

**Segregated neighborhoods, segregated schools:
Do charters break a stubborn link?**

Online Appendix

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Online Appendix

Alternative Segregation Indices

Our study foregrounds measures school and residential segregation using the Variance Ratio Index because of its simple interpretation and because, when estimated for racial dyads, it can be decomposed into different administrative or geographic levels (Reardon and Firebaugh, 2002). Another popular, decomposable segregation index is Theil's binary information theory index (H) (Stroub and Richards 2013; Reardon 2009; Lichter, Parisi, and Taquino 2015). Similar to the Variance Ratio Index, H is less sensitive to bias than other common segregation indices when evaluating segregation among small units (Fossett, 2017) such as schools with as few as 10 students enrolled. Unlike indices of Exposure and Isolation (Frankenberg et al., 2011), the Variance Ratio Index and H are also insensitive to changes in the overall school district racial composition, making it suitable for comparison over time (Reardon and Owens 2014).

Figure A1 reports selected results from analyses of the association between charter school growth and school and residential segregation, measured with H . Other than changing the segregation index in our outcome (and related segregation control variables), all other specifications in Figure A1 are identical to those presented in Figure 2. Results from the preferred model (letter "a" in each plot) lead to the same substantive conclusion: charter school expansion is associated with a simultaneous increase in White-Black school segregation and decrease in White-Black residential segregation. Charter school growth does not appear to have affected White-Hispanic school segregation, though White-Hispanic residential segregation did decline in response, mirroring our results using the Variance Ratio Index. Robustness checks (see Figure 2 notes and text) lettered "b" through "f" do not alter these conclusions. We presented results measuring segregation with the Variance Ratio Index due to its ease of interpretation.

Nonetheless, the results from Figure A1 give us confidence that our finding is not an artifact specific to index choice.

We further conducted a parallel analysis evaluating the association between charter growth and segregation measured with D , the Index of Dissimilarity. D is the most common index of segregation used in studies of residential segregation, popularized because it expresses an intuitive idea—the percentage of one racial group that would need to swap neighborhoods (or schools) with a second racial group so that all neighborhoods within the school district have the same racial composition (Massey & Denton, 1988). Like both the Variance Ratio Index and H , D has the advantage of measuring relative segregation rather than absolute exposure and is thus suitable for comparison over time. However, despite its popularity, D has an important limitation: it centers attention on change that is above or below racial parity in the *overall* school district. On the other hand, the Variance Ratio Index and H register changes across the racial composition distribution rather than at a select inflection point, and thus do not suffer from this issue (see Fossett (2017) for a thorough discussion).

Charter schools may influence segregation at points of the racial composition distribution without ever leading to a switch in school enrollment (or neighborhood choice) that is above or below racial parity. To test for this possibility, we present in Figure A2 a set of models that measure segregation using D . We emphasize that this is not a test of the robustness of our findings, as D measures a different phenomenon than the Variance Ratio Index or H . Still, Figure A2 shows that charters led to an increase in White-Black school dissimilarity and a decrease in residential dissimilarity as shown in the main analysis. Results also reveal a decline in White-Hispanic residential dissimilarity consistent with the main analysis. We find declining White-Hispanic school segregation (only in some model specifications) when measured with D

rather than the Variance Ratio Index or H . This deviation from the main results suggests that charter expansion led to a decline in White-Hispanic school dissimilarity relative to the school district overall in some districts; the estimated effects on D have wider confidence intervals, however, suggesting that in other school districts, charters affected changes at other points of the racial composition distribution.

Decomposition of the Variance Ratio Index

Table 3 reports results from a decomposition analysis of total MSA school and neighborhood segregation. Our approach takes advantage of the fact that, in dyadic measures of segregation, the Variance Ratio Index can be decomposed into additive components (Reardon and Firebaugh, 2002). This requires the common practice of ignoring all other non-dyad racial groups from the denominator when computing percent White and percent Black (for simplicity, we refer only to the White-Black decomposition, though we apply parallel procedures for White-Hispanic segregation).

Our school segregation decomposition uses a framework similar to the one developed in Clotfelter (2004) and Fiel (2013). Notably, these studies measure the White-Black Exposure Index under various counterfactual scenarios in which school racial composition is adjusted to reflect sector, school district, or aggregate MSA composition. Comparison between observed and adjusted counterfactual scenarios reveals how racial imbalance within versus between sectors and school districts contributes to overall observed segregation levels. Clotfelter (2004) applies this approach to evaluate the Coleman Segregation Index, which is another name (and formulaic derivation) of the Variance Ratio Index (Coleman, Kelley, & Moore, 1975; see also Fossett, 2017 and Monarrez et al., 2019).

We begin by identifying public schools by their sector type (TPS, charter, magnet) within their geographic school district nested within MSA. We treat private schools as part of a separate, MSA-wide sector because enrollment is not defined by student residence, and many students travel across district lines to attend private schools in other areas. Note that our nesting structure, unlike Fiel (2013), considers charter schools as nested within geographic school districts rather than as sectors spanning across districts (Fahle et al., 2019 define nesting levels similar to ours). For each MSA-year observation, we decompose segregation using the following sequential procedure (Stata code is available in an online replication package):

1. Calculate the Variance Ratio Index for White and Black students as observed in their MSA ($=VR_1$).
2. Rebalance White and Black student enrollment in all charter, magnet, and private schools so that their total student enrollment count does not change but their percent White and percent Black reflect the composition of their respective sector within the district (note: for private schools, their composition is set to match the racial composition of all private school students in the MSA). Calculate the Variance Ratio Index ($=VR_2$).

For Steps 3-5, we follow the same formula in Step 2 for rebalancing White and Black student enrollment in the following sectors, then calculate the Variance Ratio Index for each combination:

3. All traditional, magnet, and private schools ($=VR_3$).
4. All traditional, charter, and private schools ($=VR_4$).
5. All traditional, charter, and magnet schools ($=VR_5$).

Steps 6-8 require that we aggregate student enrollment counts by race to the following levels, then calculate the Variance Ratio Index for each:

6. Sector (traditional, charter, magnet, private) within each school district (or, for private schools, throughout the MSA) ($=VR_6$).
7. School district (or, for private schools, throughout the MSA). ($=VR_7$).
8. All public schools throughout the MSA and all private schools throughout the MSA. ($=VR_8$).
9. Next, we use the values for each Variance Ratio Index derived in Steps 1-8 to calculate additive components of segregation for each MSA-year observation¹:
 - a. Total MSA segregation = VR_1
 - b. School segregation due to private versus public enrollment = VR_8
 - c. Segregation among private schools in MSA = $VR_5 - VR_6$
 - d. Segregation between public school districts in MSA = $VR_7 - VR_8$
 - e. Segregation within public school districts = $VR_1 - VR_7 - (VR_5 - VR_6)$
 - f. Segregation between traditional, charter, and magnet sectors = $VR_6 - VR_7$
 - g. Segregation among traditional public schools = $VR_2 - VR_6$
 - h. Segregation among charter schools = $VR_3 - VR_6$
 - i. Segregation among magnet schools = $VR_4 - VR_6$
10. Lastly, to produce results reported in Table 3, we take the unweighted mean of each segregation component in Step 9 across sample MSAs within year.

¹ Note that adding terms in steps 9b through 9e yields total segregation (step 9a). Segregation within districts (9e) also equals the sum of steps 9f through 9i. An equivalent computation of 9e measures unique segregation scores for schools within each public school district in the MSA, then takes the average across districts, weighted by the size and diversity (Simpson's Interaction Index) of the district relative to the MSA overall—an approach that yields identical results (Reardon and Firebaugh, 2002).

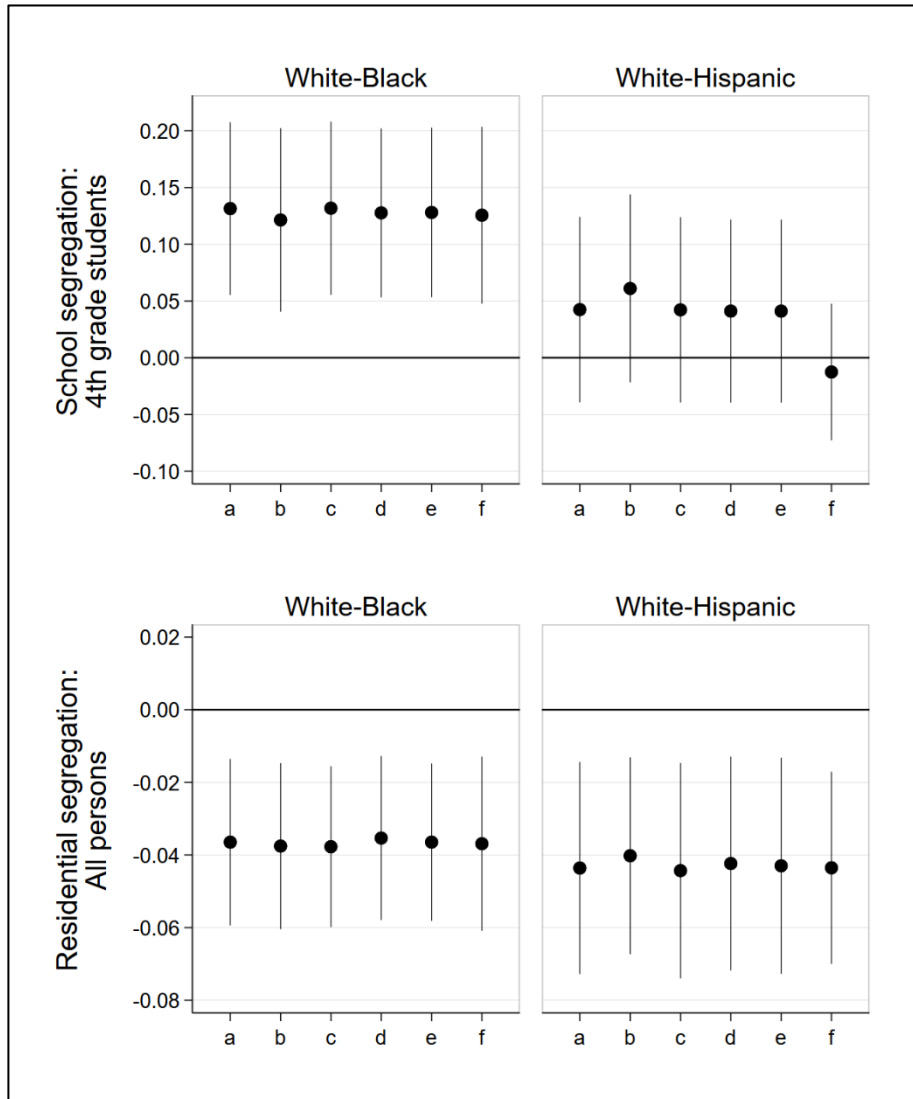
The bottom panel of Table 3 decomposes residential segregation to components between versus within jurisdictional school district boundaries. We compute residential segregation components separately by MSA and year, and report their unweighted means across MSAs in Table 3. Total segregation (row 10) is the Variance Ratio Index for all neighborhoods in the MSA. Segregation between school district jurisdictions (row 11) is the Variance Ratio Index computed after neighborhood population counts by race are aggregated to the school district level. Segregation within school district jurisdictions (row 12) equals total segregation minus segregation between districts.

Appendix References

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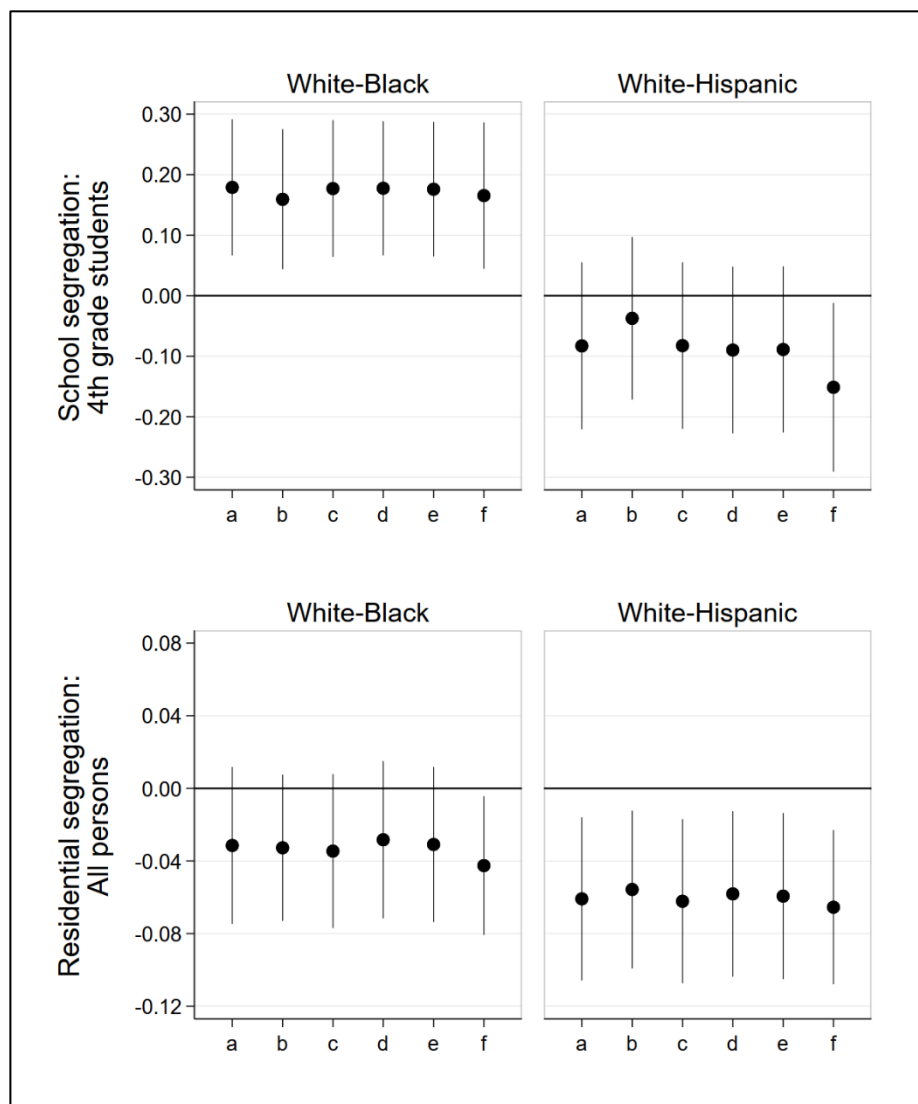
Appendix Figures and Tables

Figure A1. Robustness checks of the estimated effect of a one percentage point increase in charter school enrollment share on school and residential segregation (Theil's Index)



Note: This figure is identical to the one presented in Figure 2, but segregation is measured using Theil's Information Theory Index (H). Full models available by request. Lines represent 95 percent confidence intervals.

Figure A2. Robustness checks of the estimated effect of a one percentage point increase in charter school enrollment share on school and residential segregation (Dissimilarity Index)



Note: This figure is identical to the one presented in Figure 2, but segregation is measured using the Dissimilarity Index (D). Full models available by request. Lines represent 95 percent confidence intervals.

Table A1. School district sample criteria

Year and sample criteria	School districts	Elementary schools	Public school 4th graders	Public 4th grade enrollment by race		
				White	Black	Hispanic
1990						
All unified and elementary school districts	12,870	44,362	3,135,046	2,126,871	525,698	354,938
1. Valid metropolitan districts	6,534	32,348	2,488,854	1,610,420	443,181	325,762
2. Minimum 2 schools, 2 neighborhoods	3,406	28,917	2,223,920	1,402,841	412,142	305,832
3a. White-Black pairwise sample	1,601	21,619	1,755,219	1,022,211	388,650	
3b. White-Hispanic pairwise sample	1,354	19,305	1,590,463	887,680		289,516
2000						
All unified and elementary school districts	12,477	46,428	3,645,993	2,220,125	635,751	602,827
1. Valid metropolitan districts	6,466	35,248	3,013,153	1,731,847	557,978	559,423
2. Minimum 2 schools, 2 neighborhoods	3,385	31,841	2,706,645	1,498,340	519,896	533,559
3a. White-Black pairwise sample	1,601	24,050	2,114,586	1,047,893	487,796	
3b. White-Hispanic pairwise sample	1,354	21,817	1,949,442	909,938		495,326
2010						
All unified and elementary school districts	12,003	48,129	3,664,408	1,938,437	605,799	824,049
1. Valid metropolitan districts	6,394	37,888	3,077,454	1,515,793	535,484	760,325
2. Minimum 2 schools, 2 neighborhoods	3,386	34,681	2,792,865	1,305,684	508,398	729,137
3a. White-Black pairwise sample	1,601	26,083	2,132,246	866,300	469,287	
3b. White-Hispanic pairwise sample	1,354	24,126	1,982,150	741,833		652,525

Note: Sample restriction criteria is reported in stepwise order. First, we restrict to districts that are located in metropolitan Core Based Statistical Areas (2003 definitions), have a non-zero 4th-grade enrollment as reported in the NCES Common Core of Data, and have a non-zero residential population count as reported in the decennial Census. Second, we restrict to school districts with a minimum of 2 schools and 2 neighborhoods; we also drop Campbell Union (CA), Detroit (MI), Fort Leavenworth (KS), New Orleans (LA), Salt Lake City (UT), and Williamsburg-James City (VA) school districts due to unreliable data and/or extreme population changes (see text). Finally, for each pairwise sample, we restrict to the subset of districts meeting the first two criteria that also have at least 5 White and Black or Hispanic 4th graders enrolled and who meet all sample criteria in 1990, 2000, and 2010.

Table A2. School district characteristics, by pairwise analytical sample

	Min	Max	White-Black		White-Hispanic	
			Mean	SD	Mean	SD
Change in charter school enrollment share, 2000-10						
Amount of change	-72	69	1.96	5.95	2.20	5.83
Type of change						
Increase			.26		.31	
No charter school presence			.72		.66	
Decrease			.02		.03	
School enrollment context						
Share of public students enrolled in charters	0	100	.63	3.06	.85	4.17
Share of public students enrolled in magnets	0	100	1.63	8.06	1.69	8.25
Ever mandated to desegregate schools	0	1	.24		.18	
Desegregation order dismissed since 1990	0	1	.06		.04	
Elementary schools (n)	2	660	15.02		16.11	
District size						
2 to 5 elementary schools			.36		.36	
6 to 15 elementary schools			.43		.41	
16 or more elementary schools			.21		.24	
Residential context						
Neighborhoods (n)	2	2,220	28.28	73.25	30.16	79.18
Share of resident children in private school	0	56	11.35	5.89	10.66	5.44
Population (1,000)	5.5	8,005.3	104.0	279.1	112.1	302.0
Area (square miles)	1.0	24,960.0	192.1	481.1	215.8	876.5
Percent White	4	97	70.22	20.41	65.70	21.99
Percent Black	0	89	12.12	13.67	8.90	12.07
Percent Hispanic	0	96	11.38	14.83	17.81	18.64
Poverty rate gap (Black - White)	-14.18	72.30	11.98	8.27	10.66	9.24
Poverty rate gap (Hispanic - White)	-19.77	62.34	10.32	8.09	10.26	6.87
Income ratio (White / Black)	.545	9.716	1.278	.409	1.368	.695
Income ratio (White / Hispanic)	.559	12.602	1.222	.555	1.155	.200
District share of MSA White residents	.088	100	14.37	21.13	13.85	21.43
District share of MSA Black residents	.002	100	18.21	28.07	17.22	27.89
District share of MSA Hispanic residents	.009	100	16.44	24.46	16.38	24.93
District includes downtown area	0	1	.16		.14	
South	0	1	.36		.23	
School districts			1,601		1,354	
MSAs			342		289	

Note: All covariates are measured in 2000 except where noted. The amount of change in charter school enrollment is the percentage of 4th-graders in 2010 attending charter schools minus the percentage of 4th-graders in 2000 attending charter schools. Elementary schools are identified as regular public schools with at least 10 fourth grade students enrolled in 2000. White and Black populations reported in the table are all non-Hispanic, except for the poverty rate gap and income ratio gap measures (in those measures only, Black statistics include both Hispanic and non-Hispanic subgroups).

Table A3. Predictors of change in White-Black school and residential segregation (Variance Ratio Index), 2000 to 2010

	School segregation (4th graders)			Residential segregation (All persons)		
	Coeff		SE	Coeff		SE
Change in charter school enrollment share, 2000-10	.144	**	(.045)	-.041	**	(.013)
Segregation level in 2000	-.303	***	(.036)	-.191	***	(.018)
Segregation change, 1990-2000	.166	***	(.048)	.213	***	(.045)
School enrollment context						
Share of public students enrolled in charters	.052		(.067)	-.053	**	(.020)
Share of public students enrolled in magnets	.032		(.025)	-.001		(.011)
Ever mandated to desegregate schools	.257		(.612)	-.169		(.254)
Desegregation order dismissed since 1990	1.581		(1.175)	-.104		(.417)
District size (ref = 2 to 5 schools)						
6 to 15 schools	-.713		(.428)	-.266		(.211)
16 or more schools	-1.140		(.824)	-.157		(.369)
Residential context						
Percent resident children in private school	.066		(.041)	.021		(.023)
Population (log)	2.356	***	(.474)	.929	***	(.227)
Area (log)	-.095		(.185)	-.019		(.109)
Percent White	-.088	**	(.030)	.022		(.014)
Percent Black	-.050		(.032)	.086	***	(.015)
Percent Hispanic	-.059		(.037)	.030		(.018)
Poverty rate gap (Black - White)	.090	***	(.023)	-.002		(.013)
Income ratio (White / Black)	-.369		(.472)	.303		(.216)
District share of MSA White residents	-.011		(.024)	-.005		(.012)
District share of MSA Black residents	.046	*	(.021)	-.016		(.009)
District share of MSA Hispanic residents	-.039		(.025)	.003		(.012)
District includes downtown area	.024		(.742)	.194		(.311)
South	1.741	**	(.626)	.350		(.318)
Constant	-15.579	**	(5.717)	-11.543	***	(2.711)
Variance of residuals	45.355	***	(4.248)	12.482	***	(1.564)
Covariance of residuals	6.376	***	(1.055)			

Note: Estimates are reported from the preferred model (Model 1 in Table 3, n=1,601 school districts). Standard errors in parentheses are clustered by MSA. Each outcome is the change in segregation between 2000 and 2010, estimated simultaneously in a generalized structural equation model with unstructured error correlation. Change in charter school enrollment is a linear measure of the percent of 4th-grade public students enrolled in 2010 minus the percent of 4th-grade public students enrolled in 2000. "Segregation level in 2000" and "Segregation change, 1990-2000" are measured uniquely to match the school or residential segregation outcome.

* p<.05, ** p<.01, ***p <.001

Table A4. Predictors of change in White-Hispanic school and residential segregation (Variance Ratio Index), 2000 to 2010

	School segregation (4th graders)		Residential segregation (All persons)	
	Coeff	SE	Coeff	SE
Change in charter school enrollment share, 2000-10	.056	(.050)	-.051 **	(.018)
Segregation level in 2000	-.265 ***	(.032)	-.178 ***	(.023)
Segregation change, 1990-2000	.161 *	(.070)	.177 ***	(.041)
School enrollment context				
Share of public students enrolled in charters	.103 *	(.046)	-.023	(.030)
Share of public students enrolled in magnets	.076 *	(.037)	-.008	(.010)
Ever mandated to desegregate schools	-1.151	(.755)	-.168	(.339)
Desegregation order dismissed since 1990	2.745	(1.818)	.190	(.629)
District size (ref = 2 to 5 schools)				
6 to 15 schools	.062	(.535)	-.261	(.265)
16 or more schools	.329	(.908)	-.372	(.375)
Residential context				
Percent resident children in private school	.091	(.047)	.099 *	(.044)
Population (log)	2.082 ***	(.411)	.667 ***	(.155)
Area (log)	.389 *	(.168)	.198 *	(.087)
Percent White	-.003	(.031)	.007	(.014)
Percent Black	.020	(.036)	.055 **	(.020)
Percent Hispanic	-.062	(.032)	.007	(.021)
Poverty rate gap (Hispanic - White)	.123 **	(.039)	.036 *	(.018)
Income ratio (White / Hispanic)	.681	(1.188)	-.040	(.472)
District share of MSA White residents	-.020	(.028)	-.024	(.014)
District share of MSA Black residents	.037	(.028)	.004	(.010)
District share of MSA Hispanic residents	-.041	(.035)	.009	(.015)
District includes downtown area	.192	(.904)	-.224	(.340)
South	-.696	(.579)	.317	(.278)
Constant	-21.579 ***	(5.432)	-8.195 ***	(2.479)
Variance of residuals	49.047 ***	(5.051)	10.335 ***	(1.040)
Covariance of residuals	7.409 ***	(1.292)		

Note: Estimates are reported from the preferred model (Model 1 in Table 5, top panel, n=1,354 school districts). Standard errors in parentheses are clustered by MSA. Each outcome is the change in segregation between 2000 and 2010, estimated simultaneously in a generalized structural equation model with unstructured error correlation. Change in charter school enrollment is a linear measure of the percent of 4th-grade public students enrolled in 2010 minus the percent of 4th-grade public students enrolled in 2000. "Segregation level in 2000" and "Segregation change, 1990-2000" are measured uniquely to match the school or residential segregation outcome.

* p<.05, ** p<.01, ***p <.001

Table A5. Selected results from alternative models measuring residential segregation of households (Variance Ratio Index)

Regression model	School (4th graders)	Residential (HH w/ children)	Residential (HH w/o children)
A. White-Black residential segregation (n=1,601)			
Change in charter school enrollment share, 2000-10	.145 ** (.045)	-.038 * (.018)	-.020 (.011)
B. White-Hispanic residential segregation (n=1,354)			
Change in charter school enrollment share, 2000-10	.054 (.050)	-.062 ** (.023)	-.037 ** (.011)

Note: Structural equation models with three outcomes include the same specifications and covariates as the preferred model (Model 1 of Table 4), but measure residential segregation separately for households with children and for households without children. Household census counts are not reported by race and Hispanic ethnicity for White and Black households in 1990 and for Black households in 2000. To adjust, in control variables drawing on 1990 data, we use population counts instead of household counts. In outcome variables drawing on 2000 and 2010 data, White counts are limited to non-Hispanic households; Black counts include an unknown combination of Hispanic and non-Hispanic households.

* p<.05, ** p<.01, ***p <.001

Table A6. Selected results from alternative models measuring school segregation at different grade levels (Variance Ratio Index)

Regression model	Elementary school (4th graders)	Middle school (8th graders)	High school (10th graders)
A. White-Black school segregation			
Change in charter school enrollment share, 2000-10	.144 ** (.045)	.186 *** (.054)	.193 ** (.068)
N districts	1,601	991	615
B. White-Hispanic school segregation			
Change in charter school enrollment share, 2000-10	.056 (.050)	.093 * (.044)	.069 (.049)
N districts	1,354	800	475

Note: Results from six separate regression models, with specifications identical to those presented in Model 1 of Table 4. We apply the sample criteria apply as in all previous analyses, but there are fewer districts at the middle school and high school levels. The reason for this is that some in-sample districts have two or more elementary schools but only one middle school or only one high school. * $p < .05$, ** $p < .01$, *** $p < .001$