of standardized biases of a given covariate, also before and after the matching. This test is obtained by the ratio between the difference of covariate means of the treatment and control groups and the squared root of the average of the variances of the same covariate for the treatment and control groups. A significant reduction in the bias, such

[76] See Breiman et al. (1984; apud HECKMAN, ICHIMURA & TODD, 1997)
[77] In fact, the authors use a Biweight weighting function.
[78] See Imbens (2004).
[79] See Imbens (2004).
[80] See Dehejia & Wahba (2002) for an application of this method.
[81] See Rosenbaum & Rubin (1983) and Dehejia & Wahba (2002).

that the bias indicator after the matching is lower than 5%, indicates that the explanatory variable was properly balanced.[82]

Another way to improve covariate balance was by using a trimming rule. This rule guarantees that observation units outside the common-support region will be excluded, as well as the treatment or control units within the common-support region located on a given interval (bin) of the histogram with a frequency lower than *q*%.[83]

With the results obtained from *Provinha Brasil* and the answers to the socioeconomic questionnaires applied to students' parents, nine groups were constructed for PSM implementation, each one of them referring to different treatments and controls. This is well illustrated in Table 4.2. In Group 1, for instance, children who started school at the age of 5 years or before were the treated subjects while those who only started school at the age of 6 or later were the controls. As previously mentioned, given that the correct age for admission to Elementary School in Sertãozinho is 6 years, treatment in Group 1 refers to the attendance of Early Childhood Education for at least one year, i.e., having started school at the age of 5 years or earlier; while control refers to not attending this stage, i.e., having started school at the age of 6 years or later.

From Groups 2 through 7, treatment *S* is always associated with a specific age at admission lower than the age at admission of children from control group *L*. All possible combinations based on this rule were employed. Differently, in Group 8, treatment refers to those students who started school at the age of 5 years or earlier in another town, whereas controls are those students who started school at the age of 6 years or later in Sertãozinho. This enabled the identification of the average difference of literacy scores between students who attended Early Childhood Education outside Sertãozinho and those who started Elementary School there. This strategy allows assessing the role of the quality of Early Childhood Education on students' literacy scores.

[82] Caliendo & Kopeinig (2005) provide the exact formula for the test. However, the maximum acceptable percentage of bias after the matching is not precisely known (the authors assert that 5% should suffice). So, it is important to analyze the two tests jointly.
[83] See Caliendo & Kopeinig (2005).

Table 4. 2 – Description of the different groups of treated and untreated units used for the Propensity Score Matching procedure

	Treated units	*Untreated units*
Group 1	*S*: Children who entered school at ages 5 or less	*L*: Children who entered school at ages 6 or more
Group 2	*S*: Children who entered school at ages 3 or less	*L*: Children who entered school at age 6
Group 3	*S*: Children who entered school at age 4	*L*: Children who entered school at age 6
Group 4	*S*: Children who entered school at age 5	*L*: Children who entered school at age 6
Group 5	*S*: Children who entered school at ages 3 or less	*L*: Children who entered school at age 5
Group 6	*S*: Children who entered school at age 4	*L* Children who entered school at age 5
Group 7	*S*: Children who entered school at ages 3 or less	*L*: Children who entered school at age 4
Group 8	S^{*}: Children who entered school at ages 5 or less in another municipality	L^{*}: Children who entered school at ages 6 or more
Group 9	S^{**}: Children who entered a private school at ages 5 or less	L^{**}: Children who entered a public school at ages 5 or less

[*] This groups were built to evaluate the quality of the Early Childhood Education of Sertãozinho by comparing the scores of children who enter school at an early age in this municipality with the scores of children who enter school with the same age some place else.

[**] This groups were built to evaluate the quality of the Public Early Childhood Education of Sertãozinho by comparing the scores of children who enter school at an early age in the public school system with the scores of children who enter private schools with the same age.

In Group 9, on the other hand, we tried to consider treatment and control units in such a manner as to distinguish the results between those who attended Early Childhood Education in public schools and those who did it in private schools. Treatment in this case consisted in starting school at the age of 5 years or earlier in private schools while the control group included those who started school at the same age but in public schools. This econometric exercise is important to complement the estimation of the effect of earlier school admission on literacy. As occurred in Group 8, this exercise goes beyond the idea that earlier school admission alone is sufficient for the improvement of future school performance, as the objective is to gather evidence of the role of Early Childhood Education quality on literacy.

4.4 Results

In this section, we present the econometric results obtained to assess the effect of Early Childhood Education on children's literacy. The variables that define the treatment and control groups used to capture this effect refer to the ages at which children were enrolled in school. These variables are more suitable to achieve the intended target, as they allow assessing whether there are striking differences between children who attended Early Childhood Education for one year and those who did it for more than one year.

First, in Table 4.3, we present the OLS estimates (with robust standard errors in parenthesis) of the effects of earlier school admission. As proposed by Rubin (1977), conditional on a set of covariates that define treatment, treatment variables are independent from potential outcomes, and an OLS estimation should produce unbiased estimates. We checked whether the fact that a child attended Early Childhood Education, i.e., if she started Early Childhood Education at the age of 5 years or earlier, has a positive effect on the literacy score (OLS 1, OLS2 and OLS3 specifications), comparatively to children who only started school at the age of 6 years or later. The OLS1 estimation coefficient represents the result that is not conditional on the child's observable characteristics, and therefore, it should be biased. In this case, we observed a literacy score of 31.45 points greater than that obtained by students who did not attend Early Childhood Education.

In OLS2 specification, it was possible to assess the effect of Early Childhood Education when we controlled for the set of covariates used to obtain the propensity score related to the probability of each student receiving treatment, which we call a "smaller set." Note that the magnitude of the coefficient of the variable "children who entered school at ages 5 or less" was lower than in OLS1 specification, producing a positive effect of 13.65 points on the literacy score compared to the control group.

The magnitudes of dummy coefficients related to the age at which a child started school changed when we inserted the covariates used to obtain the propensity score (smaller set). In the OLS5 specification, we observed that children who started school at the age of 5, 4 or 3 years presented literacy scores 10.91, 11.33 and 17.66 points higher than those who entered school at the age of 6 years or later, respectively. The same was observed in the OLS6 specification, in which we used more covariates (full set).

The estimates based on Propensity Score Matching are shown in Table 4.4.[84] As mentioned in the previous section, our main results are based on Kernel Matching,[85] which are highlighted in gray. The other matching methodologies were implemented to check the robustness of the results.

[84] The standard errors of these estimates were calculated conventionally and not by bootstrapping. Abadie & Imbens (2006) show that standard errors are not valid if calculated by the bootstrapping method when Nearest Neighbor Matching is implemented. For the other matching algorithms it is not clear whether it is possible or not to apply this technique. We calculated these standard errors, which can be obtained from the authors upon request. However, we highlight that no important difference was verified.

[85] Table A.4 of the Appendix 3 shows the number of observations on and off common-support region obtained by Kernel Matching.

By analyzing Group 1 (treatment and control), we observed that treatment effect is positive and significant. Children who started school at the age of 5 years or less, presented literacy scores of 17.33 points higher compared to those who only started school at the age of 6 years or later.

In Group 2, which is composed of children enrolled in school at the age of 3 years or less (treatment group) and of children enrolled at school at the age of 6 years (control group), we found a difference of 19.54 points in the literacy scores between the treatment and control groups. If we consider the same treatment individuals and the control units as children who were enrolled in school at the age of 5 years (Group 5), the difference was 10.09 points, slightly lower than in Group 1. However, there was no statistically significant difference in the literacy scores between the children who entered school at the age of 3 or less with those entered at the age of 4 (Group 7).

Table 4. 3 – OLS estimates of the effects of Early Childhood Education on Provinha Brasil literacy scores conditioning on covariates

	OLS 1	OLS 2	OLS 3	OLS 4	OLS 5	OLS 6
Children who entered school at ages 5 or less	31.45*** (5.00)	13.65** (5.47)	14.99*** (5.56)	..	..	..
Children who entered school at age 5	..	..	..	21.98*** (6.10)	10.81* (6.45)	12.22* (6.52)
Children who entered school at age 4	..	..	..	33.44*** (5.56)	11.33* (6.07)	13.16** (6.19)
Children who entered school at age 3 or less	..	..	..	35.11*** (5.57)	17.66*** (5.97)	18.50*** (6.08)
Covariates	no	yes (smaller set)	yes (full set)	no	yes (smaller set)	yes (full set)
R-squared	0,02	0,15	0,18	0,03	0,15	0,18
N	1,756	1,599	1,528	1,756	1,599	1,528

(1) The smaller set of covariates contains dummy variables equal to 1 if the following statement is true (and 0 otherwise): lives with mother and father; a set of dummy variables indicating mother education (College Education completed, High School Education completed, 8th grade completed, and 4th grade completed - the omitted comparison group are the children whose mothers have no education or doesn't have the 4th grade completed); parents go to school meeting; more than three rooms in the house ; lives with more than 5 persons; child study less than one day a week; parents see their children reading 3 or 4 days a week; parents see their child playing 3 or 4 days a week; male student ; black student. (2) Besides the smaller set of covariates, the full set of covariates contains the following additional variables (equal to 1 if the following statement is true and 0 otherwise): there is a quiet place for studying in the house; there is a computer with access to the internet; there are one or more DVD devices in the house; family has one or more automobiles. (3) The omitted category refers to those students who entered school at ages 6 or more.

On the other hand, if treatment refers to school admission occurred at the age of 4 years, while control refers to school admission at the age of 6 years (group 3), we observed a positive and significant effect of 18.25 points in the literacy scores of treated children.

However, this effect is not perceived in Group 6, in which the treated children are exactly the same students in Group 3, and control subjects are those students enrolled in school at the age of 5 years.

Group 4 refers to students who started school at the age of 5 years (treatment) and those who entered school at the age of 6 years (control). In this case, we observed that treated children had a literacy score 17.89 points higher.

It is important to underscore that we carried out two additional exercises. One to evaluate the effect of a child starting school at the age of 5 years or less (i.e., submitted to Early Childhood Education) in another municipality; and another one to measure the effect of a child having attended a private school at the same age. First, Group 8 presents the comparison between students who enrolled in school at the age of 5 years or less in another municipality (treatment) and those who enrolled in school at the age of 6 years (control) in Sertãozinho. Note that treated children had a literacy score of 5.65 points lower, but this difference was not statistically significant. This result indicates that the literacy scores obtained by students in each of these groups are similar. It also indicates the fact that students had Early Childhood Education does not guarantee that they will have higher literacy scores, and thus it favors the choice of a municipality in which Early Childhood Education is well structured.

Group 9 included children admitted to a private school at the age of 5 years or less (treatment), and those who had Early Childhood Education in a public school (control). The results do not show significant differences in literacy scores between the two groups. This result confirms that Early Childhood Education provided by public schools is as good as that offered at private schools, suggesting that public schools, with the largest number of vacancies in Sertãozinho, have a good structure and fulfill the purpose of educating rather than just taking care of children of worker parents (considering that private schools offer appropriate quality standard).

Generally, the other Propensity Score Matching procedures produce very similar results to those of Kernel Matching. The exceptions are the estimates generated by Nearest Neighbor and Nearest Neighbor Matching without reposition, whose results were mostly nonsignificant. However, both methods work more adequately when the amount of control units is much larger than treated ones, which is not the case in this paper.

Table 4.4 – Estimates of the Average Treatment Effect on the treated for different groups of treated and control units

	GROUPS								
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***
OLS - Reciprocal of Propensity Score as weights	10.32 (7.65)	18.39*** (6.92)	13.39* (7.88)	15.32** (7.24)	8.79 (5.39)	0.4 (5.60)	7.34 (4.82)	-2.62 (16.18)	-14.9 (21.54)
OLS with the Propensity Score as covariate	13.33** (5.63)	18.63*** (6.45)	15.01** (6.91)	15.66** (7.04)	7.25 (5.36)	0.41 (5.34)	6.47 (4.70)	-8.58 (12.36)	5.96 (7.07)
Epanechnikov Kernel bandwith (0.06)	17.33*** (6.67)	19.54*** (7.44)	18.25** (8.03)	17.89** (7.51)	10.09* (5.69)	-1.33 (5.71)	6.47 (4.91)	-5.65 (13.49)	7.87 (9.53)
Nearest Neighbor with replacement	18.67* (10.16)	13.18 (10.69)	5.24 (12.36)	22.38** (11.24)	-1.29 (9.09)	-3.54 (9.85)	3.46 (8.86)	11.2 (16.22)	7.65 (12.09)
Nearest Neighbor without replacement	-5.98 (7.02)	13.58* (7.26)	12.28* (7.13)	12.93* (7.22)	2.22 (6.01)	-0.84 (5.91)	5.17 (4.70)	-3.35 (13.95)	4.47 (7.60)
Nearest 10 Neighbors with replacement	17.6** (7.42)	18.04** (7.73)	21.23** (8.23)	19.26** (7.91)	8.69 (5.93)	-1.41 (6.03)	6.52 (5.20)	-0.65 (13.40)	2.64 (8.56)
Radius (Caliper δ = 0.1)	20.76*** (6.23)	20.33*** (7.06)	19.62** (7.75)	19.91*** (7.17)	9.85* (5.56)	-0.01 (5.60)	6.15 (4.76)	-3.04 (13.39)	9.53 (8.70)
Radius (Caliper δ = 0.001)	16.74** (8.29)	21.74** (9.09)	24.68** (10.52)	17.75* (9.05)	3.03 (6.88)	2.21 (6.92)	10.84* (5.53)	-6.08 (15.30)	11.13 (10.31)
Radius (Caliper δ = 0.0001)	20.54** (8.52)	15.53 (9.65)	19.89* (10.99)	22.98** (9.81)	6.6 (7.25)	1.98 (7.23)	6.46 (5.82)	-9.67 (15.72)	2.36 (11.29)
Matching within stratum (5 strata)	16.11 (13.44)	18.3 (18.09)	15.44** (7.51)	14.92 (19.33)	15.25 (22.06)	6.35 (11.33)	4.9 (9.26)	-5.33 (12.08)	3.25 (24.22)
Matching within stratum (10 strata)	14.87 (14.44)	18.55 (25.82)	17.15 (16.20)	13.29 (20.92)	18.05 (28.98)	6.76 (18.37)	10.13 (12.92)	-9.7 (47.04)	12.69 (29.71)

(1) The propensity score is estimated using the probit method. The covariates included in the equation are all dummy variables equal to 1 if the following statement is true (and 0 otherwise): lives with mother and father; a set of dummy variables indicating mother education (College Education completed, High School Education completed, 8th grade completed, and 4th grade completed - the omitted comparison group are the children whose mothers have no education or doesn't have the 4th grade completed); parents go to school meeting; more than three rooms in the house ; lives with more than 5 persons; child study less than one day a week; parents see their children reading 3 or 4 days a week; parents see their child playing 3 or 4 days a week; male student ; black student. The results of the probit estimations can be obtained upon request. (2) The group 9 includes the following additional covariates in the probit model (equal to 1 if the following statement is true and 0 otherwise): there is a quiet place for studying in the house; there is a computer with access to the internet; there are one or more DVD devices in the house; family has one or more automobiles. This was necessary because of the Treatment status in this case, given by the students enrolled at private schools at ages of 5 or less, opposed to those enrolled at public school with the same age (control units). We had to include more covariates that discriminate family income to obtain a better matching.

Finally, the results obtained show that children who attended at least one year of Early Childhood Education (i.e. enrolled in school at the age of 5 years or less) presented a higher literacy score than those who did not attend this stage. Furthermore, the sooner the student entered the Early Childhood Education, compared with those who did not attend this level of education, the greater the literacy scores. But the returns (in terms of literacy scores) of an additional year of education at an early age seems to be diminishing, as one can note by the statistically significant difference in mean literacy scores between children who entered school at the ages of 5 and 6 years (The last referring to those that did not enrolled at Early Childhood Education) together with a smaller and statistically significant difference in scores between those who were enrolled at the age of 5 years and those who were enrolled at the age of 3 years or less. This leads to the conclusion that one year of Early Childhood Education (just before entering the K-12 education), offered by a well structured educational system such as that in Sertãozinho, may be enough for children to be practically literate by the age of 7 or 8 years. This does not mean that there will not be skill differences between those who attended Early Childhood Education for one year and those who did it for a longer period of time. In this paper only a limited set of skills was assessed: those skills that determine literacy. Enrollment in school at the age of 3 years or less, for instance, may contribute to the development of other important skills not contemplated by *Provinha Brasil*. Thus, assessing a broader set of skills may well be consistent with constant or even increasing returns to Early Childhood Education.

4.5 Testing

In what follows, we present the tests carried out to verify matching quality. This process was done simultaneously with the propensity score estimation, so that the final specification could show an adequate covariate balance of treatment and control units.

As mentioned in Section 4.3, two types of tests were performed to verify whether the covariates that determine the treatment (Groups 1 through 9)[86] were balanced between treated and control subjects. One of them consists of the difference in covariate means

[86] See Table 4.2.

between treated and control individuals, and the other one consists of the calculation of bias reduction, both carried out after the matching. The differences between covariate means and the standardized bias calculated before the matching are not reported in Table 4.5, but they may be obtained upon request. Both tests are based on Kernel PSM, defined as the main method in this paper. Figures 4.1 through 18 show additional tests used to analyze matching quality. These figures represent Kernel density functions of the estimated propensity scores (with Epanechnikov weighting function, to be consistent with the strategy used in this paper) before and after the matching.

The first column of Table 4.5 show the tests for Group 1. Considering a 5% maximum acceptable rate for standardized bias, and a p-value of at least 10% for the difference of means *t* test after the matching, four variables could not be balanced according to the two tests: Lives with mother and father; Mother with High School Education; Mother with 8th grade completed; and Parents see their children playing 3 or 4 days a week. Even after attempts to include cross variables and the application of trimming rules with many values, these variables could not be balanced.[87] However, the bias was substantially reduced for these variables (on average 54.5%).[88] In addition, Figures 4.1 and 4.2 clearly show that densities after the matching overlap, indicating that the procedure was successful, despite the fact that the tests demonstrate that the four variables mentioned above could not be balanced.

In the second column of Table 4.5, referring to treatment and control Group 2, three variables presented standardized bias greater than 5% after the matching: Lives with mother and father; Mother with High School Education, and Parents see their children playing 3 or 4 days a week. However, the p-value of the *t* test for all covariates was higher than 10%, and Figures 4.3 and 4.4 show that density functions overlap almost perfectly after the matching, indicating an adequate balance.

[87] The final result estimated for Group 1 was based on a trimming rule of 10% without crossed variables. This yielded the best results for covariate balance.
[88] This result can obtained from the authors upon request.

Table 4.5 – Tests of difference between the covariates of treated and control groups after Matching

		GROUPS								
		1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***
lives with mother and father	Treated	0.76	0.69	0.81	0.77	0.71	0.81	0.70	0.80	0.85
	Control	0.73	0.66	0.81	0.77	0.69	0.82	0.72	0.78	0.81
	Bias (%)	6.3	6.8	-0.7	0.9	3.1	-1.4	-4.7	4.9	11.7
	Diff p>|t|	0.11	0.29	0.91	0.91	0.62	0.81	0.46	0.78	0.27
Mother with College Education	Treated	0.00	0.00	0.00	0.00	0.10	0.04	0.10	0.04	0.33
	Control	0.00	0.00	0.00	0.00	0.08	0.04	0.11	0.04	0.34
	Bias(%)	-1.8	0.0	0.0	0.0	7.7	-0.9	-3.0	0.0	-3.2
	Diff p>|t|	0.17	.	.	.	0.27	0.89	0.69	1.00	0.84
Mother with High School Education	Treated	0.25	0.27	0.26	0.18	0.24	0.27	0.24	0.27	0.33
	Control	0.19	0.24	0.23	0.18	0.25	0.27	0.25	0.27	0.30
	Bias (%)	16.3	7.9	8.8	1.2	-1.7	-1.6	-1.0	1.0	6.1
	Diff p>|t|	0.00	0.30	0.25	0.90	0.80	0.81	0.87	0.97	0.60
Mother with 8th grade completed	Treated	0.24	0.25	0.27	0.18	0.22	0.24	0.22	0.13	0.13
	Control	0.28	0.26	0.31	0.18	0.23	0.24	0.23	0.13	0.12
	Bias (%)	-8.9	-2.5	-12.0	1.5	-1.6	-0.4	-0.7	0.4	0.7
	Diff p>|t|	0.05	0.72	0.11	0.86	0.80	0.96	0.90	0.98	0.94
Mother with 4th grade completed	Treated	0.38	0.33	0.38	0.44	0.30	0.36	0.30	0.42	0.16
	Control	0.40	0.35	0.36	0.44	0.30	0.35	0.29	0.41	0.18
	Bias (%)	-2.8	-3.6	3.8	-0.2	-0.6	2.2	1.9	0.9	-2.9
	Diff p>|t|	0.49	0.57	0.56	0.98	0.92	0.73	0.75	0.96	0.76
Parents go to school meeting	Treated	0.03	0.05	0.02	0.05	0.04	0.02	0.04	0.04	0.01
	Control	0.03	0.04	0.02	0.06	0.04	0.02	0.04	0.04	0.01
	Bias (%)	1.3	2.9	0.3	-3.4	1.6	2.7	1.7	-2.3	-0.6
	Diff p>|t|	0.60	0.55	0.93	0.61	0.78	0.59	0.81	0.88	0.93
More than three rooms in the house	Treated	0.28	0.30	0.29	0.24	0.35	0.33	0.35	0.15	0.59
	Control	0.30	0.29	0.33	0.25	0.34	0.32	0.35	0.13	0.58
	Bias (%)	-4.1	2.4	-7.2	-2.7	0.9	1.6	-1.0	3.2	2.2
	Diff p>|t|	0.34	0.73	0.31	0.75	0.89	0.81	0.88	0.86	0.86
Lives with 5 or more persons	Treated	0.42	0.39	0.44	0.46	0.37	0.43	0.37	0.36	0.22
	Control	0.43	0.39	0.43	0.46	0.37	0.40	0.36	0.36	0.24
	Bias (%)	-0.4	-0.2	2.3	1.3	-0.2	4.5	1.4	0.3	-4.2
	Diff p>|t|	0.91	0.98	0.73	0.87	0.98	0.48	0.82	0.99	0.68
Child study less than one day a week	Treated	0.05	0.06	0.06	0.05	0.06	0.05	0.06	0.04	0.02
	Control	0.07	0.07	0.09	0.06	0.06	0.04	0.06	0.05	0.02
	Bias (%)	-5.0	-1.1	-8.9	-4.2	-1.9	2.8	-1.0	-3.4	-2.8
	Diff p>|t|	0.11	0.83	0.11	0.50	0.76	0.64	0.87	0.80	0.74
Parents see their children reading 3 or 4 days a week	Treated	0.41	0.40	0.45	0.37	0.41	0.45	0.41	0.38	0.48
	Control	0.40	0.39	0.43	0.38	0.41	0.43	0.42	0.35	0.48
	Bias (%)	2.5	0.8	4.4	-3.8	1.1	3.8	-0.6	6.9	0.3
	Diff p>|t|	0.55	0.90	0.52	0.65	0.86	0.56	0.92	0.72	0.98
Parents see their children playing 3 or 4 days a week	Treated	0.87	0.86	0.87	0.88	0.86	0.88	0.86	0.82	0.93
	Control	0.84	0.84	0.83	0.88	0.88	0.89	0.86	0.82	0.91
	Bias (%)	7.6	6.2	9.8	1.6	-3.5	-2.4	-0.2	0.5	6.1
	Diff p>|t|	0.04	0.31	0.12	0.83	0.57	0.70	0.97	0.98	0.53
Male student	Treated	0.53	0.51	0.53	0.57	0.50	0.53	0.50	0.58	0.53
	Control	0.54	0.50	0.54	0.57	0.51	0.55	0.50	0.58	0.58
	Bias (%)	-1.6	1.1	-0.4	-0.5	-2.8	-3.7	-0.1	0.7	-10.8
	Diff p>|t|	0.70	0.86	0.95	0.95	0.64	0.56	0.99	0.97	0.34
Black student	Treated	0.03	0.05	0.02	0.03	0.04	0.03	0.04	0.02	0.01
	Control	0.04	0.06	0.03	0.03	0.05	0.03	0.04	0.01	0.01
	Bias (%)	-2.4	-3.0	-3.4	-0.8	-2.6	0.8	2.9	1.7	-2.3
	Diff p>|t|	0.44	0.60	0.49	0.90	0.69	0.89	0.63	0.88	0.72

(1) The dots indicate that all observations were excluded after matching because the treated and control groups could not be balanced. (2) The tests for the covariates of Group 9 include additional variables (equal to 1 if the following statement is true and 0 otherwise) such as: there is a quiet place for studying in the house; there is a computer with access to the internet; there are one or more DVD devices in the house; family has one or more automobiles. All tests show that the covariates are balanced, but we decide to omit the results for these additional variables to save space. The results of the tests can be obtained on request.

For Group 3 (third column of Table 4.5), the standardized bias test indicated five covariates with bias greater than 5%: Mother with High School Education; Mother with 8th grade completed; More than three rooms in the house; Child studies less than one day a week; and Parents see their children playing 3 or 4 days a week. But, in none of these cases did the *t* test reject the null hypothesis of equality between covariate averages of treatment and control groups. Moreover, figures 4.5 and 4.6 show a practically perfect overlapping of densities after the matching.

In group 4, both the t test and the standardized bias test demonstrate adequate balance of the explanatory variables of the regression necessary to obtain the propensity scores. Figures 4.7 and 4.8 show that density largely overlaps, which allows us to conclude that the variables could be properly balanced.

The only variable that presents a standardized bias greater than 5% in Group 5 is "Mother with College Education". On the other hand, the result of the *t* test shows that the null hypothesis of equality between the mean values of the covariate of treated and control units cannot be rejected. All the other variables were balanced after the matching according to the two tests used and with figures 4.9 and 4.10.

In groups 6 and 7, the results of the tests for covariate balance were satisfactory in all cases. Figures 4.11 through 4.14 confirm improved compatibility after the matching. On the other hand, in Group 8, the variable "Parents see their children reading 3 or 4 days a week" presented a standardized bias greater than 5% (equal to 6.9%). But the *t* test did not reject the null hypothesis of equality between the means of the control and treatment units, and Figures 4.15 and 4.16 also demonstrate that matching was adequate.

In Group 9, Lives with mother and father; Mother with High School Education; Parents see their children playing 3 or 4 days a week; and Male student[89] presented a standardized bias greater than 5%, and therefore, they did not have an adequate balance according to this criterion. However, considering the *t* test, the hypothesis of equality between

[89]Two of four covariates of Group 9 not reported in Tables 4.5 (see note 2 in this table to know all the variables whose tests were not reported) presented standardized bias greater than 5%: There are one or more DVD players in the household (bias of 5.9%); family owns one or more cars (bias of 7.2%). However, the p-values of the *t* tests performed for these variables were all smaller than 10%, indicating no significant differences between treatment and control groups.

the means of the variables for the treatment and control groups could not be rejected. Figures 4.17 and 4.18 show that density functions remarkably overlapped after the matching.[90]

[90]Figures 4.17 and 4.18 have different scales. If they are placed on the same scale, it is possible to observe intense overlapping of the density function of the propensity score after the matching.

Figure 4.1 - Kernel density before matching - Group 1: Treated (Age 5 or less) vs Control (Age 6 or more)

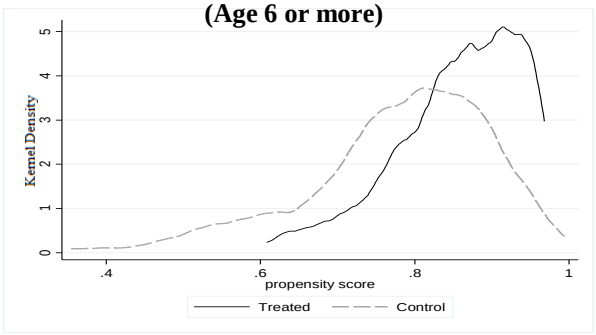


Figure 4.2- Kernel density after matching - Group 1: Treated (Age 5 or less) vs Control (Age 6 or more)

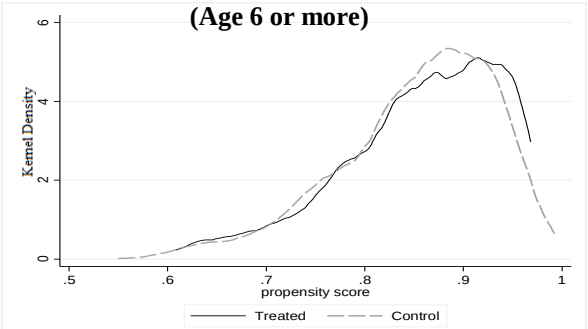


Figure 4.3 - Kernel density before matching - Group 2: Treated (Age 3 or less) vs Control (Age 6)

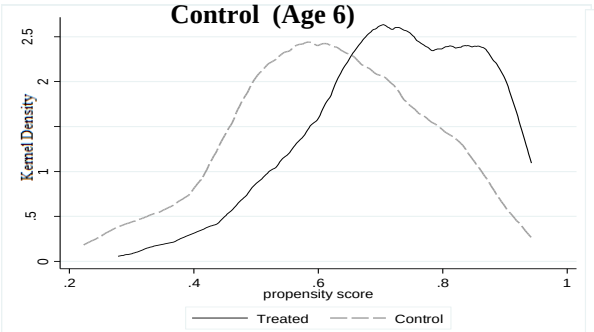


Figure 4.4 - Kernel density after matching - Group 2: Treated (Age 3 or less) vs Control (Age 6)

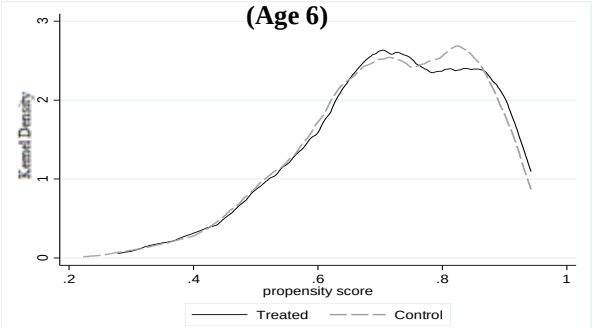


Figure 4.5 - Kernel density before matching - Group 3: Treated (Age 4) vs Control (Age 6)

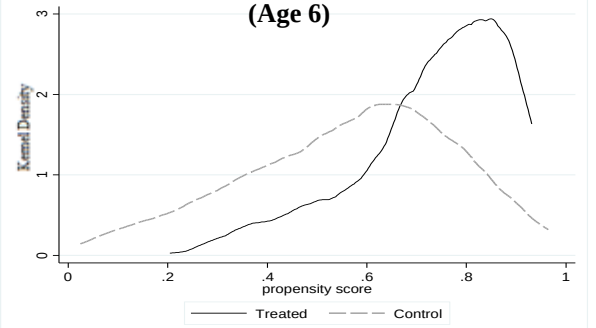


Figure 4.6 - Kernel density after matching - Group 3: Treated (Age 4) vs Control (Age 6)

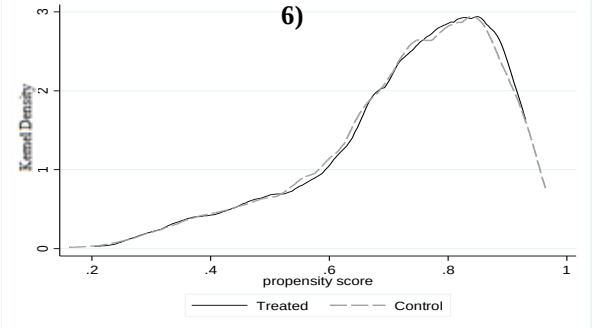


Figure 4.7 - Kernel density before matching - Group 4: Treated (Age 6) vs (Control: Age 5)

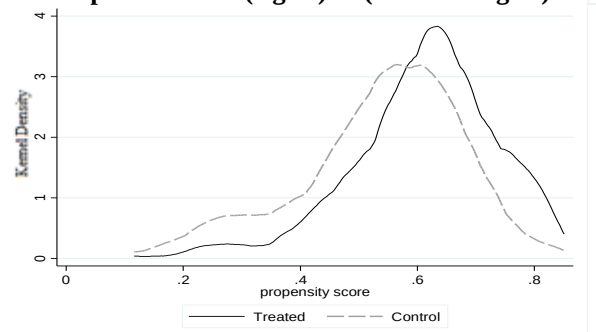


Figure 4.8 - Kernel density after matching - Group 4: Treated (Age 6) vs (Control: Age 5)

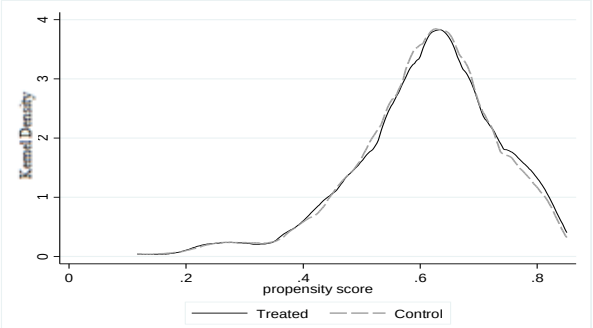


Figure 4.9 - Kernel density before matching - Group 5: Treated (Age 5) vs (Control: Age 3 or less)

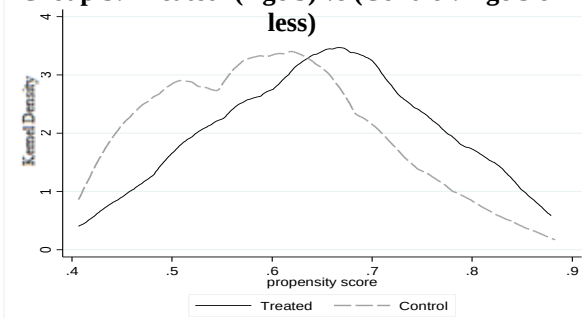


Figure 4.10 - Kernel density after matching - Group 5: Treated (Age 5) vs (Control: Age 3 or less)

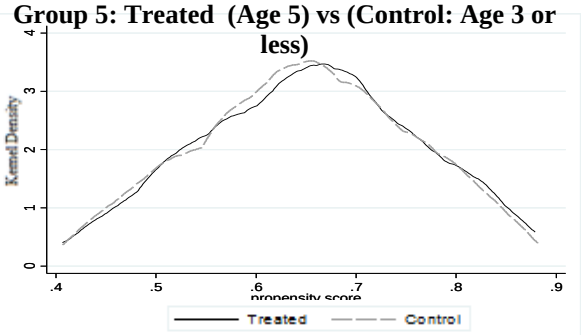


Figure 4.11 - Kernel density before matching - Group 6: Treated (Age 5) vs (Control: Age 4)

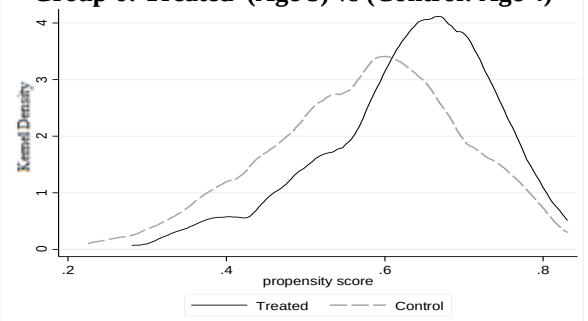


Figure 4.12 - Kernel density after matching - Group 6: Treated (Age 5) vs (Control: Age 4)

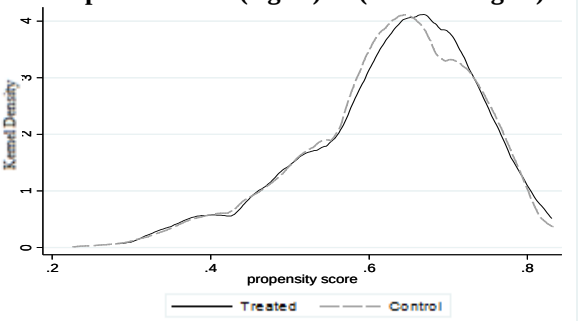


Figure 4.13 - Kernel density before matching - Group 7: Treated (Age 4) vs (Control: Age 3 or less)

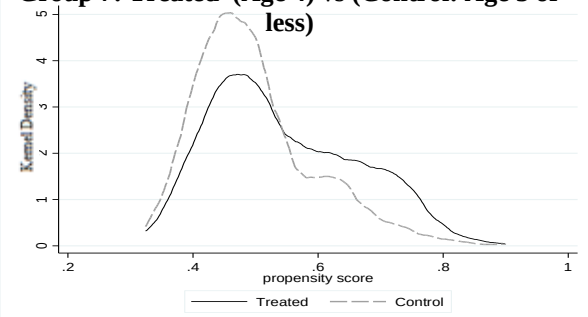


Figure 4.14 - Kernel density after matching - Group 7: Treated (Age 4) vs (Control: Age 3 or less)

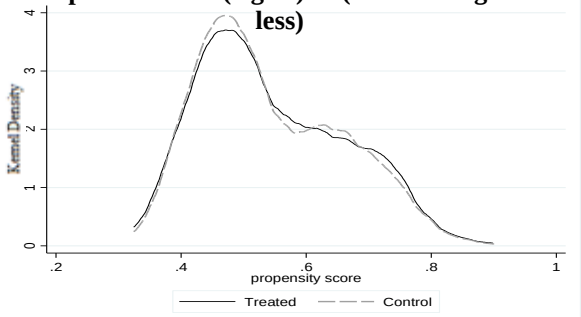


Figure 4.15 - Kernel density before matching - Group 8: (Treated: Age 5 - another municipaly) vs (Control: Age 6 or more in the municipality)

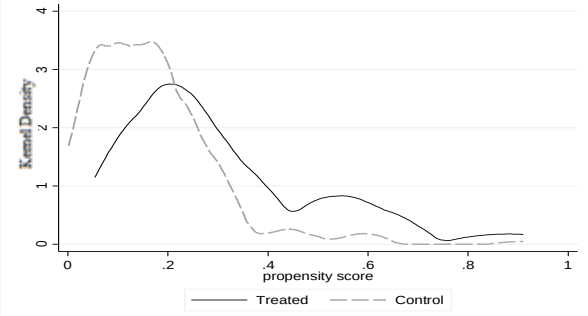
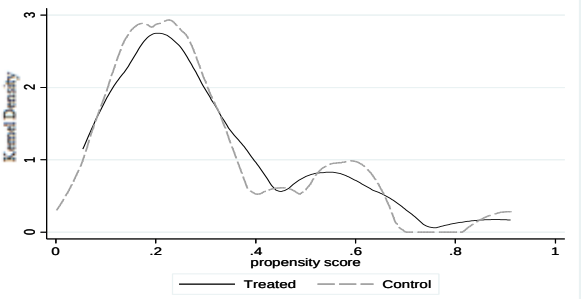


Figure 4.16 - Kernel density after matching - Group 8: (Treated: Age 5- another municipaly) vs (Control: Age 6 or more in the municipality)



Finally, we should highlight that the test results suggest good covariate balance. This means that the treatment and control groups are very similar after the matching, attaching high reliability to the results estimated in Section 5.

Figure 4.17 - Kernel density after matching - Group 9: (Treated: Age 5- private school) vs (Control: Age 5- public school)

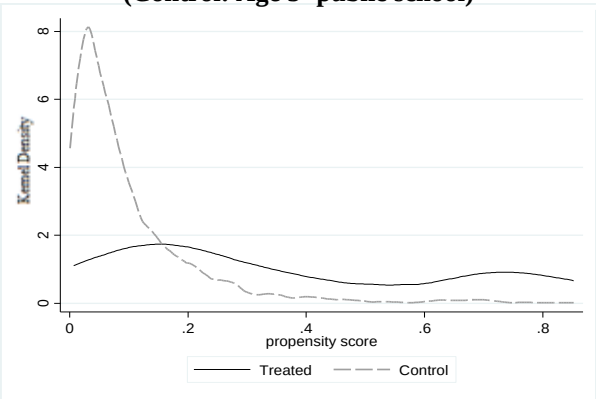
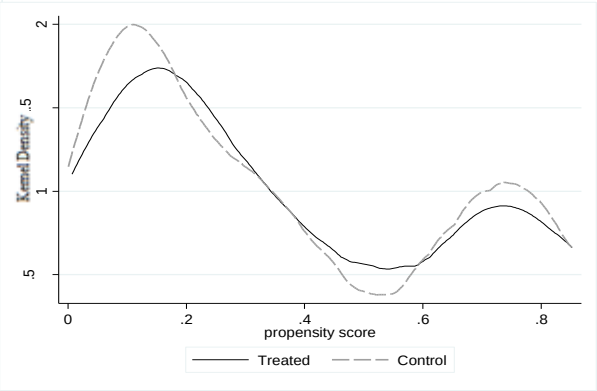


Figure 4.18 - Kernel density before matching - Group 9: (Treated: Age 5- private school) vs (Control: Age 5- public school)



4.6 Final Remarks

This paper aimed to identify the effects of Early Childhood Education on children's literacy scores. To do that, we used data from *Provinha Brazil* applied in Sertãozinho to students attending the 2nd grade of Elementary School plus a socioeconomic questionnaire answered by the parents. The main contribution of this paper to the literature was to explore this new assessment tool proposed by the Brazilian Ministry of Education. In addition, to our knowledge, there are no studies in the literature, at least not in Brazil, that evaluate the relationship between earlier school admission and literacy scores.

The results obtained in this paper with Propensity Score Matching (and also with OLS) demonstrate that students who started school at the age of 5 years or less had higher literacy scores than those who started school at the age of 6 or later. In general, students who started school at the ages of 5, 4 and 3 years or less obtained literacy scores between 12.22 and 19.54 points higher than those who started school at the age of 6 (or later). The results reasonably suggest that the returns in terms of literacy scores are diminishing in relation to the

number of years of Early Childhood Education as the effect of attending school at the age of 3 or less (ie. Three or more years of Early Childhood Education) are less than three times greater that found among students that entered school at the age of 5 years (ie. One year of Early Childhood Education).

Indeed, there might be a problem with external validity of these results. Although the study used a non-experimental method to estimate the treatment effect, it has the same problems as experiments or non-experimental studies with treatment and control groups that belong to one locality. The effect of Early Childhood Education on the literacy of students all over Brazil can be even more pronounced. But we believe that the results obtained in this work constitute a good guidance for the implementation of public policies.

Finally, we underscore that this discussion is very relevant to the Brazilian case. If investments in education in early childhood are essential to skill development later in life, it is necessary to invest more heavily in Early Childhood Education (before the age of 6 years) in order to improve the quality of education in Brazil. However, school attendance rates in Brazil are not universalized yet, and expenditures per student are much lower than those verified in developed countries. This stresses that a lot more effort should be put in to expand the coverage and improve the quality of this stage of education.

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APPENDIX

Appendix 1st Essay: Table A. 4– Results Dependent Variable: Per young education expenditure

Independent Variables	Fixed-Effect Poterba	POLS	FE	POLS-IV (Group I)	FE-IV (Group I)	POLS-IV (Group II)	FE-IV (Group II)
Elderly above 65 years who co-reside with young under 18	-	-0.0059	0.0669***	0.4271***	0.7669***	0.5532***	0.5157***
		(0.014)	(0.0172)	(0.1385)	(0.289)	(0.1667)	(0.19)
Elderly over 65	-0.0559***	-0.0446***	-0.0708***	-0.1941***	-0.2668***	-0.2381***	-0.1934***
	(0.0102)	(0.0074)	(0.0103)	(0.0481)	(0.0834)	(0.0572)	(0.0578)
Per capita Income	0.0055	0.3065***	0,0086	0.4567***	0,0418	0.4999***	0,0299
	(0.053)	(0,034)	(0,0527)	(0,066)	(0,0656)	(0,0759)	(0,0575)
Young under 18	-0.0144**	-0.0322***	-0.0140**	-0.0569***	-0,0113	-0.0642***	-0.0122*
	(0.006)	(0.0032)	(0.006)	(0.0084)	(0.0088)	(0.0101)	(0.0074)
Non-white	-0.0029***	-0.0002	-0.0025***	-0.0032***	0.0022	-0.0041***	0.0004
	(0.0009)	(0.0006)	(0.0009)	(0.0011)	(0.0024)	(0.0013)	(0.0018)
Urban Population	0.0002	0.0001	-0.0001	-0.0017*	-0.0029	-0.0022**	-0.0019
	(0.0017)	(0.0006)	(0.0017)	(0.0009)	(0.0027)	(0.001)	(0.0023)
Young black share in the black population - Elderly black (share in the black population)	-0.0044	0.1216	0.0208	0.3067**	0.2919	0.3607**	0.194
	(0.1218)	(0.1023)	(0.1197)	(0.1366)	(0.2095)	(0.1521)	(0.1762)
Less than 5 years of migration	0.0053**	0.0095***	0.0052**	0.0080***	0.003	0.0076***	0.0039
	(0.0025)	(0.0019)	(0.0025)	(0.0022)	(0.0037)	(0.0024)	(0.0031)
Elderly who migrated less than 5 years ago	0.0529	0.0423	0.0477	0.0436	0.0236	0.0447	0.0299
	(0.0515)	(0.0309)	(0.0514)	(0.0443)	(0.064)	(0.0501)	(0.0548)
Demographic density	0.0028	0.0049	-0.0094	-0.0173	-0.1492	-0.0237*	-0.0981
	(0.1126)	(0.0085)	(0.1045)	(0.0115)	(0.1676)	(0.013)	(0.1203)
Population	-1.1548***	-0.2509***	-1.1448***	-0.2800***	-1.1443***	-0.2886***	-1.1364***
	(0.1438)	(0.0105)	(0.1372)	(0.0155)	(0.1983)	(0.0169)	(0.1537)
Constant	16.2170***	6.9096***	16.0670***	7.8889***	-[C]	8.1854***	-[C]
	(1.0972)	(0.2445)	(1.0675)	(0.4037)		(0.4605)	
Dummy Year (2000)	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R^2	0.92	0.82	0.92	0.78	0.74	0.75	0.8
Observations	4106	4106	4106	4106	4104	4106	4104

Note: Standard errors are in parentheses. * p<0.10. ** p<0.05. *** p<0.01

c – constant was not reported by the Stata 9.2 software (command xtivreg2. fe robust).

Appendix 1st Essay: Table A. 5– Results Dependent Variable: Per pupil education expenditure

Independent Variables	Fixed-Effect Poterba	POLS	FE	POLS-IV (Group I)	FE-IV (Group I)	POLS-IV (Group II)	FE-IV (Group II)
Elderly above 65 years who co-reside with young under 18	-	-0.0327	0.1475***	0.4271***	0.7669***	0.5532***	0.5157***
		(0.025)	(0.0398)	(0.1385)	(0.289)	(0.1667)	(0.19)
Elderly above 65	-0.0559***	-0.0805***	-0.2467***	-0.1941***	-0.2668***	-0.2381***	-0.1934***
	(0.0102)	(0.0132)	(0.0275)	(0.0481)	(0.0834)	(0.0572)	(0.0578)
Per capita Income	0.0055	0.6941***	-0.2236**	0.4567***	0.0418	0.4999***	0.0299
	(0.053)	(0.0614)	(0.1107)	(0.066)	(0.0656)	(0.0759)	(0.0575)
Young under 18	-0.0144**	-0.0428***	-0.0738***	-0.0569***	-0.0113	-0.0642***	-0.0122*
	(0.006)	(0.0056)	(0.0126)	(0.0084)	(0.0088)	(0.0101)	(0.0074)
Non-white	-0.0029***	-0.0046***	-0.0086***	-0.0032***	0.0022	-0.0041***	0.0004
	(0.0009)	(0.0009)	(0.0022)	(0.0011)	(0.0024)	(0.0013)	(0.0018)
Urban population	0.0002	0.0051***	-0.0092***	-0.0017*	-0.0029	-0.0022**	-0.0019
	(0.0017)	(0.0009)	(0.0034)	(0.0009)	(0.0027)	(0.001)	(0.0023)
Young black (share in the black population - Elderly black (share in the black population)	-0.0044	0.3489*	0.0836	0.3067**	0.2919	0.3607**	0.194
	(0.1218)	(0.1844)	(0.2851)	(0.1366)	(0.2095)	(0.1521)	(0.1762)
Less than 5 years of migration	0.0053**	0.0034	0.0068	0.0080***	0.003	0.0076***	0.0039
	(0.0025)	(0.0034)	(0.0065)	(0.0022)	(0.0037)	(0.0024)	(0.0031)
Elderly who migrated than 5 years ago	0.0529	-0.0567	0.0064	0.0436	0.0236	0.0447	0.0299
	(0.0515)	(0.0591)	(0.1092)	(0.0443)	(0.064)	(0.0501)	(0.0548)
Demographic density	0.0028	-0.0056	-0.0437	-0.0173	-0.1492	-0.0237*	-0.0981
	(0.1126)	(0.0139)	(0.4691)	(0.0115)	(0.1676)	(0.013)	(0.1203)
Population	-1.1548***	-0.2351***	-1.5040***	-0.2800***	-1.1443***	-0.2886***	-1.1364***
	(0.1438)	(0.0168)	(0.4819)	(0.0155)	(0.1983)	(0.0169)	(0.1537)
Constant	16.2170***	8.0286***	27.0916***	7.8889***	-c	8.1854***	-c
	(1.0972)	(0.4577)	(3.1975)	(0.4037)		(0.4605)	
Dummy Year (2000)	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R^2	0.92	0.61	0.49	0.78	0.74	0.75	0.8
Observations	4106	3638	3638	4106	4104	4106	4104

Note: Standard errors are in parentheses. * p<0.10. ** p<0.05. *** p<0.01 c

Appendix 2nd Essay: Table A. 6 – Ouput and Input measures used in studies of efficiency in higher education

(continues)

Study	Technique Employed	Inputs	Outputs
Celik and Ecer (2009)	DEA	students (number of students; and minimun entrance score); faculty members (number of faculty members; number of faculting members in accounting and finance; number of students per faculty member; number of students per faculty member in accounting and finance; number of publications per faculty member); programs (the share of the accounting courses); and financial resources (total financial resources; investment resources)	SEPP (Selection Exam for Public Personnel) Score
Crespi and Geuna (2008)	Stochastic frontier	HERD (higher education research and development) expensive and Non-HERD expensive	publications (as a proxy for the production of codified research); and citations (as a impact adjusted proxy for codified)
Laureti (2008)	Stochastic frontier	Teacher to student ratio; researchs; equipment; places in lectures halls to student ratio; book; and high-school mark	the average of grade of the exams of the university
Johnes (2005)	DEA	total number of undergraduate students studying for a first degree multiplied by average points for first year full-time undergraduated students; total number of postgraduated students; total number of full-time academic staff for teaching or teaching and research only purpose; total depreciation and interest payable in £; total expenditure on central libraries and information services , and on central computer and computer networks excluding academic staff costs and depreciation in £; and expenditure on central administration and central services excluding academic staff costs and depreciation in £.	Total number of first degrees awarded weighted by degree classification; total number of higher degrees awarded (includes both doctorate and other higher degrees); and value of the recurrent grant for research awarded by the Higher Education Funding Council for England
Joumady e Ris (2004)	DEA	students entry characteristics (entry qualification and entry grade) ; study provision (teaching characteristics, equipment and stocking of libraries, supply of teaching material and technical equipment); intensity of job search (number of job seeking modes used by graduates and duration of job search); and study provision (provision of work placements and importance of work experience in HE institution)	level of vocational competencies acquired; level of generic competencies acquired; vertical vocational competencies match; vertical generic competencies match; and horizontal competencies match
Afonso e Santos (2004)	DEA	total expenses and academic staff numbers	students numbers (undergraduated and graduated)

Source: Own formulation.

Appendix 2nd Essay: Table A. 3– Ouput and Input measures used in studies of efficiency in higher education

(conclusion)

Study	Technique Employed	Inputs	Outputs
Warning (2004)	DEA	expenditure on personnel and other expenditure	SSCI publications; SCI publications; SSCI graduates; SCI graduates;
Ferrari and Laureti (2004)	DEA	human resources (average number of full and associate professors per graduate; average number of researchers per graduate); capital resources (average number of seats in lecture halls per student; average number of lecture halls per student; average number of books in the library per student; average number of journals and reviews in the library per student; average number of university pieces of furniture per student; average number of university pieces of equipment); individual input (final high-school mark)	the average grade of the exams
Abbott e Doucouliagos (2003)	DEA	total number of academic staff; the number of non-academic staff; expenditure on all other inputs other than labor inputs; and value of nun-current assets	measures of teaching (number of equivalent full-time students; the number of post-graduated and under-graduated degrees enrolled; the number of post-graduate degrees coferred; and the number of under-graduated degrees conferred); and measure of research (Research Quantun Allocation that each university received)
Dolton, Marcenaro and Navarro (2003)	Stochastic frontier	personal characteristics (age; gender; own transprt); time use (formal education; self- study; private tuition; language; travel; leisure; paid work); parent's characteristic(mother university studies; parents´s divorced; family size); residence (university residence; rent flat); motivation of the students (satisfaction; ambition); other characteristics related to the students' background (grant)	the average scores obtanined by the students during the first semester
Izadi, Johnes, Oskrochi and Crouchley (2002)	Stochastic frontier	undergraduate student load in (broadly defined) arts subjects; undergraduate student load in (broadly defined) science subjects; postgraduate student load; and value research grants and contracts	total expenditure
Robst (2001)	Stochastic frontier	educational and general expenditures; price (compensation; revenues; tuition revenue; state appropiation;state share of revenue; number of institutions; number of observations)	carnegie classification (research institution; doctoral institution; masters institution; bachelors institution); undergraduate students; graduated students; and research expenditures

Source: Own formulation.

Appendix 3rd Essay: Table A. 4– Treated and Untreated Units On and Off Common Support using Kernel Propensity Score Matching

	Treated - On Support	***Control - On Support***	***Treated - Off Support***	***Control - Off Support***
Group 1 (Treated: Age 5 or less) vs (Control: Age 6 or more)	1231	238	130	0
Group 2 (Treated: Age 3 or less) vs (Control: Age 6)	488	220	1	0
Group 3 (Treated: Age 4) vs (Control: Age 6)	459	220	18	0
Group 4 (Treated: Age 5) vs (Control: Age 6)	303	220	2	0
Group 5 (Treated: Age 3 or less) vs (Control: Age 5)	544	317	2	0
Group 6 (Treated: Age 4) vs (Control: Age 5)	490	317	8	0
Group 7 (Treated: Age 3 or less) vs (Control: Age 4)	545	498	1	0
Group 8 (Treated: Age 5or less another municipality) vs (Control: Age 6or more in the municipality)	55	238	5	0
Group 9 (Treated: Age 5- private school) vs (Control: Age 5- public school)	164	1081	0	0

Source: Own formulation