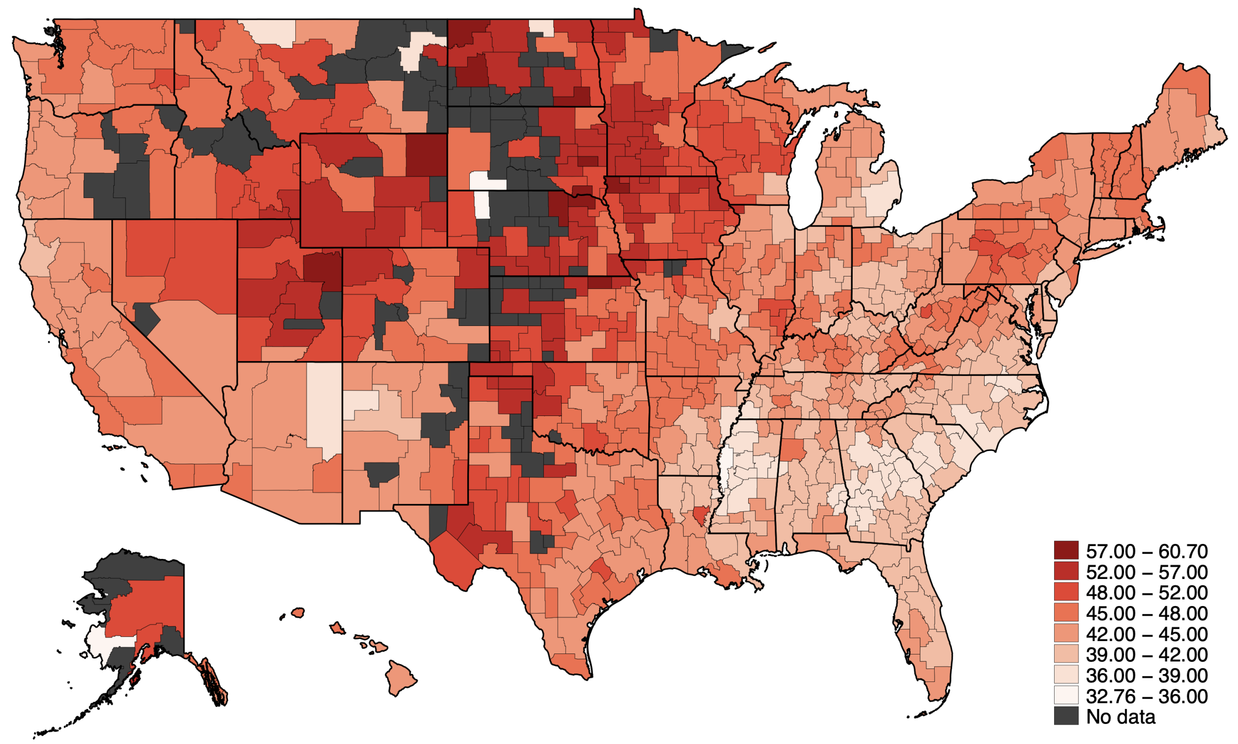
Online Appendix

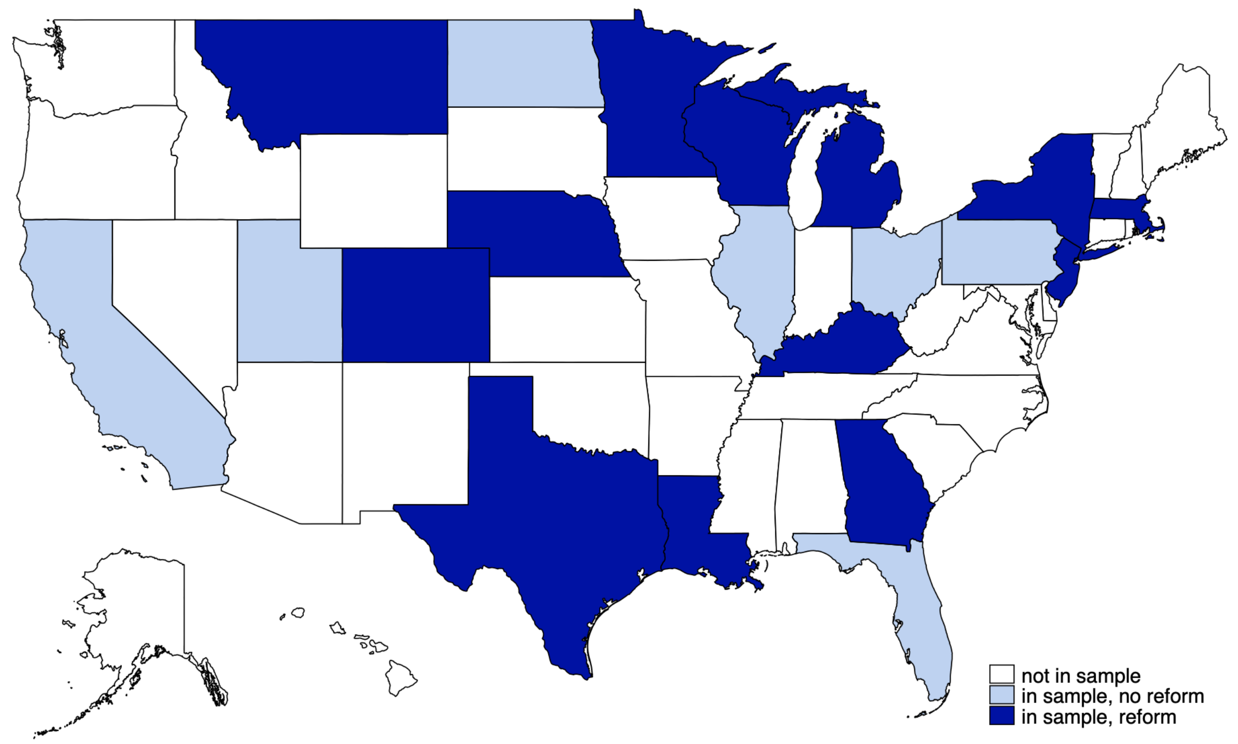
Appendix A Additional Figures and Tables

Figure AI: Intergenerational Mobility Across US Commuting Zones: Expected Income Percentile for Children with Parents on the 25th Percentile, Cohorts 1980-1986



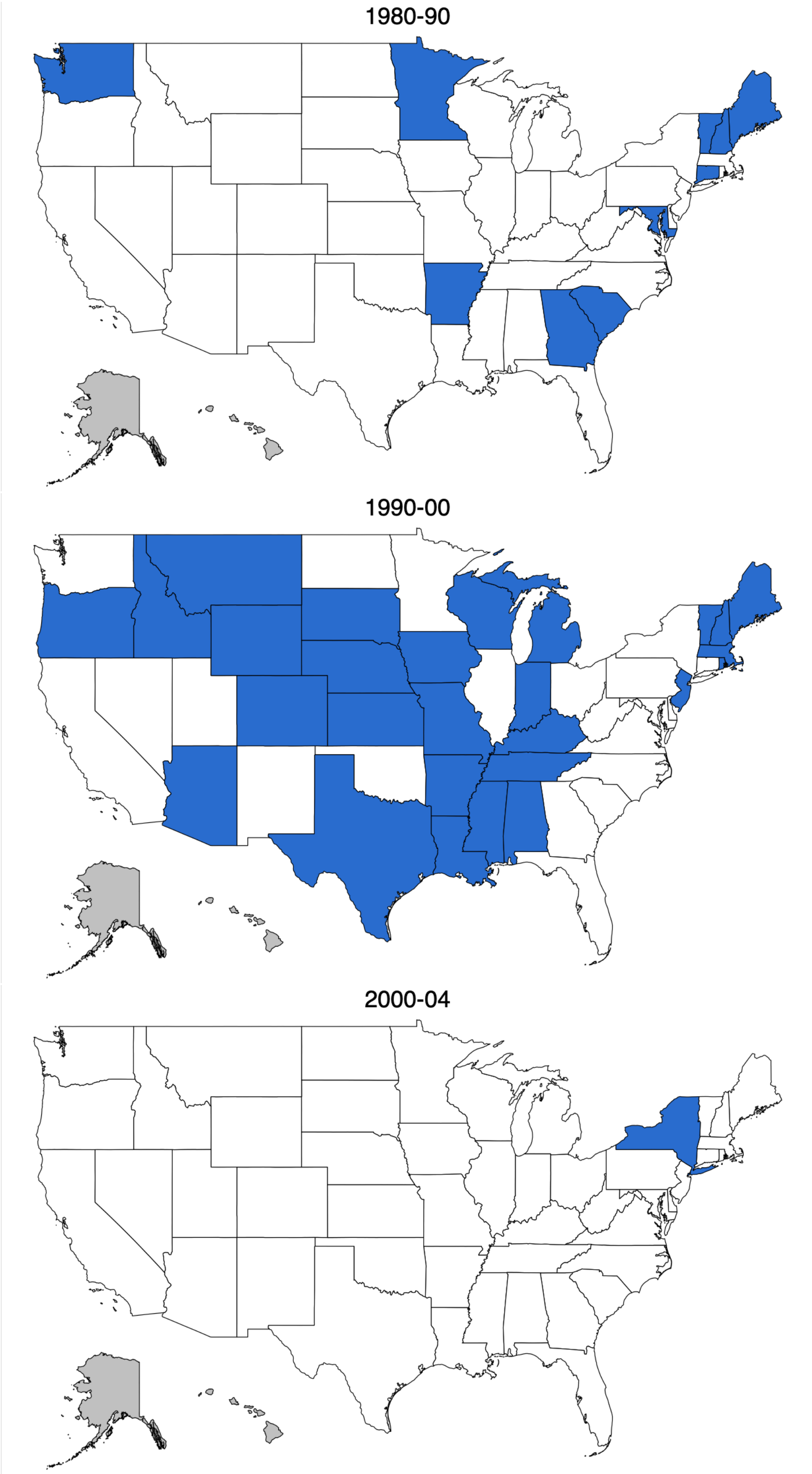
Note: Mean income percentile of children born between 1980 and 1986 with parents on the 25th national percentile. Each shaded area corresponds to a CZ. Weighted average across cohorts with number of children used as weights.

Figure AII: US States Included In The Estimation Sample With And Without A Reform, And States Not Included



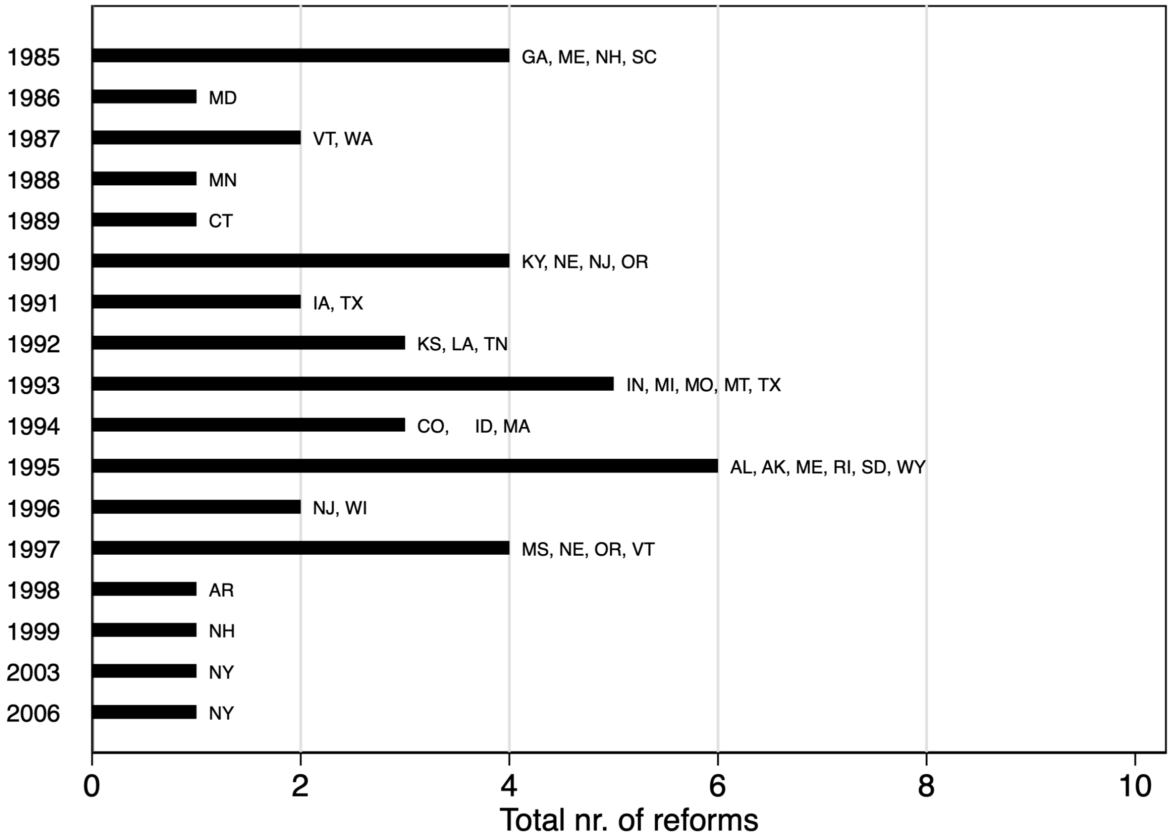
Note: The figure shows states included in the analysis sample with a reform and without a reform, as well as states not included in the analysis. The first group includes Colorado, Florida, Georgia, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Jersey, New York, Pennsylvania, Texas, and Wisconsin. The second includes California, Florida, Illinois, North Dakota, Ohio, Pennsylvania, and Utah. The third includes all remaining states.

Figure AIII: US States with School Finance Equalization Reforms, 1980-2010



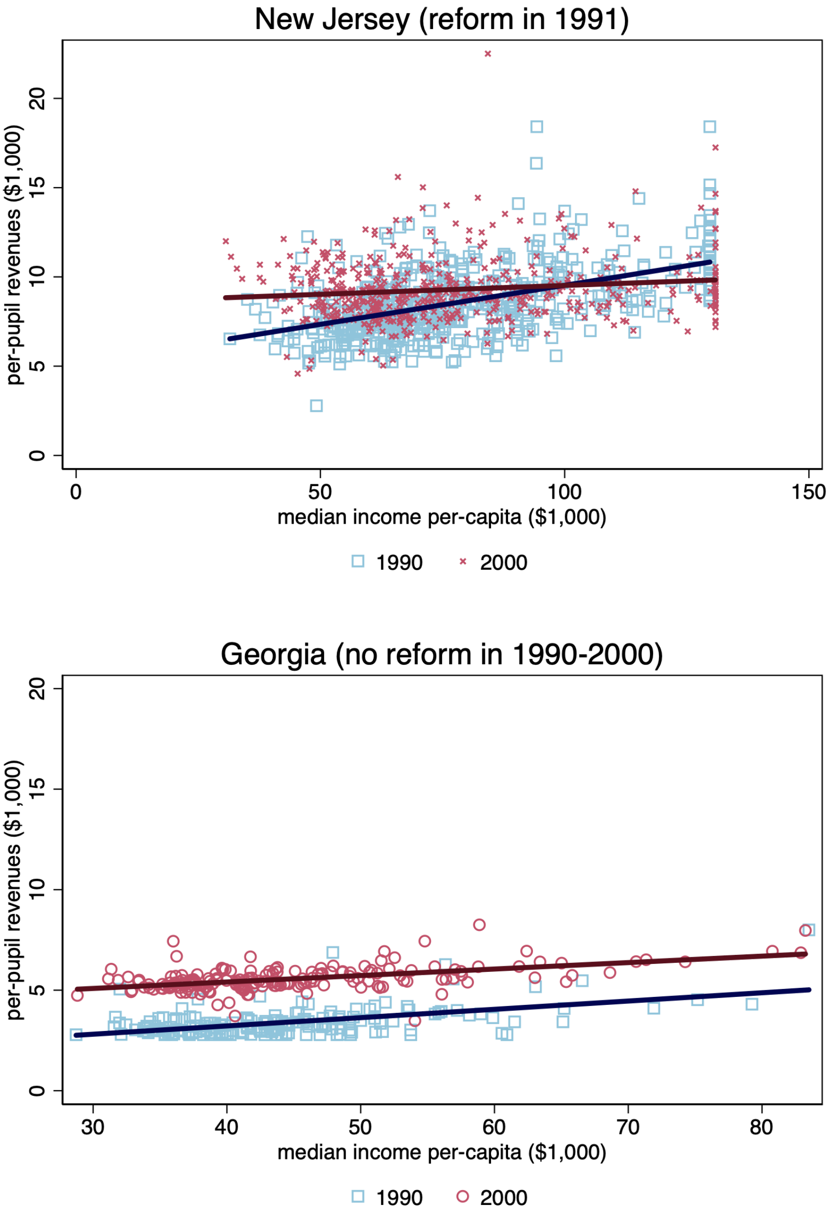
Note: Shaded areas denote states which passed a school finance equalization reform during each time period. Alaska and Hawaii (excluded from the estimation sample) had one (1987, a revision of its school finance foundation program) and zero reforms in this time period, respectively. Source: "Public School Finance Programs of United States and Canada" (1990-1991 and 1998–1999), Verstegen and Jordan (2009), Jackson et al. (2015), and Lafortune et al. (2018).

Figure AIV: School Finance Reforms Over Time



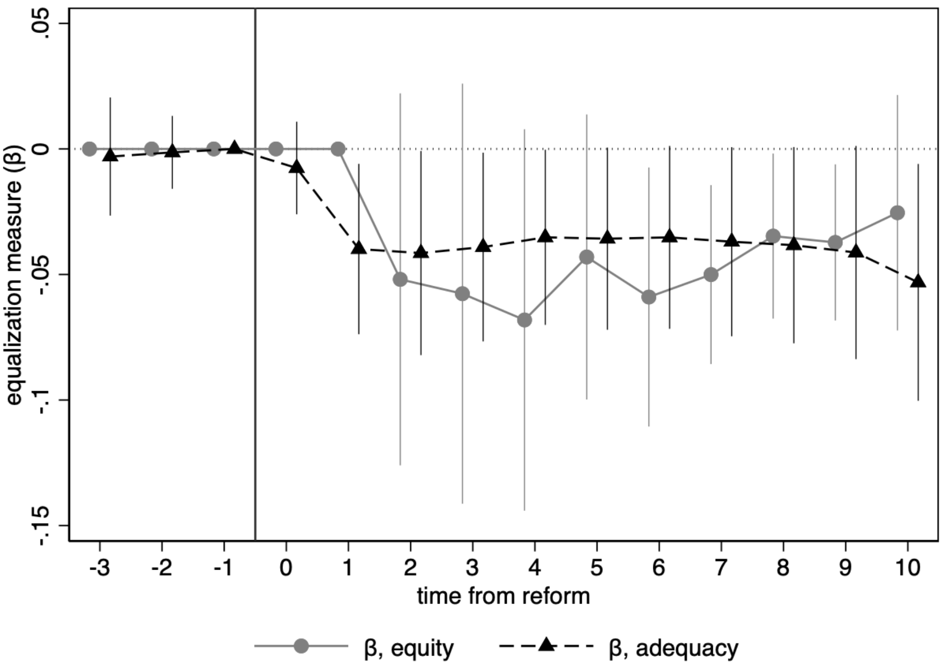
Note: Number of school finance reforms by year.

Figure AV: Per-pupil Revenues and Per-capita Income in New Jersey and Georgia, 1990 and 2000



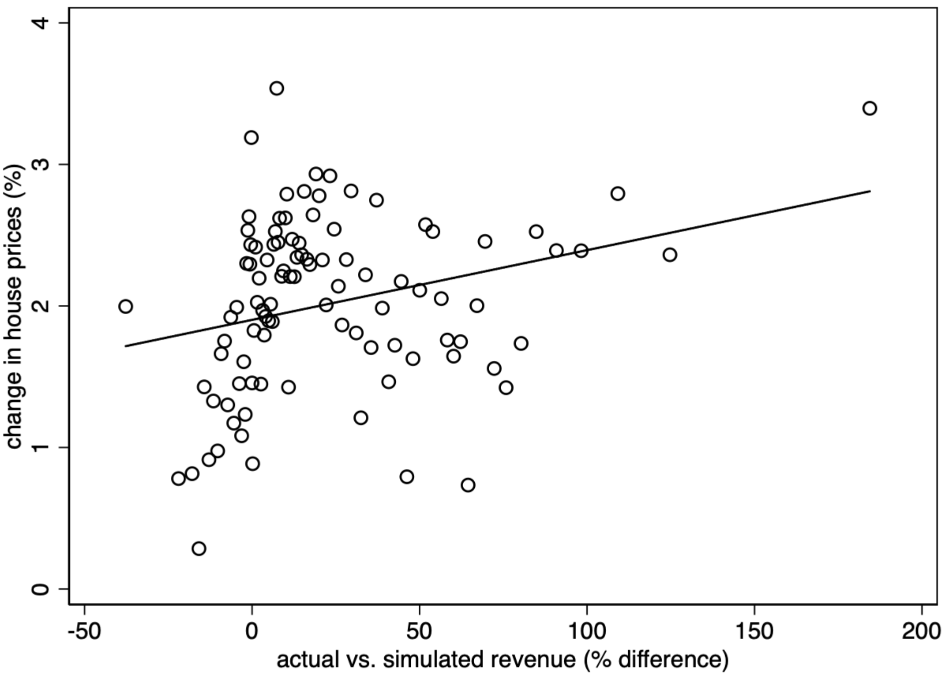
Note: Per-pupil revenues (y-axis) and per-capita income (x-axis) in 1990 and 2000, in New Jersey (which had a reform in 1991) and Georgia (which did not have a reform between 1990 and 2000). Each observation is a school district.

Figure AVI: Event Study of Equalization Measure β Around A School Finance Reform: "Equity" Reforms (passed before 1990) and "Adequacy" Reforms (passed after 1990)



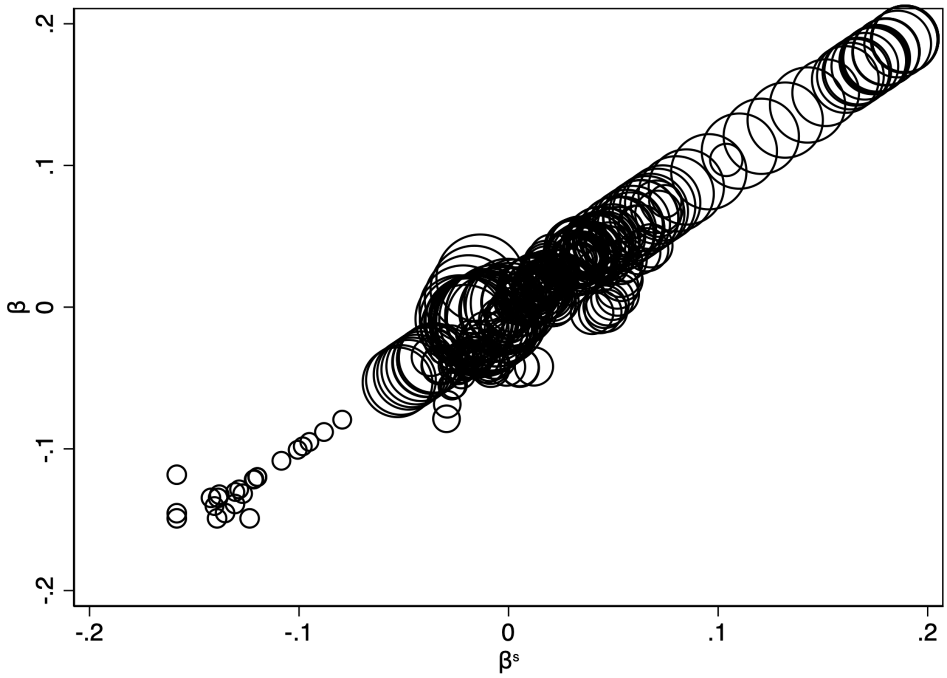
Note: Point estimates and 90 percent confidence intervals for the coefficients δ_k in regression $\beta_{st} = \sum_k \delta_k R_s 1(t - ryear_s = k) + \varepsilon_{st}$, where β_{st} is the slope coefficient in equation (7), estimated separately for each state s and year t from 1986 to 2004, R_s equals 1 if state s had a school finance reform in the years 1980-2004, and $ryear_s$ is the year of the first reform in this time period. The coefficient δ_{-1} is normalized to equal zero. Estimates are obtained and shown separately for reforms passed before or in 1990 ("equity", solid line) and for reforms passed after 1990 ("adequacy", dashed line). Standard errors are clustered at the state level. The sample is restricted to California, Colorado, Florida, Georgia, Illinois, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Utah, Texas, and Wisconsin.

Figure AVII: Change in House Prices and Difference Between Actual vs. Simulated Revenues



Note: Binned scatterplot of the annual percentage change in zip code-level annual house price indexes (y-axis) and the percentage difference between actual and simulated revenues in the corresponding school district (x-axis). Each dot corresponds to a percentile in the distribution of the percentage difference between actual and simulated revenues. Annual house price index data are taken from the Federal Housing Finance Agency, and cover years 1986 to 2004.

Figure AVIII: First Stage: Correlation Between β and β_s



Note: Binned scatterplot of β (vertical axis) and β^{sim} (horizontal axis).

Table AI: Differences Between US States Included in The Sample and Other States

	(1) In sample	Not in sample	Difference
population (2000 Census)	3287992.9	9375981.8	-6087988.8***
			(1642271.0)
in urban area	0.52	0.53	-0.014
			(0.080)
racial segregation	0.13	0.15	-0.017
			(0.018)
income segregation	0.045	0.047	-0.0023
			(0.0065)
school expenditure in 1996 ($1,000)	6.16	6.33	-0.16
			(0.33)
Gini coefficient	0.42	0.41	0.012
			(0.016)
crime rate	0.0017	0.0014	0.00034
			(0.00027)
share single mothers	0.21	0.20	0.014
			(0.011)
share divorced	0.10	0.093	0.0087**
			(0.0037)

Note: The table shows means and differences in means in a set of state-level variables between US states included in the analysis sample (California, Colorado, Florida, Georgia, Illinois, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Utah, Texas, and Wisconsin) and all the other states. The variables are defined as in Figure VII of Chetty et al. (2014).

Table AII: Simulated Instrument, House Prices, and Migration: OLS, Dependent Variable is β Simulated

	β simulated		
	(1)	(2)	(3)
avg change in house prices	-0.0514	0.0036	0.0210
	(0.0613)	(0.0752)	(0.0664)
in-migration rate		0.0283	-0.1949
		(0.8690)	(1.0835)
out-migration rate		-0.1727	-1.4894
		(0.8781)	(1.0416)
income in-migrants/ income incumbents			-0.0997
			(0.7614)
income out-migrants/ income incumbents			1.1085
			(0.8922)
State FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N (state $\times$ year)	289	247	223
F-stat of joint significance	0.703	0.018	0.513

Note: The dependent variable is β *simulated*, estimated as β in equation (7) using simulated revenues instead of actual revenues. The variable *avg change in house prices* represents the average change in the house price index in each state and year. The variables *in-migration rate* and *out-migration rate* are ratios of the number of in-migrants and out-migrants in a county, respectively, and the county's population; these rates are averaged across all counties in a state and year using population weights. The variables *income in-migrants/ income incumbents* and *income out-migrants/ income incumbents* are ratios of incomes of in-migrants and out-migrants of a county and the incomes of the county's incumbent residents, also averaged across all counties in a state and year using population weights. All specifications include state and year fixed effects. Standard errors in parentheses are clustered at the state level. *** p<0.01, ** p<0.05, * p<0.1.

Table AIII: 2SLS Estimates of Equalization On Intergenerational Mobility Using Jackson, Johnson, Persico (2015) IV Approach: First Stage

	Approach 1		Approach 2	
	(1)	(2)	(3)	(4)
	β	$\beta\times$ parent centile	β	$\beta\times$ parent centile
β (IV, approach 1)	0.8969***	-4.1167		
	(0.0426)	(2.5328)		
β (IV, approach 1) $\times$ parent centile	0.0000	0.9722***		
	(0.0000)	(0.0211)		
β (IV, approach 2)			1.0759***	-4.8650
			(0.0683)	(4.0634)
β (IV, approach 2) $\times$ parent centile			-0.0000	1.1621***
			(0.0000)	(0.0147)
Parent centile FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
CZ FE	Yes	Yes	No	No
State FE	No	No	Yes	Yes
Kleibergen-Paap Wald F-stat	1.81		1.79	
N (CZ $\times$ parent cent. $\times$ cohort)	12924	12924	5886	5886

Note: The table shows the first stage of the 2SLS estimation of the parameters δ_0 and δ in equation (11). The variable β is the OLS estimate of the slope coefficient in equation (7), computed separately for each state and cohort, and standardized across all states and cohorts. The variable *parent centile* is the percentile of parents in the national income distribution. The variables β *(IV, approach 1)* and β *(IV, approach 2)* are estimated as β using the instruments for revenues developed by Jackson, Johnson, and Persico (2015). In this first stage, the variables β *(IV, approach 1 or 2)* and β *(IV, approach 1 or 2)* $\times$ *parent centile* are used as instruments for β and $\beta\times$ *parent centile*. All specifications include parent percentile and cohort fixed effects; columns 1 and 2 include CZ fixed effects, and columns 3 and 4 include state fixed effects. Bootstrapped standard errors in parentheses are clustered at the state and birth cohort level. The sample is restricted to California, Colorado, Florida, Georgia, Illinois, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Utah, Texas, and Wisconsin. *** p<0.01, ** p<0.05, * p<0.1.

Table AIV: 2SLS Estimates of Equalization On Intergenerational Mobility Using Jackson, Johnson, Persico (2015) IV Approach: Second Stage

	Approach 1		Approach 2	
	(1)	(2)	(3)	(4)
β	-3.1625*	-3.1648*	-2.2985	-2.2859
	(1.7555)	(1.7152)	(1.9636)	(1.9245)
$\beta \times$ parent centile	0.0247***	0.0236***	0.0256***	0.0249***
	(0.0022)	(0.0023)	(0.0031)	(0.0028)
Parent centile FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
CZ FE	Yes	No	Yes	No
State FE	No	Yes	No	Yes
N (CZ $\times$ parent cent. $\times$ cohort)	12924	12924	5886	5886
10th			2.043	2.037
10th [p-value]			0.298	0.290
25th			1.660	1.662
25th [p-value]			0.398	0.388
90th			-0.002	0.041
90th [p-value]			0.999	0.983

Note: The dependent variable is children's income percentile for each parental income quintile in the state distribution, for cohorts 1980 to 1986. The variable β is the OLS estimate of the slope coefficient in equation (7), computed separately for each state and cohort, and standardized across all states and cohorts. The variable *parent centile* is the percentile of parents in the national income distribution. The variable β is instrumented using a version of the same β calculated using the instrument for school revenues developed by Jackson, Johnson, and Persico (2015) (their Approach 1 is shown in columns 1 and 2, their Approach 2 is shown in columns 3 and 4). All specifications include parent percentile and cohort fixed effects; columns 1 and 3 include CZ fixed effects, and columns 2 and 4 include state fixed effects. Bootstrapped standard errors in parentheses are clustered at the state and birth cohort level. The sample is restricted to California, Colorado, Florida, Georgia, Illinois, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Utah, Texas, and Wisconsin. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table AV: Heterogeneous Effects of School Finance Equalization by Competition Among Districts. 2SLS, Dependent Variable is Children's Income Percentile

	High Competition		Low Competition	
	(1)	(2)	(3)	(4)
β	-5.1363**	-4.8499**	-7.6407***	-7.6407***
	(2.3808)	(2.2469)	(1.9419)	(1.8993)
$\beta\times$ parent centile	0.0228***	0.0228***	0.0871***	0.0871***
	(0.0019)	(0.0020)	(0.0164)	(0.0170)
Parent centile FE	Yes	Yes	Yes	Yes
State FE	No	Yes	No	Yes
CZ FE	Yes	No	Yes	No
Cohort FE	Yes	Yes	Yes	Yes
N (CZ $\times$ parent cent. $\times$ cohort)	8790	8790	4788	4788
10th	4.908	4.622	6.769	6.769
10th [p-value]	0.040	0.040	0.000	0.000
25th	4.567	4.280	5.463	5.463
25th [p-value]	0.056	0.058	0.003	0.002
90th	3.085	2.799	-0.201	-0.201
90th [p-value]	0.204	0.224	0.917	0.915

Note: The dependent variable is children's income percentile in the national distribution for each parental income quintile in the state distribution, for cohorts 1980 to 1986. The variable β is the OLS estimate of the slope coefficient in equation (7), computed separately for each state and cohort, and standardized across all states and cohorts. The variable *parent centile* is the percentile of parents in the national income distribution. All specifications include parent percentile and cohort fixed effects; columns 1 and 3 include CZ fixed effects, and columns 2 and 4 include state fixed effects. "Low Competition" ("High Competition") refers to states below (above) the median level of cross-district competition, measured as the number of districts per student in the state in 1980. Bootstrapped standard errors in parentheses are clustered at the state and birth cohort level. The sample is restricted to California, Colorado, Florida, Georgia, Illinois, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Utah, Texas, and Wisconsin. *** p<0.01, ** p<0.05, * p<0.1.

Table AVI: Heterogeneous Effects of School Finance Equalization by CZs' Income Inequality. OLS, Dependent Variable is Children's Income Percentile

	Low Inequality		High Inequality	
	(1)	(2)	(3)	(4)
β	-3.4435	-3.4413	-4.3553**	-4.1678**
	(2.3945)	(2.3905)	(1.8954)	(2.0086)
$\beta\times$ parent centile	0.0281***	0.0281***	0.0222***	0.0222***
	(0.0063)	(0.0067)	(0.0016)	(0.0018)
Parent centile FE	Yes	Yes	Yes	Yes
State FE	No	Yes	No	Yes
CZ FE	Yes	No	Yes	No
Cohort FE	Yes	Yes	Yes	Yes
N (CZ $\times$ parent cent. $\times$ cohort)	5586	5586	7950	7950
10th	3.162	3.160	4.134	3.946
10th [p-value]	0.184	0.183	0.029	0.049
25th	2.741	2.739	3.801	3.614
25th [p-value]	0.245	0.245	0.045	0.072
90th	0.914	0.912	2.360	2.173
90th [p-value]	0.693	0.694	0.215	0.278

Note: The dependent variable is children's income percentile in the national distribution for each parental income quintile in the state distribution, for cohorts 1980 to 1986. The variable β is the OLS estimate of the slope coefficient in equation (7), computed separately for each state and cohort, and standardized across all states and cohorts. The variable *parent centile* is the percentile of parents in the national income distribution. All specifications include parent percentile and cohort fixed effects; columns 1 and 3 include CZ fixed effects, and columns 2 and 4 include state fixed effects. "Low Inequality" ("High Inequality") refers to CZs below (above) the median level of income inequality, measured as the percentage difference in average income between the richest and poorest district in each CZ in 1990. Bootstrapped standard errors in parentheses are clustered at the state and birth cohort level. The sample is restricted to California, Colorado, Florida, Georgia, Illinois, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Utah, Texas, and Wisconsin. *** p<0.01, ** p<0.05, * p<0.1.

Table AVII: Heterogeneous Effects of School Finance Equalization by CZs' Income Segregation. OLS, Dependent Variable is Children's Income Percentile

	Low Segregation		High Segregation	
	(1)	(2)	(3)	(4)
β	-4.3188**	-4.3188**	-4.1464**	-3.9669**
	(2.0241)	(1.8243)	(1.9019)	(1.9901)
$\beta \times$ parent centile	0.0318***	0.0318***	0.0240***	0.0240***
	(0.0047)	(0.0045)	(0.0018)	(0.0020)
Parent centile FE	Yes	Yes	Yes	Yes
State FE	No	Yes	No	Yes
CZ FE	Yes	No	Yes	No
Cohort FE	Yes	Yes	Yes	Yes
N (CZ $\times$ parent cent. $\times$ cohort)	5880	5880	7698	7698
10th	4.001	4.001	3.907	3.727
10th [p-value]	0.047	0.028	0.040	0.061
25th	3.524	3.524	3.547	3.368
25th [p-value]	0.078	0.052	0.062	0.090
90th	1.458	1.458	1.990	1.810
90th [p-value]	0.459	0.421	0.297	0.361

Note: The dependent variable is children's income percentile in the national distribution for each parental income quintile in the state distribution, for cohorts 1980 to 1986. The variable β is the OLS estimate of the slope coefficient in equation (7), computed separately for each state and cohort, and standardized across all states and cohorts. The variable *parent centile* is the percentile of parents in the national income distribution. All specifications include parent percentile and cohort fixed effects; columns 1 and 3 include CZ fixed effects, and columns 2 and 4 include state fixed effects. "Low Segregation" ("High Segregation") refers to CZs below (above) the median level of income segregation across all CZs, where income segregation is measured with a Theil index calculated across districts within each CZ using data from 1990. Bootstrapped standard errors in parentheses are clustered at the state and birth cohort level. The sample is restricted to California, Colorado, Florida, Georgia, Illinois, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Utah, Texas, and Wisconsin. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table AVIII: School Finance Equalization and Intergenerational Mobility. OLS and 2SLS, Dependent Variable is is Children's Income Percentile. No Imputation of Income for Intercensal Years

	OLS	First stage		2SLS
	(1)	(2)	(3)	(4)
β	-6.0891***			-6.9990***
	(1.7404)			(2.1231)
$\beta\times$ parent centile	0.0255***			0.0251***
	(0.0021)			(0.0021)
β simulated		0.8078***	-9.4193**	
		(0.0710)	(4.1537)	
β simulated $\times$ parent centile		0.0000	0.9598***	
		(0.0000)	(0.0099)	
Parent centile FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
CZ FE	Yes	Yes	Yes	Yes
N (CZ $\times$ parent cent. $\times$ cohort)	13578	13578	13578	13578
Kleibergen-Paap Wald F-stat		34.080		
10th	5.834			6.748
10th [p-value]	0.001			0.001
25th	5.451			6.372
25th [p-value]	0.002			0.003
90th	3.794			4.742
90th [p-value]	0.028			0.024

Note: The table shows OLS estimates (columns 1 and 2) as well as the 2SLS first stage (column 3) and second stage (columns 4 and 5) estimates of the parameters δ_0 and δ in equation (11). The dependent variable is children's income percentile for each parental income quintile in the state distribution, for cohorts 1980 to 1986. The variable β is the OLS estimate of the slope coefficient in equation (7), computed separately for each state and cohort using income values from 1990 for all years (instead of the imputation procedure described in the text), and standardized across all states and cohorts. The variable *parent centile* is the percentile of parents in the national income distribution. In columns 2-4, the variable β is instrumented using β *simulated*, estimated as β using simulated revenues instead of actual revenues and income values from 1990 for all years; columns 2 and 3 show the 2SLS first stage, and column 4 shows the second stage. All specifications include CZ, parent percentile, and cohort fixed effects. Bootstrapped standard errors in parentheses are clustered at the state and birth cohort level. The sample is restricted to California, Colorado, Florida, Georgia, Illinois, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Utah, Texas, and Wisconsin. *** p<0.01, ** p<0.05, * p<0.1.

Table AIX: School Finance Equalization and Intergenerational Mobility. 2SLS, Dependent Variable is Children's Income Percentile. CZs With and Without A State Border

	Without border		With border	
	(1)	(2)	(3)	(4)
β	-5.8429**	-5.7714**	-5.0405***	-5.0370***
	(2.6145)	(2.5248)	(1.9059)	(1.8744)
$\beta\times$ parent centile	0.0256***	0.0256***	0.0180***	0.0180***
	(0.0025)	(0.0026)	(0.0027)	(0.0023)
Parent centile FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
CZ FE	Yes	No	Yes	No
State FE	No	Yes	No	Yes
N (CZ $\times$ parent cent. $\times$ cohort)	189400	189400	36900	36900
10th	5.587	5.516	4.861	4.857
10th [p-value]	0.032	0.029	0.011	0.009
25th	5.204	5.132	4.591	4.588
25th [p-value]	0.046	0.042	0.016	0.014
90th	3.542	3.470	3.424	3.420
90th [p-value]	0.172	0.169	0.075	0.067

Note: The dependent variable is children's income percentile for each parental income quintile in the state distribution, for cohorts 1980 to 1986. The variable β is the OLS estimate of the slope coefficient in equation (7), computed separately for each state and cohort, and standardized across all states and cohorts. The variable *parent centile* is the percentile of parents on the national income distribution. All the specifications include parent percentile and cohort fixed effects; columns 1, and 3 include CZ fixed effects, and columns 2 and 4 include state fixed effects. "Without border" refers to CZs entirely belonging to one state, and "With border" refers to CZs belonging to two or more states. Bootstrapped standard errors in parentheses are clustered at the state and birth cohort level. The sample is restricted to California, Colorado, Florida, Georgia, Illinois, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Utah, Texas, and Wisconsin. *** p<0.01, ** p<0.05, * p<0.1.

Table AX: School Finance Equalization and Intergenerational Mobility. 2SLS, Dependent Variable is Children's Income Percentile. Parental Income Quintiles Defined Based On the National Income Distribution

	(1)	(2)	(3)	(4)
β	-5.5522**	-5.4954**	-5.5125**	-5.4355***
	(2.2935)	(2.2338)	(2.1744)	(2.0468)
$\beta\times$ parent centile	0.0235***	0.0235***	0.0235***	0.0235***
	(0.0021)	(0.0022)	(0.0021)	(0.0022)
e_{sc}			0.0418	0.0631
			(0.6497)	(0.6204)
Parent centile FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
CZ FE	Yes	No	Yes	No
State FE	No	Yes	No	Yes
N (CZ $\times$ parent cent. $\times$ cohort)	13578	13578	13578	13578
10th	5.317	5.260	5.277	5.200
25th	4.964	4.907	4.924	4.847
90th	3.434	3.377	3.394	3.317

Note: The dependent variable is children's income percentile for each parental income quintile in the national distribution, for cohorts 1980 to 1986. The variable β is the OLS estimate of the slope coefficient in equation (7), computed separately for each state and cohort, and standardized across all states and cohorts. The variable *parent centile* is the percentile of parents on the national income distribution. All the specifications include parent percentile and cohort fixed effects; columns 1, and 3 include CZ fixed effects, and columns 2 and 4 include state fixed effects. "Without border" refers to CZs entirely belonging to one state, and "With border" refers to CZs belonging to two or more states. Bootstrapped standard errors in parentheses are clustered at the state and birth cohort level. The sample is restricted to California, Colorado, Florida, Georgia, Illinois, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Utah, Texas, and Wisconsin. *** p<0.01, ** p<0.05, * p<0.1.

Table AXI: School Finance Equalization and Intergenerational Mobility. 2SLS, Dependent Variable is Children's Income Percentile. Parental Income Quintiles Defined Based On the CZ-Specific Income Distribution

	(1)	(2)	(3)	(4)
β	-5.9967***	-5.8392***	-5.8358***	-5.6563***
	(2.2647)	(2.1958)	(2.1610)	(1.9962)
$\beta\times$ parent centile	0.0272***	0.0259***	0.0272***	0.0259***
	(0.0022)	(0.0022)	(0.0022)	(0.0022)
e_{sc}			0.1669	0.1898
			(0.6572)	(0.6336)
Parent centile FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
CZ FE	Yes	No	Yes	No
State FE	No	Yes	No	Yes
N (CZ $\times$ parent cent. $\times$ cohort)	14458	14458	14458	14458
10th	5.724	5.580	5.564	5.397
25th	5.316	5.192	5.155	5.009
90th	3.546	3.508	3.385	3.325

Note: The dependent variable is children's income percentile for each parental income quintile in the CZ distribution, for cohorts 1980 to 1986. The variable β is the OLS estimate of the slope coefficient in equation (7), computed separately for each state and cohort, and standardized across all states and cohorts. The variable *parent centile* is the percentile of parents on the national income distribution. All the specifications include parent percentile and cohort fixed effects; columns 1, and 3 include CZ fixed effects, and columns 2 and 4 include state fixed effects. "Without border" refers to CZs entirely belonging to one state, and "With border" refers to CZs belonging to two or more states. Bootstrapped standard errors in parentheses are clustered at the state and birth cohort level. The sample is restricted to California, Colorado, Florida, Georgia, Illinois, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Utah, Texas, and Wisconsin. *** p<0.01, ** p<0.05, * p<0.1.

Table AXII: School Finance Equalization and College Enrollment. OLS, Dependent Variable is Children's Probability of College Enrollment at Age 19

	(1)	(2)	(3)	(4)
β	-0.1040**	-0.0993**		
	(0.0430)	(0.0466)		
$\beta\times$ parent centile	0.0002***	0.0002***		
	(0.0000)	(0.0000)		
$\beta\times$ reform in elementary school			-0.1529***	-0.1463***
			(0.0450)	(0.0479)
$\beta\times$ parent centile $\times$ reform in elementary school			0.0003***	0.0003***
			(0.0001)	(0.0001)
$\beta\times$ reform in middle school			-0.1544***	-0.1471***
			(0.0453)	(0.0476)
$\beta\times$ parent centile $\times$ reform in middle school			0.0002**	0.0002**
			(0.0001)	(0.0001)
$\beta\times$ reform in high school			-0.1760**	-0.1698*
			(0.0781)	(0.1007)
$\beta\times$ parent centile $\times$ reform in high school			0.0005***	0.0005***
			(0.0001)	(0.0001)
Parent centile FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
CZ FE	Yes	No	Yes	No
State FE	No	Yes	No	Yes
N (CZ $\times$ parent cent. $\times$ cohort)	13296	13296	13296	13296
Mean of dep. var.	0.593	0.593	0.593	0.593
10th	0.102	0.097		
25th	0.099	0.094		
90th	0.086	0.081		
10th, High School			0.171	0.165
25th, High School			0.164	0.158
90th, High School			0.132	0.126

Note: The dependent variable is the probability of college enrollment by age 19 for each parental income quintile in the state distribution, for cohorts 1984 to 1990. The variable β is the OLS estimate of the slope coefficient in equation (7), computed separately for each state and cohort, and standardized across all states and cohorts. The variable *parent centile* is the percentile of parents in the national income distribution. The variables *reform in elementary school*, *reform in middle school*, and *reform in high school* equal one for cohorts and states for which a reform hit during elementary, middle, and high school, respectively. All specifications include parent percentile and cohort fixed effects; columns 1 and 3 include CZ fixed effects, while columns 2 and 4 include state fixed effects. Bootstrapped standard errors in parentheses are clustered at the state and birth cohort level. The sample is restricted to California, Colorado, Florida, Georgia, Illinois, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Utah, Texas, and Wisconsin. *** p<0.01, ** p<0.05, * p<0.1.

Appendix B Construction of the dataset

Income

I use tabulations of household income at the school district level from the US Census of Population and Housing for the years 1980, 1990 and 2000, and from the American Community Survey 5-year estimates (2008-2012) for the year 2010. Income tabulations at the school district level are contained in the Census STF3F file for 1980, and published as part of the School District Demographic System for the years 1990, 2000, and 2010. Income data at the district level is reported in the form of tabulations of the counts of households in 17, 25, 16 and 16 income bins in each school district in 1980, 1990, 2000 and 2010 respectively. To calculate median income from these tabulations, I assume a uniform distribution of households in each bin, and I assign each district the level of income of the class containing the median household. I winsorize the top and bottom 1 percent of observations in the distribution of each year. In the final sample, median income is available for 15,960, 15,272, 14,373, and 13,576 districts in 1980, 1990, 2000, and 2010 respectively.

Actual and Simulated School Revenues

To obtain actual and simulated revenues for each district, I have collected data from each state's Department of Education on the variables entering the school funding formula in each available year between 1986 and 2004. These variables include, but are not limited to, assessments of property values, property tax rates, income, measures of enrollment (such as full-time-equivalents or average daily membership/attendance, weighted by type of students or unweighted). Detailed information on the variables used in each formula is contained in Table CI. I successfully obtained this information for the following states (years): California (data available for the years 1996-2004), Colorado (1993-2004), Florida (1986-2004), Georgia (1988-2004), Kentucky (1991-2004), Illinois (1987-2004), Louisiana (1993-2004), Massachusetts (1995-2004), Montana (1994-2004), Michigan (1993-2004), Minnesota (1991-2004), Nebraska (1993-2004), New Jersey (1998-2004), New York (1986-2004), North Dakota (1986-2004), Ohio (1986-2004), Pennsylvania (1995-2004), Utah (1986-2004), Texas (1986-2004), and Wisconsin (1986-2004), and for a total of 8,102 school districts.

After collecting data on the formula variables from each state, I constructed the funding formula preceding and following each school finance reform, which allows to calculate total revenue as a function of the various variables and of formula parameters set by each state. These formulas are described in Appendix D.

Equalization measures

To estimate state-year specific β as in equation 7, I match per pupil revenues data with median district income data. I assign state-year estimates to states and cohorts using the timing of each reform, with the procedure described in the paper. I also match districts to CZs using the 1990 county-CZ crosswalk provided by Chetty et al. (2014) and Chetty et al. (2014) and information on districts' counties provided by the NCES Common Core of Data.

To construct the simulated β^{sim}, instrument for β, I simulate post-reform revenues keeping endogenous variables, such as property values and income, at their levels at the time of passage of each reform. I adjust property values using the US Annual Price Index (calculated by the Federal

Housing Finance Authority using a repeated-sales method). Third, I estimate the simulated β^s using simulated revenues and median income at the district level, for each Census year as well as for the first and last year for which simulated revenues are available. I then impute β^{sim} to each school year using the same procedure described in the text for the imputation of β. To maximize the size of the sample, I set $\beta^{sim} = \beta$ for all states without a school finance reform in the years 1986-2004, which include California, Florida, Georgia, Illinois, New York, North Dakota, Ohio, Pennsylvania, and Utah. β^s is available for a total of 327 CZs with non-missing mobility information.

Intergenerational Mobility

Chetty et al. (2014) (Online Table 1) calculate and report intergenerational mobility measures, separately for each cohort of children and for each of the 637 out of 722 CZs in the US, using individual-level data from IRS tax records (estimates are not available for CZs with a very low number of children). These measures include the intercept and the slope of the linear relationship between parents' and children's income ranks (on the national income distribution of parents' income and children's income, respectively), separately for each CZ and for cohorts 1980-86.[50] Parents' income is calculated as the average yearly income in years 1996-2000, measured in 2010 dollars. Children's income is calculated as the average yearly income in years 2010, 2011 and 2012, measured in 2010 dollars.[51] Each child is matched to his or her parent (or parents), i.e. the taxpayer who claimed him or her as dependent when he or she was age 25 or younger in IRS tax records covering the period 1996-2011.[52] Matched parent-child pairs are assigned to a CZ based on the earliest non-missing zip code reported on the tax form of the parent. The sample is restricted to children of parents with non-missing zip codes and non-negative income. The final sample of children includes nearly 24 million US citizens born in the period 1980-1986.[53]

My measure of mobility is the national income rank of children given their CZ, cohort, and percentile of parental income in the state. I construct this measure as follows. Chetty et al. (2014) (Online Data Table 7) report the parents' income distribution for each CZ. Specifically, they report income levels corresponding to the 10th, 25th, 50th, 75th, 90th, and 99th percentile in each CZ. I aggregate these distributions at the state level assuming a uniform income distribution within each percentile and using numbers of children in each CZ as weights. This allows me to construct the income levels corresponding to the 10th, 25th, 50th, 75th, 90th, and 99th percentile in each state. I then match these income levels to the corresponding percentiles in the national distribution. Lastly, I use the slope and intercept of the linear relationship between parents' and

[50] A commuting zone is defined by the Census Bureau and the United States Department of Agriculture as "[...] a geographic unit that better captures the economic and social diversity of non-metro areas." For confidentiality issues, mobility measures are not disclosed for 13 CZs with less than 250 children.

[51] See Chetty et al. (2014) for a detailed description of the income definitions used to compute intergenerational mobility measures.

[52] If an individual was claimed as dependent by more than one taxpayer, he or she is considered as the dependent of the taxpayer who claimed him or her in the earliest year.

[53] Differently from Chetty et al. (2014) who base their analysis of income mobility on a "core sample" of children born in 1980 and 1981, my sample also includes younger children. As explained by Chetty et al. (2014), measuring children's income at early ages can overestimate mobility with respect to lifetime income, because children with high lifetime incomes have steeper earnings profiles when young (which stabilize around age 30). Children in the younger cohort in my income mobility sample (born in 1986) are 26 in 2012. The measurement error generated by the inclusion of the younger cohorts, however, should be quite limited (see Chetty et al., 2014, Figure IIIA). In addition, younger cohorts are more likely to be correctly matched to the the zip code where they grew up.

children's national income ranks (provided in the Online Data Table 1 of Chetty et al. (2014)) to back out the national income rank of the child, for each of these parental income percentiles in each state, for each CZ, and for each cohort born between 1980 and 1986. Assuming that the income distributions did not change over time (and across cohorts) in each CZ, this procedure allows to approximate the distribution of income for children in each CZ and birth cohort, given each parent's income percentile in the state distribution.

Appendix C Using The Instrumental-Variables Approach of Jackson, Johnson, and Persico (2015)

To compare my simulated instruments estimation strategy with the instrumental variables approach of Jackson et al. (2015), I estimate a version of my main equation of interest (equation (11)) using their approach. To do this, I obtain instruments for actual school district revenues following their approaches 1 and 2 (described in Jackson et al., 2015, pages 171-179). The two approaches are described below.

1. Approach 1 consists in estimating the parameters of the following equation via OLS:

$$e_{dt} = \sum_{q=1}^{4} \sum_{k} \delta_{qk} \mathbb{1}(Q_d^e = q) \mathbb{1}(t - ryear_d = k) + \theta_d + \tau_t + \omega_{dt}$$

   where e_{dt} are actual revenues of school district d in year t, Q_d^e is the quartile of district d in the state distribution of district revenues in 1980, $ryear_d$ is the year in which the first school finance reform was passed between 1986 and 2004, θ_d are district fixed effects, and τ_t are year fixed effects. This equation is analogous to equation (3) of Jackson et al. (2015) (page 172). Using OLS estimates of this equation, I predict $\tilde{e}_{dt}$ for each d and t, and I construct an instrument $\tilde{\beta}_{st}$ as the estimate of the slope coefficient in the equation $\tilde{e}_{dt} = \alpha_{st} + \tilde{\beta}_{st} y_{dt} + \varepsilon_{dt}$. I then assign $\tilde{\beta}_{st}$ to each cohort depending on the state and the year in which the cohort was in grades 1 to 12, and I use $\tilde{\beta}$ as an instrument for β in equation (11). The first stage estimates are shown in Table AIII (columns 1 and 2); the second stage estimates are shown in Table AIV (columns 1 and 2).

2. Approach 2 consists in estimating the parameters of the following equation via OLS:

$$\begin{aligned} e_{dt} \quad = \quad & \sum_{q=1}^{4} \sum_{k} \delta_{qk} \mathbb{1}(Q_d^e = q) \mathbb{1}(t - ryear_d = k) \\ & + \sum_{q=1}^{4} \sum_{k} \sum_{r} \delta_{qkr} \mathbb{1}(Q_d^y = q) \mathbb{1}(t - ryear_d = k) \mathbb{1}(Type_d = r) + \theta_d + \tau_t + \omega_{dt} \end{aligned}$$

   where Q_d^y is the quartile of district d in the state distribution of district median income in 1980, $ryear_d$ is the year in which the first school finance reform was passed between 1986 and 2004, $Type_d$ is a vector of indicators for the type of reform (I use the same classification as Jackson, Johnson and Persico and classify reforms into foundation, equalization, revenue limit, adequacy, and reward for effort; a reform can be of more than one type), θ_d are district fixed effects, and τ_t are year fixed effects. This equation is analogous to equation (4) of Jackson et al. (2015) (page 178). For each district d, I estimate this equation via OLS using data for all the other states, and I then use these estimates to predict revenues for district d, which I define as $\tilde{\tilde{e}}_{dt}$. I then construct the instrument $\tilde{\tilde{\beta}}_{st}$ as the estimate of the slope coefficient in the equation $\tilde{\tilde{e}}_{dt} = \alpha_{st} + \tilde{\tilde{\beta}}_{st} y_{dt} + \varepsilon_{dt}$. Lastly, I assign $\tilde{\tilde{\beta}}_{st}$ to each cohort depending on the state and the year in which the cohort was in grades 1 to 12, and I use $\tilde{\tilde{\beta}}$ as an instrument for β in equation (11). The first stage estimates are shown in Table AIII (columns

3 and 4); the second stage estimates are shown in Table AIV (columns 3 and 4).

Appendix D School Finance Equalization Reforms

California

The school finance plan in place in 1986 in California is the product of the *Serrano* vs. *Priest* lawsuit, and the passage of Proposition 13 (1978), which limited property tax rates to 1% of assessed property value. The passage of Proposition 98 in 1988 slightly modified the funding scheme, by earmarking a fixed minimum percentage of the state budget to education. After these changes, control of school finance has been shifted more and more to the state. State aid is distributed through a foundation plan. The foundation base, called Revenue Limit, is based on historical revenues adjusted by the cost of living, with increases inversely related to the level of revenues. The formula, although very complicated, can be summarized as follows:

$$\begin{aligned} R &= \max\{\max\{2,400, 400 \times n\}, \max\{\text{RL} - 0.01p\}\} + 0.01p \\ RL &= \bar{RL}_{-1} \times CODB \end{aligned}$$

where RL is the revenue limit, $\bar{RL}_{-1}$ is the average of previous year's revenue limit, $CODB$ is the cost of doing business, proxy for the cost of living, and p is property value.

Colorado

Until 1993, Colorado had a Guaranteed Tax Base formula with a fixed tax rate. Local revenues came from property taxes as well as from appropriations of revenues from an ownership tax on all registered vehicles. The formula was as follows:

$$\begin{aligned} R &= \min\{t * max\{p, B\} + t * 10, ARB\} \\ \text{where } t &= \text{tax rate in district} = 1\% \text{ fixed (collected and redistributed at county/city level)} \\ R^o &= \text{per-pupil revenues from ownership tax base} \\ B &= \text{minimum guaranteed tax base, comes from the state} \\ ARB &= \text{authorized revenue base} \end{aligned}$$

The Public School Finance Act of 1994 changed the formula to a foundation plan. The foundation amount is determined by the Per-Pupil-Revenue and it is district-specific, to account for differences in the cost of living in the number of at-risk children. The formula in place between 1994 and 2004 is as follows:

$$\begin{aligned} R &= t * p + \max\{0, PPR - t * p - R^o\} \\ \text{where } t &= \text{tax rate in district } = 1\% \text{ (fixed)} \\ R^o &= \text{per-pupil revenues of ownership tax base} \\ p^o &= \text{per-pupil ownership tax base} \\ PPR &= \text{per-pupil revenue, function of "base" and cost of living, as well as number of "at risk" children} \end{aligned}$$

Florida

Florida's school funding scheme in the years 1988-2004 involved a combination of a Foundation Grant and a Guaranteed Tax Base. The formula was as follows:

$$
\begin{aligned}
R &= f * cost\_diff + \max\{t - \bar{t}, 0\} * p \\
\text{where } t &= \text{ tax rate in district} \\
t - \bar{t} &\leq 0.0005 \\
\bar{t} &= \text{required tax rate (decided by the state)} \\
\bar{t} * p &\leq 0.9 * f \\
p &= \text{ per-pupil property value} \\
f &= \text{ foundation grant (\$3,223.06 in 1998-1999)} \\
cost\_diff &= \text{cost of living adjustment}
\end{aligned}
$$

Georgia

Georgia's school finance plan for the years 1987-2004 was introduced in 1985 as part of the Quality Basic Education program. It involves a Foundation grant and a Required Local Effort component. The formula is as follows:

$$
\begin{aligned}
R &= f + t1 * p + t2 * \max\{p90, p\} + t3 * p \\
&\quad \text{such that } t1 + t2 + t3 \leq 0.02 \\
\text{where } f &= \text{foundation grant base amount (\$2038.74 in 1998-99)} \\
t1 &= \text{compulsory local effort (5 mills)} \\
t2 &= \text{optional additional effort subject to equalization (max. 3.25 mills)} \\
t3 &= \text{optional additional effort in addition to 5 + 3.25 mills}
\end{aligned}
$$

Illinois

The school finance plan in place in 1986 had been implemented in 1980. The funding formula has three tiers: Foundation, Alternate Method and Flat Grant. Per pupil property wealth in each district determines which formula must be used to compute the funding. The state aid formula compares the district valuation to a guaranteed wealth per ADA. The guaranteed level varies by the type of school district: in 1999 it was equal to $188,478 for elementary districts, $361,250 for secondary districts, and $144,500 for unit districts. Districts qualifying under the Foundation formula have per pupil valuation less than 93% of the foundation level. Districts qualifying under the Alternate Method formula have per pupil valuation of at least 93% but less than 175% of the foundation level. Districts qualifying under the Flat Grant formula have per pupil valuation greater than 175% of the foundation level. The foundation level was $4,225 in 1999, the flat grant was \$218. The formula can be summarized as follows:

$$\begin{aligned}
R &= \text{Aid} + \tau * p * n \\
\text{Aid} &= \text{Foundation or AM or FG} \\
\text{Foundation} &= n(f - \text{Local Resources}) \\
\text{AM} &= nf[0.07 - ((\text{Local Percentage} - 0.93)/0.82)0.02] \\
\text{FG} &= n * 218 \\
\text{Local Resources} &= np_i\hat{\tau} + \text{CPPRT}/n \\
\text{Local Percentage} &= 100 \times \text{Local Resources}/f
\end{aligned}$$

where τ is the property tax rate, p is per pupil property valuation, n is the weighted count of pupils, f is the foundation level, $\hat{\tau}$ is equal to 2.3% for elementary districts, 1.2% for secondary districts and 3.0% for unit districts, and CPPRT denotes the Corporate Personal Property Replacement Taxes.

Kentucky

Kentucky changed its school finance plan in 1990, with the Kentucky Education Reform Act (KERA). The post-reform plan is a mix between a Foundation plan and a Power Equalization. The formula is as follows:

$$\begin{aligned}
R &= t * p + t2 * \max\{\bar{p}, p\} + \max\{f - t * p - t2 * \max\{\bar{p}, p\}, 0\} + t3 * p \\
\text{where } t &= \text{tax rate, compulsory effort and fixed at 0.003} \\
t2 * \max\{\bar{p}, p\} &\leq 0.15 * f \\
p &= \text{property valuation per pupil} \\
t2 &* \max\{\bar{p}, p\} \leq 0.3 * f \\
\bar{p} &= \text{level of guaranteed tax base, 1.5 * average state} \\
t2 &= \text{discretionary additional fiscal effort (tier 1, power equalization)} \\
t3 &= \text{discretionary additional fiscal effort (tier 2, no equalization)} \\
f &= \text{foundation base: \$2,839 in 1998-99}
\end{aligned}$$

Louisiana

Louisiana had a school finance reform in 1992; this reform introduced the Minimum Foundation Plan. The post-reform formula involves two tiers: a foundation plan and a required local effort plan. Tier 1 is as follows:

$$\begin{aligned} R_1 &= t * pi + (p/P * n * f/N * 0.65) \\ \text{where } t &= t = 0.005 \text{ (but can be bigger)} \\ \text{Local + State} &= f * n \\ \text{Local share} &= p/P * n * f/N * 0.35 \\ \text{State share} &= p/P * n * f/N * 0.65 \end{aligned}$$

and where f is the foundation amount, n is district enrollment, N is state enrollment, p is local revenue capacity (encompassing both property and sales tax base) per pupil, and P is the state revenue capacity per pupil.

Tier 2 funding is only awarded to districts with $p/P \leq 1.66$ and $t * p > p/P * n * f/N * 0.35$:

$$R_2 = t * p * (1 - 0.6 * p/P)$$

Total revenues are therefore $R = R_1 + R_2$.

Massachusetts

Massachusetts' school finance plan was implemented in 1994, with a reform that introduced the so-called Chapter 70 state aid. The formula involves a foundation plan with required local spending. The state establishes a foundation budget (F) as the sum of per pupil cost categories, which are a function of student enrollment in different grades and student categories (e.g. special education students), and a net school spending (NS), which is a function of the foundation amount in the previous year. If $NS \geq F$, districts receive the same aid as the previous year, plus a minimum \$100 increase per pupil. If $NS < F$, districts receive $F - NS + \$100$ per pupil. Districts and the state then share the burden of this required spending: specifically, districts are required to contribute a local share, which is a function of property values and income. The formula is therefore as follows:

$$R = \min NS, F + \$100$$

Michigan

The school finance plan in place in 1986 dates back to 1974. Under this finance scheme, district revenues came from local property taxes (constitutionally capped at 50 mills) and from state aid, distributed to districts using a Guaranteed Tax Base plan and a foundation allowance. The formula worked as follows:

$$\begin{aligned}
R &= \tau p + \max\{f + \tau(\bar{p} - p), 0\} \\
f &= \text{Foundation allowance (\$400)} \\
\tau &= \text{actual property tax rate} \\
p &= \text{value of property per pupil} \\
\bar{p} &= \text{guaranteed tax base (\$102,500)}
\end{aligned}$$

By 1993-94, however, only approximately 60 percent of districts were receiving any aid, and differences in per pupil expenditure spending between the highest- and lowest-spending districts had increased considerably. Further, school property tax rates were very close to the constitutional limit for most districts. For this reason, in 1993 governor John Engler signed P.A. 145. The Act reduced the share of operating revenue for public schools coming from local property taxes, and increased the importance of state aid.

The nature of the new funding scheme is a foundation plan. The state guarantees each district a basic level of funding per pupil, provided that the district levies a minimum local voter-approved property tax at a millage rate set by the Legislature (equal to 18 mills). Districts' foundation allowances each year have been based upon their foundation allowances of the immediately preceding year. In the first year of the reform (1994-95), the foundation allowance was set at $5,000; however, districts whose revenues were above and below this level the preceding year were assigned an allowance between $4,200 and $6,500, and gradually moved towards $5,000. The formula can be summarized as follows:

$$\begin{aligned}
R &= f + \tau p - \bar{\tau} p \\
f &= \text{Foundation allowance} \\
\tau &= \text{actual property tax rate} \\
\bar{\tau} &= 0.018 \\
p &= \text{non-homestead property per pupil}
\end{aligned}$$

Minnesota

The funding plan in place in Minnesota was implemented in 1988 and it is a simple foundation amount. The cost of the foundation is split between the state and the school districts based on the ratio between a district's adjusted net total capacity per pupil (ANTC, proxy for property tax base) and a guaranteed ANTC (GANTC) set by the state. Districts raise their share of the foundation through local property taxes. The formula is as follows:

$$\begin{aligned}
R &= \text{Basic Revenue (foundation amount - \$3,530 in 1998-99)} \\
\text{Local Share} &= \text{Basic Revenue} * \min\{1, ANTC/GANTC\} \\
\text{State Share} &= \text{Basic Revenue - Local Share}
\end{aligned}$$

Montana

Montana's school funding formula was introduced in 1993. It involves a foundation amount and a guaranteed tax base; the foundation amount must cover 80 percent of the total budget. The formula is as follows:

$$R = f + tp + t * \max\{1.74 * P/F - p, 0\} - t^F * p$$

where t is the tax rate chosen by the district, t^F is the state tax rate intended to finance the foundation aid (equal to 0.095), p is per pupil property value, f is the foundation amount, F is the sum of all foundation grants in the state, and P is the total property value in the state.

Nebraska

The school plan in Nebraska was implemented in 1990. The formula consists in a foundation plan with incentives for local effort. The formula is as follows:

$$R = \max\{f - LC, 0\} + t * p$$

where f is the foundation amount, p is the property value per pupil, t is the district's property tax rate, and LC is the local capacity, defined as the local tax revenue a district could raise at a "normal" tax rate.

New Jersey

In 1986 school finance in New Jersey followed the provisions of Chapter 212, as mandated by the *Public School Education Act* of 1975. State aid was distributed to districts under the form of an equalization grant. The formula is as follows:

$$R = \tau p + \max\{0.1\bar{S}, \max\{0, (1 - \frac{p}{1.35\bar{p}}) \min\{e, \bar{S}\}\}\}$$

where τ is the property tax rate chosen by the district, p is property value, $\bar{S}$ is the state aid limit, $\bar{p}$ is the average property value, and e is previous year's current expenditures.

Following a court declaration of unconstitutionality of the funding scheme resulting from the *Abbott* vs. *Burke* lawsuit started in 1981, in 1990 Governor Florio signed the *Quality Education Act* (QEA) into law. Among other provisions, the QEA substantially changed the financing formula, which became a foundation program. The local share had to be determined considering a district's property valuation and average income. The new formula, in place from 1992, is as follows:

$$R = \tau p + \max\{0, f - 0.5(Pp + Yy)\}$$

where f is the foundation amount ($6,640 in 1992); P and Y are, respectively, the property and the income multipliers, used to compute a district's fiscal capacity; p is property valuation and y is average income.

The formula introduced with the QEA was declared unconstitutional by the NJ Supreme Court in 1994 (*Abbott* vs. *Burke* III), because it did not equalize funding or guarantee needed supplemental programs. In 1996, Governor Whitman signs into law the *Comprehensive Education Improvement and Financing Act* (CEIFA). The act leaves the formula substantially unchanged, but it allocates \$246 million ("parity aid") to 28 designated poor urban districts, denominated "Abbott districts". The funding scheme designed with CEIFA was ruled unconstitutional already in 1997, but the formula remained unchanged through 2004.

New York

The school finance plan in place in New York from 1986 to 2004 consisted in a combination of state and local funds. The largest part of local revenues came from property taxes. State aid was distributed through a variety of programs. The largest of them were:

- Basic Operating Aid (BOA), proportional to a district's Approved Operating Expenses (AOE, including salaries of administrators, teachers and non- professionals, fringe benefits, utilities, and maintenance of school facilities), and inversely proportional to its wealth:

$$
\begin{aligned}
\text{BOA} &= \max\{\text{Formula Aid}, 400\} \\
\text{Formula Aid} &= \text{OAR} \times \text{Ceiling} \\
\text{OAR} &= \min\{\max\{0, [1.37 - (1.23 \times \text{CWR})], \\
&\quad [1.00 - (0.64 \times \text{CWR})], \\
&\quad [0.80 - (0.39 \times \text{CWR})], \\
&\quad [0.51 - (0.22 \times \text{CWR})]\}, 0.9\} \\
\text{CWR} &= 0.5[(p/\bar{p}) + (y/\bar{y}) \\
\text{Ceiling} &= 3,900 + [\min\{8,000, \text{AOE}/n\} - 3,900] \times [\max\{0.075, 0.075/\text{CWR}\}] \\
n &= \text{weighted pupil count (TAPU)} \\
p &= \text{property value per pupil} \\
\bar{p} &= \text{mean property value per pupil} \\
y &= \text{average gross income per pupil} \\
\bar{y} &= \text{mean average gross income value per pupil}
\end{aligned}
$$

- Extraordinary Needs Aid (ENA), which provides extra funds to districts with high concentration of at-risk pupils:

$$
\begin{aligned}
\text{ENA} &= (3,900 + \text{Ceiling}) \times \text{ENA Ratio} \times \text{ENC} \times 0.11 \times \text{Concentration Factor} \\
\text{ENA Ratio} &= (1 - (p/\bar{p}) \times 0.40) \\
\text{Concentration Factor} &= \max\{1 + [(\text{ENC}/\text{Enrollment}) - 0.745]/0.387, 1\} \\
\text{ENC} &= \text{Free \& Reduced Price Lunch Students} \\
&\quad +\text{Limited English Proficiency Students} \\
&\quad +\text{Sparsity Count} \\
\text{Sparsity Count} &= 25\text{–(Enrollment/Square Mile)}/58
\end{aligned}
$$

- Growth Aid, which supplements operating aid for districts experiencing enrollment growth:

$$\begin{aligned}\text{Growth Aid} &= (\text{Growth Index } - 1.004) \times \text{BOA} \\ \text{Growth Index} &= \text{Enrollment/Enrollment}_{-1}\end{aligned}$$

- Tax Effort Aid (TEffA), for districts with particularly low levels of property valuation per pupil:

$$\begin{aligned}\text{TEffA} &= 912.48 \times \text{Tax Effort Factor} \times n \\ \text{Tax Effort Factor} &= [\min\{(\text{Tax levy}/yn) \times 100, 7\} - 3]/4\end{aligned}$$

- Tax Equalization Adjustment (TEqA), for districts with exceptionally high tax rates:

$$\begin{aligned}\text{TEqA} &= (\text{Expense per pupil} - \text{Tax levy per pupil}) \times n \\ \text{Expense per pupil} &= \min\{8,000, \text{AOE}_{-1}/n_{-1} - \text{BOA}/n\}\end{aligned}$$

North Dakota

The school finance plan in place North Dakota between 1986 and 2004 consisted in an equalized foundation formula:

$$R = t * p + \max\{f + T + tr - 0.0032t * p\}$$

where t is the property tax rate (capped at 0.185 and with some restrictions on its increase from one year to the other), p is the property valuation per pupil, f is the foundation base ($2,032 per pupil in 1998-99), T is a tuition apportionment ($223 per child aged 6-17 living in the school district and not necessarily enrolled in public schools), and tr is transportation aid, determined on a per district basis.

Ohio

The school finance plan in place in Ohio in 1986 was implemented in 1982. The formula in place is based on a foundation plan with a required minimum local effort. The formula is as follows:

$$R = \tau p + \max\{nf(C) - \bar{\tau} p\} + e(\tau_1^e, \bar{p}_1, p) + gn$$

where R is total revenues, f is the per pupil foundation amount, C is the cost of doing business, n is the weighted count of pupils, $\bar{\tau}$ is the required local effort (or "charge-off mileage", 0.23 percent in 1998-99), p is local property valuation, and τ is the property tax rate chosen by the district. In order for the districts to receive state aid, τ must be at least 20 mills.

The lawsuit *DeRolph vs. Ohio*, started in 1991, has led to a series of court rulings (including in 1997 and 2002) which have found the funding scheme unconstitutional and have led to an overall increase in state aid (i.e. a gradual increase in f over time). The funding formula, however, has remained the same.

Pennsylvania

In the period 1986-2004, Pennsylvania did not have a school finance reform. Its funding formula involved a percentage-equalized foundation plan as follows:

$$R = t_1 p + t_2 y + f(0.6(1 - p/\bar{p}) + 0.4 * (1 - y/\bar{y})) * 1(0.6 * (1 - p/\bar{p}) + 0.4 * (1 - y/\bar{y}) \geq 0.4)$$

where t_1 is the property tax rate (capped at 25 mills), p is per pupil property valuation, t_2 is the income income tax rate, y is per pupil taxable income, $\bar{p}$ is a statewide average of per pupil property valuation, $\bar{y}$ is a statewide average of income, and f is the foundation base.

Texas

In 1986, school district revenues in Texas stemmed mainly from state aid and local revenues. State aid was provided through a Foundation Program. The foundation amount was calculated as the sum of a Basic per pupil Allotment, a supplemental Experienced Teacher Allotment (which provided extra funds to districts employing more experienced, and therefore more costly, teachers), an Education Improvement Allotment, and an Enrichment Equalization Allotment, which provided districts with a matching transfer based on district fiscal effort and wealth. Districts were required to cover a share of the total cost of the Foundation Program with local revenues, raising at least $0.33 for every $100 of property valuation (Stevens, 1989). The resulting revenues formula is the following:

$$R = \max\{nf(X) - \bar{\tau}_1 p\} + \tau p + e(\tau^e_{1i}, \bar{p}_1, p) + gn$$

where R is total revenues, f is the foundation amount, function of n (weighted count of pupils) and X (characteristics of the district, such as price index, small size, etc.), $\bar{\tau}_1$ is the mandatory share of local effort ($0.33 per $100), p is local property valuation, τ is the property tax rate chosen by the district, e is the Enrichment Equalization Allotment, which depends on the district's property valuation, the average property valuation in the state, and local effort as summarized by a reference tax rate τ^e_1, and g is a flat grant.

The formula changed in October 1989, when the Texas Supreme Court declared the state school finance system to be unconstitutional, as part of the *Edgewood* vs. *Kirby* lawsuit. The legislature responded with Senate Bill 1019, which modified the formula as follows. First, it modified some parameters of the original formula. Second, it eliminated the Equalization Allotment, substituting it with a Guaranteed Tax Yield, which provides a specified amount per weighted pupil per penny of tax effort ($\bar{p}_2$), for up to 36 cents above the local fund assignment tax rate ($\bar{\tau}_2$). The flat grant was eliminated. The resulting formula, implemented in 1991, is as follows:

$$R = \max\{nf(X) - \bar{\tau}_2 p\} + \tau p + \tau^e_2 \max\{\bar{p}_2 - p\}$$

Senate Bill 1019 was declared unconstitutional in 1992 (Picus and Hertert, 1993). In 1994, a new bill (Senate Bill 351) was enacted to design a new school finance scheme. The 1989 formula was preserved, but its parameters changed:

$$R = \max\{nf(X) - \bar{\tau}_3 p\} + \tau p + \tau^e_3 \max\{\bar{p}_3 - p\}$$

Utah

The funding plan in place in Utah between 1986 and 2004 was a foundation plan. The formula was as follows:

$$R = t * p + \max\{f - t_l * p\}$$

where t is a district's property tax rate, p are property values, f is the foundation amount, and t_l is a "required" local effort.

Wisconsin

Until 1996, Wisconsin used a two-tiered Guaranteed Tax Base (GTB) formula to allocate state aid to the districts. A third tier has been added in 1996. With this formula, the state shares part of the costs (such as operating expenses, capital outlays, and debt service) with the districts, by guaranteeing districts with a certain amount of local revenues per mill of tax levied. The formula can be summarized as follows:

$$\begin{aligned}
R &= T^1 + \max\{T^2 + T^3, 0\} + \tau p \\
T^1 &= (1 - p/\bar{p^1}) * \min\{C, \bar{C}^1\} \\
T^2 &= (1 - p/\bar{p^2}) * \min\{C - \bar{C}^1, \bar{C}^2\} \\
T^2 &= (1 - p/\bar{p^3}) * \max\{C - \bar{C}^2, 0\}
\end{aligned}$$

where R is per pupil revenue, τ is its local property tax rate, p is the district's per pupil equalized expenditure, and T^1, T^2, and T^3 are the three tiers of state aid. The variables p^1, p^2, p^3 represent per pupil guaranteed tax base in each tier, whereas $\bar{C}^1$ and $\bar{C}^2$ are the cost ceilings for the first two tiers of expenditure. In words, the state guarantees a certain level of tax revenue for different portions of the total shared costs. In addition, while a negative third-tier aid can decrease second-tier aid, a negative sum of second- and third-tier aid cannot decrease first-tier aid. In addition, districts are subject to a limit on the annual increase in their revenue per pupil derived from state aid and property taxes. In 1999, this increase could not exceed $208.88. A school district that exceeds its revenue limit is subject to a penalty, in the form of reduced state aid, in the amount of the excess revenue.

Table DI: Details on the elements of the funding formula

state	data starts	data ends	reform in	variables of the formula (kept constant in simulation)	parameters of the formula
California	1996	2004		property values, enrollment	property tax rate (1 percent); revenue limit
Colorado	1994	2004	1994	assessed property value (tax base for property tax); specific ownership tax revenue (tax on registered vehicles); enrollment	per-pupil revenue formula (function of cost-of-living and enrollment)
Florida	1988	2004		property values, property tax rates, enrollment	foundation amount, limits on property tax rate, "required" property tax rate, cost-of-living adjustment
Georgia	1987	2004	1985	property values, property tax rates, enrollment	foundation amount, upper bound on equalization mills, minimum tax rate to receive guaranteed tax base aid
Illinois	1987	2004		equalized property valuation, property tax rate, enrollment	foundation amount, flat grant amount, thresholds for property values to assign tiers
Kentucky	1991	2004	1990	property values, property tax rates, enrollment	foundation amount, thresholds between tiers
Louisiana	1993	2004	1992	local revenue capacity, district enrollment, tax rates	foundation amount, state revenue capacity, state enrollment
Massachusetts	1993	2004	1994	property values, income, enrollent	foundation amount, net spending, tax rates
Michigan	1990	2004	1993	non-homestead property values, enrollment, property tax rates	foundation amount, threshold tax base
Minnesota	1991	2004	1988	enrollment, property tax rates, adjusted net total capacity (measure of property tax base)	foundation amount (basic revenue), guaranteed adjusted net total capacity
Montana	1994	2004	1993	enrollment, property values, tax rates	foundation amount, tax rate to finance the foundation amount
Nebraska	1993	2004	1990	enrollment, property values, tax rates	foundation amount
New Jersey	1988	2004	1990	property values, enrollment, property tax rates, average district income	foundation amount, property and income multipliers
New York	1986	2004		enrollment, property values, income	maximum amount of Basic Operation Amount, threshold to Ceiling for Formula aid,
North Dakota	1986	2004		enrollment, property values, income, number of children aged 6-17 living in the district	foundation amount, transportation aid, tuition apportionment
Ohio	1986	2004		property values, property tax rates, enrollment	foundation amount, cost-of-doing-business, required local effort tax rate, lower bound for tax rate
Pennsylvania	1995	2004		property values, property tax rates, income, income tax rate, enrollment	foundation amount, cap on local property tax rate
Texas	1986	2004	1989, 1993	property values, property tax rates, enrollment	foundation amount, local fund assignment tax rate, parameters of guaranteed tax yield
Utah	1986	2004		property values, property tax rates, enrollment	foundation amount, required local effort
Wisconsin	1986	2004	1996	property values, property tax rates, enrollment	guaranteed tax base in each tier, ceilings of expenditure in each tier, revenue limit

Appendix E List of School Finance Reforms

State	Reform?	Pre-Reform Formula	Reform Year	Reform Name	Reform Type	Reform Formula
Alabama	Yes	Foundation w/equalization	1995	*Ace v. Hunt*, 624 So.2d 107 (Ala. 1993)	Court-ruled	Foundation w/equalization
Arizona	Yes	Foundation w/equalization + maximum spending	1998	*Roosevelt vs. Bishop*	Court-ruled	Foundation w/equalization + maximum spending + extra aid for minimum infrastructure
Arkansas	Yes		1983	*Dupree v. Alma School District No. 30* (Ark. 1983)	Court-ruled	
			1995	Equitable School Finance Plan (Acts 917, 916, and 1194)	Legislated	Foundation w/equalization
California		Foundation + flat grant				
Colorado	Yes	Guaranteed tax base	1994	Public School Finance Act of 1994	Legislated	Foundation
Connecticut	Yes	Guaranteed tax base	1989	Education Cost Sharing	Legislated	Foundation w/ equalization
Delaware		Guaranteed tax base				
Florida		Foundaton + guaranteed tax base				
Georgia		Foundation + required local effort + equalization	1985	Quality Basic Education (QBE)	Legislated	Foundation + required local effort + equalization
Idaho	Yes	Foundation + equalization	1994	Senate Bill 1560	Legislation	Foundation (allocation based on salaries) + equalization
Illinois		Hybrid: foundation, alternate, flat grant				
Indiana	Yes	Foundation	1993	*Lake Central v. State of Indiana*	Court-ruled	Guaranteed tax base
Iowa	Yes	Foundation + equalization	1991	Code of Iowa, Chapter 257	Legislated	Foundation + equalization
Kansas	Yes	Guaranteed tax base	1992	School District Finance and Quality Performance Act (SDFQPA, 1992)	Legislated	Foundation + recapture
Kentucky	Yes	Foundation with power equalization	1990	*Rose v. Council for Better Education*, 790 S.W.2d 186 (Ky. 1989), followed by Kentucky Education Reform Act (1990)	Court-ruled	Minimum foundation with power equalization

Louisiana	Yes	Foundation	1992	Legislature	Legislated	Foundation
Maine	Yes		1985	School Finance Act of 1985	Legislated	Foundation
			1995	School Finance Act of 1995	Legislated	Foundation (minimum change in how state aid is calculated)
Maryland	Yes	Foundation	1986	Action Plan for Education Excellence (APEX),	Legislated	Foundation with required local effort
Massachusetts	Yes	Foundation	1994	*Mc Duffy v. Secretary of the Executive Office of Education*, 1993; Chapter 70	Court-ruled	Foundation
Michigan	Yes	Foundation + Guaranteed Tax Base	1993	P.A. 145 2 of 1993	Legislated	Foundation
Minnesota	Yes	Foundation	1988	General Education Revenue Program	Legislated	Foundation
Mississippi	Yes	Foundation	1997	Mississippi Adequate Education Program	Legislated	Foundation with required local effort
Missouri	Yes	Foundation + Guaranteed Tax Base	1993	Committee for Educational Equality v. Missouri; Outstanding Schools Act (OSA)	Court-ruled	Foundation with required local effort
Montana	Yes	Foundation	1993	*Montana Rural Ed. Association v. Montana*; House Bill 667	Court-ruled	Foundation + Guaranteed Tax Base
Nebraska	Yes	Foundation	1990	Tax Equity and Educational Opportunities Support Act (LB1059)	Legislated	Foundation
			1997	LB 806 (minor changes)	Legislated	Foundation
Nevada		Foundation				
New Hampshire	Yes	Foundation	1985	Statute	Legislated	Flat grant + equalization
			1999	*Claremont v. Governor*	Court-ruled	Flat grant + equalization
New Jersey	Yes	Guaranteed tax base	1990	*Abbott v. Burke* 575 A.2d 359 (N.J. 1990)	Court-ruled	Foundation
			1996	"Comprehensive Educational Improvement and Financing Act of 1996	Legislated	Foundation
New Mexico		Foundation				
New York	Yes	Percentage equalization + flat grant	2003	*Campaign for Fiscal Equity, Inc. v. State*	Court-ruled	Percentage equalization + flat grant
			2006	*Campaign for Fiscal Equity, Inc. v. State*	Court-ruled	Percentage equalization + flat grant
North Carolina		Flat grant				

North Dakota		Equalized foundation				
Ohio		Foundation with local effort				
Oklahoma		Foundation + Guaranteed Tax Base				
Oregon	Yes	Foundation	1990	Measure 5; Chapter 780, Oregon Laws 1991	Legislated	Foundation (caps on local tax rates)
			1997	Measure 50	Legislated	Foundation (caps on local tax rates)
Pennsylvania		Foundation + percentage equalization				
Rhode Island	Yes	Foundation	1995	Legislation	Legislated	Flat grant
South Carolina	Yes	Foundation	1985	Education Improvement Act (EIA)	Legislated	Foundation + categorical (with required local effort)
South Dakota	Yes	Expenditure-driven formula	1995	Legislation	Legislated	Foundation
Tennessee	Yes	Foundation	1992	Education Improvement Act	Legislated	
Texas	Yes	Foundation	1989	Edgewood Independent School District v. Kirby	Court-ruled	Foundation
			1993	Senate Bill 7	Court-ruled	Foundation (tier 1) + Guaranteed Tax Yield (tier 2) + Recapture component
Utah		Foundation + required local effort				
Vermont	Yes	Percentage equalization	1987	Legislation	Legislated	Foundation
			1997	*Brigham v. State*, followed by Act 60	Court-ruled	Flat grant + guaranteed tax yield
Virginia		Foundation				
Washington	Yes	Foundation	1987	Legislation	Legislated	Foundation + Guaranteed Tax Yield
West Virginia		Foundation				
Wisconsin	Yes	Guaranteed tax base - 2 tiers	1996	Legislation	Legislated	Guaranteed tax base - 3 tiers
Wyoming	Yes	Foundation	1995	*Campbell County v. State*	Court-ruled	Foundation