Enhancing quality of education in Latin America: Evaluating the impact of the Brazilian Public School Mathematics Olympics

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Abstract

The Brazilian Public School Math Olympics (*Olimpíada Brasileira de Matemática das Escolas Públicas*, or OBMEP) has been held yearly since 2005, aiming at motivating students to study Mathematics and improving basic education. In this paper we evaluate the OBMEP's impact on school performance in Mathematics, using regression combined with propensity score analysis, and do a cost-benefit analysis. The results show that OBMEP has a positive and statistically significant impact on school performance in Mathematics among nineth-graders. This impact increases for schools that participate in repeated editions of OBMEPs and is larger in higher test score percentiles. The cost-benefit analysis shows that the benefits of OBMEP in terms of the participants' future income outweigh its costs.

Keywords: impact evaluation, doubly-robust estimators, school achievement, economic return.

JEL Classification: I2 Education

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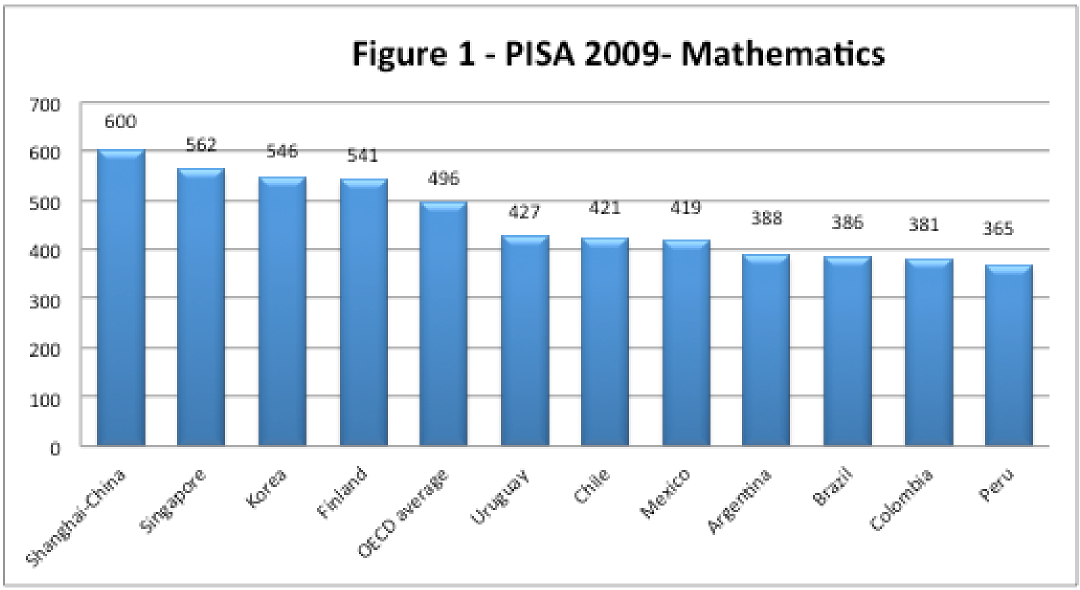
1 Introduction

The current educational debate in Latin America is centered on the need to raise the quality of the education offered and to universalize school attendance. In the latter respect, while many Latin American countries have achieved almost universal school attendance among 7 to 14 year-olds, much remains to be done in terms of older and younger groups (Lopez-Calva and Lustig, 2010). With respect to educational quality, international test score results show that Latin American students tend to perform very badly in comparison to students of other countries. Figure 1, for example, compares the average performance in Math test scores of the Latin American countries with that of the high scoring ones and with the OECD average, using the results of the latest (2009) PISA international evaluation. The figure shows quite clearly that the relative performance of Latin American students is dismal, even if we take into account that the improvement in results over time in Brazil and Chile were among the greatest in this PISA.



Hanushek and Woessmann (2009) examine the importance of educational quality, measured by cognitive tests, for growth in various regions. Their estimated effects of cognitive skills are smaller in the Latin American subsample, compared to other regions, but are still important and statistically significant. Various government educational policies, along with initiatives from civil society and business, have aimed at addressing the questions of attainment and quality, but particular emphasis has been focused on improving the quality of the education offered by public schools in these countries (see Glewwe and Kremer, 2006, for a review). This paper contributes to this literature by estimating the impact and analyzing the cost-benefit relationship of a specific educational program, the Public School Math Olympics (OBMEP), a program aimed at encouraging better Mathematics teaching and learning in Brazil.

Math Olympics can be found in several countries around the world. One of the oldest ones is the International Mathematical Olympiad (IMO) that runs since 1959 and includes both public and private schools. In 2011, one hundred and one countries took part on the IMO, with teams of around six participants (participants are high schools students aged 19 or less). The event is held in a different country every year. The main goal of the IMO is to identify and recognize the top young Mathematicians in the world. In the process of selecting their national teams, it is expected that participating countries stimulate interest in Mathematics in their country.

Two examples of national Olympics are from USA and Colombia, and both declare that the main objective of the competition is to buster educational quality in general. In USA there are competitions for all school grades and in Colombia, similarly to Brazil, participation is offered to students at secondary school or over. Differently from Brazil, the Olympics in other countries are open to all schools, without distinction between public and private schools.

In Brazil there are two Math Olympics run by the federal government. OBM includes public and private schools and OBMEP restricts its focus to public schools. The latter will be the focus of this study. The Public School Math Olympics program has been promoted yearly since 2005 by the Ministry of Education and the Ministry of Science and Technology in partnership with the Institute of Pure and Applied Mathematics (IMPA) and the Brazilian Mathematical Society (SBM), the last two responsible for its academic direction. Students from secondary and high school[1] can participate in the Olympics.

The stated objectives of the OBMEP are to stimulate and promote the study of Mathematics among public school students; to contribute to the quality of basic education; to identify talented young people and encourage them to pursue careers in science and technology; to encourage the professional improvement of public school teachers; to contribute to the integration of public schools and public universities, research institutes and scientific societies; and to promote social inclusion by spreading knowledge.

Because of its objectives to improve the quality of public Math education and its scope in terms of geographic coverage and the number of participants, it is reasonable to assume that OBMEP could have a positive influence on the results of the public school assessments carried out by the federal government to measure educational quality, such as the *Prova Brasil*.

The number of participants in the OBMEP is increasing over time: almost 20 million students participated in the first phase of the 2010 edition, and almost all municipalities of Brazil had at least one school enrolled (Table 1). The number of students participating in this program is substantial when compared to other educational evaluations in the country. Indeed, the program is considered one of the major competitions held among public school students in the country. The IMPA has an extensive team, organized into regional groups to operationalize the program, and rural as well as urban schools are included.

Table 1 – Schools and Students Participating in the OBMEP – 1st Phase

	Number of students			**Number of schools****			Share of public Secondary
	OBMEP participants	Total Public *	Share of participants	OBMEP participants	Public Secondary	Public High	
2005	10,520,831	24,373,817	43.2%	31,030	46,700	16,570	66.4%
2006	14,181,705	24,432,158	58.0%	32,655	47,533	17,072	68.7%
2007	17,341,732	23,302,080	74.4%	38,450	49,327	17,576	77.9%
2008	18,326,029	23,341,647	78.5%	40,377	49,799	18,193	81.1%
2009	19,198,710	23,073,958	83.2%	43,654	50,397	18,508	86.6%

Source: Data from the OBMEP. * Enrollment in the grades of low secondary school and high school, which can participate in the Olympics. ** There is an intersection of schools offering secondary and high school grades. Numbers do not include the schools offering adult education.

[1] The Brazilian educational system will be explained later in the paper.

All schools that sign up for the Math Olympics receive a booklet of sample questions and answers, which is sent to the teachers. Its use is optional. It is intended not only to prepare students specifically for the Olympics, but also to have a positive influence on the overall teaching of Math at the participating schools and thus the performance of their students. This booklet is prepared by professors of the IMPA and members of the SBM to assure its high quality.

This paper evaluates the impact of the OBMEP. Our aim is to quantify its effects on the quality of education received by Brazilian students by assessing its impact on the average Math scores of the schools participating in the program on a standardized achievement test (*Prova Brasil*), and by calculating the economic return of the program by comparing the current costs against the future benefits generated for the students. Due to the test scores availability, we will focus our estimation on the impact of the 2007 OBMEP edition on the Math test scores of the 9th graders of this calendar year.

In light of the objectives of the Math Olympics, the questions posed here are: is it possible to identify in large-scale government evaluations the effect of the incentives provided by the OBMEP to the study of Math in public schools? And more specifically: does participation in the OBMEP bring a measurable improvement in average Math performance at the participating schools? The econometric methodology we use is linear regression weighted by the propensity score in difference in differences specifications. The resulting estimator is doubly-robust and points to a positive and statistically significant impact on the average Math scores of ninth-graders on the 2007 *Prova Brasil*. Since the majority of schools participated in more than one edition of the OBMEP, we also investigated whether the impact is heterogeneous by number of participations.

We find an impact on the Math test scores due to the participation on the OBMEP. The impact is greater for schools participating more than once. We also carried out estimations considering the percentiles of the distribution of student scores and found a significant effect, not only for better performing students, but also for those with lower scores, although the impact is relatively greater for higher achievers.

It is important to understand the mechanisms leading to this impact. Even if partially aimed at the most talented students, the Olympics show improvements for the entire test score distribution, so that its impact does not occur only through the incentives provided to the best students. Besides, we show that the results are stronger for the schools that participate more than once. One possible channel is through teachers, as they receive materials and may profit from it, increasing the quality of their classes to any classroom. On the other hand, as the evidence indicates that Reading ability also seems to improve, there must be an element of students' motivation, possibly coming from the competition climate among them. It seems that OBMEP has been able to enhance not only the teacher's knowledge, but also the motivation of the students.

The OBMEP program seems to provide an extrinsic motivation for the students, that is, when the act of studying aims at achieving a separable outcome, not for the joy of studying itself. There is an important distinction in the incentives' literature between intrinsic and extrinsic motivation. Lepper et al (2005), for example, find that the two kinds of motivations are necessarily correlated. In their experiment, intrinsic motivation diminishes with age, but not the extrinsic one. The problem is that when the extrinsic motivation (such as the prize) is over, the effects of the program may dissipate, as observed by a meta-analysis organized in Deci *et alli* (1999). The best alternative would be to find a way to use the Olympics to burst the intrinsic motivation, so that it endures in the following years.

In the next section we present the institutional background, data sources and the sample used in the empirical analysis. Then, we describe the strategies to identify the impact. Finally, we present the results and calculate the economic return of the program, with some assumptions on the future of students participating in the program.

2 Institutional background and Data

The education system in Brazil is organized as follows: basic education comprises 12 school years, the first 5 ones include one grade that used to be preschool (when children are 6 years old) and 4 grades of the so-called primary school; the next four grades could be compared to a low secondary school, and the 3 last grades are the secondary school or high school. Children have to begin school when they are 6 years old, and it is compulsory to finish the low secondary school, no matter at which age[2].

Most schools offering basic education are public (80% of them were public in 2009 and are known to have lower quality than the private ones). This is the major reason why there is a separated Olympics only for public schools. Children go to the schools in their neighborhood, provided there are vacancies in them. Teachers and principals are public servants, in general their salary increases with tenure and not with performance.

The potential participants in the OBMEP are students in the sixth to twelfth school grades. The students signing up are divided into the following levels: I- students enrolled in the six and seven grades; II – students enrolled in the eight or nine grades, including adult education students; and III – high school students (10 to12 grades). See table 2 for the distribution of the students among the levels of the Olympics.

The Mathematics Olympics occurs in two phases. In the first, all public schools can sign up voluntarily to participate with their students in any or all of the three levels, depending on the grades offered at the particular school. At this time each school receives the booklet of sample questions and answers. The tests in this phase are given and corrected at each participating school, which can send the top 5% of its students to take part in the second phase of the Olympics. Students receiving a score of zero in the first phase are not classified for the second phase.

Table 2 – Number of schools signing up for the OBMEP by level and year (1st phase)

Year	Level I			Level II			Level III		
	Students signing up	Total enrollment in the public schools*	Schools signing up	Students signing up	Total enrollment in the public schools**	Schools signing up	Students signing up	Total enrollment in the public schools***	Schools signing up
2005	3,655,677	8,539,257	27,508	3,077,481	6,827,153	27,383	3,787,673	9,007,407	13,255
2006	4,851,150	8,584,864	29,766	4,026,207	6,789,770	29,132	5,304,348	9,057,524	14,277
2007	5,963,883	8,155,621	35,260	4,917,276	6,450,282	34,360	6,460,573	8,671,609	16,321

Notes: Prepared by authors with data from the OBMEP. * Enrollment in 5th and 6th grades of lowsecondary school. ** Enrollment in 7th and 8th grades of low secondary school. *** Enrollment in grades of high school.

Most schools that participate in the OBMEP do so repeatedly. Moreover, considering the OBMEP for 2007 at level II, the proportion of students participating in relation to students enrolled in those schools was very high. The median of this proportion among all the participating schools was 94%, and in the first quartile of the distribution this proportion was 75%. This shows that, even though one of the goals of the Olympics is to identify high performance students, schools tend to sign up the great majority of their students in the first phase.

The OBMEP is widely advertised by agencies responsible for their organization (Ministry of Education and Institute of Pure and Applied Mathematics) on websites, television, newspapers and radio

[2] Basic education in Brazil changed its duration from 11 to 12 years. Children shall now enter school sooner, with 6 years of age.

stations, just before the start of the registration period. In addition, all public schools receive by mail a notice with the timetable for OBMEP. The principals and Math teachers choose to enroll their students in the competition. After enrollment, they receive a booklet with the instructions for the OBMEP and a sample of questions and solutions of Math problems, which is meant to help teachers to train their students. However, its use is optional and there is no record of it.

We believe that the participation of schools in the OBMEP is related to their specific characteristics such as location, size of its municipality, socioeconomic conditions, number of students enrolled, participation in other government programs, in addition to features specific to principals and teachers. Possibly, the teachers and principals better informed and trained, for example, are more likely to enroll their students in OBMEP. In the empirical analysis we assume that the motivation of teachers and principals to enroll students in OBMEP is only related to their experience, age, education and other observable conditions.

To analyze the impact of the OBMEP we used as an indicator the score on the 2007 *Prova Brasil*, a standardized assessment test given every two years (since 2005) by the National Educational Research Institute (Inep), part of the Ministry of Education (MEC), to all urban public schools in the country. This evaluation is censitary, ensuring that scores are representative for the schools. The test is given to students in the 5th and 9th grades of all urban schools with at least 20 students enrolled in each grade. The *Prova Brasil* methodology is based on the item response theory (IRT), which allows comparison of the scores in Reading (Portuguese) and Mathematics of students in different grades and over time. Moreover, teachers, principals and students answer a quite complete socioeconomic questionnaire, from which were taken the school's characteristics related to their proficiency and participation in OBMEP. The infrastructure characteristics and educational indicators of the schools used as controls come from the 2006 School Census and the municipal population and per capita income figures come from the 2000 Demographic Census (IBGE-2000).

Therefore, the impact evaluation is restricted to urban schools that administered the 2007 *Prova Brasil* to 9th-graders. Since it was impossible to identify the students that participated in the program and their scores on the *Prova Brasil*, we used the average score of each school as the outcome of interest. In other words, our unit of observation is the school, not the student.

The schools sign up for the OBMEP at the start to the school year and the tests in the first phase are given at the start of the second semester (middle of August). Then the second phase occurs in October or November. The 2007 *Prova Brasil*, in turn, was given to students in November that year, so its result could be already influenced by the Mathematics Olympics.

2.1 The sample

Among the 168,436 active public schools in Brazil (2006 School Census), 68,961 were potential participants in the OBMEP at level II, that is, they had students enrolled in the 8th or 9th grades, or offered adult education programs of equivalent grade level.[3] However, only 34,222 of these signed up for the Olympics, and not all of these participated in the *Prova Brasil*. Table 3 presents the sample of schools in the treatment group (participants in the 2007 OBMEP) and comparison group (non-participants in the 2007 OBMEP). Among the 34,222 participating schools at level II of the Olympics in 2007, 22,996 participated in the *Prova Brasil* in 2007.

Among the 68,000 schools that could potentially have participated in the 2007 OBMEP, 34,739 did not do so, making them candidates for the control group. However, among them only 4,052 took part in the

[3] This sample includes schools that offer adult education, hence the difference with respect to Table 1, which does not.

2007 *Prova Brasil*. This failure to participate in the *Prova Brasil* is due to the fact that 58% of the schools were rural and of the remainder, most did not have more than 20 students in the 9th grade. Additionally we remove from the sample of treated schools, schools that signed up fewer than 10% of their students for the first phase (few schools were eliminated from the sample due to this criteria).

Table 3 – Sample

Active public schools in Brazil in 2006	168,436	
Potential OBMEP participants (level II)	68,961	
	Treated schools	**Comparison schools**
	Signed up for the 2007 OBMEP	Non-participants in the 2007 OBMEP
All schools	34,222	34,739
Participants in the 2007 *Prova Brasil*	22,996	4,052
Final sample after the filters *	**22,703**	**1,756**

* Treated schools: we defined a minimum threshold of 10% of students regularly enrolled in the 8th and 9th grades signed up to take the first phase of the Olympics. This cut-off criterion eliminated only 293 schools of treatment group. Comparison schools: we kept in the sample only those schools that have never participated in the OBMEP. This criterion eliminated 2,296 schools.

The small sample size of the control group (or comparison) is mainly due the fact that schools that did not participate in the Olympics in 2007 are located in rural area of municipalities, or are located in small municipalities that have a predominance of small rural schools. In fact, this feature has affected the control group more than the treatment group, indicating that schools that decided to participate in the OBMEP are predominantly urban. Moreover, among the 4,052 schools in the control group that participated on the 2007 *Prova Brasil*, 2,296 of them participated in some edition of OBMEP before 2007 and therefore were also excluded from the sample. Thus, 1,756 schools formed the control group.

Table A in the Appendix shows the comparative statistics between the schools participating and not participating in the OBMEP of this sample. It can be seen that, even after restricting the sample to urban and bigger schools, the treated schools are larger, with more students and teachers, and also have relatively better average student characteristics, such as higher percentages of students with at least one parent who completed college, that went to preschool, that do not work and that were never held back. This is reflected in the average scores on the *Prova Brasil*: in both years analyzed and both subjects (Portuguese and Math), the scores of the schools that signed up for the OBMEP were higher.

By directly comparing the average score of treated with that of untreated schools, without first ensuring that the two groups are similar with respect to other characteristics, we would be obtaining a biased estimate of the impact of OBMEP on students' test scores. Below we explain the strategy adopted to correct this problem, by weighting the schools of the control group according to their similarities in observable characteristics to schools in the treatment group.

3 Impact evaluation methodology

To infer the quantitative effect of the Olympics on the average Math scores of the schools that signed up for the program, we need to know what these schools' scores would have been had they not taken part in the OBMEP. This question brings the problem of the unobserved counterfactual, because obviously we cannot observe the Math scores of the students participating in the OBMEP if they had not participated. To address this question we need a control group (non-participating schools) to replace the counterfactual that is similar to the treated schools (participants in the OBMEP), to avoid the problem of selection bias.

Formally stated, we can define Y_0 as the potential result of a particular school if it did not sign up for the Olympics; Y_1 as the potential result of that school if it did sign up; T = 1 when the school signed up and T = 0 when it did not. We can observe $Y_1|T=1$ and $Y_0|T=0$, but never observe $Y_1|T=0$ and $Y_0|T=1$. We want to know the difference between the score obtained by schools that signed up for the program and the score they would have received had they not signed up. We can write this as $D = E[Y_1 | T = 1] - E[Y_0 | T = 1]$.

What we are really observing is $G = E[Y_1 | T = 1] - E[Y_0 | T = 0]$, so the difference between these terms gives us the selection bias $B = G - D = [Y_0 | T = 1] - E[Y_0 | T = 0]$. This bias arises if the control group is inadequate, such as when the schools that did not sign up for the program were very different from those that did. Since signing up for the OBMEP is voluntary, inclusion in the treated or control group is not random, case in which there would be a potential problem of selection bias.

In response to this, we use a control group with similar characteristics to the treated group, working with the hypothesis of selection on observables. This hypothesis appears reasonable since we have many variables reflecting school management, infrastructure, the teaching and student bodies, among others. Additionaly, we observe the schools' test score results before the 2007 Olympics, so we can use the differences-in-differences specification to control for differences in scores before the treatment. This has the advantage of controlling for unobservable characteristics that do not change over time. Hence, the estimate of the average effect of the treatment on the treated (ATT) will be more reliable.

Through adequate econometric methods, this rich set of characteristics can be used to predict the conditional probability of receiving the treatment among all the schools in the sample, allowing us to find a control group that resolves the potential selection bias problem. Assuming the matrix X is a set of observable characteristics that determine the participation in the treatment and its result, the key hypotheses to eliminate selection bias are:

(a) $Y_0 \perp T \mid X$, that is, independence of the potential results in relation to the treatment, given the characteristics of the observables (treatment ignorability assumption);

(b) Implicit common support hypothesis: $0 < \Pr(T=1 \mid X) = p(X) < 1 \ \forall X \in \chi$, where χ is the support of the distribution of X. There is no value of X for which one can say for sure to which group (T=1 or T=0) it belongs.

These two hypotheses are known as strong ignorability. Rosenbaum and Rubin (1983) showed that, given (a) and (b), then the following also holds:

(c) $Y_0 \perp T \mid p(X)$, where p(X) is the probability of being treated given X, or the propensity score. This hypothesis reduces the dimension necessary to resolve the matching.

The identification assumption thus depends on there being no unobservable variables that affect the schools' results differently between the treated and control group.

The current econometric literature contains various methods based on propensity scoring to infer causality between the treatment and the result. One of the best known is propensity score matching, whereby the treated units are matched with the control units according to their estimated probabilities, assuming some hypothesis on the functional form with which X affects the treatment probabilities and the result. The use of the propensity score has the advantage of reducing the dimensional size of the covariates, facilitating their operationalization. However, the literature contains criticisms of this method. The main bone of contention is that the function p(X) is estimated and it can affect the variance of the estimator in the matching. It is impossible to know the asymptotic distribution of the propensity score, therefore the standard errors of the estimators may be unreliable.

We thus used linear regression with estimated propensity score weighting to find the estimate of the average effect of the treatment on the treated (ATT). The idea is to attribute different weights to the schools in the control group according to the characteristics and probabilities of participating in the OBMEP. According to the econometric literature, this method has advantages over others based on the propensity score, mainly with respect to the estimator's efficiency even with imposition of a functional form to estimate p(X)[4].

We implemented this method of combining regression with propensity scoring weighting in two steps. In the first step we estimated $\hat{p}(X) = pr(T_i = 1 | X_i = x)$ from a binary response model assuming a standard logistic distribution (logit) function. In the second step we used a linear regression of Y_i (Math score) on T_i and X_i weighted by a function of the treatment and non-treatment probabilities resulting from the first step estimation. We report results with the dependent variable in levels:

$$Y_{i,l,2007} = \alpha_1 + \gamma TREAT_{i,l,2007} + X_{il}^{'}\beta_1 + \eta_1 Y_{i,l,2005} + P_{i,l}^{'}\delta_1 + T_{i,l}^{'}\lambda_1 + S_{i,l}^{'}\varphi_1 + M_{m,l}^{'}\phi_1 + DR_l^{'}\theta_1 + u_{i,l} \qquad (1)$$

and in differences (also known as a differences-in-differences model):

$$\Delta Y_{i,l,(2007-2005)} = \alpha_2 + \gamma TREAT_{i,l,2007} + X_{il}^{'}\beta_2 + P_{i,l}^{'}\delta_2 + T_{i,l}^{'}\lambda_2 + S_{i,l}^{'}\varphi_2 + M_{m,l}^{'}\phi_2 + DR_l^{'}\theta_2 + \varepsilon_{i,l} \qquad (2)$$

Where: $TREAT_{i,l,2007}$ is a dummy variable which identifies if the school *i* located in the region *l* participated in the Olympics in 2007; $Y_{i,l,2007}$ is the average Math score on the *Prova Brasil* 2007 of 9th-graders of the school *i* located in the region *l;* $\Delta Y_{i,l,(2007-2005)}$ is the mean difference in Math score between the years 2007 and 2005 on the *Prova Brasil* of 9th-graders of the school *i* located in the region *l*; $Y_{i,l,2005}$ is the average Math score on the *Prova Brasil* 2005 of 9th-graders of the school *i* located in the region *l;* $X_{i,l}$ is the vector of covariates on the characteristics of the school *i* located in the region *l*; $P_{i,l}$ is a vector of covariates on the principals characteristics of the school *i* located in the region *l;* $T_{i,l}$ is a vector of covariates on the teachers characteristics of the school *i* located in the region *l;* $S_{i,l}$ is a vector of covariates on the students characteristics of the school *i* located in the region *l;* $M_{m,l}$ is vector of covariates on the municipality' characteristics in which the school operates*;* DR_l are dummy variables which identifies if the school *i* belongs to the *l*th region and $\varepsilon_{i,l}$, and $u_{i,l}$ - are i.i.d. error components.

The weighting is given by:

$$w_i = \frac{\hat{p}(x_i)}{p} \circ \frac{1-p}{1-\hat{p}(x_i)} \circ \frac{1-T_i}{1-p} \text{ for the untreated observations; and} \qquad (3)$$

$$w_i = \frac{T_i}{p} \text{ for treated observations} \qquad (4)$$

[4] For more details on the impact methodologies, see also Imbens and Wooldridge (2008).

where $p = \sum_{n=1}^{n1} \hat{p}(X)|T = 1$ and n1 = number of treated units.

The resulting estimator can be defined as doubly-robust according to the estimators developed by Robins and Rotnitzky (1995)[5]. In explaining the advantages of the method combining regression and propensity score, Imbens and Wooldridge (2008) made an analogy to the omitted variable bias problem. Suppose one's interest is to estimate the coefficient of the treatment in a linear regression of Y_i on T_i, X_i and a constant. Upon carrying out a regression of Y_i only on T_i and the constant, a bias is produced, equal to the product of the coefficient of X_i of the long regression and the coefficient of X_i in a regression of T_i on a constant and on X_i. The weighting factor can be interpreted as the factor that removes the correlation between T_i and X_i, and the linear regression can be interpreted as the factor that removes the direct effect of X_i. As a result, this estimator leads to additional robustness not found in other methods based on the estimated propensity score, by removing the correlation between the omitted covariates and by reducing the correlation between the omitted and included variables.

To choose the set of variables X used to estimate the logit and the weighted regression of Y_i on T_i and X_i, we used the method of "stratification by estimated probability" proposed by Dehejia and Wahba (1999). Within each stratum we verified the balancing of each component of X between the treatment and control groups. This method ensures efficient estimation of $\hat{p}(X)$. We divided the sample into four strata according to the estimated $\hat{p}(X)$ and tested the balance of each component of X. For cases of imbalance, we performed iterations or changed the model's functional form until all the included variables were balanced.

The last column in Table A of the Appendix shows the t-statistics of the balancing test. It can be seen that there are no significant differences between the treatment and control groups when the samples are divided by strata of $\hat{p}(X)$, proving that the distribution of the included variables is balanced between the two groups.

The covariates included in the model are the infrastructure and teaching conditions of the schools (average class size, average number of hours per day, school size), characteristics of the municipalities where they are located and information on the students. The student data were taken from the socioeconomic questionnaire of the *Prova Brasil* and contain important information on the profile of the students attending the treated and untreated schools. We also included dummies to identify the different regions of Brazil where the schools are located. We included the Maths scores for 2005 on the *Prova Brasil* because each school's raw score in the evaluations can bring relevant information not captured by the other school inputs considered in the model, such as school quality or management. These can influence the probability that a school participates in the Olympics, so it can be correlated with the result of the Math evaluation[6]. In the difference-in-difference model, instead of using the students' characteristics in level, we considered their variations between 2005 and 2007, to capture the changes in student profiles that could be related to their performance.

In the first step of the method, the explanatory power of the logit with the inclusion of all covariates was 12.9% (see Table B in the appendix). Most of them were significant at 10% to explain participation in the OBMEP, except the following (7 out of 28 variables): per capita municipality income; if it is a municipal school (rather than a state one); high teacher turnover, interruption of school activities; and three student

[5] See also Scharfstein, Rotnitzky and Robins (1999).
[6] In this form, we restricted the sample and the results found to schools that participated in the 2005 and 2007 *Prova Brasil*.

profile variables (race, sex and previous attendance in preschool)[7]. In the next section we present the results of the impact evaluation.

4 Results

The results presented here refer to the impact of schools' participation in the 2007 OBMEP on the average Math achievement of 9th-grade students on the *Prova Brasil* for 2007. As mentioned in the methodology section, the method of combining regression and propensity score weighting is valid to eliminate the selection bias under the assumption of selection on observables. The most reliable estimates will be the differences in differences one, but they could be underestimated, because there are schools that participated since 2005 and the scores that year could have been influenced by this participation. Hence, the estimates by this method control for the potential problems of bias more adequately, but they can underestimate the impact found.

Table 4 shows the simple score difference and the results of the Average Treatment Effect on the Treated (ATT) in levels and in differences[8]. The difference between the average scores of treated and comparison schools in 2007, without any controls, is 7.44 points. In contrast, the ATT levels estimate is 2.27 points, and the differences-in-differences estimate is 1.91 (equivalent to 10% of the standard deviation of the school test scores), all of which are statistically significant at 1%. Table C in the Appendix presents the results of the second step, according to equations (1) and (2), for the scores in differences.

Table 4 – Impact of the 2007 OBMEP on the Math **scores**

	Difference in Means	**ATT (levels)**	**ATT (diffs-in-diffs)**
Coefficient	7.44***	2.27***	1.91***
(robust std. error)	(0.68)	(0.57)	(0.58)
N	24,459	14,778	14,778

Notes: Robust standard error in parentheses: *** Estimates significant at 1%. Eicker-White standard errors in brackets. Dependent variable: average 9th graders math score in 2007 (levels) and differences between 2007 and 2005 (diffs-in-diffs). Doubly-robust estimator. Controls are the characteristics of schools, districts, principals, teachers and students plus regional dummies.

The results presented in Table 4 could be interpreted as the average impact of participating in the 2007 OBMEP, independently of the number of times the schools participated in previous years. As stated before, most of the schools that participated in the OBMEP in 2007 also did so in at least one previous year. Table 5 shows the distribution of schools by the number of participations in the OBMEP since 2005. Based on this, we also performed estimates to distinguish the impact according to the number of participations in

[7] We performed another test to see if the variables included fit well with the probabilities of participation in the program between the treated and untreated schools. To do this, we compared the distributions of $\hat{p}(X)$ before and after the matching. The distributions before and after matching were very similar, demonstrating that the variables included ensure good quality of the matching. The graph A in the appendix compares the density kernel distributions before and after matching for the treated and control schools.

[8] The complete set of results is presented in Table A of the Appendix. We also carried out the estimates using the more traditional propensity score matching method. The results had the same sign and significance of those presented here

the three versions of the OBMEP from 2005 to 2007. We constructed three samples: i) the first considered as treated the schools that only participated in 2007; ii) the second considered as treated only the schools that participated twice (in 2006 and 2007 or 2005 and 2007); and iii) the third considered as treated only the schools participating in all three years. The control group in each case was composed of the schools that never participated in the OBMEP. We applied the same method and set of variables explained before, both in the in the levels and differences-in-differences specifications. Table 6 summarizes the results.

Table 5 – Number of participations in the OBMEP

Participations	Number of Schools	Percentage
Once	1,960	9%
Twice	5,104	22%
Three Times	15,639	69%
Total	22,703	100%

Table 6 –Impact by number of participations

	Difference in Means	**ATT (level)**	**ATT (diff-in-diff)**	**No. of schools (Treated x Control)**	
	2.29***	0.07	0.13		
Once	(0.83)	(0.56)	(0.63)	1,960	1,756
	4.24***	1.45***	1.30**		
Twice	(0.70)	(0.53)	(0.58)	5,104	1,756
	9.34***	2.63***	2.28***		
Three Times	(0.64)	(0.63)	(0.61)	15,639	1,756

Notes: Robust standard error in brackets. *** Estimates significant at 1%, ** estimates significant at 5%. Dependent variable: average 9th graders math score in 2007 (levels) and differences between 2007 and 2005 (diffs-in-diffs). Doubly-robust estimator. Controls are the characteristics of schools, districts, principals, teachers and students plus regional dummies.

The ATT estimates show positive and statistically significant impacts and indicate that the higher the number of participations in the Mathematical Olympics, the greater the effect on the school score. The diffs-in-diffs estimate shows a 1.30 impact for two participations and a 2.28 points impact for three participations. The non-significant impact for the few schools that had only participated in 2007 indicates that the treatment needs time to spread its effect among all students (remember the 2007 test score is applied in the end of 2007, at the very moment as the Olympics itself is at its final steps).

4.1 Robustness

There are several concerns about our main results presented above. The main one is endogeneity, as schools becoming better over time may, at the same time, decide to enroll in the Olympics. We also want to understand better the mechanisms driving our main results. Therefore, we performed several robustness checks, displayed in Table 7.

As a placebo test, we examined whether we obtain the same result for a population that was not directly exposed to the treatment, although related to the group of schools that did receive the treatment. In order to do that, we used as a new dependent variable the Math scores of the fifth-grade students of the schools that participated in the OBMEP in 2007. These students were not directly exposed to the treatment, since the OBMEP is offered only to students starting in the sixth grade. Besides, according to the Brazilian school systems, primary teachers (teaching until the 5th grade) are not allowed to teach the upper grades and vice-versa, so there should be no externality of impact in this way. A positive impact would indicate that unobserved variables may be influencing (biasing) the results for the 9th graders. The first column of Table 7 shows that the impact was not statistically significant.

To examine the importance of outliers to the results, we trimmed the 1% top and bottom of Math test score distributions from 2005 and 2007. The results remained qualitatively the same, positive and significant in the diffs-in-diffs specification, as the second column of Table 7 shows.

We now examine if the Math competition can also influence the performance in other subjects. As we also have the Reading (Portuguese) test scores from *Prova Brasil*, we have performed the same empirical exercises using a different outcome. The idea is to examine if the incentives for one subject may influence the other ones as well and, if so, in which direction. The third column of Table 7 shows the results. There is a positive impact in the Reading tests, though smaller in magnitude and only marginally statistically. In light of this result, in the fourth column we also considered a triple difference estimate, controlling additionally for the Reading score change. The result shows that the triple difference impact on Math is no longer significant. Therefore, it seems that there is a positive externality brought about by the OBMEP, probably related to the learning motivation of students that spread to other disciplines as well. Another interpretation of this result is that the reading scores are in fact controlling for other omitted school variables that trend positively over time. This would mean that the Math results presented so far are to be seen as an upper bound of the true impact, with the triple-differences result of this table being the lower bound.

Another important issue is that some schools in the treatment group already participated in the OBMEP in 2005 (baseline). Therefore, we ran another robustness check, excluding from the treatment group the schools that participated in all three editions, keeping only the schools that participated both in 2006 and 2007 editions of OBMEP. The fifth column shows that the diffs-in-diffs impact for this sample is marginally statistically significant.[9] It seems, therefore, that most of the impact of OBMEP in comes from the sample of schools that participated in the three editions of the Olympics, which, in effect, represent almost 70% of the sample, as Table 5 shows.

Table 7 – Robustness

	5th Graders	**Trimming**	**Reading**	**Triple Differences**	**Dropping 2005 Schools**
Coefficient	1.13	1.56***	1.12*	0.79	0,96*
(robust std. error)	(0.96)	(0.55)	(0.63)	(0.51)	(0.57)
N	8,934	14,778	14,778	14,778	4,742

Notes: Robust standard error in parentheses: *** Estimates significant at 1%, * estimates significant at 10%. Standard errors estimated by Eicker-White procedure. Dependent variable: difference in math scores between 2007 and 2005 (diffs-in-diffs). Estimates are results of the doubly-robust estimator Controls are the characteristics of schools, districts, principals, teachers and students plus regional dummies.

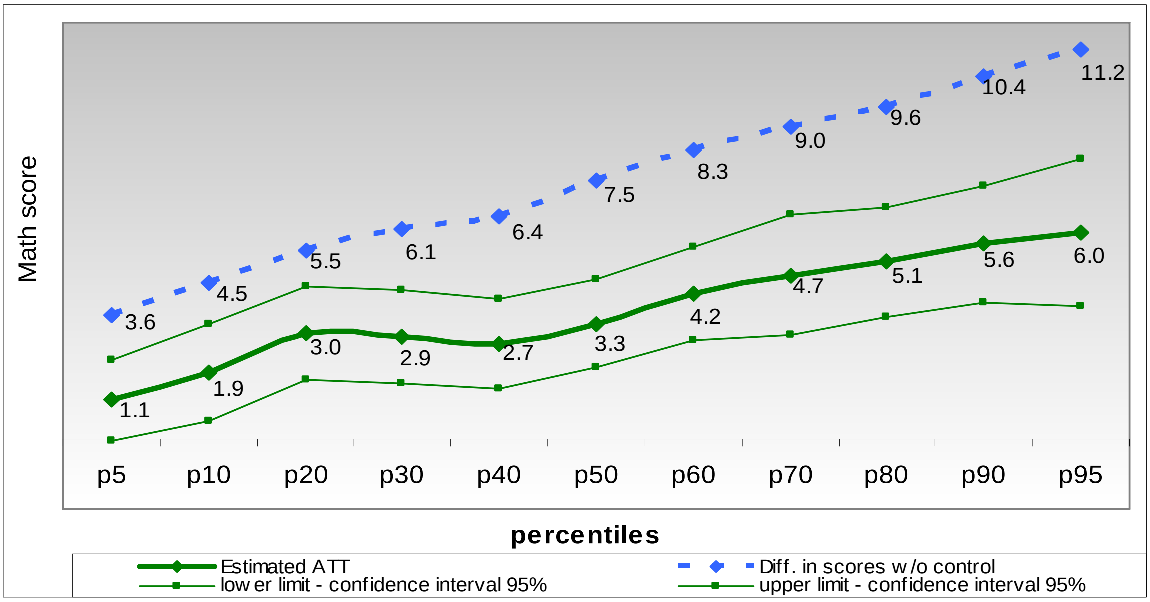
[9] No significant impact was found for the subsample that includes in treatment schools that participated only in 2007, however.

4.2 Heterogeneity

One of the objectives of the OBMEP is to identify young people with a talent for Math so as to give better opportunities to youths who may come from adverse socioeconomic conditions. Also, according to the rules only the students with scores in the top 5% continue to the second phase of the Mathematical Olympics. Therefore, we calculated estimates separately, considering the student scores in specific percentiles as the result variable, to shed light on whether there is a difference in the impact depending on higher or lower student scores on the *Prova Brasil*.

From the distribution of Math scores of all 9th-graders, we calculated the scores in the deciles of the distribution, and also in the 5th and 95th percentiles, and used these as results in the impact estimates. For each percentile we applied the same methodology and same set of observable characteristics as described previously, considering all the schools participating in 2007, irrespective of the number of times participating. The graph below depicts the results.

Graph 1 – Estimates of the impact of the OBMEP by Math **score percentiles**



All the estimates are significant at 5%, except in the first percentile which is significant at 10%. We used the specification in level of the scores in the percentiles.

The solid bold line shows the ATT estimates in the percentiles. All the results are significant and positive for all levels, indicating the OBMEP improves the scores of all students. However, the effect is stronger for the higher percentiles, with impacts ranging from 1 to 6 points on the Math score. The dotted line depicts the difference in the simple average between the scores of the treated and control schools, which increases more sharply than the impact of OBMEP.

Table 8 shows the average scores observed in the treatment and control schools in each percentile, the estimated ATT and the ratio between this and the average score of the control schools. The results here show that the relative impact is greater for students with better performance on the *Prova Brasil*, but is present for all students. This fact is important, demonstrating that the OBMEP improves the average performance of schools, and that this gain affects all students, not only the higher achievers.

Table 8 – Math score percentiles: average treated and control schools, ATT and relative impact

Percentiles	Score of the participating schools	Score of the non-participating schools	Estimated ATT	ATT/mean score of untreated schools (%)
p5	178.52	174.95	1.13	0.644
p10	190.66	186.15	1.93	1.039
p20	206.92	201.45	3.04	1.509
p30	219.11	213.04	2.94	1.381
p40	229.79	223.37	2.74	1.227
p50	239.90	232.44	3.34	1.437
p60	250.14	241.80	4.21	1.741
p70	261.28	252.26	4.72	1.871
p80	274.44	264.88	5.11	1.928
p90	292.53	282.09	5.64	1.999
p95	306.94	295.71	5.95	2.013

Dependent variable: math score in 2007 of 9th grades students in each percentile. Estimates of ATT are results of the doubly-robust estimator. Controls are the characteristics of schools, districts, principals, teachers and students plus regional dummies. All the estimates are significant at 5%, except that of the first percentile, which is significant at 10%.

The Olympics prizes are distributed for several categories of winners. 3,000 medals are distributed among the top best students (300 gold, 900 silver and 1,800 bronze), and are equally divided between the three levels of the competition (I, II and III). Additionally up to 30,000 Honor Certificates are distributed to the next best students. Considering all these categories, 9,775 schools of our sample have had winner students in the year of 2007, which comprises 43% of the treated schools. Each of the winner schools had in average 2.75 winner students.

Is the impact of the Olympics higher for schools with winners? If the mechanism through which OBMEP increases test scores has to do with competition and motivation, we would expect the effect to be stronger when a significant share of the students has a real chance of winning. Therefore, in Table 9 we report results of our basic specifications, including an indicator for the schools with winning students. The results show that the impact of OBMEP is higher and only statistically significant in the schools with winning students. Moreover, the number of winners in each school is probably insufficient to drive a spurious correlation between participation in the OBMEP and the average test scores in Prova Brasil.

Table 9 - Olympic Winners

	Difference in Means	**ATT (level)**	**ATT (diffs-in-diffs)**
Participation in OBMEP 2007	1.20***	0.44	0.90
	(0.44)	(0.51)	(0.58)
With Winners	16.12***	3.86***	2.21***
	(0.23)	(0.45)	(0.35)

N: 14,769 schools. Schools with winners = 6,663. Schools without winners = 8,106.

Notes: Robust standard error in parentheses: *** Estimates significant at 1%. Dependent variable: 9th graders average math score in 2007 (levels) and difference between 2007 and 2005 (diffs-in-diffs). Doubly-robust estimator. Controls are the characteristics of schools, districts, principals, teachers and students, plus regional dummies. Sample includes all schools of original sample (Table 3) and indicators for schools with winning students.

4.3 Additional impact estimates

Table 10 shows the impact of the Olympics on other dependent variables. We find a significant impact on the school promotion and dropout rates in 2007. But we find no impact on next year enrollment, or class sizes. We also investigate possible heterogeneous effects on the Math test scores among different municipalities (measured by *per capita* income) and different school administrations (state or local control). The impact is stronger in richer municipalities, but no significant differences were found between state and municipal schools.

Table 10 – Additional results

Dependent variable:	Average of dependent variable in the sample	Coefficient. (ATT)	robust std. error
Promotion rate (6th-9th grades) [1]	76.2	1.07**	(0.53)
Repetition rate (6th-9th grades) [1]	14.3	-0.44	(0.38)
Dropout rate (6th-9th grades) [1]	9.5	-0.63*	(0.36)
Enrollment (8th and 9th grades) [2]	180.8	-1.50	(4.69)
Class size (6th-9th grades) [2]	31.2	-0.02	(0.25)
Heterogeneous effects: distribution of *per capita* municipal income [3]			
1st one-third ($15 - $98)	228.9	1.71**	(0.85)
2nd one-third ($98 - $166)	242.5	1.52*	(0.90)
3rd one-third ($166 - $516)	246.5	2.71***	(0.74)
Heterogeneous effects: educational system (municipal or state schools)			
State schools	240.4	2.07***	(0.71)
Municipal schools	236.9	2.01***	(0.74)

***, ** and * estimates significant at 1%, 5% and 10%. Standard errors estimated by Eicker-White procedure. [1] Average rates between the 6th and 9th grades in 2007. [2] 2008 School Census Data. [3] Computed at 2000 prices. All estimates are results of the doubly-robust estimator. Controls are the characteristics of schools, districts, principals, teachers and students, plus regional dummies.

5 Analysis of the Economic Return

From the estimated impacts of the OBMEP on the Math scores on the *Prova Brasil* of 9th-graders, we performed an analysis comparing the costs and benefits of the program over the students' lifetimes. The idea is to translate the effect found in the previous section into monetary benefits. This required making some assumptions on how higher Math scores can affect job earnings and constructing scenarios to compare the additional earnings against the amounts invested in the program.

In 2007, 4.9 million students took part in the first phase of the OBMEP at level 2, of whom 9% participated only in 2007, 23% in one other year (2005 or 2006) and 69% in all three years. All these students could have benefited from the OBMEP.To analyze the flow of benefits we used the following hypotheses and procedures:

(i) The estimated positive impact on the average score of 9th-graders holds in absolute values for all the students signed up for the first phase of the 2007 OBMEP. Since we know the impact separately according to the number of participations, we performed three calculations of the return.

(ii) The expected monetary return from participation of the students in the OBMEP was calculated from this improvement in performance, by number of participations. A study with panel data in the United States shows this relationship exists (MURNANE et al., 2000). There are no panel data available in Brazil to follow the same individuals, but the study by Curi and Menezes-Filho (2007) evaluated whether the quality of learning measured in terms of Math proficiency obtained on the SAEB (Basic Education Evaluation Test) among high school seniors of a determined generation affects the salaries of this cohort five years later. The authors showed that the performance on the educational evaluations affects future salaries with an estimated elasticity of 0.3. According to these findings, the improved performance of the 9th-graders on the *Prova Brasil* will boost their future wage income with an estimated elasticity of 0.3.

(iii) We assumed that the returns of education are constant over time. With data from the 2007 PNAD (National Household Survey), we projected the annual wage earnings of an 18-year-old with nine years of schooling when entering the job market until retirement age of 60.

From the estimated impact on the Math scores of students by the number of participations in the OBMEP and the performance-income elasticity, we calculated the expected variations in annual salaries. For one participation (percentage variation of 0.32% on the average of the treated students) we assumed an increase of 0.10% in future annual salaries, with these percentages rising to 0.19% with two participations and 0.30% with three.

With respect to the costs of the OBMEP, we considered a figure of R$2 per student per year, as this is the value reported by the OBMEP organizers. And one other scenario considers the costs per student of the *Prova Brasil* 2007, whose structure is similar to OBMEP´s: R$17 per student. We considered the costs to be proportional to the number of times the schools participated in the OBMEP.

The table that follows presents the economic return of the program, broken down by number of participations, considering the three cost scenarios. As school participation only on 2007 did not show a significant impact, we consider the future salary benefits only for students from schools that had previous participations.

Table 11 – Economic Return of the OBMEP

Nb of years of participations:		Two	Three	Total
Scenario 1 (OBMEP)	Total NPV	R$ 116,7 mi	R$ 704,1 mi	R$ 820.8 mi
	NPV/student	R$ 115	R$ 202	R$ 169
	IRR/year	39%	45%	39%

Scenario 2 (*Prova Brasil*)	Total NPV	R$ 86,2 mi	R$ 547,4 mi	R$ 633.6 mi
	NPV/student	R$ 85	R$ 157	R$ 130
	IRR/year	14%	16%	14%

We considered a discount rate of 5% a year to calculate the IRR.
US$1 = R$2.19 (average 1st semester 2009).

In all cost scenarios, the program's return is positive and high, as we consider a risk free discount rate of 5% a year. By calculating the overall average return, we obtained in the scenario 2 a NPV per student of R$130 and an IRR of 14% a year. This indicates that the Mathematical Olympics is a good investment in terms of public policy because the costs are very low per student and the number of beneficiaries is very high.

Therefore, according to this impact evaluation, the OBMEP has a positive influence on the quality of public school education, increasing the average Math score of the treated schools in national educational assessments. This result becomes more pronounced as the number of times a school participates increases and for students with better school performance. Our calculation of the economic return shows that the OBMEP has a high rate of return and will generate future earnings benefits for the participants, without considering other possible positive externalities for the students and for the society in general.

6 Conclusion

We carried out an economic evaluation of the Brazilian Public School Mathematical Olympics (OBMEP), a program promoted since 2005 by the Institute of Pure and Applied Mathematics (IMPA) in partnership with the Ministry of Education and the Ministry of Science and Technology. One of the program's aims is to encourage the study of Mathematics at public schools and to increase the quality of public education.

Each year since its inception the OBMEP has attracted an increasing number of participants from schools and students in the sixth through 12th grades. In 2010 the number of students participating was over 19 million. It is currently considered the leading school academic competition in the country. To see whether it is living up to its goals, we evaluated the impact of schools' participation in the 2007 OBMEP on the average Math scores obtained in the 2007 *Prova Brasil* (INEP/MEC) for 9th-graders.

We used a two-step estimation, combining linear regression with propensity score weighting. The resulting estimator is asymptotically more efficient than other methods based on this estimated probability and thus is considered doubly-robust. We showed that the OBMEP has a positive and statistically significant effect on the average Math scores of the 9th-graders of schools on the *Prova Brasil* (2007). This impact rises as the number of times the school participates in the program increases, and is greater in the higher student score percentiles, although all percentiles benefit from the Olympics. We also show a positive effect on Reading test scores, arguing that, at the currently low levels of educational quality, students' motivation from the OBMEP was able to spread to other subjects.

The analysis of the economic return brought positive results, showing that the OBMEP, by enhancing the quality of public school education in the country, will generate future gains in terms of earnings of the participants and is cost-effective.

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APPENDIX

Table A – Profile of schools participating in the OBMEP

			Difference of means test	
	Participants	Non-participants	t-statistic before balancing	t-statistic after balancing ***
1. Information from the *Prova Brasil**				
Score_9th_MAT 05	239.7	233.1	-12.15	-
Score_9th_MAT 07	239.8	231.7	-17.25	-
Score_9th_Portugues 05	224.4	220.8	-7.35	-
Score_9th_Portuguese 07	227.8	222.4	-12.68	-
1.1 Questionnaire on Principals				
% of principals with postgraduate degree	71.2	62.5	-7.53	-0.53
% of principals with 11 to 15 years in heading the school	4.7	6.9	4.00	-1.12
% of principals with more than 15 years heading the school	3.2	4.1	2.07	0.35
% of principals between the ages of 30 and 39	24.1	22.0	-1.97	-0.63
% of principals who were chosen by a competitive exam or election process	17.5	13.4	-4.20	0.35
% of schools receiving state government funding	68.0	58.1	-7.44	0.35
% of schools with student entry test	0.8	1.0	1.12	0.17
% of schools with high staff turnover	38.7	32.9	-4.67	-1.06
% of schools with interruption in school activities	19.0	20.8	1.81	0.44
1.2 Questionnaire on Students (9th grade)				
% of students starting with preschool	81.7	78.1	-10.02	-0.33
% of boys	45.7	46.0	0.86	0.85
% of students with parents who attend parent-teacher meetings	91.6	89.1	-13.63	-1.88
% of students with at least one parent who completed high school	7.4	5.2	-12.71	-0.37
Average number of cars owned by the household	1.7	1.7	7.94	1.18
% of white students	35.7	34.2	-2.96	-0.21
Average 8th-grade enrollment	92.7	63.2	-18.09	-1.64
% of municipal schools (as opposed to state schools)	35.0	44.6	8.16	-1.21
2. 2006 School Census*				
Average number of teachers in 1st-9th grades	28.2	26.0	-6.40	0.01
% of schools with Internet access	57.0	44.5	-10.25	1.17
% of schools that have computers for use by 8th and 9th graders	39.0	25.5	-11.21	0.79
% of teachers with college diplomas	88.3	84.6	-6.73	-1.69

% of schools with a "cycle system"[10]	36.7	32.2	-3.74	1.76
Average class size in the 9th grade	32.3	30.2	-9.45	-0.28
Average number of hours in the 9th grade school day	4.4	4.3	-10.92	0.19
3. 2000 Demographic Census**				
Average population of the municipalities	635,183	1,414,768	15.57	-1.26
Average per capita income of the municipalities (R$)	263.4	311.8	12.31	-1.73

Source: *Inep/MEC **IBGE.

*** For the balancing test, we divided the sample into four p-score strata, to provide the statistics for the first quartile, with the results for the other quartiles following the same scheme.

[10] A system where schooling is organized into cycles lasting 2 to 4 years, where students can only be held back one year at the end of a cycle.

Table B – Logit estimate - Decision of schools to participate in the OBMEP

Y = participation in OBMEP in 2007	Coef.	Std. Err.	z	P>z
Dummy_Midwest Region	-1.02	0.18	-5.58	0.000
Dummy_Southeast Region	-1.47	0.15	-10.03	0.000
Dummy_South Region	-2.29	0.20	-11.31	0.000
Municipal_school	**0.16**	**0.14**	**1.15**	**0.250**
No of teachers 1st-8th grades	0.03	0.00	7.94	0.000
School has Internet access	0.46	0.09	4.90	0.000
Use_computers by students	0.20	0.09	2.12	0.034
School with cycle system	0.55	0.14	4.04	0.000
Cycle*municipal school (iteration)	-0.83	0.18	-4.61	0.000
Prop. of teachers with college degrees (squared)	0.63	0.15	4.20	0.000
Average hours in school day	0.21	0.12	1.80	0.072
Score_*Prova Brasil*05_MATH8th	0.03	0.00	9.54	0.000
Log_municipal population	-0.37	0.04	-9.85	0.000
Log_per capita municipal income	**0.18**	**0.14**	**1.27**	**0.203**
% of principals with postgraduate degrees	0.36	0.08	4.31	0.000
% of schools with high staff turnover	**0.11**	**0.08**	**1.40**	**0.161**
% of schools with interruption in school activities	**-0.13**	**0.10**	**-1.36**	**0.175**
Age_principal (between 30 and 39)	0.19	0.10	1.99	0.047
Time heading school (more than 10 years)	-0.41	0.14	-2.88	0.004
Principal chosen by competitive exam or election	0.27	0.12	2.31	0.021
School has student entrance exam	-0.85	0.39	-2.20	0.028
School receives state government funding	0.23	0.11	2.17	0.030
% of white students	**0.11**	**0.34**	**0.32**	**0.752**
% of parents who attend parent-teacher meetings	2.00	0.48	4.21	0.000
% of students whose parents have a car	-1.58	0.42	-3.72	0.000
% of students who started with preschool	**-0.19**	**0.31**	**-0.61**	**0.544**
% of boys	**-0.03**	**0.42**	**-0.07**	**0.945**
% of students whose parents completed high-school	1.24	0.71	1.75	0.079
Constant	**-1.87**	**1.41**	**-1.32**	**0.185**

Number of observations = 14,778   Pseudo R2 = 0.1287

Table C – Diff-in diff: OLS regression weighted by the propensity score (doubly robust)
Math 9th grade

Y = Diff_in_diff (score2007 - score2005)	Coef.	robust Std. Err.	t	P>t
Participated_2007 OBMEP	1.91	0.58	3.32	0.001
Dummy_Midwest Region	-0.71	0.97	-0.73	0.467
Dummy_Southeast Region	-0.33	1.19	-0.28	0.781
Dummy_South Region	-1.93	1.14	-1.69	0.091
Municipal_school	0.04	0.91	0.04	0.969
No. of teachers in 1st-8th grades	0.03	0.03	1.00	0.317
School has Internet access	0.00	0.66	-0.01	0.994
Use_computers by students	-0.36	0.68	-0.52	0.600
School has cycle system	2.24	0.88	2.55	0.011
Cycle*municipal school (iteration)	-1.15	1.43	-0.81	0.419
Prop. of teachers with college degrees (squared)	-0.96	1.18	-0.81	0.417
Average hours in school day	-1.08	0.75	-1.43	0.153
Log_municipal population	-0.75	0.23	-3.31	0.001
Log_per capita municipal income	1.45	0.86	1.69	0.092
% of principals with postgraduate degrees	0.51	0.57	0.89	0.371
% of schools with high staff turnover	0.15	0.59	0.25	0.801
% of schools with interruption in school activities	-1.56	0.65	-2.40	0.016
Age_principal (between 30 and 39)	-1.03	0.76	-1.35	0.178
Time heading school (more than 10 years)	-2.06	1.04	-1.99	0.047
Principal chosen by competitive exam or election	0.20	0.92	0.21	0.832
School has student entrance exam	8.23	4.16	1.98	0.048
School received state government funding	0.22	0.81	0.27	0.787
Var. in % of white students	0.03	3.50	0.01	0.992
Var. in % of boys	9.49	2.91	3.26	0.001
Var. in % of students who live with their parents [both]	6.42	2.46	2.61	0.009
Var in % of students starting in preschool	7.81	3.88	2.02	0.044
Var in % of students who work	-17.22	2.70	-6.37	0.000
Var. in % of students with washing machine at home	-4.89	3.14	-1.55	0.120
Var. in % of students whose parents completed high school (at least one)	7.96	5.27	1.51	0.131
Var. in % of students who did not respond to question on mother's schooling level	-1.90	2.18	-0.87	0.383
Var. in % of students with Internet access at home	-8.01	4.29	-1.87	0.062
Constant	3.78	4.21	0.90	0.369

R2 = 0.0718
Number of observations: 14,776

Graph A – Quality of matching (nearest neighbor): Density kernel of the probabilities of treatment before and after matching