Research Design Meets Market Design: Using Centralized Assignment for Impact Evaluation Online Appendix

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B Empirical Appendix

B.1 Data

The Denver Public Schools (DPS) analysis file is constructed using application, school assignment, enrollment, demographic, and outcome data provided by DPS for school years 2011-2012 and 2012-2013. All files are de-identified, but students can be matched across years and files. Applicant data are from the 2012-2013 SchoolChoice assignment file and test score data are from the CSAP (Colorado Student Assessment Program) and the TCAP (Transitional Colorado Assessment Program) files. The CSAP was discontinued in 2011, and was replaced by the TCAP beginning with the 2012-2013 school year. Enrollment, demographic, and outcome data are available for students enrolled in DPS only; enrollment data are for October.

Applications and assignment: The SchoolChoice file

The 2012-2013 SchoolChoice assignment file contains information on applicants' preferences over schools (school rankings), school priorities over applicants, applicants' school assignments (offers) and lottery numbers, a flag for whether the applicant is subject to the family link policy described in the main text and, if so, to which sibling the applicant is linked. Each observation in the assignment file corresponds to an applicant applying for a seat in programs within schools known as a bucket.[1] Each applicant receives at most one offer across all buckets at a school. Information on applicant preferences, school priorities, lottery numbers, and offers are used to compute the DA propensity score and the simulated propensity score.

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[1]Since applicants' rankings are at the school-level but seats are assigned at the bucket level, the SchoolChoice assignment mechanism translates school-level rankings into bucket-level rankings. For example, if an applicant ranked school A first and school B second, and if all seats at both A and B are split into two categories, one for faculty children ("Faculty") and one for any type of applicant ("Any"), then the applicant's ranking of the programs at A and B would be listed as 10 for Faculty at A, 11 for Any at A, 20 for Faculty at B, 21 for Any at B where numbers code preferences (smaller is more preferred).

Appendix Table B1 describes the construction of the analysis sample starting from all applicants in the 2012-2013 SchoolChoice assignment file. Out of a total of 25,687 applicants seeking a seat in DPS in the academic year 2012-2013, 5,669 applied to any charter school seats in grades 4 through 10. We focus the analysis on applicants to grades 4 through 10 because baseline grade test scores are available for these grades only. We further limit the sample to 4,964 applicants who were enrolled in DPS in the baseline grade (the grade prior to the application grade) in the baseline year (2011-2012), for whom baseline enrollment demographic characteristics are available.

Enrollment and demographic characteristics

Each observation in the enrollment files describes a student enrolled in a school in a year, and includes information on grade attended, student sex, race, gifted status, bilingual status, special education status, limited English proficiency status, and subsidized lunch eligibility.[2] Demographic and enrollment information are from the first calendar year a student spent in each grade.

Applicant outcomes: CSAP/TCAP

Test scores and proficiency levels for the CSAP/TCAP math, reading, and writing exams are available for grades 3 through 10. Each observation in the CSAP/TCAP data file corresponds to a student's test results in a particular subject, grade, and year. For each grade, we use scores from the first attempt at a given subject test, and exclude the lowest obtainable scores as outliers. As a result, 41 observed math scores, 19 observed reading scores, and 1 observed writing score are excluded from the sample of charter applicants that are in DPS in baseline year. After outlier exclusion, score variables are standardized to have mean zero and unit standard deviation in a subject-grade-year in the DPS district.

School classification: Parent Guide

We classify schools as charters, traditional public schools, magnet schools, innovation schools, contract schools, or alternative schools (i.e. intensive pathways and multiple pathways schools) according to the 2012-2013 Denver SchoolChoice Parent Guides for Elementary and Middle Schools and High Schools. School classification is by grade, since some schools run magnet programs for a few grades only. Schools not included in the Parent Guide (i.e. SIMS Fayola International Academy Denver) were classified according to information from the school's website.

[2]Race is coded as black, white, asian, hispanic, and other. In DPS these are mutually-exclusive categories.

Table B1: SchoolChoice application records

	All applicants		In DPS at baseline	
	Applicants	Types	Applicants	Types
	(1)	(2)	(3)	(4)
All applicants	25,687	16,087	15,487	9,564
Applicants to grades 4 through 10	12,507	7,480	10,898	6,642
Applicants to any charters (grades 4 through 10)	5,669	4,833	4,964	4,282

Notes: All applications are for the 2012-2013 academic year. Columns 1 and 2 include all applicants in the SchoolChoice assignment file (see Data Appendix for details). Columns 3 and 4 exclude applicants who were not in DPS at the baseline grade (the grade prior to application grade) in baseline year (2011-2012). Applicants to grade "EC" (early childhood, or pre-kindergarten) are excluded from columns 3 and 4 because there is no baseline grade for those applicants. Columns 2 and 4 count unique combinations of applicant preferences over school programs and school priorities in those programs.

Table B2: Attrition by offer status

			Propensity score controls		
				Nonparametric	
	Non-offered mean	No controls	Linear control	Rounded (hundredths)	Saturated
	(1)	(2)	(3)	(4)	(5)
			A. DA score (frequency)		
Enrolled in DPS in follow-up year	0.905	0.029***	0.041**	0.040**	0.038**
		(0.008)	(0.019)	(0.019)	(0.019)
Has scores in follow-up year	0.881	0.032***	0.050**	0.049**	0.048**
		(0.009)	(0.020)	(0.020)	(0.021)
N	2,939	4,964	1,436	1,289	1,247
			B. DA score (formula)		
Enrolled in DPS in follow-up year	0.905	0.029***	0.036**	0.027	0.031
		(0.008)	(0.017)	(0.018)	(0.020)
Has scores in follow-up year	0.881	0.032***	0.032*	0.026	0.038*
		(0.009)	(0.018)	(0.020)	(0.022)
N	2,939	4,964	1,508	1,472	1,224
			C. Simulated score		
Enrolled in DPS in follow-up year	0.905	0.029***	0.037**	0.040**	
		(0.008)	(0.018)	(0.019)	
Has scores in follow-up year	0.881	0.032***	0.040**	0.043**	
		(0.009)	(0.020)	(0.021)	
N	2,939	4,964	1,523	1,290	

Notes: This table reports coefficients from regressions of DPS enrollment and test-score availability indicators on charter offers, for the sample of charter applicants potentially available to construct the 2SLS estimates reported in Table 7. Column 1 reports follow-up rates for charter applicants who did not receive a charter offer. The propensity score control schemes used to construct the estimates in columns 3-5 parallel those used for Table 7. All models control for the covariates used for that table as well. Robust standard errors are reported in parentheses.

*significant at 10%; **significant at 5%; ***significant at 1%

Table B3a: Statistical tests for balance in application characteristics

			DA score (formula)		
				Nonparametric	
Application variable	Non-offered mean (1)	No controls (2)	Linear control (3)	Rounded (hundredths) (4)	Saturated (5)
Number of schools ranked	4.375	-0.341***	-0.317***	-0.056	-0.001
		(0.046)	(0.093)	(0.086)	(0.094)
Number of charter schools ranked	1.425	0.476***	0.062	0.016	0.002
		(0.024)	(0.043)	(0.041)	(0.044)
First school ranked is charter	0.291	0.612***	0.003	-0.005	-0.007
		(0.011)	(0.023)	(0.020)	(0.019)
N	2,939	4,964	1,508	1,472	1,224
Risk set points of support			156	43	58
Robust F-test for joint significance		1190	8.06	0.47	0.05
p-value		0.000	0.000	0.701	0.986

Notes: This table reports balance coefficients and standard errors like those shown in Table 5a, with the modification that score control uses the formula version of the DA score. Robust standard errors are reported in parentheses. P-values for robust joint significance tests are estimated by stacking outcomes and clustering standard errors at the student level.
*significant at 10%; **significant at 5%; ***significant at 1%

Table B3b: Statistical tests for balance in student characteristics

			DA score (formula)		
				Nonparametric	
	Non-offered mean	No controls	Linear control	Rounded (hundredths)	Saturated
Student characteristics	(1)	(2)	(3)	(4)	(5)
Origin school is charter	0.086	0.108***	0.085***	-0.012	-0.037**
		(0.010)	(0.022)	(0.017)	(0.017)
Female	0.520	-0.005	0.014	0.041	0.020
		(0.014)	(0.030)	(0.032)	(0.035)
Race					
Hispanic	0.595	0.095***	-0.004	-0.031	0.003
		(0.014)	(0.028)	(0.028)	(0.029)
Black	0.183	-0.033***	-0.008	0.008	-0.009
		(0.011)	(0.024)	(0.025)	(0.027)
Gifted	0.203	-0.028**	-0.047**	-0.040*	-0.036
		(0.011)	(0.023)	(0.024)	(0.027)
Bilingual	0.289	0.086***	0.021	-0.002	0.010
		(0.014)	(0.029)	(0.030)	(0.033)
Subsidized lunch	0.767	0.073***	-0.007	0.011	0.002
		(0.011)	(0.024)	(0.023)	(0.026)
Limited English proficient	0.289	0.086***	0.021	-0.002	0.010
		(0.014)	(0.029)	(0.030)	(0.033)
Special education	0.084	0.004	0.027*	0.036**	0.033*
		(0.008)	(0.016)	(0.017)	(0.018)
N	2,939	4,964	1,508	1,472	1,224
Baseline scores					
Math	0.022	-0.002	0.018	-0.049	-0.080
		(0.027)	(0.056)	(0.057)	(0.063)
Reading	0.040	-0.085***	-0.023	-0.067	-0.100*
		(0.026)	(0.053)	(0.053)	(0.057)
Writing	0.035	-0.072***	-0.039	-0.068	-0.108*
		(0.026)	(0.051)	(0.051)	(0.055)
N	2,891	4,889	1,491	1,455	1,213
Robust F-test for joint significance		19.1	2.38	1.16	1.18
p-value		0.000	0.005	0.309	0.290

Notes: This table reports balance coefficients and standard errors like those shown in Table 5b, with the modification that score control uses the formula version of the DA score. Robust standard errors are reported in parentheses. P-values for robust joint significance tests are estimated by stacking outcomes and clustering standard errors at the student level.

*significant at 10%; **significant at 5%; ***significant at 1%

Table B4: Expected covariate balance by market size

		DA score (frequency) controls (saturated)			
	No controls	Actual size	Double size	Four times larger	Eight times larger
	(1)	(2)	(3)	(4)	(5)
Number of schools ranked	-0.341	0.052	0.023	0.010	0.003
Number of charter schools ranked	0.474	0.055	0.019	0.004	-0.001
First school ranked is charter	0.616	0.001	0.000	0.000	0.001
Origin school is charter	0.115	0.001	0.001	0.001	0.001
Female	-0.007	0.003	0.001	0.001	0.000
Race					
Hispanic	0.094	-0.005	0.001	0.002	0.003
Black	-0.031	0.001	-0.001	-0.002	-0.001
Gifted	-0.022	-0.005	-0.002	-0.002	-0.001
Bilingual	0.020	0.001	0.001	0.001	0.001
Subsidized lunch	0.073	0.003	0.002	0.000	0.000
Limited English proficient	0.084	-0.005	-0.003	-0.002	-0.002
Special education	-0.004	-0.003	-0.003	-0.002	-0.002
Baseline scores					
Math	0.010	-0.020	-0.013	-0.009	-0.009
Reading	-0.070	-0.014	-0.009	-0.005	-0.005
Writing	-0.056	-0.016	-0.008	-0.005	-0.006
Average sample size	4,964	1,419	2,636	5,436	11058

Notes: This table repeats the expected balance calculations reported in Table 4 with markets of increasing size. Columns 1 and 2 are the same as columns 2 and 5 in Table 4. Columns 3-5 show balance after scaling market size by factors of 2, 4, and 8; this is accomplished by drawing additional lottery numbers and multiplying the number of seats accordingly. Except for column 1, the sample size reported at the bottom of the table shows the average number of participants in the appropriately scaled market with variation in the any-charter offer dummy conditional on the propensity score estimate that is relevant for that column.

Table B5: Comparison of 2SLS and OLS estimates of charter attendance effects without covariate controls

	2SLS estimates					
	DA score					
	Frequency (saturated) (1)	Formula (saturated) (2)	Simulation rounded (hundredths) (3)	No score controls (4)	OLS (5)	OLS with score controls (6)
First stage	0.399***	0.376***	0.367***	0.734***		
	(0.032)	(0.032)	(0.032)	(0.011)		
Math	0.339**	0.363**	0.409**	0.239***	0.285***	0.457***
	(0.148)	(0.158)	(0.162)	(0.039)	(0.028)	(0.067)
Reading	-0.102	-0.108	-0.091	-0.050	0.039	0.158***
	(0.136)	(0.144)	(0.150)	(0.038)	(0.027)	(0.059)
Writing	0.116	0.134	0.140	0.052	0.127***	0.282***
	(0.137)	(0.144)	(0.150)	(0.039)	(0.027)	(0.059)
N	1,102	1,083	1,137	4,317	4,317	1,102

Notes: This table reports estimates analogous to those reported in Table 7, computed in models without covariate controls. Robust standard errors are reported in parentheses.

*significant at 10%; **significant at 5%; ***significant at 1%

Table B6: DPS innovation schools

School	Total applicants (1)	Applicants offered seats (2)	Propensity score in (0,1) DA score (frequency) (3)	DA score (formula) (4)	Simulated (5)
Elementary and middle schools					
Cole Arts and Science Academy	31	15	11	9	10
DCIS at Ford	16	0	0	0	1
DCIS at Montbello	412	125	163	156	170
Denver Green School	153	62	29	46	52
Godsman Elementary	10	8	0	0	0
Green Valley Elementary	53	15	3	23	35
Martin Luther King Jr. Early College	427	177	117	120	121
McAuliffe International School	406	165	91	115	112
McGlone	14	2	1	4	3
Montclair Elementary	15	11	2	1	1
Noel Community Arts School	288	108	92	97	105
Valdez Elementary	6	3	0	1	1
Whittier K-8 School	47	8	1	3	4
High schools					
Collegiate Preparatory Academy	433	125	173	158	153
DCIS at Montbello	506	125	208	169	174
High-Tech Early College	481	125	209	193	214
Manual High School	390	130	152	159	187
Martin Luther King Jr. Early College	515	144	179	151	162
Noel Community Arts School	334	78	112	112	107

Notes: This table describes DPS innovation applications in a format like that used for charters in Table 1 (excluding column 6).

Table B7: Covariate balance and differential attrition for DPS innovation schools

			Propensity score controls					
			DA score (frequency)			Simulated score		
				Nonparametric			Nonparametric	
	Non-offered mean	No controls	Linear control	Rounded (hundredths)	Saturated	Linear control	Rounded (hundredths)	Rounded (ten thousandths)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				A. Application covariates				
Number of schools ranked	4.657	-0.142**	0.164	0.012	0.034	0.135	0.132	0.190
		(0.058)	(0.119)	(0.107)	(0.106)	(0.114)	(0.110)	(0.158)
Number of innovation schools ranked	1.279	0.710***	0.192**	0.086	0.035	0.121	0.092	0.097
		(0.035)	(0.079)	(0.062)	(0.059)	(0.076)	(0.069)	(0.118)
First school ranked is innovation	0.052	0.611***	-0.003	-0.007	-0.005	-0.030	-0.030	-0.043
		(0.015)	(0.036)	(0.022)	(0.018)	(0.032)	(0.027)	(0.037)
				B. Baseline covariates				
Origin school is innovation	0.116	0.125***	0.032	0.045	0.044	0.010	0.040	0.100*
		(0.015)	(0.034)	(0.036)	(0.036)	(0.033)	(0.034)	(0.053)
Female	0.526	-0.011	0.030	0.028	0.028	0.063	0.060	0.077
		(0.020)	(0.046)	(0.047)	(0.049)	(0.044)	(0.048)	(0.087)
Race								
Hispanic	0.491	0.136***	0.028	0.015	-0.001	0.037	0.043	0.039
		(0.020)	(0.045)	(0.044)	(0.046)	(0.044)	(0.044)	(0.077)
Black	0.262	-0.064***	0.018	0.018	0.030	0.003	0.009	0.023
		(0.017)	(0.038)	(0.039)	(0.041)	(0.036)	(0.040)	(0.071)
Gifted	0.198	-0.056***	-0.019	-0.028	-0.041	0.017	0.020	0.008
		(0.015)	(0.034)	(0.035)	(0.036)	(0.033)	(0.035)	(0.062)
Bilingual	0.018	0.007	-0.025	-0.027*	-0.029*	-0.020	-0.014	-0.006
		(0.006)	(0.016)	(0.016)	(0.015)	(0.015)	(0.015)	(0.029)
Subsidized lunch	0.763	0.047***	0.029	0.034	0.016	0.011	0.013	-0.044
		(0.016)	(0.037)	(0.036)	(0.037)	(0.037)	(0.036)	(0.061)
Limited English proficient	0.253	0.047***	0.016	0.032	0.031	0.007	-0.001	-0.030
		(0.018)	(0.041)	(0.042)	(0.043)	(0.041)	(0.043)	(0.085)
Special education	0.092	0.004	-0.021	-0.031	-0.036	-0.026	-0.037	-0.050
		(0.012)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.062)
N	1,176	2,483	769	717	623	888	705	279
Baseline scores								
Math	-0.017	-0.186***	-0.032	-0.018	-0.057	0.023	0.042	0.030
		(0.040)	(0.091)	(0.087)	(0.088)	(0.088)	(0.091)	(0.158)
Reading	0.036	-0.220***	-0.066	-0.047	-0.047	-0.013	0.002	0.015
		(0.038)	(0.084)	(0.082)	(0.084)	(0.080)	(0.083)	(0.153)
Writing	0.000	-0.163***	0.025	0.041	0.030	0.079	0.081	0.119
		(0.038)	(0.085)	(0.082)	(0.084)	(0.082)	(0.084)	(0.165)
N	1,158	2,434	752	704	614	869	689	273
Robust F-test for joint significance		143	1.10	0.99	0.91	0.80	0.92	1.52
p-value		0.000	0.354	0.457	0.548	0.669	0.535	0.102
				C. Differential attrition				
Enrolls in Denver in follow-up year	0.920	-0.001	-0.017	-0.012	-0.011	-0.015	-0.020	-0.008
		(0.011)	(0.026)	(0.027)	(0.029)	(0.024)	(0.027)	(0.044)
Has scores in follow-up year	0.897	-0.011	-0.019	-0.014	-0.018	-0.008	-0.017	0.018
		(0.012)	(0.027)	(0.029)	(0.030)	(0.026)	(0.029)	(0.051)
N	1,176	2,483	769	717	623	888	705	279

Notes: Panels A and B report covariate balance tests for innovation offers in a manner analogous to that used for charter offer balance in Tables 5a and 5b. Panel C reports attrition differentials for innovation offers in a manner analogous to that used for charter offer in Appendix Table B2. Robust standard errors are reported in parentheses. P-values for robust joint significance tests are estimated by stacking outcomes and clustering standard errors at the student level.

*significant at 10%; **significant at 5%; ***significant at 1%