
Evaluating the impact of participation in the “Brazilian Public School Mathematical Olympiad” on math scores in students’ standardized tests

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Bogota
Dec 2009

Outline

- Introduction
 - Data and sample choice
 - Descriptive analysis
 - Identification strategy
 - Impact results
 - Cost-benefit analysis
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Introduction: the program

- The OBMEP-Public school olympiad occurs annually since 2005
- Promoted by:
 - Instituto Nacional de Matemática Pura e Aplicada –IMPA (organizer)
 - Ministério da Educação –MEC and Ministério da Ciência e Tecnologia -MCT
 - Sociedade Brasileira de Matemática - SBM
- Students eligible to participate:
 - Public schools (urban and rural)
 - 6th to 12th grades (low secondary school and high school)
- School self-selection into participation
- 3 test levels:
 - nível I – 6th and 7th grades; nível II – 8th and 9th grades; III – high school
- Test is applied in two phases
 - 1st: all enrolled students; 2nd: the 5% with better performance in the 1st phase within schools

Introduction: OBMEP Objectives

- 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.
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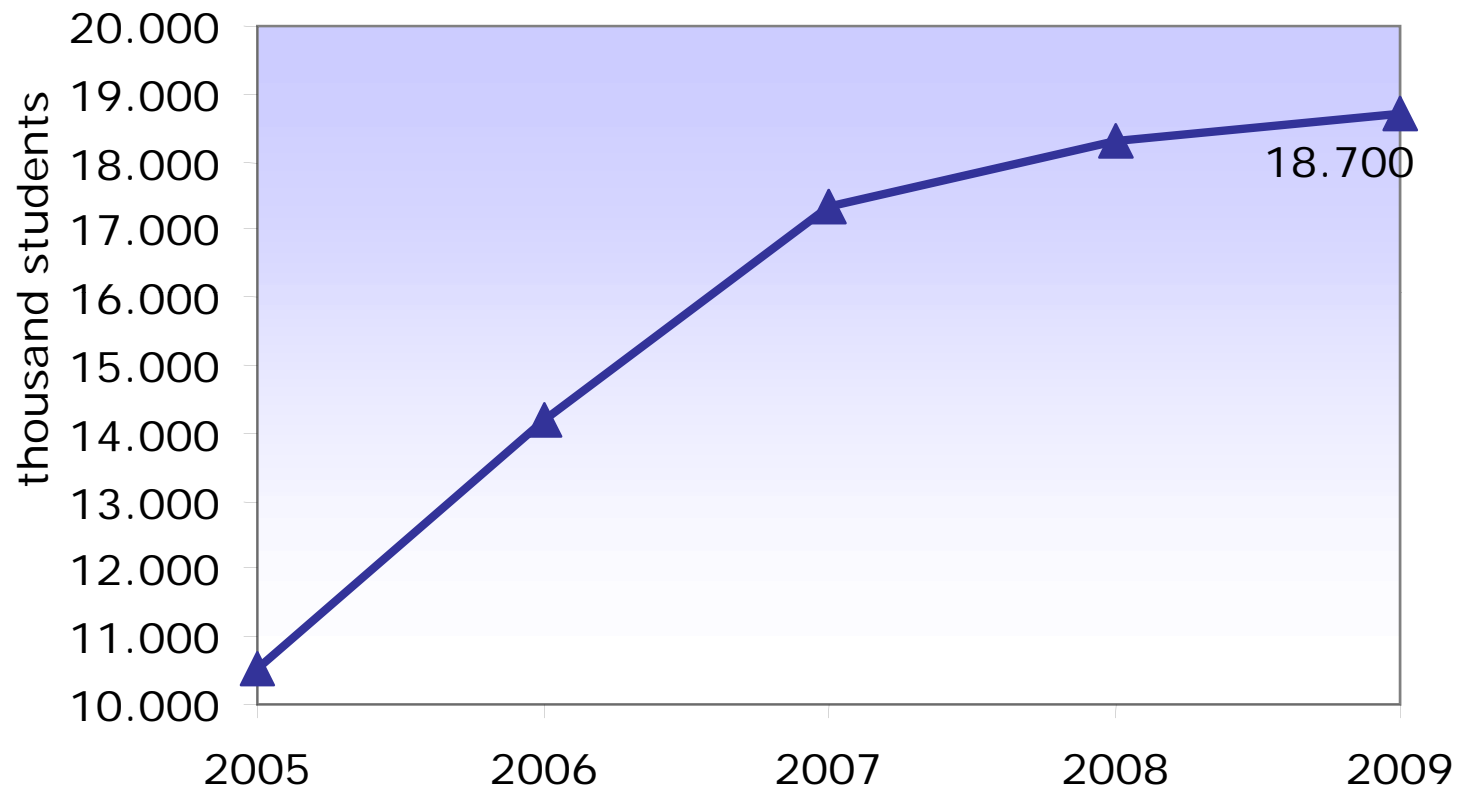
Introduction: schools in OBMEP

Number of schools enrolled in level II, phase 1:

2005	27.383
2006	29.132
2007	34.360
2008	36.349

1 participation = 16%
2 participations = 25%
3 participations = 59%

Introduction: number of students participation



Source: IMPA

Introduction: impact evaluation

- We will investigate the impact of OBMEP on the average math scores of the schools that signed up for the program
 - on the 9th graders (participants of OBMEP level II)

Data: sources of data

- **Prova Brasil (INEP/MEC)**

- Test scores
- Socioeconomic surveys (students, teachers and principals)

- **Censo Escolar 2006 (INEP/MEC)**

- Enrollment data; infrastructure; quality variables (school hours; class size; % teachers with undergraduate certificate)

- **Censo Demográfico 2000 (IBGE)**

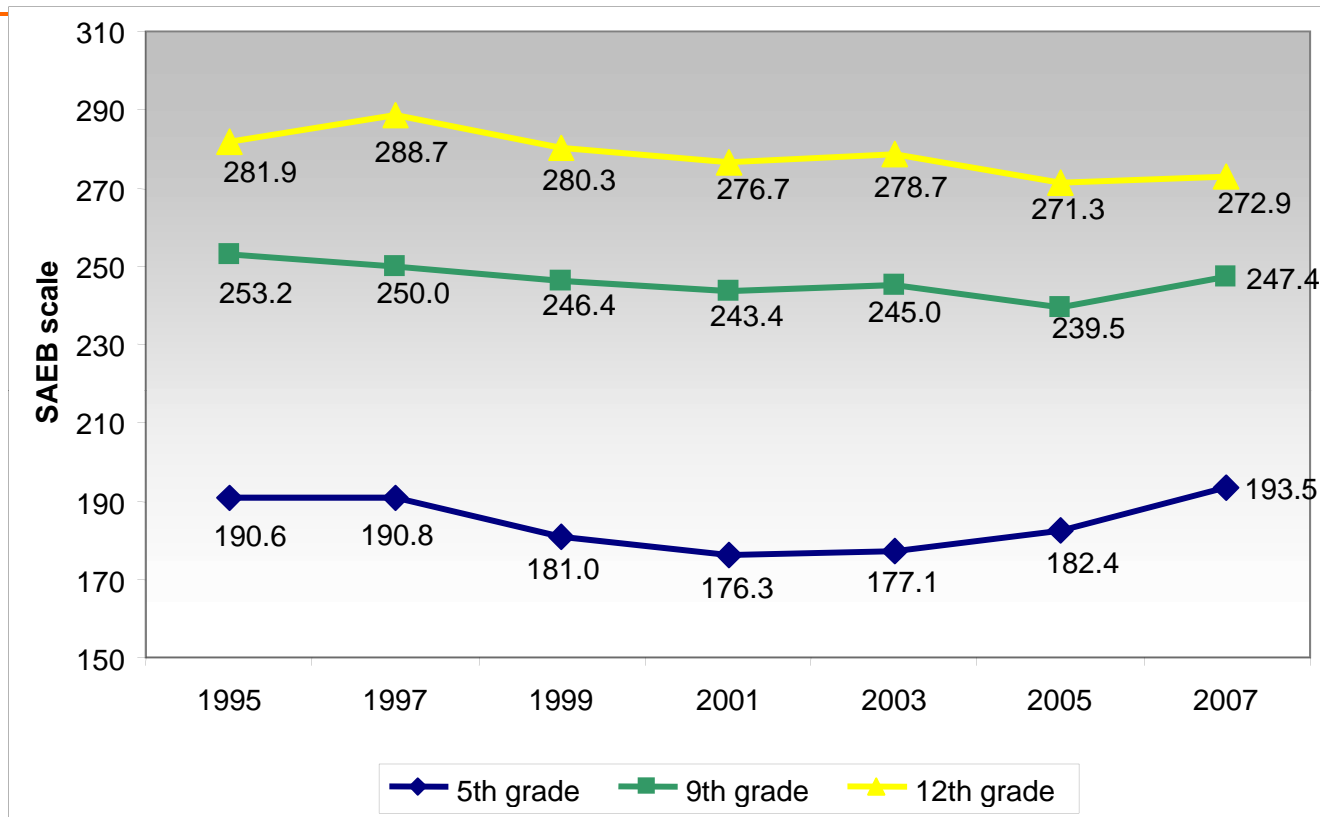
- Population of municipality; average per capita income

Data: Prova Brasil

- a standardized assessment test from National Educational Research Institute (Inep), part of the Ministry of Education
- given every two years (since 2005)
- censitary to all urban public schools
- 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* uses the same methodology as another assessment test (SAEB), that exists since 1995 for a sample of schools.
- They are based on the item response theory (IRT), which permits comparison of the scores in Portuguese and mathematics of students in different grades at the same time.

Data: Mathematics scores on SAEB



Source: Inep/MEC

Sample choice

Eligible and enrolled schools - sample data		
Public schools	168.436	
Eligible schools	71.820	
Eligible schools – level II	68.961	
	Treatment	Control
Eligible level II 2007	34.222	35.263
urban	25.841	14.571
participants of Prova Brasil 2007	22.996	4.052
never participate of OBMEP		1.756
at least 10% of the school students enrolled	22.703	

* in School Census 2006

	Nb of participations	percent
one	1,960	9%
two	5,104	22%
three	15,639	69%
Total	22,703	100

Descriptive analysis: Prova Brasil test scores

9th grade	Participants	Non participants	differences at 95%
Math 2005	239,7	233,1	*
Math 2007	239,8	231,7	*
Portuguese 2005	224,4	220,8	*
Portuguese 2007	227,8	222,4	*

Descriptive analysis: school Characteristics

	Participants	Non participants	difference at 95%
% students that attended preschool	81,7	78,1	*
% students with Parents with undergraduate certificate	7,4	5,2	*
% schools reported with high Teacher turn over	38,7	32,9	*
% municipal schools	35,0	44,6	*
% schools with non-repetition system	36,7	32,2	*
Average class size 9th grade	32,3	30,2	*
% teachers with undergraduation	88,3	84,6	*

Source: Prova Brasil and Censo Escolar

Identification strategy

- Method:

- linear regression with estimated propensity score weighting to find the estimate of the average effect of the treatment on the treated (ATT):
 - Test score in level (hypothesis of selection on observables)
 - Difference in Differences (additionally controlled by time invariant unobserved variables)

Identification strategy

- Two steps:
 - 1st: estimate of propensity score $P(X)$ (logit)
 - 2nd: linear regression Y on T and X , weighted by:

$$w_i = \frac{\hat{p}(x_i)}{p} \circ \frac{1-p}{1-\hat{p}(x_i)} \circ \frac{1-T_i}{1-p} \quad \text{Control observations}$$

$$w_i = \frac{T_i}{p} \quad \text{Treatment observations}$$

where: $p = E[p(X)|T = 1]$
Y result, T treatment, X covariates

- estimator is doubly robust, Robins and Rotnitzky (1995)

Identification strategy: choice of covariates X

- Stratification method, Dehejia e Wahba (1999):
 - within each stratum (four) we verified the balancing of each component of X between the treatment and control groups.
 - For cases of imbalance, we performed iterations or changed the model's functional form until all the included variables were balanced.
 - This method ensures efficient estimation of $p(X)$.

Impact results

Effect of OBMEP 2007 on average math test scores

	observed difference	ATT (level)	ATT (dif-in-dif)
coeficient	7,44***	2,14***	1,99***

*** Significance at 1%

= 8% of standard-deviation between schools with 9th-grade

In 10 years the math scores on SAEB: **increased 3 points** in the 5th grade and **decreased 3 points** in 9th grade

Impact results: robustness check

- Estimation of impact for population not directly exposed to the Olympiad: 5th grade students
- Same methodology:
 - In level: ATT = 1,06 (t = 1,20)
 - Diff-in-Diff: ATT = -0,02 (t = -0,04)

IMpact results: heterogeneous effects

- Different number of participations by school
 - 59% of schools participated in 3 editions (2007/06/05)
- Test score distribution within schools
 - 2nd phase of OBMEP: only the 5% best students within schools participate

Heterogeneous effects: number of participations

OBMEP impact

	observed differences	ATT (level)	ATT (dif-in-dif)	Nb schools	
				treated	control
One time	1,83*	0,76*	0,65*	1.960	1.756
two	3,92***	1,51***	1,51***	5.104	1.756
three	8,94***	2,38***	2,19***	15.639	1.756

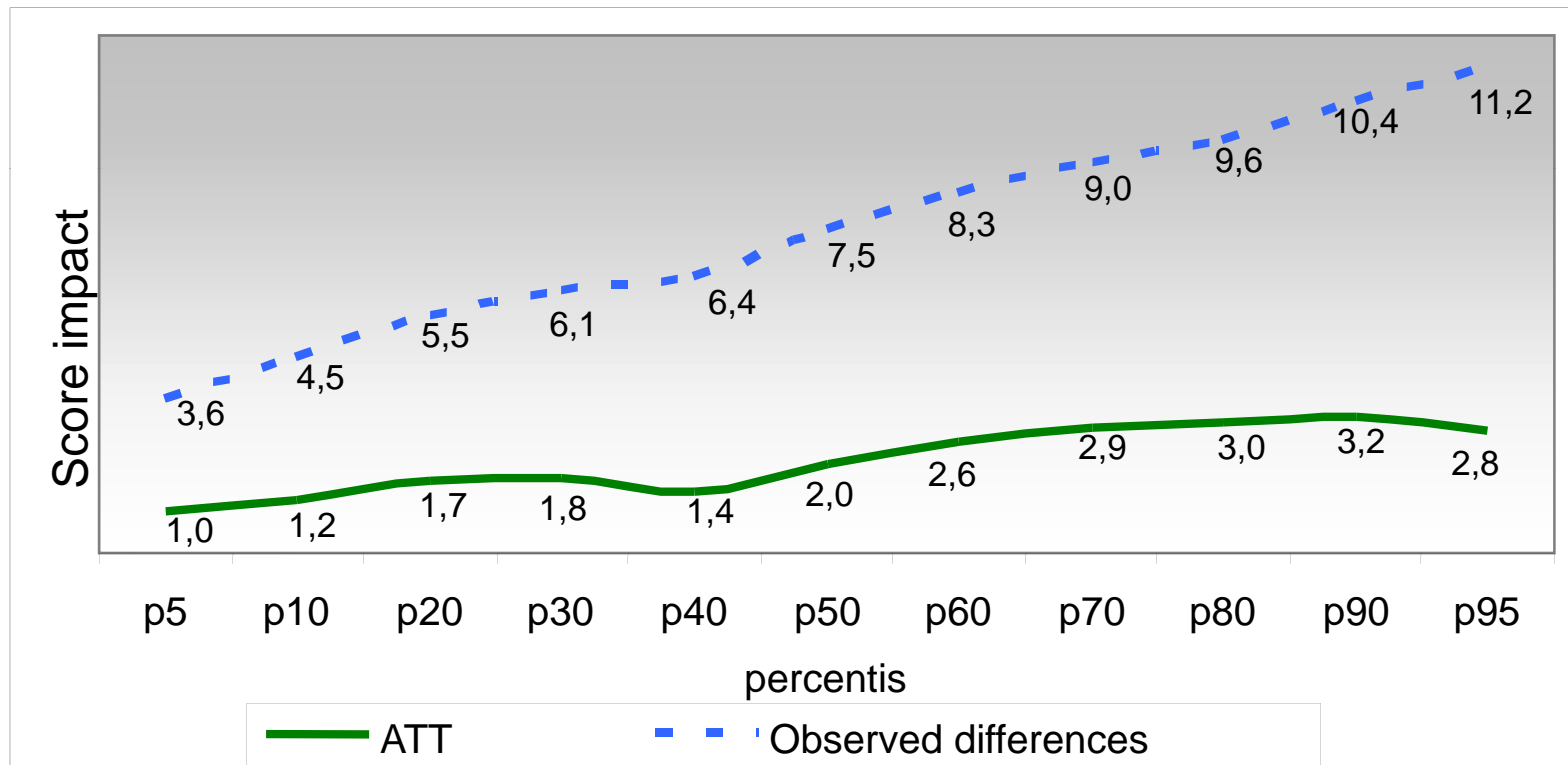
Differencial on score per participation = (0,65; 0,74; 0,88)

* Level of significance: 10%

*** level of significance: 1%

Heterogeneous effects: score distribution within schools

OBMEP impact by students' test score percentiles



* All estimates significant at 10%

Cost-benefit analysis

Scenario for benefits:

- I. Average impact valid for all participants of OBMEP 2007 level II
- II. Elasticity between test scores and future income = 0,3 [Curi e Menezes-Filho, 2007 – using Brazilian data]
- III. Constant education return by level of education and age (Pnad, 2007): for individual with 8 years of schooling, from 18 to 60 years of age

Cost-benefit analysis

Scenarios for costs:

1. R\$ 2,00 / student per Olympiad edition
2. R\$ 7,60 / student per edition
(for opportunity costs, several participations, etc.)

Cost-benefit analysis

		Number of participations		
		one	two	three
Scenario 1	NPV Total	R\$ 28,3 MM	R\$ 136 MM	R\$ 736,9 MM
	NPV/student	R\$ 67,80	R\$ 133,70	R\$ 211,65
	IRR per year	39%	42%	45%
Scenario 2	NPV Total	R\$ 26 MM	R\$ 124,6 MM	R\$ 678,4 MM
	NPV/student	R\$ 62,20	R\$ 122,50	R\$ 194,85
	IRR per year	22%	23%	25%

US\$1 = R\$2.19 (average 1st semester 2009).

NPV Total = R\$ 901 MM

We considered:

- a discount rate of 5% a year to calculate the IRR
- total number of enrolled student OBMEP 2007 level II = 4,9 MM

Concluding remarks

- OBMEP enhances education quality
 - Increasing impact with number of years participations
 - Increasing impact for better students within schools
- Positive economic return

Anexos

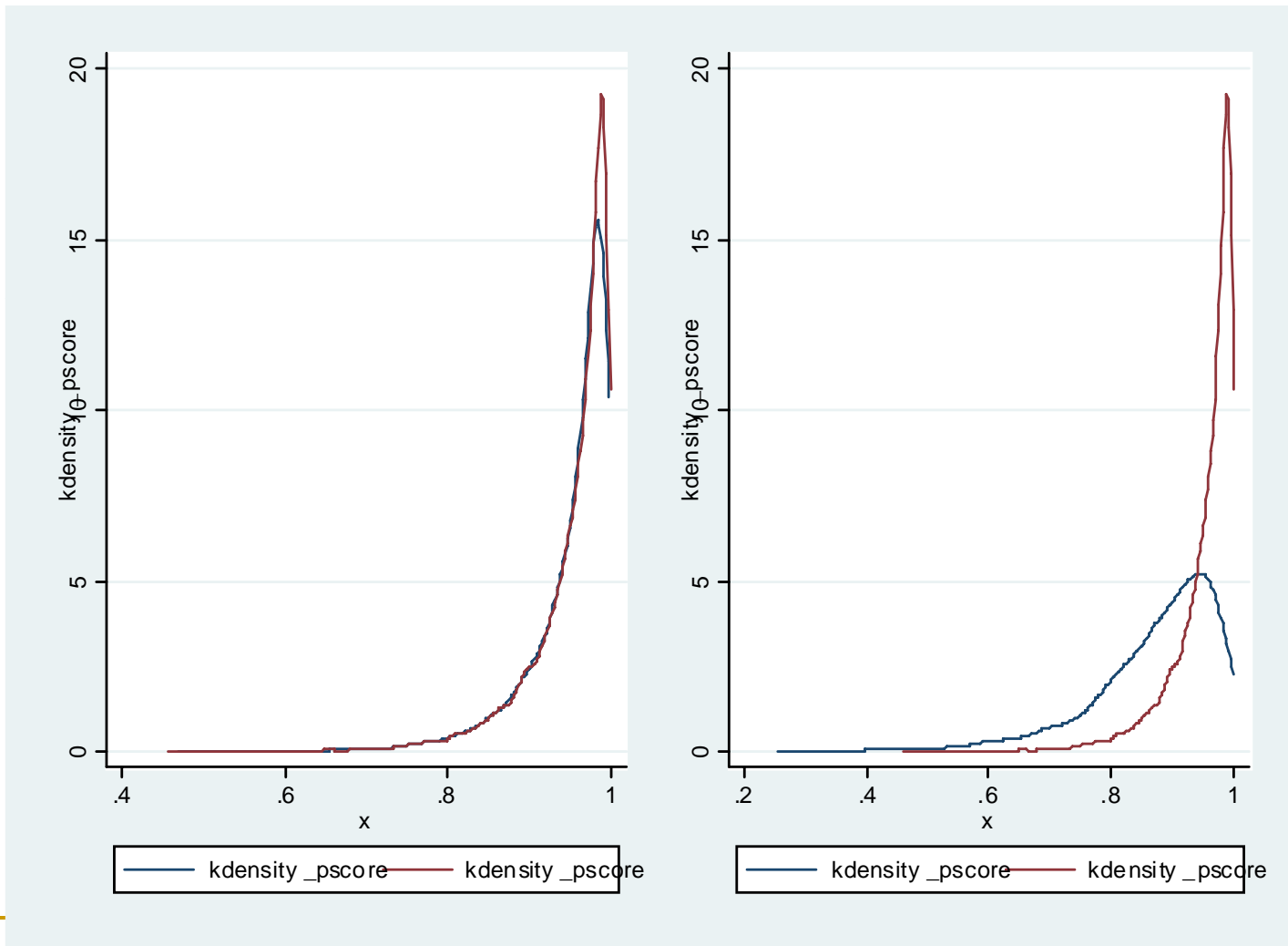
Balancing of covariates X

	Participantes	Não participantes	Teste de Diferenças de médias	
			estat. t antes do balanceamento	estat. t após o balanceamento***
1. Informações da Prova Brasil*				
nota_8a_MAT 05	239,7	233,1	-12,15	-
nota_8a_MAT 07	239,8	231,7	-17,25	-
nota_8a_LP 05	224,4	220,8	-7,35	1,23
nota_8a_LP 07	227,8	222,4	-12,68	0,36
1.1 Questionários dos Diretores				
% diretores com pós-graduação completa	71,2	62,5	-7,53	-0,53
% diretor com 11 a 15 anos na direção da escola	4,7	6,9	4,00	-1,12
% diretor com mais de 15 anos na direção da escola	3,2	4,1	2,07	0,35
% diretores com 30 a 39 anos de idade	24,1	22,0	-1,97	-0,63
% diretores passaram por seleção e eleição	17,5	13,4	-4,20	0,35
% escolas têm apoio finan. Gov. estadual	68,0	58,1	-7,44	0,35
% escolas têm prova para seleção alunos	0,8	1,0	1,12	0,17
% escolas com rotatividade do corpo docente	38,7	32,9	-4,67	-1,06
% escolas com interrupção das atividades escolares	19,0	20,8	1,81	0,44

Balancing of covariates X

	Participantes	Não participantes	estat. t antes do balanceamento	estat. t após o balanceamento***
1.2 Questionário dos alunos (8a série)				
% alunos iniciaram os estudos na pré-escola	81,7	78,1	-10,02	-0,33
% alunos homens	45,7	46,0	0,86	0,85
% com pais que comparecem à reunião	91,6	89,1	-13,63	-1,88
% alunos com pais que completaram ES	7,4	5,2	-12,71	-0,37
número médio de automóveis que possui	1,7	1,7	7,94	1,18
% alunos brancos	35,7	34,2	-2,96	-0,21
média matrículas na 8a série	92,7	63,2	-18,09	-1,64
% escolas municipais	35,0	44,6	8,16	-1,21
2. Censo Escolar 2006*				
nº médio de prof. no EF	28,2	26,0	-6,40	0,01
% escolas com acesso à internet	57,0	44,5	-10,25	1,17
% escolas que uso dos comp. pelos alunos EFII	39,0	25,5	-11,21	0,79
% prof. com ensino superior	88,3	84,6	-6,73	-1,69
% escolas com sistema ciclos	36,7	32,2	-3,74	1,76
média alunos por turma na 8a série	32,3	30,2	-9,45	-0,28
média de hora aula na 8a série	4,4	4,3	-10,92	0,19
3. Censo Populacional 2000**				
População média nos municípios	635.183	1.414.768	15,57	-1,26
Média de renda per capita nos municípios (R\$)	263,4	311,8	12,31	-1,73

Distribution of p_score (after and before matching)



Variáveis de controle das regressões (i)

1. Informações da Prova Brasil

Nota média_8^a série LP 2005

Nota média_8^a série LP 2007

Nota média_8^a série MAT 2005 (especificação dif-em-dif)

Variáveis de controle das regressões (ii)

1.1 Questionários dos Diretores

% diretores com ensino superior

% diretor com 11 a 15 anos experiência

% diretor com mais de 15 anos experiência

% diretores assumiram por seleção e eleição

% escolas tem prova de seleção de alunos

% escola tem apoio financeiro do Governo estadual

% escolas com elevado índice de falta de professores

% escolas com elevado índice de falta de alunos

% escolas com rotatividade do corpo docente

% escolas com interrupção das atividades escolares

Variáveis de controle das regressões (iii)

1.2 Questionário dos alunos (8ª série)

% alunos moram com os pais

% alunos iniciaram os estudos na pré-escola

idade média

% alunos homens

% alunos trabalham fora

% pais que comparecem reunião escolar

% alunos que já foram reprovados

% alunos com pais que completaram ensino superior

% alunos brancos

Variáveis de controle das regressões (iv)

2. Censo Escolar 2006

Nº médio de matrículas na 8a série

Nº médio de matrículas na 7a série

% escolas municipais

nº médio de prof. no EF

% tem computador na escola

% acesso à internet

% uso dos comp. pelos alunos EFII

% prof. com ensino superior

% escolas com sistema ciclos

média alunos por turma na 8a série

média de hora aula na 8a série

Variáveis de controle das regressões (v)

3. Censo Populacional 2000

População média dos municípios

Média de Renda per capita nos municípios

Dummy de região

Comparação de métodos

Métodos baseados no propensity score (Imbens e Wooldridge, 2008)

		ATT	t
Propensity score $p(x)$	não conhecemos a função $p(\cdot)$. Afeta a variância do estimador no 2o estágio		
Propensity score matching (NN)	propriedades assintóticas do matching não são bem estabelecidas, e estimativas do erro-padrão não são eficientes	4.25	3.06
Regressão no pscore	erro-padrão do estimador não eficiente	5.57	6.58
Reponderação usando pscore estimado	qdo $p(x)$ estimado for próximo 1, pesos contrafactuais serão muito altos levando comportamento ruim em amostras finitas, estimador impreciso	2.85	8.81
Estratificação por intervalo do pscore	método arbitrário na escolha do n^o de estratos	5.12	
Combinando regressão e ponderação pelo pscore	leva a robustez adicional, pois tira viés ao omitir X da regressão. Duplamente robusto.	2.14	4.73