Appendices

Appendix A. Estimating District-Level Achievement Trends

Step 1. Estimating the Annual District-Level Trend

$$A_{dgyb} = \beta_0 + \beta_1(grade_{dgyb} - 5.5) + \beta_2(year_{dgyb} - 2012) + \beta_3(math_{dgyb} - 0.5) + u_{dgyb} + \varepsilon_{dgyb}$$

$$\beta_0 = \gamma_{00} + v_{0d}$$
$$\beta_1 = \gamma_{00} + v_{1d}$$
$$\beta_2 = \gamma_{20} + v_{2d}$$
$$\beta_3 = \gamma_{30} + v_{3d}$$

$$u_{dygb} \sim N(0, \omega^2_{dygb})$$
$$\varepsilon_{dygb} \sim N(0, \sigma^2_{dygb})$$
$$[v_{0d}, v_{1d}, v_{2d}, v_{3d}] \sim MVN(0, \boldsymbol{\tau})$$

The parameter of interest in step one is β_2, the slope of the relationship between years $(year_{dgyb} - 2012)$ and student achievement (A_{dgyb}) (e.g., how the third graders in a particular district in 2015 perform on the state's standardized math test compared to the third graders in 2014; note that the estimate here pools observations across grades, years, and subjects, so it is the *average* change in the *average* grade in the *average* subject). If successive cohorts of students in a particular district earn higher scores on average over time, this number will be positive; if they get lower scores on average over time, this number will be negative. A_{dgyb} represents SEDA's estimate of the average student achievement for a given district-grade-year-subject, in standard deviations; $grade_{dgyb} - 5.5$ is the centered grade (between 3rd and 8th grades); $year_{dgyb} - 2012$ is the centered year (between 2009 and 2015); and $math_{dgyb} - 0.5$ is the centered subject. ω^2_{dygb} is a known parameter; σ^2_{dygb} and $\boldsymbol{\tau}$ are estimated.

For step two, I use the estimate of β_2 (the estimated annual district-level trend) from step one as the outcome. For simplicity's sake, due to the number of Greek letters and subscripts, the nestedness of the models, and in the interest of general readability, I refer to this as $\hat{\alpha}_{ds}$ in Step 2 (the estimate of a district *d*'s annual achievement trend in state *s*). I use the variance of the district-level residuals (ψ^2_{ds}), produced in the $\boldsymbol{\tau}$ matrix estimated in step one, for the precision-weighting in step two.

Trends in achievement gaps are estimated similarly, except I use three steps to estimate them instead of two. In these cases, the first model estimates the average achievement gap, nesting state-district-grade-year-subject-subgroup observations within state-district-grade-year-subject observations; subsequent models are identical to those above.

One potential source of concern for the quantitative analysis is that Tennessee changed its state proficiency cut-off after 2009. However, this does not impact analyses in this study due to how SEDA estimates are first standardized within each state-subject-grade-year (Fahle et al., 2021), putting all estimates on a common scale within each year (and state, subject, and grade). State-subject-grade-year distributions were then placed on the common NAEP scale in the years for which there is NAEP data (2009, 2011, 2013, 2015) for interpretation. Additionally, because Tennessee raised the proficiency level, we might expect the number of students estimated to be

proficient to decrease (if all else was equal). Even if this change in proficiency did impact estimates here, then, this impact would bias downward Tennessee's achievement gains.

Appendix B. Testing the Ecological Fallacy

In addition to identifying broad trends in achievement and disparity narrowing, it is also important to assess whether districts in which students experience increasing achievement also those in which students experience achievement disparity narrowing. I gain traction on this question by identifying pairwise correlations between districts' improving achievement and achievement disparity closures for districts both inside and outside of Tennessee. If the districts with increasing achievement also experience increasing achievement disparities, this would yield a positive correlation; if districts with increasing achievement are experiencing declining achievement disparities (the more optimal outcome), this would yield a negative correlation. Appendix Table 4 reports these results.

In Tennessee, there is no significant correlation between achievement and disparity narrowing. This suggests that Tennessee's achievement trends are not being driven by distinctly different "types" of districts (e.g., "high-performing" districts versus "disparity-narrowing" districts). Put another way, whether a district is high performing appears not to have a relationship with whether that district is closing disparities. This indicates that districts can work toward narrowing achievement disparities without doing so at the expense of increasing average achievement. In the rest of the United States, correlations between racial/ethnic disparity trends and overall achievement trends suggest there is a small but significant relationship such that districts that tend to increase achievement also tend to decrease disparities. This is even more promising.

Appendix Table 1

Descriptive Statistics of Covariates and Outcomes

	Mean	SD	Min	Max	Count
Outcomes					
Overall Trend	0.009	0.048	-0.942	2.007	11,317
Socioeconomic Disparity Trend	0.004	0.055	-1.022	1.144	8,297
White-Black Disparity Trend	0.003	0.046	-0.383	0.629	2,665
White-Hispanic Disparity Trend	-0.007	0.050	-0.611	0.630	3,455
Predictor of Interest					
Tennessee	0.012	0.108	0	1	11,317
District-Level Demographic Variables					
Mean Achievement	-0.000	0.329	-2.013	1.215	11,317
Mean Socioeconomic Achievement Disparity	0.485	0.174	-0.782	1.596	8,787
Mean White-Black Disparity	0.570	0.209	0.027	1.670	2,872
Mean White-Hispanic Disparity	0.460	0.216	-0.598	1.580	3,794
Neighborhood SES	0.100	0.906	-4.398	2.936	11,317
Change in Neighborhood SES	-0.098	0.338	-2.062	1.291	11,317
% Poor Enrollment	0.477	0.219	0.000	1.000	11,317
Change in % Poor Enrollment	0.011	0.016	-0.144	0.160	11,317
% Asian Enrollment	0.022	0.049	0.000	0.730	11,317
Change in % Asian Enrollment	0.000	0.003	-0.042	0.036	11,317
% Black Enrollment	0.079	0.163	0.000	0.998	11,317
Change in % Black Enrollment	-0.001	0.004	-0.075	0.051	11,317
% Hispanic Enrollment	0.134	0.203	0.000	0.999	11,317
Change in % Hispanic Enrollment	0.005	0.007	-0.090	0.100	11,317
State-Level Demographic Variables					
State Mean Achievement	-0.025	0.206	-0.415	0.470	48
State SES Disparity	0.498	0.065	0.342	0.655	48
State White-Black Disparity	0.577	0.067	0.415	0.776	48
State White-Hispanic Disparity	0.469	0.067	0.299	0.623	48
State SES	0.017	0.526	-1.170	0.964	48
State SES Change	-0.112	0.104	-0.325	0.189	48
State % Poor Enrollment	0.497	0.132	0.201	0.762	48
State % Poor Enrollment Change	0.012	0.010	-0.007	0.043	48
State % Asian Enrollment	0.017	0.014	0.003	0.067	48
State % Asian Enrollment Change	-0.000	0.001	-0.001	0.002	48
State % Black Enrollment	0.106	0.140	0.004	0.565	48
State % Black Enrollment Change	-0.001	0.001	-0.007	0.001	48
State % Hispanic Enrollment	0.112	0.115	0.009	0.549	48
State % Hispanic Enrollment Change	0.005	0.003	-0.001	0.011	48
State-Level Policy Variables					
State Mean Per Pupil Expenditures (in $100s)	89.473	22.868	58.109	178.722	48
State Per Pupil Expenditure Change (in $100s)	-0.062	1.246	-1.819	3.241	48
State Won Race to the Top Round 1	0.042	0.202	0	1	48
State Won Race to the Top Round 2	0.167	0.377	0	1	48
State Won Race to the Top Round 3	0.146	0.357	0	1	48
State Mean Per Pupil Race to the Top Award (in $100s)	1.754	3.714	0	17.144	48
State Received NCLB Waiver	0.875	0.334	0	1	48

Note: Trend estimates reflect the annual estimated change in achievement between spring 2009 and spring 2015. These estimates were assessed in step one of the modeling strategy. See Appendix A.

Appendix Table 2

Policy Indicators by State, 2009-2015

	Annual PP Expenditures (in $100s)	Change in PP Expenditures (in $100s)	Won RTT Round 1	Won RTT Round 2	Won RTT in Round 3	RTT PP Award (in $100s)	Received NCLB Waiver
Alabama	69.56	-0.83	0	0	0	0	1
Alaska	178.72	2.95	0	0	0	0	1
Arizona	78.13	-0.42	0	0	1	0.50	1
Arkansas	76.42	-0.15	0	0	0	0	1
California	73.03	-0.62	0	0	0	0	0
Colorado	85.25	-0.20	0	0	1	0.47	1
Connecticut	109.65	2.90	0	0	0	0	1
Delaware	87.85	-0.25	1	0	0	17.14	1
Florida	71.83	-1.12	0	1	0	5.79	1
Georgia	71.52	-1.24	0	1	0	5.17	1
Idaho	74.13	-1.44	0	0	0	0	1
Illinois	75.99	1.46	0	0	1	0.47	1
Indiana	70.16	-0.65	0	0	0	0	1
Iowa	81.30	0.51	0	0	0	0	0
Kansas	94.70	-0.63	0	0	0	0	1
Kentucky	74.59	-0.76	0	0	1	0.56	1
Louisiana	84.89	-1.08	0	0	1	0.54	1
Maine	121.85	-0.62	0	0	0	0	1
Maryland	88.60	-0.85	0	1	0	6.72	1
Massachusetts	92.23	0.47	0	1	0	5.84	1
Michigan	74.39	-0.49	0	0	0	0	1
Minnesota	84.72	-0.20	0	0	0	0	1
Mississippi	67.52	-0.64	0	0	0	0	1
Missouri	79.08	-0.42	0	0	0	0	1
Montana	115.84	-0.53	0	0	0	0	0
Nebraska	111.24	2.74	0	0	0	0	0
Nevada	94.68	-1.82	0	0	0	0	1
New Hampshire	117.84	2.64	0	0	0	0	1
New Jersey	98.67	0.39	0	0	1	0.64	1
New Mexico	109.46	0.01	0	0	0	0	1
New York	134.79	1.97	0	1	0	5.86	1
North Carolina	69.29	-1.46	0	1	0	5.74	1
North Dakota	112.89	3.24	0	0	0	0	0
Ohio	72.69	-0.25	0	1	0	5.10	1
Oklahoma	73.14	-0.76	0	0	0	0	1
Oregon	95.43	-0.86	0	0	0	0	1
Pennsylvania	87.75	1.08	0	0	1	0.52	1
Rhode Island	101.14	0.11	0	1	0	11.85	1
South Carolina	71.57	-0.52	0	0	0	0	1
South Dakota	85.42	0.35	0	0	0	0	1
Tennessee	63.63	-0.06	1	0	0	11.25	1
Texas	78.83	-1.45	0	0	0	0	1
Utah	58.11	-0.53	0	0	0	0	1
Virginia	71.89	-0.77	0	0	0	0	1
Washington	88.36	-0.25	0	0	0	0	1

	Annual PP Expenditures (in $100s)	Change in PP Expenditures (in $100s)	Won RTT Round 1	Won RTT Round 2	Won RTT in Round 3	RTT PP Award (in $100s)	Received NCLB Waiver
West Virginia	87.63	-1.16	0	0	0	0	1
Wisconsin	84.87	-0.82	0	0	0	0	1
Wyoming	143.41	0.05	0	0	0	0	0

Note: This table includes each state's observations of the coarse policy indicators included in this study. For instance, column 4 includes an indicator for whether a state won the first round of Race to the Top. The annual per pupil expenditures (in $100s) are the mean per pupil state expenditures over the study period, and the change in per pupil expenditures is the annual change in per pupil expenditures (in $100s). The column "RTT PP Award" indicates the Race to the Top award amount per pupil, using the number of students enrolled in the year following the award. For example, Race to the Top awards were announced in March 2010, so I use the student enrollment for the 2010-11 school year to estimate the per pupil allocation.

Appendix Table 3

U.S. Chamber of Commerce Report Card, Tennessee, 2007 & 2014

	2007	**2014**
Data Quality	B	A
Truth in Advertising About Student Proficiency	F	A
21st Century Teaching Force	B	B
Return on Investment	C	C
Postsecondary and Workforce Readiness	F	C
Academic Achievement	D	D
Academic Achievement of Low-Income and Minority Students	F	D
Rigor of Standards	C	N/A
Flexibility in Management and Policy	C	N/A

Note: Rigor of standards and flexibility in management and policy were not rated in 2014 nor in any other year that the report has run. The most recent year for which grades were released for the corresponding areas is 2014.

Appendix Table 4

Pairwise Correlations of Improving Achievement and Disparity Narrowing

Disparity	Tennessee	US
Socioeconomic	-0.026	-0.008
(N)	130	8,258
White-Black	0.108	-0.043*
(N)	64	2,625
White-Hispanic	0.184	-0.045**
(N)	47	3,442

Note: Results in this table show the extent to which each disparity (socioeconomic, White-Black, and White-Hispanic) is correlated with overall achievement improving over time in Tennessee and the US broadly (without Tennessee). For example, the first column of correlations shows that in Tennessee, there is a non-significant correlation of -0.026 between districts' socioeconomic disparity trends and overall achievement trends. ǂ $p<0.10$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$