An International Comparison of Private and Public Schools using Multilevel Propensity Score Methods and Graphics

Jason M. Bryer
University at Albany

Robert M. Pruzek
University at Albany

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Abstract

As can be seen from the recent Special Issue of *Multivariate Behavioral Research* on propensity score methods the use of propensity score analysis (PSA) has gained increasing popularity for estimating causal effects in observational studies. However, PSA use with multilevel or clustered data has been limited, and to date there seems to have been no development of specialized graphics for such data. This paper will introduce the `multilevelPSA` package for R that provides cluster-based functions for estimating propensity scores (potentially for large datasets) as well as graphics to exhibit results for multilevel data. This work extends to the multilevel case the framework for visualizing propensity score analysis introduced by Helmreich and Pruzek (2009). International data from the Programme for International Student Assessment, PISA, (Organization for Economic Co-operation and Development, 2009) are comprehensively examined to compare private with public schools on reading, mathematics, and science outcomes after adjusting for covariate differences in the multilevel context.

Keywords: *PSA, propensity score analysis, multilevel, graphics*

Introduction

Programme for International Student Assessment

Visualizing Multilevel Propensity Score Analysis

The focus is on use of graphics for interpreting results of propensity score analyses where data are clustered. The goal is to use propensity score methods based on available covariates (all measures at the level of individuals) to adjust for differences between students in the two kinds of

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Source code for the `multilevelPSA` R package can be obtained from `http://jbryer.github.com/multilevelPSA`.

schools. Modern graphics permit learning how large extant differences are, and how results vary by countries, i.e. clusters.

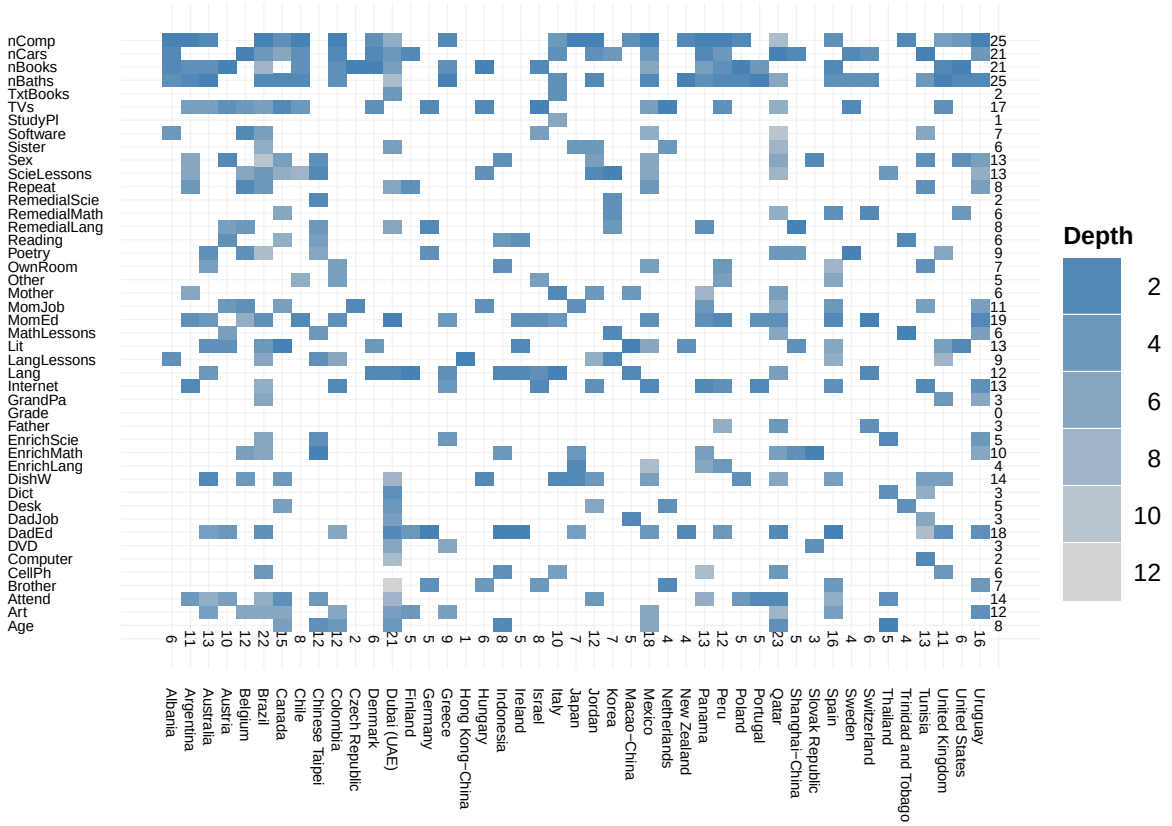

Figure 1. Tree Heat of Multilevel Conditional Inference Trees

Figure 2 represents a multilevel assessment plot for the math assessment given at the end of secondary school. Coordinates for each point, one for each country, are overall adjusted means for stratifications based upon conditional inference trees of public and private schools on x- and y-axes. The size of each point (bubble) corresponds to the number of students sampled or tested within each country. Each point is projected, parallel to the identity line, to a cross on the line with slope -1 in the bottom left of the figure, to show the distribution of differences between public and private school scores across countries. The average difference and a confidence interval are also shown.

Figure **??** provides a more detailed representation of the distribution of differences. The x-axis corresponds to the difference scores and the y-axis to each country, for which differences are used to order results for countries. Blue dots correspond to the overall adjusted mean difference for each country along with the confidence intervals in green. The light grey dots correspond to differences for strata within each country. Similar to Figure 1, the vertical blue and green lines correspond to the overall adjusted mean difference and confidence interval, respectively.

Results and Discussion

Particularly for analyses of large data sets, focusing on statistical significance is limiting. As can readily be seen, overall results favor private over public schools, at least for end of secondary school math achievement. But the graphics, especially Figure 2, provide a more nuanced understanding of the nature and magnitude of adjusted differences for countries. Furthermore, the graphics are readily interpreted by a non-??technical audience. Broadly speaking, it is seen that modern graphics can enhance and extend conventional numerical summaries by focusing on details of what data have to say for multilevel comparisons of many countries based on PS methods.

References

Helmreich, J., & Pruzek, R. (2009). Psagraphics: An r package to support propensity score analysis. *Journal of Statistical Software*, *29*(6).

Organization for Economic Co-operation and Development. (2009). *Programme for International Student AssessmentAnalysis.* Available from `http://dx.doi.org/10.1787/9789264095298-en`

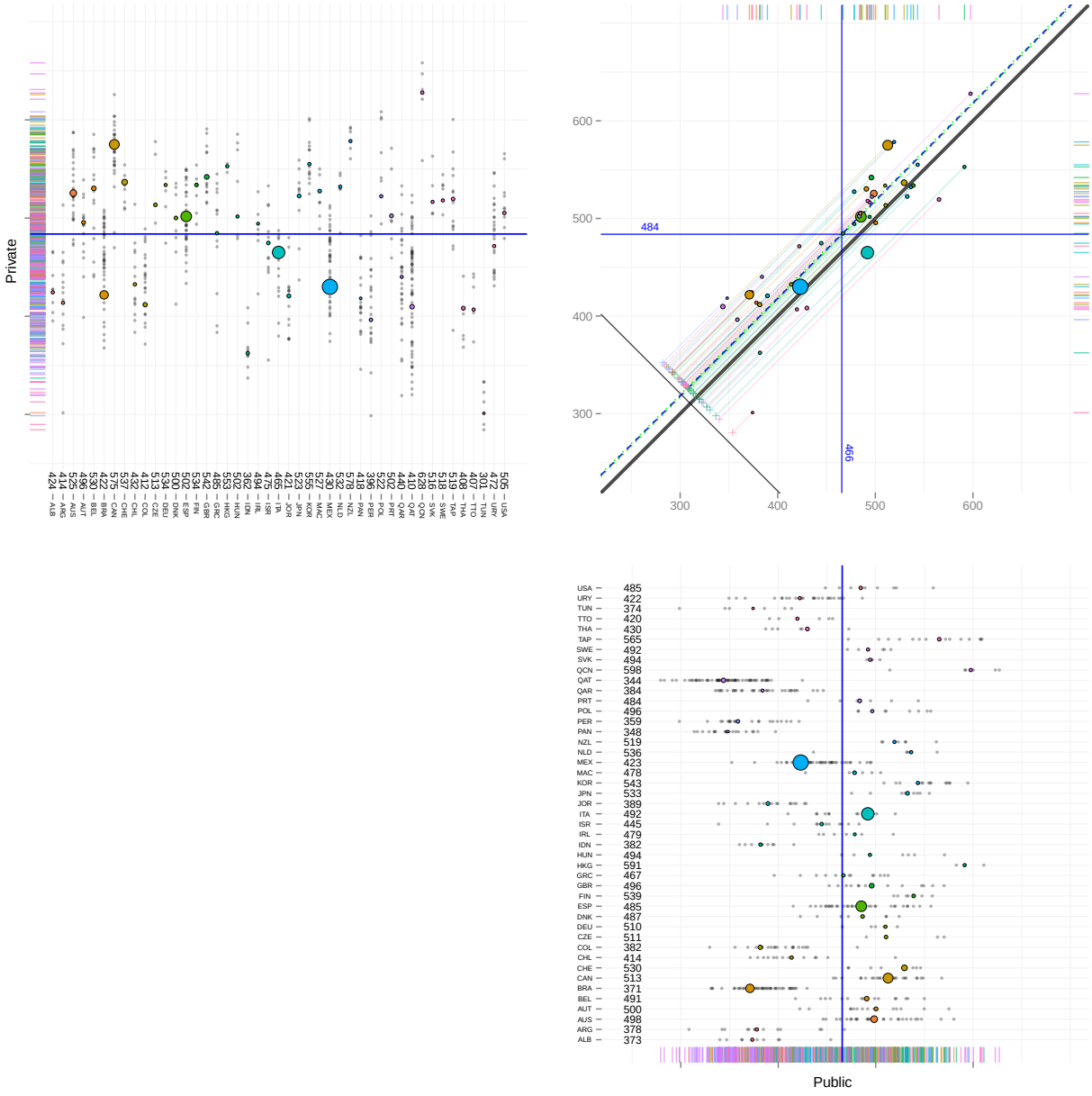

Figure 2. Multilevel PSA Assessment Plot: Mathematics

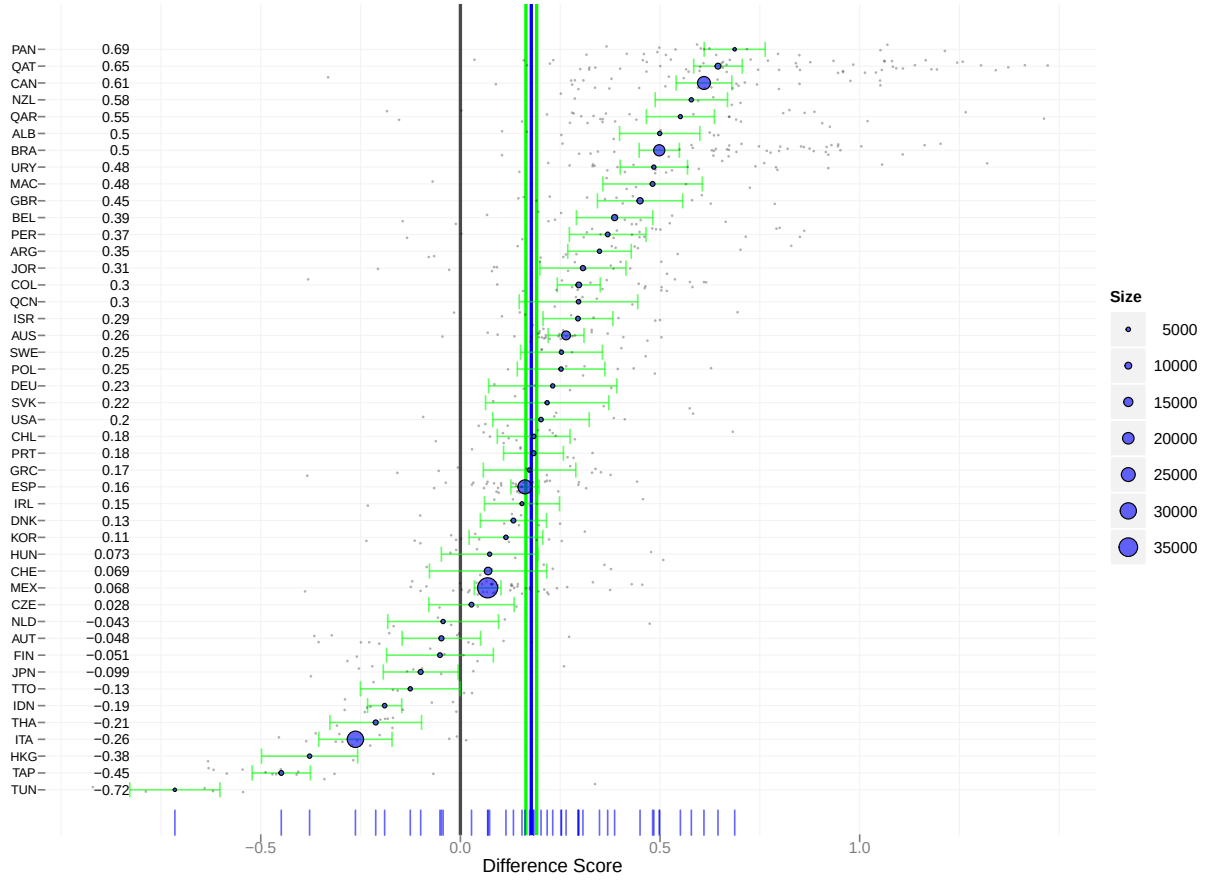

Figure 3. Multilevel PSA Difference Plot: Mathematics

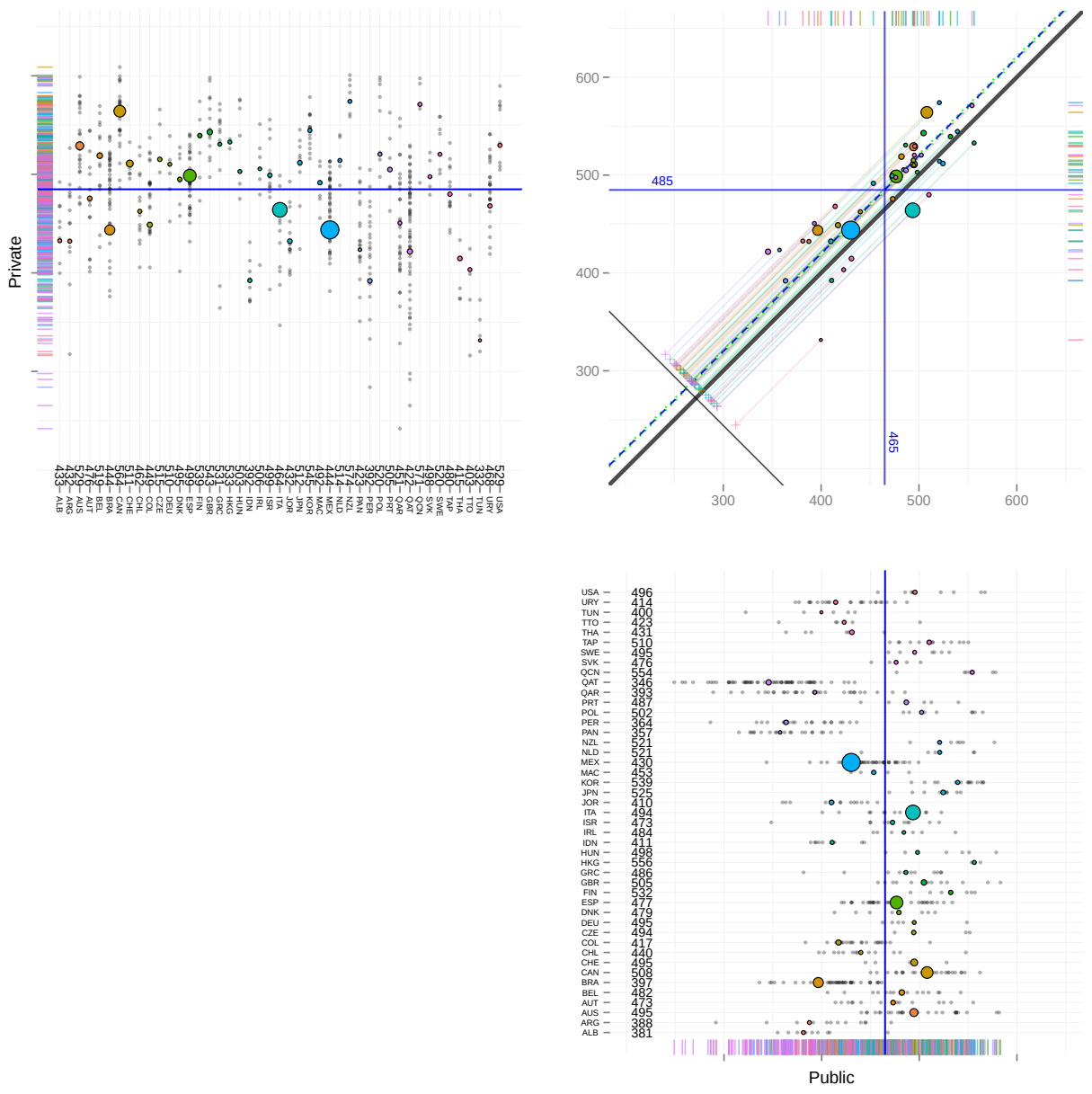

Figure 4. Multilevel PSA Assessment Plot: Reading

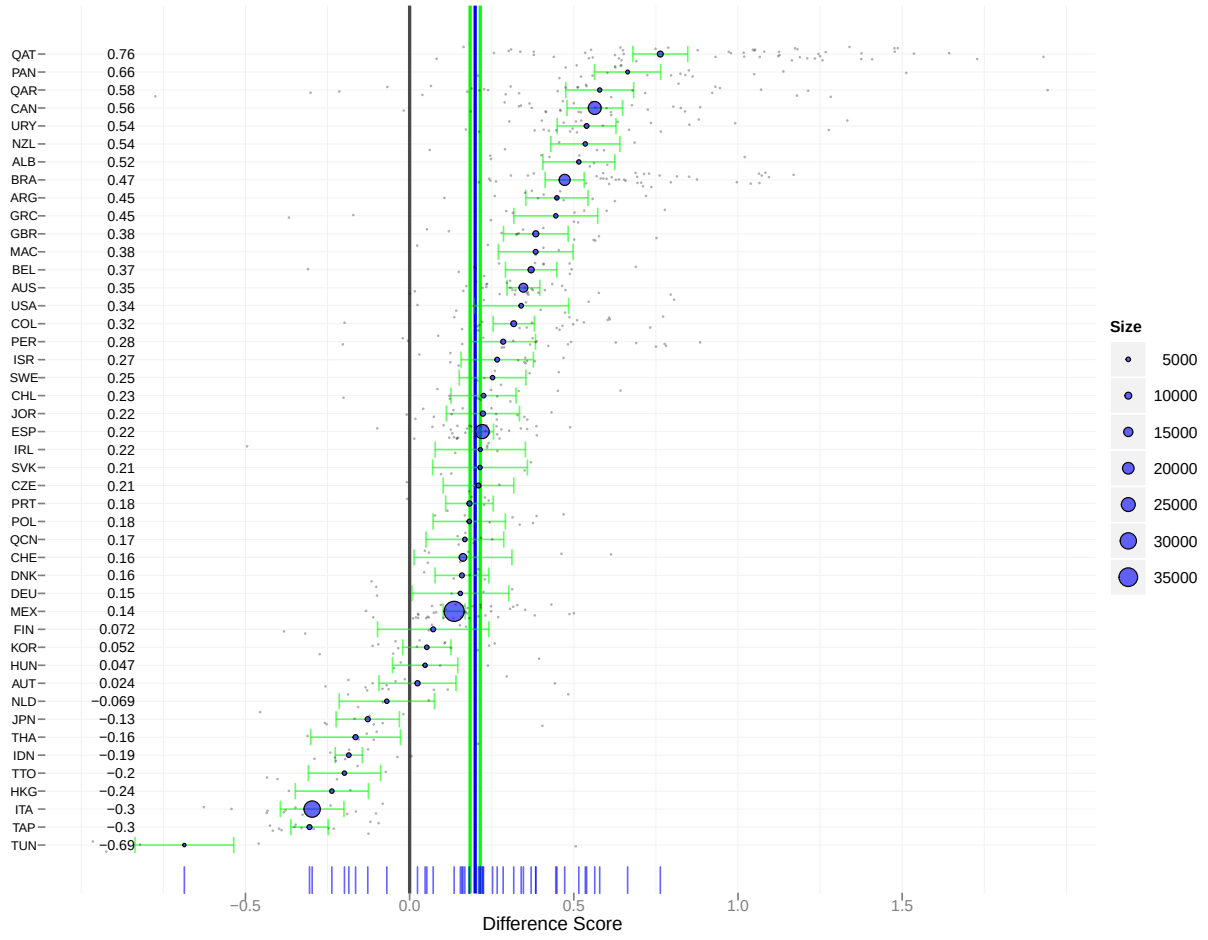

Figure 5. Multilevel PSA Difference Plot: Reading

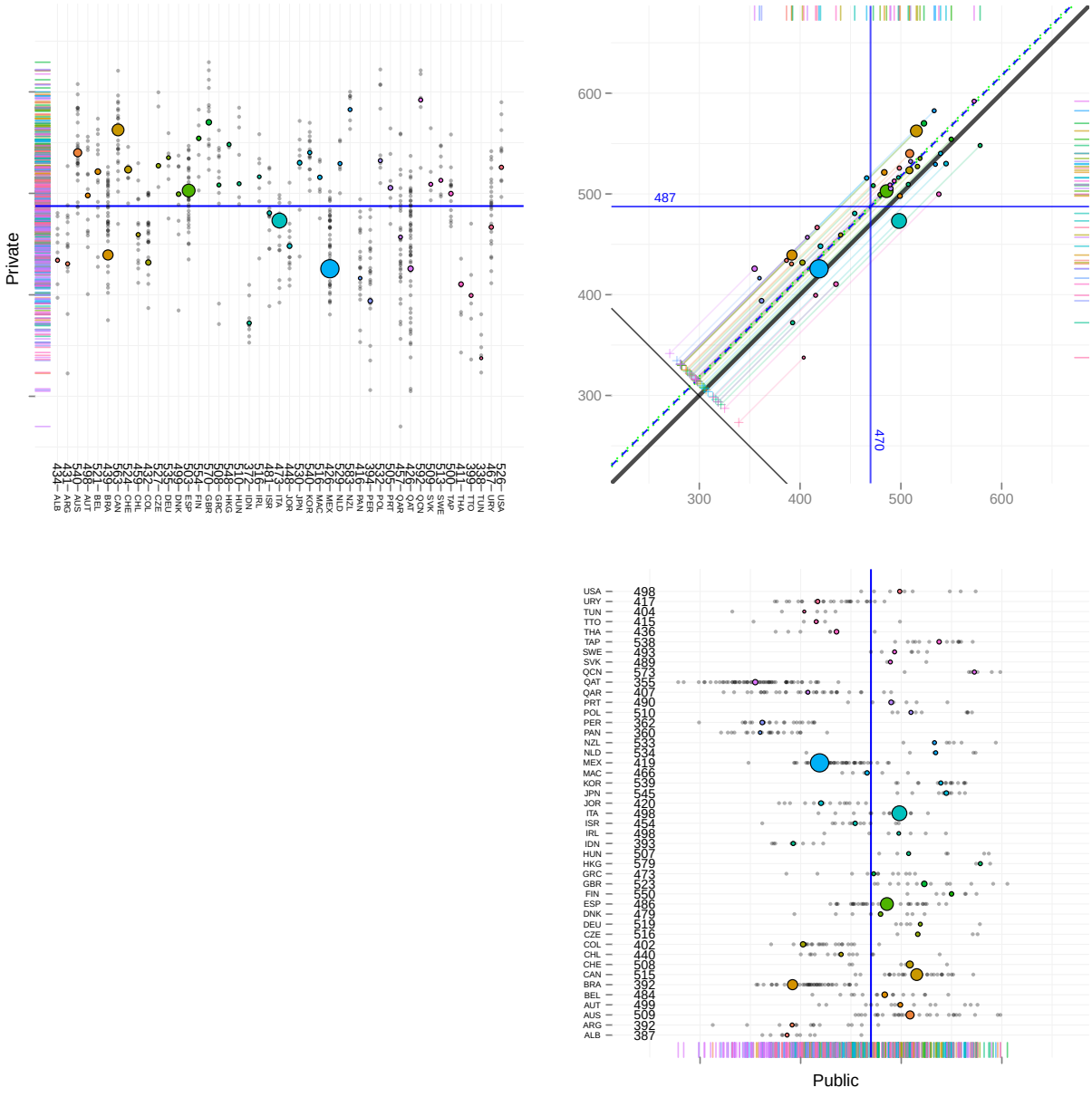

Figure 6. Multilevel PSA Assessment Plot: Science

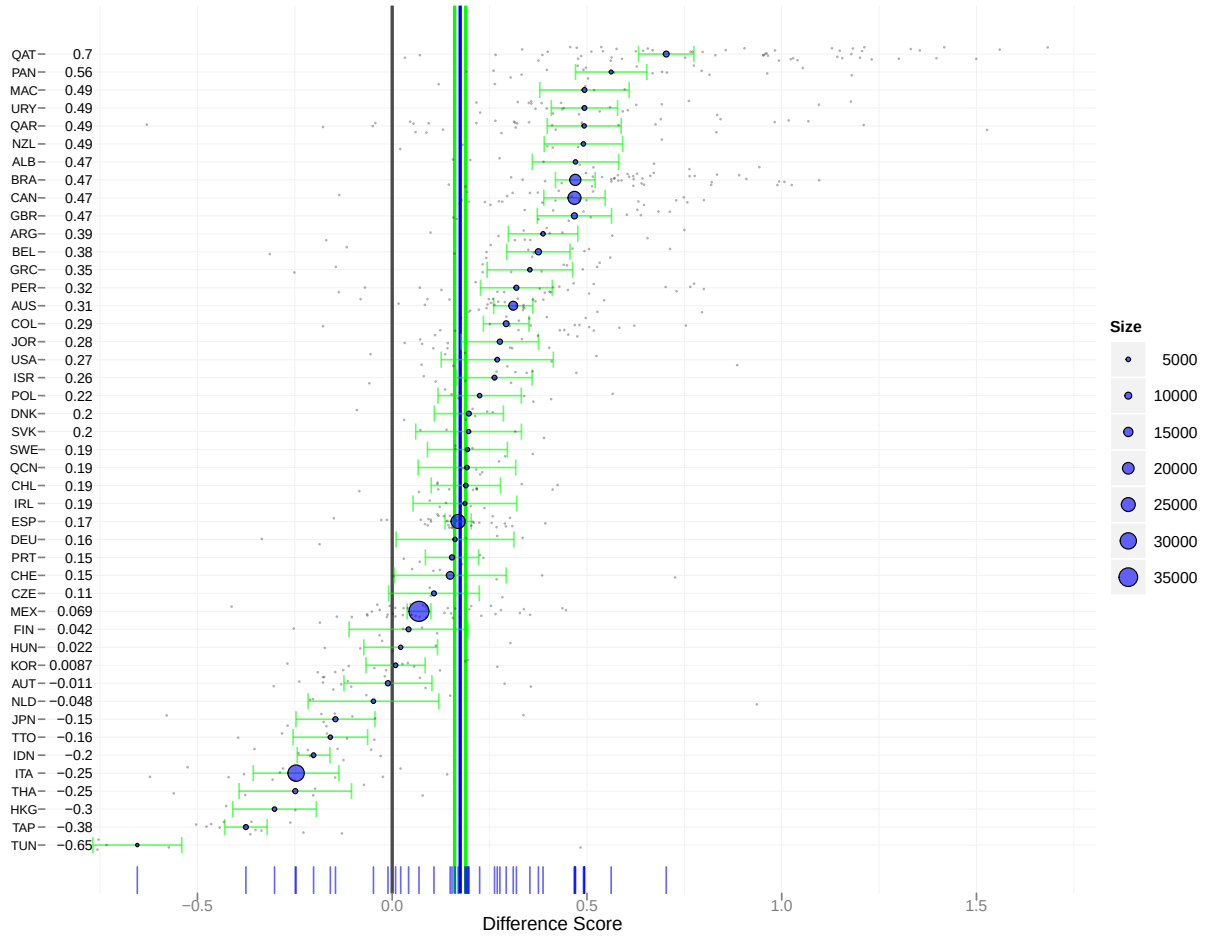

Figure 7. Multilevel PSA Difference Plot: Science

Country	Public		Private		Diff	CI	
	Mean	n	Mean	n		Min	Max
Albania	373.5	4201	420.9	395	47.4	37.1	57.6
Argentina	381.7	3172	410.0	1535	28.2	19.9	36.6
Australia	497.6	8715	525.7	5536	28.1	23.5	32.7
Austria	500.6	5563	494.4	842	-6.2	-16.4	4.0
Belgium	490.4	2658	530.5	5830	40.1	32.1	48.1
Brazil	370.9	16847	420.6	2265	49.7	44.4	55.1
Canada	512.8	21426	574.6	1609	61.9	54.1	69.6
Switzerland	529.6	11262	538.9	383	9.4	-4.7	23.5
Chile	414.2	2139	432.2	3022	18.0	8.3	27.7
Colombia	381.9	6247	410.2	1448	28.3	22.5	34.1
Czech Republic	510.6	5481	513.5	270	2.8	-8.1	13.8
Germany	510.6	4314	529.8	241	19.2	3.2	35.2
Denmark	486.4	4798	500.7	1041	14.3	5.8	22.8
Spain	484.7	15329	501.7	10034	17.0	13.6	20.5
Finland	539.0	5476	533.8	279	-5.2	-18.9	8.4
United Kingdom	501.3	7763	538.5	439	37.3	27.9	46.6
Greece	468.2	4344	490.0	321	21.8	10.8	32.8
Hong Kong-China	591.3	318	552.7	4486	-38.6	-50.9	-26.3
Hungary	494.3	4044	501.6	539	7.3	-4.3	18.9
Indonesia	381.7	2761	362.5	2375	-19.2	-23.5	-15.0
Ireland	478.9	1466	493.8	2462	14.9	3.2	26.5
Israel	445.0	4630	471.1	977	26.1	15.9	36.2
Italy	491.9	28593	464.6	1641	-27.3	-37.8	-16.9
Jordan	389.5	5549	419.7	890	30.3	20.7	39.9
Japan	532.7	4416	521.8	1672	-10.9	-20.5	-1.3
Korea	548.4	3091	549.3	1898	0.8	-7.1	8.8
Macao-China	480.9	236	527.8	5392	46.9	34.7	59.2
Mexico	423.0	34080	430.2	4044	7.2	4.0	10.4
Netherlands	535.9	1795	532.0	2872	-3.9	-18.1	10.3
New Zealand	519.9	4401	573.8	242	53.9	44.6	63.3
Panama	344.1	2689	409.4	919	65.4	57.0	73.8
Peru	357.5	4830	387.2	1155	29.7	19.8	39.6
Poland	496.4	4475	522.4	328	26.0	14.7	37.2
Portugal	483.6	5616	503.2	682	19.6	11.9	27.3
Dubai (UAE)	384.2	1154	444.2	3281	60.0	51.3	68.7
Qatar	344.6	5612	410.2	2244	65.6	58.7	72.6
Shanghai-China	597.6	4454	627.9	512	30.3	15.2	45.4
Slovak Republic	494.3	4212	516.3	343	22.0	6.6	37.4
Sweden	492.4	4024	516.6	543	24.2	14.1	34.3
Chinese Taipei	566.2	3560	518.4	2225	-47.9	-54.5	-41.2
Thailand	429.9	5409	407.0	800	-22.9	-35.7	-10.2
Trinidad and Tobago	420.4	3789	402.7	815	-17.7	-25.9	-9.5
Tunisia	377.2	2319	301.4	95	-75.8	-88.6	-63.1
Uruguay	416.3	4444	469.1	1018	52.7	44.2	61.2
United States	484.8	4888	504.5	345	19.7	7.3	32.1

Table 1: Results by Country: Mathematics

Country	Public		Private		Diff	CI	
	Mean	n	Mean	n		Min	Max
Albania	381.4	4201	432.6	395	51.2	40.4	62.1
Argentina	387.5	3172	432.1	1535	44.6	35.2	54.0
Australia	494.5	8715	529.0	5536	34.5	29.5	39.4
Austria	473.2	5563	475.6	842	2.4	-9.3	14.0
Belgium	482.1	2658	518.9	5830	36.8	29.0	44.6
Brazil	396.6	16847	443.6	2265	47.0	41.0	52.9
Canada	508.1	21426	564.1	1609	56.1	47.7	64.5
Switzerland	494.8	11262	511.0	383	16.2	1.3	31.0
Chile	440.1	2139	462.5	3022	22.4	12.5	32.2
Colombia	417.3	6247	448.8	1448	31.5	25.3	37.8
Czech Republic	494.4	5481	515.2	270	20.9	10.2	31.5
Germany	494.8	4314	510.2	241	15.4	0.7	30.0
Denmark	479.1	4798	494.9	1041	15.8	7.7	23.9
Spain	476.7	15329	498.7	10034	22.0	18.5	25.4
Finland	532.2	5476	539.4	279	7.1	-9.7	24.0
United Kingdom	504.7	7763	542.9	439	38.2	28.4	48.0
Greece	486.3	4344	530.6	321	44.3	31.6	57.0
Hong Kong-China	556.4	318	532.8	4486	-23.6	-34.6	-12.5
Hungary	498.2	4044	502.9	539	4.7	-5.2	14.6
Indonesia	410.7	2761	392.3	2375	-18.4	-22.5	-14.3
Ireland	484.2	1466	505.6	2462	21.4	7.7	35.1
Israel	472.6	4630	499.2	977	26.5	15.6	37.5
Italy	493.6	28593	464.0	1641	-29.5	-39.1	-19.9
Jordan	410.0	5549	432.2	890	22.2	11.1	33.3
Japan	524.5	4416	511.8	1672	-12.7	-22.3	-3.1
Korea	539.3	3091	544.5	1898	5.2	-2.1	12.5
Macao-China	453.4	236	491.6	5392	38.2	26.9	49.5
Mexico	430.2	34080	443.7	4044	13.5	10.1	16.8
Netherlands	520.9	1795	514.0	2872	-6.9	-21.3	7.5
New Zealand	520.9	4401	574.1	242	53.2	42.7	63.7
Panama	357.5	2689	423.5	919	66.0	56.0	76.0
Peru	363.6	4830	392.0	1155	28.3	18.5	38.1
Poland	502.4	4475	520.4	328	18.1	7.1	29.0
Portugal	486.8	5616	504.9	682	18.1	10.9	25.3
Dubai (UAE)	393.1	1154	450.6	3281	57.6	47.3	67.8
Qatar	345.8	5612	421.7	2244	75.9	67.6	84.2
Shanghai-China	554.3	4454	571.0	512	16.7	5.0	28.5
Slovak Republic	476.3	4212	497.6	343	21.3	7.0	35.7
Sweden	495.3	4024	520.4	543	25.1	15.0	35.2
Chinese Taipei	510.2	3560	479.9	2225	-30.3	-36.0	-24.7
Thailand	431.0	5409	414.6	800	-16.4	-30.0	-2.8
Trinidad and Tobago	423.0	3789	403.3	815	-19.7	-30.7	-8.8
Tunisia	399.7	2319	331.5	95	-68.2	-83.2	-53.3
Uruguay	414.4	4444	468.0	1018	53.6	44.7	62.5
United States	495.6	4888	529.4	345	33.8	19.4	48.1

Table 2: Results by Country: Reading

Country	Public		Private		Diff	CI	
	Mean	n	Mean	n		Min	Max
Albania	386.5	4201	434.0	395	47.5	36.3	58.7
Argentina	391.5	3172	430.6	1535	39.1	30.1	48.1
Australia	508.8	8715	540.1	5536	31.4	26.3	36.4
Austria	499.1	5563	498.0	842	-1.1	-12.5	10.3
Belgium	483.6	2658	521.4	5830	37.9	29.7	46.1
Brazil	391.9	16847	439.3	2265	47.4	42.3	52.6
Canada	515.4	21426	562.6	1609	47.2	39.3	55.2
Switzerland	508.5	11262	523.5	383	15.0	0.5	29.5
Chile	440.2	2139	459.3	3022	19.1	10.1	28.0
Colombia	402.3	6247	431.9	1448	29.5	23.6	35.4
Czech Republic	516.4	5481	527.3	270	10.8	-0.9	22.6
Germany	518.9	4314	535.2	241	16.3	1.0	31.5
Denmark	479.4	4798	499.3	1041	19.9	10.9	28.8
Spain	485.8	15329	502.8	10034	17.1	13.7	20.5
Finland	550.0	5476	554.3	279	4.2	-11.2	19.6
United Kingdom	522.9	7763	570.1	439	47.2	37.6	56.8
Greece	472.6	4344	508.3	321	35.7	24.6	46.7
Hong Kong-China	578.6	318	548.1	4486	-30.5	-41.3	-19.7
Hungary	507.3	4044	509.5	539	2.2	-7.3	11.7
Indonesia	392.6	2761	372.2	2375	-20.4	-24.6	-16.1
Ireland	497.5	1466	516.4	2462	18.8	5.4	32.3
Israel	454.2	4630	480.7	977	26.5	16.8	36.2
Italy	498.1	28593	473.3	1641	-24.9	-36.0	-13.8
Jordan	420.2	5549	448.1	890	27.9	17.9	37.9
Japan	544.8	4416	530.1	1672	-14.7	-24.9	-4.5
Korea	539.3	3091	540.2	1898	0.9	-6.8	8.5
Macao-China	466.0	236	515.8	5392	49.8	38.2	61.4
Mexico	418.8	34080	425.7	4044	6.9	3.9	10.0
Netherlands	534.2	1795	529.4	2872	-4.9	-21.8	12.1
New Zealand	533.0	4401	582.6	242	49.5	39.4	59.7
Panama	359.7	2689	416.4	919	56.7	47.5	66.0
Peru	361.8	4830	394.0	1155	32.2	22.9	41.5
Poland	509.6	4475	532.3	328	22.6	11.9	33.4
Portugal	490.0	5616	505.5	682	15.5	8.6	22.4
Dubai (UAE)	407.2	1154	456.9	3281	49.7	40.2	59.3
Qatar	354.8	5612	425.8	2244	71.0	63.8	78.2
Shanghai-China	572.7	4454	592.0	512	19.4	6.7	32.0
Slovak Republic	489.2	4212	509.0	343	19.8	6.1	33.5
Sweden	493.4	4024	512.9	543	19.5	9.1	29.8
Chinese Taipei	537.7	3560	499.8	2225	-37.9	-43.4	-32.4
Thailand	435.6	5409	410.5	800	-25.1	-39.7	-10.6
Trinidad and Tobago	415.4	3789	399.4	815	-16.0	-25.7	-6.4
Tunisia	403.6	2319	337.6	95	-66.0	-77.5	-54.5
Uruguay	416.9	4444	466.7	1018	49.8	41.2	58.4
United States	498.5	4888	525.7	345	27.2	12.7	41.7

Table 3: Results by Country: Science