

## **Abstract Title Page**

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**Title:** Analyzing the effect of City Connects on student achievement using a regression discontinuity design.

**Authors:**

Diego A. Luna Bazaldua<sup>1</sup>, Mary E. Walsh<sup>1</sup>, Erin Sibley<sup>1</sup>, Terrence J. Lee St. John<sup>2</sup>, Eric Dearing<sup>1</sup>, Laura O'Dwyer, Anastasia E. Raczek<sup>1</sup>, & Claire Foley<sup>1</sup>

**Institutional Affiliations:**

<sup>1</sup> Lynch School of Education, Boston College

<sup>2</sup>SRI International

**Contact email:** diego.lunabazaldua@bc.edu, mary.walsh@bc.edu, erin.sibley@bc.edu, tjleestjohn@gmail.com, laura.odwyer@bc.edu, anastasia.raczek@bc.edu, claire.foley@bc.edu

**Presenting author:** Diego A. Luna Bazaldua.

## **Analyzing the effect of City Connects on student achievement using a regression discontinuity design.**

### **Background**

City Connects is a systemic student support approach based on a theory of change (see Figure 1). At the core of the intervention is a full-time school coordinator. In the fall of each school year, each classroom teacher and the coordinator meet to discuss the strengths and needs of every student in the class in four developmental domains: academic, family, health, and behavioral/social/emotional. Based on this assessment, each child is assigned to a tier that indicates the severity of strengths and needs. For children identified as having intensive needs, coordinators arrange individual student reviews with a wider team of professionals –school psychologists, teachers, principals, nurses, and community agency staff– to discuss specific goals and strategies for that student and to develop additional supports. As a result, coordinators design tailored plans for each student, identifying services and supports that could promote student strengths and meet student needs. In addition to developing student support plans, coordinators help teachers manage student crises, implement classroom and school-wide prevention programs, and facilitate social emotional skills groups throughout the school year. Coordinators are also responsible for developing and maintaining working relationships with local community partners.

The intervention has demonstrated positive effects on academic achievement (An, 2015; Dearing et al., 2016; Shields, Walsh, & Lee-St. John, 2016; Walsh et al., 2014) and on non-cognitive skills (Lee-St. John, 2013; O'Dwyer, Lee-St. John, Raczek, & Walsh, 2016). Moreover, City Connects has proven to be a cost-effective approach to delivering a customized and comprehensive set of resources to elementary school students (Bowden et al., 2015).

### **Purpose**

This study aims to determine the effect of an additional year in City Connects using date of birth to establish the cutoff point of discontinuity in a regression discontinuity design (RDD). The data comes from the Boston Public Schools (BPS) district, where some public schools have taken part of the intervention. The analysis is enriched due to the availability of data for comparison students within schools in the district that did not receive the intervention, making it possible to produce a comparative RDD.

### **Methodology**

In this study, the point of discontinuity is date of birth. In BPS, a student must have turned 5 years old by the beginning of the school year in order to enroll in kindergarten. This means that September 1<sup>st</sup> is a sharp point of discontinuity in the date of birth; students born on or after this date were assigned to kindergarten a full year later than those born just before this date. Given the year the intervention starts in the schools and date of birth of each student, it is possible to estimate a treatment effect using a RDD for those students who experience the intervention for one or more years.

In our use of this method, one complication is that the students born right after the cutoff took the Massachusetts Comprehensive Assessment System examination (MCAS; Massachusetts Department of Elementary & Secondary Education, 2014) –test used to measure academic achievement in English Language Arts and Mathematics in this study– at an older age (although at the same grade level) as students born right before the cutoff date. Age at the time of testing is

known to influence performance on test scores (Cascio & Schanzenbach, 2007). To address this complication, the study added a comparison group of students within the same school district who were never enrolled in schools taking part of City Connects.

The sample included students from eleven schools within the district that began implementing the intervention in school years 2007-08 or 2010-11. Comparison students were enrolled during the same years in schools that never implemented the intervention. Students from schools in the district that implemented City Connect before 2007-08 were excluded from the sample. Additional student-level criteria to be included in the sample were as follows: students could not have been retained (i.e., repeated a grade) in previous school years; students had to have been born within the range of 12 months above or below the cutoff date; students with severe special educational needs requiring instruction in substantially separate classrooms according to the district criteria were excluded from the analysis; and students had to have sociodemographic and outcome variable data. Table 1 summarizes the sample size and attrition based on the response rates in the MCAS outcomes. Table 2 shows the correlation between the DOB rating variable and the outcomes. In addition, Tables 3 and 4 summarize sociodemographic covariate balance between pre- and post-cutoff treatment groups and between treatment and comparison groups.

Two-level hierarchical models were used to estimate the treatment effect in this comparative RDD. Level one in the model corresponds to students and level two to schools. Outcome variables were the 3<sup>rd</sup> to 5<sup>th</sup> grade standardized scores. Following the guidelines on RDD, models with only main effects, interactions, quadratic and cubic terms, and sociodemographic covariates were estimated for each outcome (Jacob, Zhu, Somers, & Bloom, 2012; WWC, 2014). This approach resulted in twelve different models for each outcome: six models without sociodemographic covariates and six models with them. The model with the lowest Akaike Information Criterion (AIC) was used as the criterion to select among the different models (Jacob et al., 2012; WWC, 2014). Table 5 summarizes the AIC statistics for the estimated RDD models.

## **Results**

As shown in Tables 6 and 7, positive effects of an additional year in the comprehensive student support intervention were observed in English Language Arts and Mathematics outcomes for students in 3<sup>rd</sup> and 5<sup>th</sup> grades. The results show that longer exposure to the intervention enhances students' academic performance; moreover, students receiving the intervention for an additional year tend to reach the performance levels of their peers in comparison schools within the district. The results are supported by graphical analyses of the rating variable and academic outcomes (see Figures 2 to 7). Methodologically, the present study confirmed the positive effects of this student support intervention and provided evidence of a causal relationship between City Connects and improvement in academic outcomes in multiple cohorts of students from different school grades.

## **References**

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**Tables in manuscript**

*Table A1. Sample size and percentage of attrition in each group*

Group	3rd grade			4th grade			5th grade		
	Total Sample	Valid Sample	Attrition (%)	Total Sample	Valid Sample	Attrition (%)	Total Sample	Valid Sample	Attrition (%)
<b>English Language Arts</b>									
Comparison pre-cutoff	4450	4202	5.57	4109	3890	5.33	3907	3712	4.99
Comparison post-cutoff	4400	4175	5.11	4198	3984	5.10	3667	3486	4.94
Intervention pre-cutoff	692	651	5.92	648	611	5.71	581	547	5.85
Intervention post-cutoff	697	652	6.46	663	625	5.73	630	606	3.81
<b>Mathematics</b>									
Comparison pre-cutoff	4450	4265	4.16	4109	3929	4.38	3907	3768	3.56
Comparison post-cutoff	4400	4222	4.05	4198	4035	3.88	3667	3528	3.79
Intervention pre-cutoff	692	669	3.32	648	624	3.70	581	560	3.61
Intervention post-cutoff	697	674	3.30	663	643	3.02	630	619	1.75

Note: "Valid sample" refers to sample without missing data in the English and Mathematics outcomes.

*Table 2. Correlations between rating variable and outcomes*

Outcome	3rd grade	4th grade	5th grade
<b>ELA , DOB</b>	-0.032	-0.030	-0.029
<b>Mathematics , DOB</b>	-0.023	-0.024	-0.016

Note: "ELA" refers to English Language Arts.

Table A2. Covariate balance between pre- and post-cutoff intervention groups

	3rd grade					4th grade					5th grade				
	Intervention Pre-cutoff		Intervention Post-cutoff		SMD	Intervention Pre-cutoff		Intervention Post-cutoff		SMD	Intervention Pre-cutoff		Intervention Post-cutoff		SMD
	Mean	SD	Mean	SD		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
<b>DOB rating variable</b>	5.95	3.51	6.07	3.43	0.034	6.05	3.40	5.92	3.45	-0.038	6.24	3.43	5.94	3.41	-0.087
<b>School distance from home</b>	1.88	1.75	1.86	1.82	-0.010	1.97	1.85	1.92	1.81	-0.031	2.11	1.96	2.09	1.81	-0.009
<b>Number of school changes</b>	0.50	0.68	0.55	0.67	0.072	0.61	0.78	0.61	0.75	-0.002	0.77	0.85	0.73	0.88	-0.046
<b>% Male</b>	0.49	0.50	0.48	0.50	-0.022	0.48	0.50	0.49	0.50	0.016	0.48	0.50	0.48	0.50	0.008
<b>% Black</b>	0.38	0.49	0.37	0.48	-0.025	0.37	0.48	0.38	0.49	0.023	0.41	0.49	0.37	0.48	-0.068
<b>% Asian</b>	0.08	0.27	0.07	0.26	-0.029	0.08	0.28	0.08	0.27	-0.016	0.08	0.27	0.09	0.28	0.023
<b>% Hispanic</b>	0.38	0.49	0.40	0.49	0.037	0.38	0.49	0.38	0.49	0.003	0.36	0.48	0.39	0.49	0.062
<b>% Other race</b>	0.02	0.14	0.02	0.13	-0.017	0.02	0.13	0.02	0.13	-0.003	0.01	0.11	0.02	0.13	0.044
<b>% Reduced price lunch</b>	0.08	0.27	0.09	0.28	0.025	0.10	0.30	0.09	0.29	-0.016	0.09	0.29	0.09	0.29	0.014
<b>% Free lunch</b>	0.72	0.45	0.69	0.46	-0.066	0.69	0.46	0.68	0.47	-0.031	0.70	0.46	0.69	0.46	-0.025
<b>% Special ed. Level 2</b>	0.07	0.25	0.07	0.25	-0.001	0.06	0.24	0.07	0.25	0.013	0.06	0.23	0.07	0.25	0.044
<b>% Special ed. Level 3</b>	0.03	0.17	0.03	0.16	-0.014	0.03	0.17	0.03	0.17	-0.014	0.03	0.17	0.03	0.18	0.023
<b>% ELL</b>	0.20	0.40	0.19	0.40	-0.009	0.22	0.42	0.21	0.41	-0.035	0.22	0.42	0.24	0.43	0.044
<b>% Foreign born</b>	0.12	0.33	0.12	0.33	0.000	0.15	0.36	0.14	0.35	-0.039	0.16	0.37	0.18	0.38	0.042

Note: The DOB rating variable was transformed in absolute values for a better comparison between groups. “ELL” refers to English Language Learners, “Special Ed.” to special education status. SMD is the Standard Mean Difference between the two groups, and SD is the covariate standard deviation.

Table A3. Covariate balance between intervention and comparison groups

	3rd grade					4th grade					5th grade				
	Comparison		Intervention		SMD	Comparison		Intervention		SMD	Comparison		Intervention		SMD
	Mean	SD	Mean	SD		Mean	SD	Mean	SD		Mean	SD			
<b>DOB rating variable</b>	6.06	3.47	6.01	3.47	-0.014	5.94	3.44	5.98	3.43	0.013	6.06	3.45	6.08	6.42	0.006
<b>School distance from home</b>	1.61	1.95	1.87	1.79	0.142	1.63	1.94	1.95	1.83	0.175	1.68	1.96	2.10	1.88	0.221
<b>Number of school changes</b>	0.58	0.70	0.53	0.67	-0.077	0.72	0.76	0.61	0.77	-0.146	0.83	0.82	0.74	0.86	-0.098
<b>% Male</b>	0.49	0.50	0.46	0.50	-0.060	0.49	0.50	0.47	0.50	-0.034	0.48	0.50	0.46	0.49	-0.045
<b>% Black</b>	0.39	0.49	0.33	0.47	-0.125	0.39	0.49	0.32	0.46	-0.152	0.40	0.49	0.33	0.47	-0.147
<b>% Asian</b>	0.06	0.24	0.16	0.37	0.266	0.07	0.25	0.19	0.39	0.318	0.06	0.25	0.18	0.39	0.307
<b>% Hispanic</b>	0.38	0.49	0.46	0.50	0.151	0.38	0.48	0.42	0.49	0.084	0.36	0.48	0.40	0.49	0.078
<b>% Other race</b>	0.02	0.14	0.01	0.11	-0.053	0.02	0.14	0.01	0.12	-0.037	0.01	0.12	0.01	0.11	-0.013
<b>% Reduced price lunch</b>	0.09	0.28	0.07	0.25	-0.089	0.10	0.30	0.08	0.27	-0.076	0.09	0.29	0.07	0.25	-0.102
<b>% Free lunch</b>	0.69	0.46	0.80	0.40	0.288	0.67	0.47	0.77	0.42	0.242	0.67	0.46	0.77	0.41	0.234
<b>% Special ed. Level 2</b>	0.07	0.25	0.07	0.26	0.024	0.06	0.24	0.07	0.25	0.017	0.06	0.23	0.06	0.24	0.012
<b>% Special ed. Level 3</b>	0.03	0.16	0.03	0.16	-0.015	0.03	0.17	0.04	0.19	0.034	0.03	0.17	0.03	0.17	-0.007
<b>% ELL</b>	0.18	0.38	0.32	0.47	0.302	0.20	0.40	0.34	0.47	0.300	0.21	0.41	0.34	0.47	0.276
<b>% Foreign born</b>	0.12	0.32	0.17	0.37	0.137	0.14	0.35	0.17	0.38	0.089	0.16	0.37	0.19	0.39	0.061

Note: The DOB rating variable was transformed in absolute values for a better comparison between groups. “ELL” refers to English Language Learners, “Special Ed.” to special education status. SMD is the Standard Mean Difference between the two groups, and SD is the covariate standard deviation.

Table A4. AIC statistics for RDD estimated models

Outcome	English language arts		Mathematics	
	without covariates	with covariates	without covariates	with covariates
Model	AIC	AIC	AIC	AIC
<b>3<sup>rd</sup> grade</b>				
<b>1</b>	25005.8	23518.8	25370.6	24145.8
<b>2</b>	25027.8	23544.1	25398.9	24174.4
<b>3</b>	25019.9	23535.0	25387.7	24162.6
<b>4</b>	25077.3	23593.0	25446.6	24223.1
<b>5</b>	25039.0	23553.2	25406.7	24181.3
<b>6</b>	25133.8	23649.8	25493.8	24270.3
<b>4<sup>th</sup> grade</b>				
<b>1</b>	22430.9	20916.2	23529.8	22366.8
<b>2</b>	22453.6	20933.8	23557.7	22393.5
<b>3</b>	22443.8	20924.0	23545.9	22381.6
<b>4</b>	22502.1	20981.8	23606.2	22441.1
<b>5</b>	22463.9	20943.4	23564.4	22399.1
<b>6</b>	22561.3	21041.4	23664.1	22499.3
<b>5<sup>th</sup> grade</b>				
<b>1</b>	21226.4	19721.9	21841.4	20510.1
<b>2</b>	21251.4	19748.3	21866.9	20537.2
<b>3</b>	21243.5	19738.8	21857.8	20527.2
<b>4</b>	21294.2	19789.2	21914.3	20584.1
<b>5</b>	21261.4	19757.4	21876.8	20546.8
<b>6</b>	21352.6	19848.8	21968.5	20637.8

Note: "AIC" refers to the Akaike Information Criterion. Model 1 is the model with main effects, model 2 includes main effects and interactions, model 3 adds a quadratic effect for the rating variable, model 4 includes quadratic effects and interactions, model 5 adds quadratic and cubic effects for the rating variable, model 6 includes quadratic and cubic effects and interactions,



Table 5. ELA and Math standardized scores by group and effect sizes

Outcome	Control group				Intervention group				Effect Size
	Pre-cutoff		Post-cutoff		Pre-cutoff		Post-cutoff		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
<b>3<sup>rd</sup> ELA</b>	0.227	0.921	0.201	0.930	-0.029	0.931	0.035	0.983	0.067
<b>3<sup>rd</sup> Math</b>	0.176	0.950	0.143	0.945	0.058	0.979	0.163	0.999	0.106
<b>4<sup>th</sup> ELA</b>	0.268	0.907	0.259	0.892	0.061	0.887	0.061	0.938	-0.001
<b>4<sup>th</sup> Math</b>	0.213	0.936	0.198	0.932	0.195	1.006	0.183	0.968	-0.012
<b>5<sup>th</sup> ELA</b>	0.277	0.893	0.239	0.919	0.026	0.948	0.140	0.906	0.123
<b>5<sup>th</sup> Math</b>	0.250	0.921	0.215	0.941	0.112	1.029	0.325	0.926	0.218

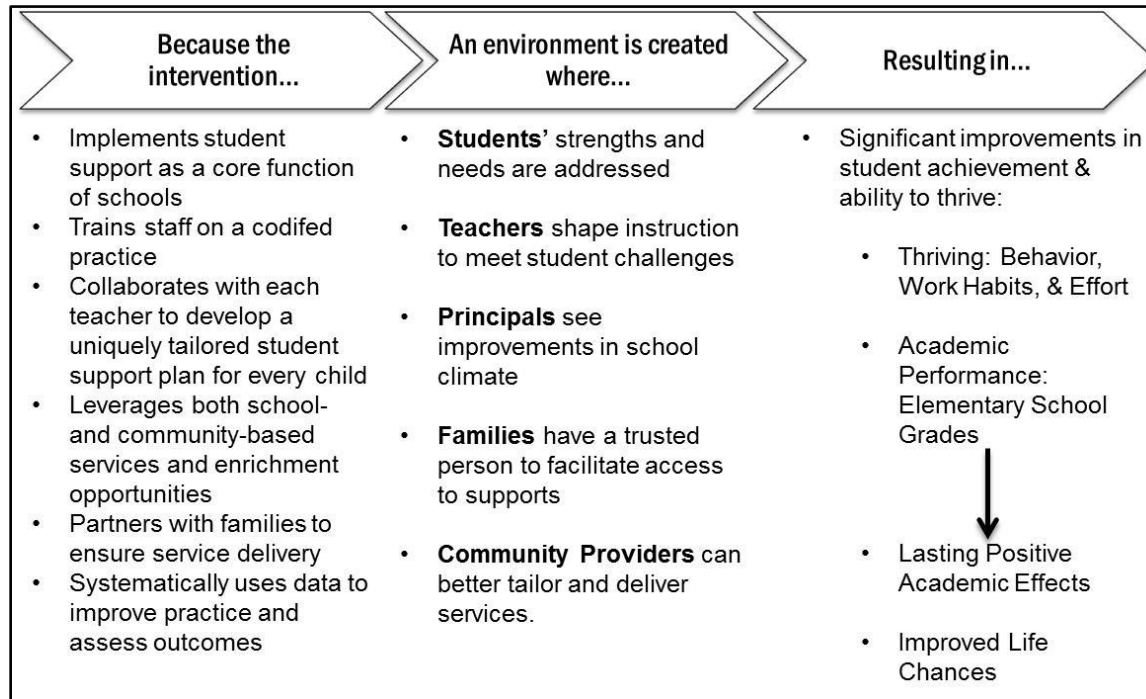
Note: In the case of the intervention group, students included in the pre-cutoff subgroup sample received the intervention for only one year, whereas those within to the post-cutoff subgroup sample received it for two years. No student in the control group participated in the intervention. “ELA” refers to the English Language Arts test score, “Math” to the mathematics test score, and SD is the standard deviation.

Table 6. RDD model for the intervention effects on standardized tests scores

	Model without covariates			Model with covariates			Model without covariates			Model with covariates		
	$\beta$	SE	<i>p-value</i>	$\beta$	SE	<i>p-value</i>	$\beta$	SE	<i>p-value</i>	$\beta$	SE	<i>p-value</i>
	<b>3<sup>rd</sup> grade Math scores</b>						<b>3<sup>rd</sup> grade ELA scores</b>					
Intercept	0.131	0.043	0.003	1.567	0.198	<0.001	0.168	0.038	<0.001	1.645	0.152	<0.001
Intervention effect	-0.191	0.123	0.121	-0.058	0.096	0.547	-0.306	0.103	0.003	-0.143	0.074	0.057
Additional year of intervention	0.152	0.051	0.002	0.147	0.048	0.002	0.093	0.052	0.072	0.086	0.048	0.073 4
Cohort effect	0.108	0.036	0.002	0.122	0.034	<0.001	0.162	0.036	<0.001	0.175	0.034	<0.001
DOB Rating effect	-0.011	0.003	<0.001	-0.012	0.002	<0.001	-0.015	0.003	<0.001	-0.016	0.002	<0.001
	<b>4<sup>th</sup> grade Math scores</b>						<b>4<sup>th</sup> grade ELA scores</b>					
Intercept	0.136	0.043	0.002	1.478	0.208	<0.001	0.173	0.039	<0.001	1.677	0.188	<0.001
Intervention effect	-0.060	0.120	0.615	0.011	0.099	0.914	-0.225	0.111	0.044	-0.129	0.089	0.154
Additional year of intervention	0.030	0.052	0.558	0.044	0.048	0.356	0.033	0.049	0.506	0.052	0.046	0.252
Cohort effect	0.098	0.036	0.006	0.140	0.034	<0.001	0.145	0.035	<0.001	0.192	0.032	<0.001
DOB Rating effect	-0.009	0.003	<0.001	-0.013	0.002	<0.001	-0.013	0.003	<0.001	-0.017	0.002	<0.001
	<b>5<sup>th</sup> grade Math scores</b>						<b>5<sup>th</sup> grade ELA scores</b>					
Intercept	0.185	0.040	<0.001	1.533	0.175	<0.001	0.203	0.038	<0.001	1.627	0.159	<0.001
Intervention effect	-0.224	0.109	0.042	-0.118	0.082	0.151	-0.292	0.101	0.004	-0.164	0.075	0.031
Additional year of intervention	0.235	0.026	<0.001	0.220	0.050	<0.001	0.143	0.054	0.007	0.137	0.049	0.005
Cohort effect	0.082	0.039	0.034	0.134	0.036	<0.001	0.112	0.038	0.004	0.167	0.035	<0.001
DOB Rating effect	-0.009	0.003	0.001	-0.012	0.003	<0.001	-0.011	0.004	<0.001	-0.015	0.002	<0.001

Note: \*\* corresponds to *p-value* < 0.01 and \* to *p-value* < 0.05.  $\beta$  refers to the estimated coefficient value, SE to the coefficient standard error, t-ratio to the ratio of coefficient divided by its standard error.

## Figures



*Figure 1. Theory of Change for the intervention*

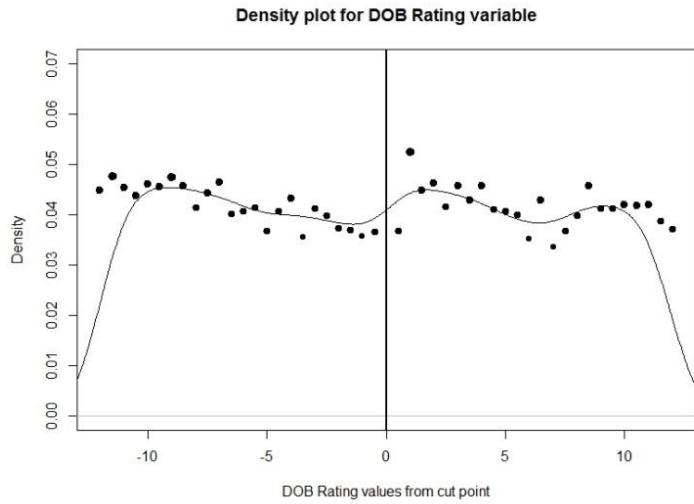


Figure 2. Density plot for the rating variable in 3<sup>rd</sup> grade

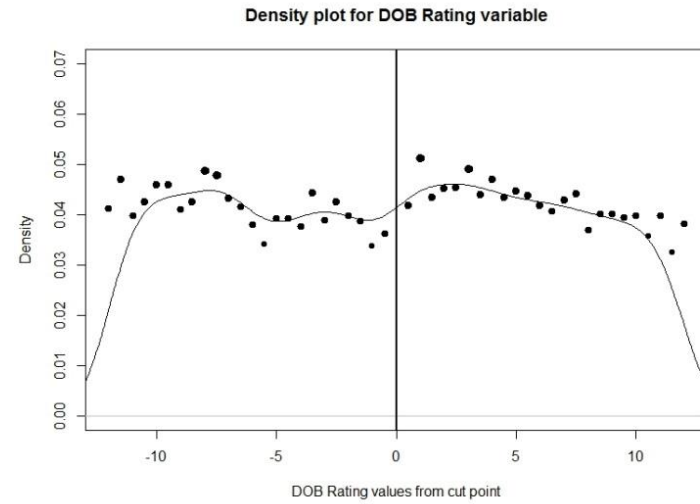


Figure 3. Density plot for the rating variable in 4<sup>th</sup> grade

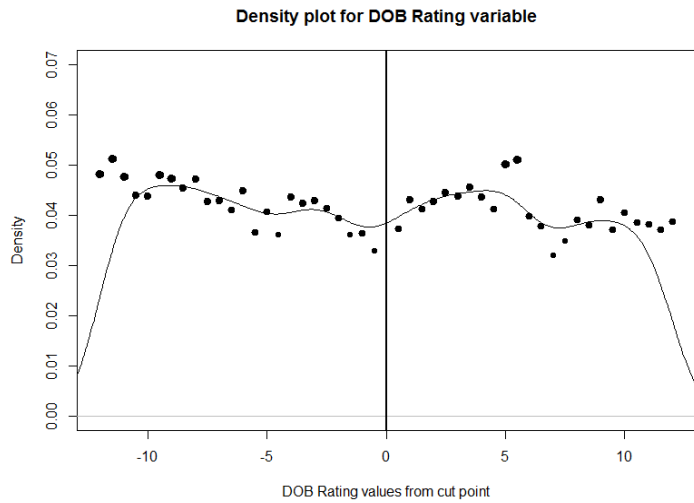


Figure 4. Density plot for the rating variable in 5<sup>th</sup> grade

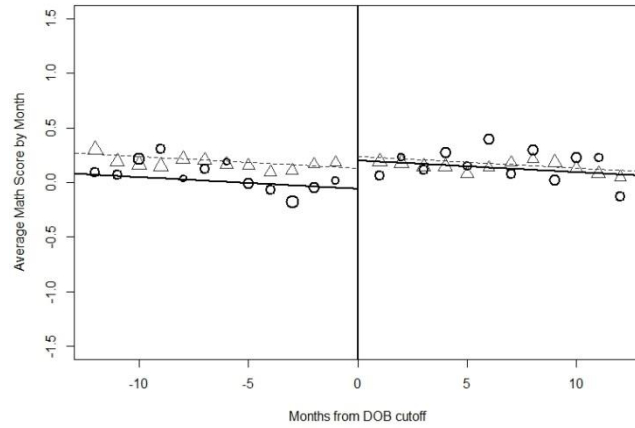


Figure 5: Average 3<sup>rd</sup> grade Mathematics scores.

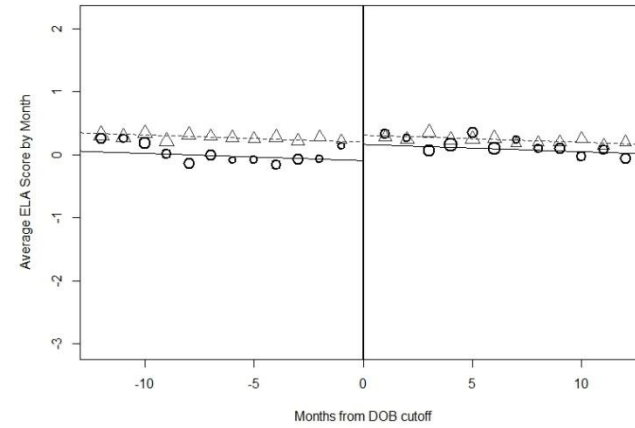


Figure 6: Average 5<sup>th</sup> grade English language arts scores.

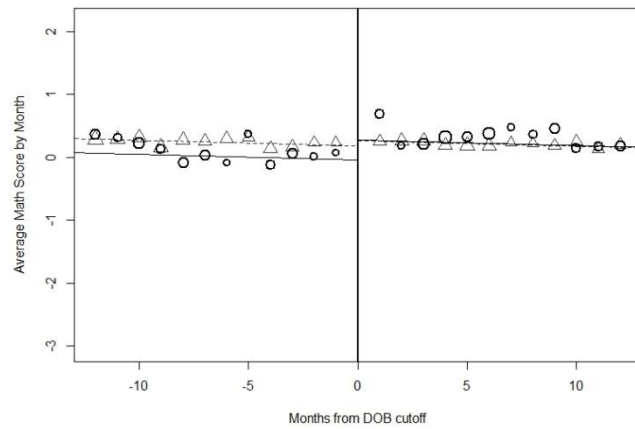


Figure 7: Average 5<sup>th</sup> grade Mathematics scores.

Note: The circles correspond to average scores for students in schools part of the intervention. The triangles are for the comparison group. The size of the circles and triangles indicates to the proportion of students born in that specific stratum of the rating variable. The solid line corresponds to regression model expected values for the intervention group, while the dashed lines to the comparison group, and the horizontal line corresponds to the cutoff date in the rating variable.