

Technical Efficiency in Producing Educational Outcomes

A Stochastic Frontier Analysis Using the National Education Cost Model

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Summary

This report estimates how efficiently U.S. school districts convert resources into student outcomes, using a stochastic frontier production model built on the National Education Cost Model (NECM). The frontier describes the best outcomes attainable at a given level of spending relative to cost. Each district's distance from it is measured as a technical efficiency rate: the share of the district's current resources, relative to cost, that a fully efficient district would need to achieve the same outcomes.

Key findings:

- **The frontier exhibits diminishing returns.** A log specification of spending relative to cost fits well; the frontier coefficient is 0.69. A 10 percent increase in resources relative to cost raises frontier outcomes by about 0.066 SD of outcomes.
- **Most districts operate close together, with a long lower tail.** The median three-year technical efficiency rate is 0.86; nearly three-quarters of district-years fall between 0.80 and 0.90, while 3 percent fall below 0.70.
- **Four efficiency bands are defensible:** most efficient (≥ 0.90 , 11 percent), typical (0.80–0.90, 73 percent), less efficient (0.70–0.80, 13 percent) and least efficient (< 0.70 , 3 percent). The lower cut points coincide with natural breaks in the distribution.
- **Dispersion has grown.** The share of districts below 0.80 roughly doubled, from 11 percent in 2011 to 22 percent in 2024, while the share at or above 0.90 also rose after 2022.
- **Efficiency is concentrated by state.** Average efficiency is highest in Idaho, North Carolina, Utah, Florida, Georgia and South Dakota and lowest in Rhode Island, West Virginia, Connecticut and Wyoming.
- **Efficiency is not productivity.** The most efficient states are not the highest-performing ones. Florida, North Carolina, Georgia and Texas are efficient at producing below-average outcomes while spending 67–78 percent of predicted cost. Massachusetts, New Jersey and Connecticut rank among the least efficient states but among the most productive, with outcomes 0.10–0.25 SD above the national average. New Jersey spends about twice as much per pupil as Florida and its outcomes are 0.20 SD higher. Across states, efficiency is unrelated to outcome levels ($r = 0.00$) and strongly related to low spending relative to cost ($r = -0.70$).

- **Less efficient districts are high-cost, not underfunded relative to need, and carry somewhat more administration.** The least efficient districts spend the most (\$18,237 per pupil) but also face the highest costs (\$20,417). They have more administrators per pupil and devote less to instruction, but the administrative spending differences are small, at most about half a percentage point of current spending.
- **Within states, the frontier is steeper and the state pattern largely disappears.** With state fixed effects, the frontier coefficient rises to 0.91. State effects mirror the state ranking above ($r = 0.96$), and the share of variance in efficiency between states falls from 20 percent to 1 percent. Rankings are otherwise similar (rank correlation 0.88; no district moves between the top and bottom bands), and the growth in the lower tail since 2011 is just as large within states. Because the outcome index relies on imperfectly linked state assessments and spending is reported under differing state practices, much of the state-level variation is likely measurement error, which makes the within-state estimates the better guide to district efficiency.
- **Relative to their own state's averages, the least efficient districts are more heavily staffed across the board.** Under state fixed effects they are about 1 SD above their state average in total staff per pupil, and 0.6–0.7 SD above in teachers, aides, school administrators and central office support staff. Their instruction share is 0.86 SD below their state average. They are also smaller and higher-spending than their state peers, so part of the staffing difference follows scale.
- **The frontier model ranks districts almost identically to a simpler residual-based analysis** (rank correlation 0.997). Its value is an interpretable efficiency scale and a common metric over time, not a different ordering.

1. Data and sample

The analysis uses the NECM 2024 district panel, 2009–2024. For each district and year, the NECM provides the predicted per-pupil cost of achieving national-average outcomes (cost model 1, bd) given student needs and cost conditions, together with actual current spending per pupil and an outcome index measured in standard deviations relative to the national average. The outcome index includes only state reading and mathematics assessments in grades 6 through 8, as placed on a common, nationally normed scale by the Stanford Education Data Archive (SEDA). SEDA covers grades 3 through 8; grades 6 through 8 were selected because middle-grades results better capture the cumulative effects of state and local education systems. Early-grade scores in some states are particularly inflated, for a variety of reasons, and drop substantially by grade 8, so including them would favor states whose results look strong early but do not hold up. SEDA's purpose is to make state assessment results comparable across states. Many states have adopted common assessments, but across the sample the tests still differ and are reported on different scales, and it is not possible to fully equate these measures across states. Some of the difference between states in the index therefore reflects measurement rather than achievement.

In several states, the outcome index is identical for a given district for three or more consecutive years, indicating carried-forward or imputed values rather than measured outcomes. Eleven states in which this

applied to nearly all districts (AK, CO, DC, ME, ND, NH, NM, NY, OR, PA and WA) are excluded entirely, and individual districts with such runs are excluded elsewhere. The ratio of spending to cost was trimmed at the 0.1st and 99.9th percentiles. The analytic sample is 128,713 district-years for 8,088 districts in 38 states.

Staffing (NCES Common Core of Data) and finance (Census F-33) data for FY2018–2024 were linked by district and fiscal year to compare the staffing and spending profiles of districts in different efficiency bands.

2. Method

2.1 The frontier model

The production frontier relates each district's outcome gap (y) to the log of its spending relative to NECM predicted cost:

$$y_{it} = \alpha_t + \beta \cdot \ln(\text{spending}_{it} / \text{cost}_{it}) + v_{it} - u_{it}$$

where α_t are year effects, v is symmetric noise, $v \sim N(0, \sigma_v^2)$, and $u \geq 0$ is inefficiency, the shortfall of a district's outcomes from the frontier. The log form captures diminishing returns and was selected over linear, quadratic, cubic and spline alternatives in earlier work; adding squared or cubic log terms, or a six-segment linear spline, here changes the frontier and state efficiency very little (Section 3.3 and Appendix Table A5). The model was estimated by enrollment-weighted pseudo-maximum likelihood with exponential and half-normal distributions for u (Table 1). The exponential specification fits better and is used throughout; the two produce identical rankings.

Stochastic frontier estimation requires residuals from a conventional regression to be negatively skewed. They are (skewness ≈ -0.1 to -0.2 in most years), but modestly so. As a result, noise is large relative to inefficiency ($\sigma_v = 0.24$ versus mean inefficiency of 0.12 SD), and the frontier runs through the upper part of the district distribution rather than enveloping it.

Table 1. Stochastic frontier estimates

Frontier	Inefficiency (u)	β $\ln(\text{spend}/\text{cost})$	$\beta \ln^2$	σ_v	$E[u]$	–Pseudo-LL
Log	Exponential (preferred)	0.691	—	0.239	0.119	12,511
Log	Half-normal	0.691	—	0.227	0.186	12,621
Log + $\log^2$	Exponential	0.695	0.026	0.240	0.119	12,486
Log + $\log^2$	Half-normal	0.694	0.026	0.228	0.185	12,597

All models include year fixed effects; $N = 128,713$ district-years; enrollment-weighted pseudo-likelihood (weights normalized to mean 1). $E[u]$ is mean inefficiency in SD units of the outcome index. Standard errors are not reported here: with enrollment weighting, conventional likelihood-based errors are not valid. District-clustered robust standard errors for the preferred specification are reported in Table 7 ($\beta = 0.691$, SE 0.015).

2.2 Measuring technical efficiency

Because outcomes are measured in standard-deviation units, which can be negative, the conventional output-oriented measure $\exp(-u)$ is not meaningful here. Instead, efficiency is expressed in input terms.

Given the log frontier, a district with inefficiency u could achieve its current outcome with resources reduced by a factor of $\exp(-u/\beta)$. Technical efficiency (TE) is therefore:

$$TE_{it} = E[\exp(-u_{it} / \beta) \mid \varepsilon_{it}]$$

estimated for each district-year from its composed residual (a Battese–Coelli-type conditional expectation). A TE of 0.85 means that a frontier-efficient district would need 85 percent of the district's current resources, relative to cost, to achieve the same outcomes. As in the companion residual analysis, TE is averaged over a trailing three-year window ($t-2$ to t), requiring all three years, so annual results begin in 2011.

2.3 Cut points

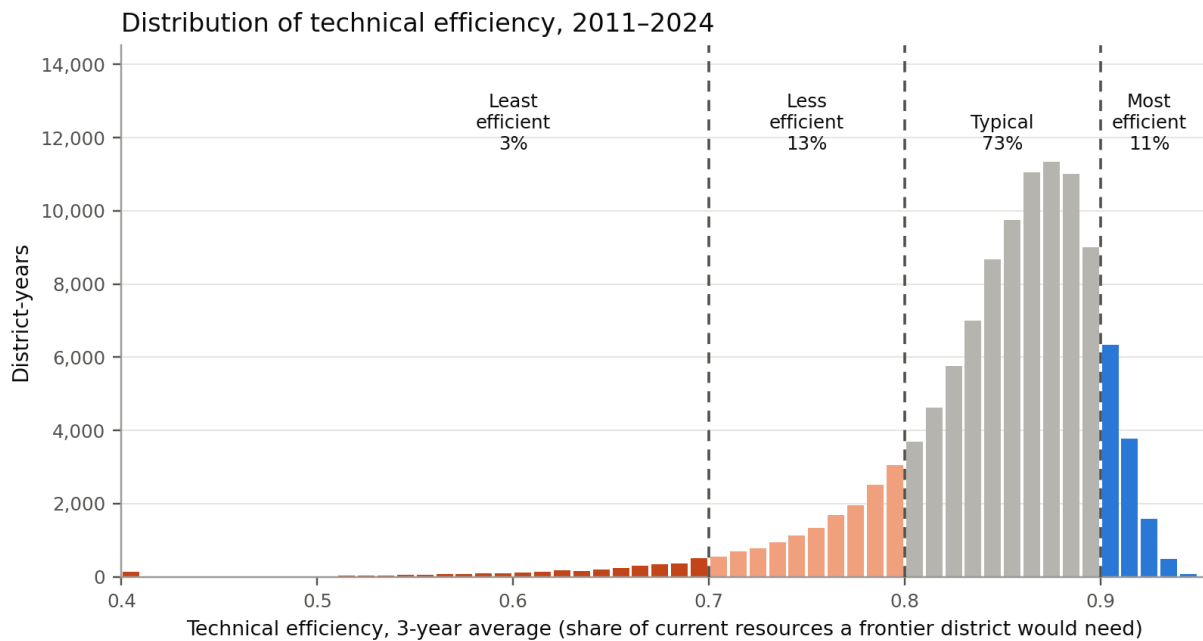
Three-year TE is concentrated between 0.80 and 0.93, with a long lower tail (Figure 1). Almost no district exceeds 0.93: with noise this large relative to inefficiency, the model shrinks estimates toward the mean and does not place any district exactly on the frontier. Cut points were chosen to be interpretable round numbers supported by the distribution (Table 2). The 0.80 and 0.70 cuts sit at natural breaks identified by one-dimensional k-means clustering. The 0.90 cut marks the top decile and corresponds to the +1 SD threshold in the residual analysis, which aids comparison.

Table 2. Technical efficiency bands

Band	3-year TE	Share of district-years	Basis for cut point
Most efficient	≥ 0.90	10.9%	Top decile; corresponds to +1 SD in the residual analysis
Typical	0.80 – 0.90	73.0%	Central mass of the distribution
Less efficient	0.70 – 0.80	13.0%	1-D k-means break at 0.798; ≈ -1 SD in the residual analysis
Least efficient	< 0.70	3.0%	1-D k-means break at 0.682

Shares are of district-years with three-year TE, 2011–2024 (N = 112,215).

Figure 1. Distribution of three-year technical efficiency, 2011–2024



Stochastic frontier, exponential inefficiency, log(spending ÷ NECM cost) frontier with year effects. Dashed lines = cut points; values below 0.40 shown at 0.40. Values below 0.40 are shown at 0.40.

2.4 Efficiency versus productivity

Technical efficiency is not the same thing as productivity, and the two can diverge sharply. In this report, productivity refers to the level of outcomes a district or state achieves. Efficiency refers to how close those outcomes come to the best achievable with the resources, relative to cost, that the district actually has. Efficiency is a relative concept: it rewards doing as well as possible with the resources at hand, regardless of how large or small those resources are.

Two implications follow. First, it is possible to be highly efficient at producing low outcomes. A district that spends far below its cost target, and whose outcomes are close to what the frontier predicts for that low level of resources, is efficient even if its outcomes are well below the national average. Second, it is possible to be highly productive without being particularly efficient. A district that spends well above its cost target and achieves above-average outcomes may still fall short of what the frontier predicts at that level of resources, and so register as inefficient. Because the frontier rises with resources, the second district can produce substantially better outcomes than the first.

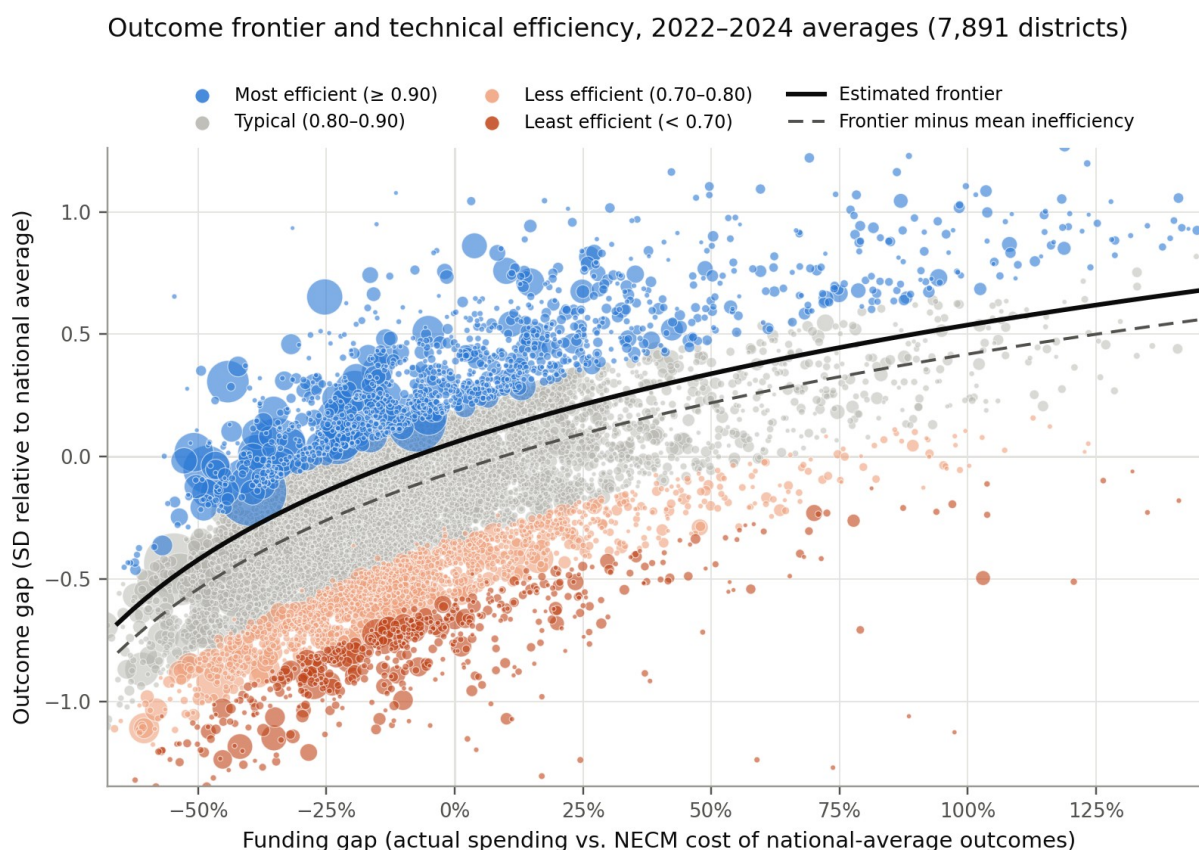
Efficiency and productivity therefore answer different questions. Efficiency asks whether a district makes good use of the resources it has; productivity asks what those resources, used as they are, produce for students. A finding that a district or state is efficient says nothing about whether its outcomes are adequate. A finding that it is inefficient does not imply that its outcomes could be sustained with less money: a less efficient district that spends more may still produce much better outcomes than an efficient district that spends little. Section 3.3 compares the two across states.

3. Results

3.1 The frontier and the distribution of efficiency

Figure 2 shows district outcome gaps against funding gaps for 2022–2024, with the estimated frontier and each district colored by its efficiency band. The frontier rises steeply among districts well below their cost targets and flattens among districts well above them. Most efficient districts appear at every level of funding, including many that are substantially underfunded relative to cost. Least efficient districts are concentrated among those near or somewhat below their cost targets, where outcomes fall well short of what similar resources yield elsewhere.

Figure 2. Outcome frontier and technical efficiency, 2022–2024 averages



Bubble area proportional to enrollment. Frontier: outcome gap = $0.06 + 0.69 \times \ln(\text{spending} \div \text{predicted cost})$, 2022–24 year effects averaged. Colors = 3-yr average technical efficiency as of 2024. Axes trimmed to show 99% of districts.

7,891 districts with data in all three years. Colors reflect three-year average TE as of 2024. Points above the frontier reflect positive noise (v), not efficiency above 1.

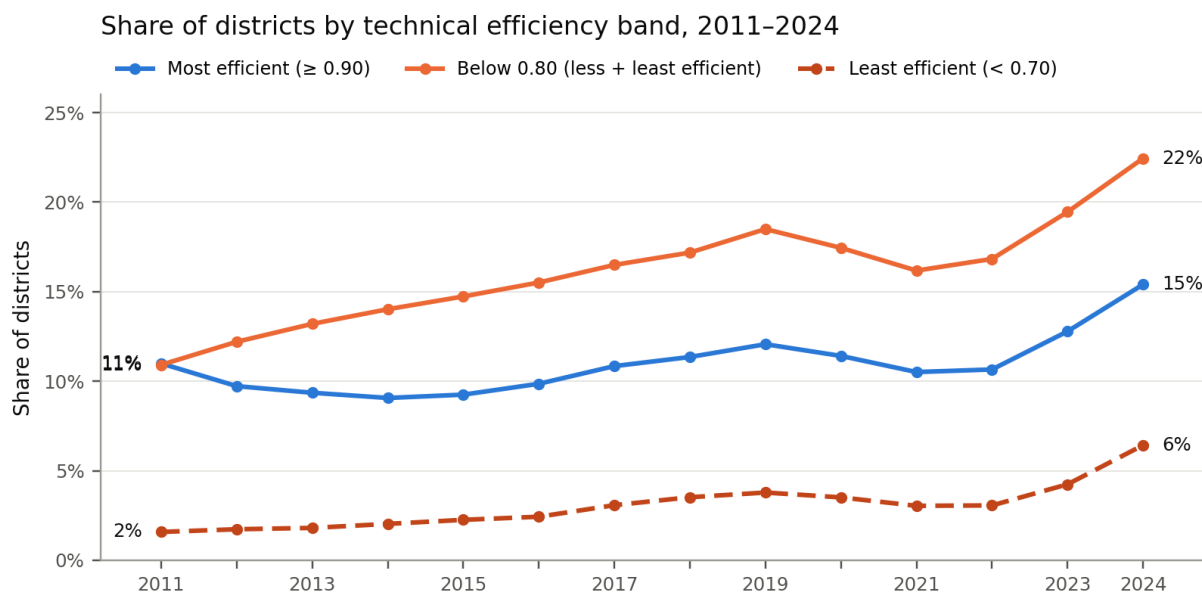
3.2 Change over time

Because TE is measured on a common scale across years, rather than standardized within each year, it can show changes in the spread of efficiency over time (Figure 3). Average enrollment-weighted TE changed little (0.86 in 2011; 0.85 in 2024). The tails, however, grew. The share of districts below 0.80 rose from 11 percent in 2011 to 18.5 percent in 2019, eased slightly during 2020–2022, then climbed to 22 percent by

2024. The share below 0.70 quadrupled, from under 2 percent to more than 6 percent. At the same time, the share at or above 0.90 rose from about 9–11 percent before 2022 to 15 percent in 2024.

The pattern after 2022 is consistent with the widely documented post-pandemic divergence in student outcomes. It may also reflect changes in assessments and reporting during that period. Either way, districts with similar resources relative to cost are further apart in outcomes than they were a decade ago.

Figure 3. Share of districts by efficiency band, 2011–2024



3-year trailing average technical efficiency; restricted sample (38 states).

Three-year trailing averages; 2024 values reflect 2022–2024.

3.3 Efficiency by state

As in the residual analysis, efficiency is strongly concentrated by state (Table 3; full results in Appendix Table A1). Idaho and Utah have the largest shares of most efficient districts (28 and 33 percent), with very few below 0.80. At the other end, nearly three-quarters of West Virginia’s district-years fall below 0.80, as do nearly half in Rhode Island and Connecticut. California and New Jersey combine sizable shares in both tails, indicating wide variation among districts within those states.

Table 3. States with the highest and lowest average technical efficiency, 2011–2024

Highest average efficiency	Mean TE	% ≥ 0.90	% < 0.80		Lowest average efficiency	Mean TE	% ≥ 0.90	% < 0.80
Idaho	0.887	27.6	4.7		Rhode Island	0.753	4.8	48.4
North Carolina	0.884	13.2	3.9		West Virginia	0.761	0.0	73.7
Utah	0.883	33.5	2.2		Connecticut	0.767	2.0	46.1
Florida	0.882	11.6	3.6		Wyoming	0.792	1.4	39.1
Georgia	0.880	12.1	4.7		New Jersey	0.802	11.6	29.0
South Dakota	0.876	17.6	3.4		California	0.829	16.7	28.3

Mean TE is enrollment-weighted; percentages are shares of district-years. Delaware (13 districts; mean TE 0.829) is omitted from this table because of small numbers; see Appendix Table A1.

State concentration of this kind should temper interpretation. A sizable portion of the differences between states, on both sides of the frontier, may be measurement error rather than efficiency. On the outcome side, the index relies on SEDA's linking of state grade 6–8 reading and mathematics assessments to a common scale, which, even with many states using common assessments, cannot fully equate tests that differ across states and are reported on different scales. On the resource side, spending as reported to the Census varies across states in accounting practice (for example, in how state-paid employee benefits and payments to other agencies are recorded), and the NECM cost estimate is itself built from the same outcome measure and may not capture all state cost conditions. Errors of this kind are shared by all districts in a state, so they show up as state-level differences in estimated efficiency. Section 3.5 separates these state effects from district efficiency by estimating the frontier with state fixed effects.

Efficiency and productivity across states. The states that rank highest on efficiency are not the states with the highest outcomes (Table 4 and Figure 4; all states in Appendix Table A4). Across the 38 states, mean efficiency is essentially unrelated to mean outcomes ($r = 0.00$) and strongly negatively related to spending relative to cost ($r = -0.70$). Mean outcomes, in contrast, rise with spending ($r = 0.42$). Much of the state efficiency ranking is therefore a ranking of how little states spend relative to cost.

Florida, North Carolina, Georgia and Texas rank among the most efficient states. They spend 67 to 78 percent of the NECM's predicted cost, and their outcomes are 0.05 to 0.15 SD below the national average. They sit on or near the frontier, but at a low level of resources where the frontier itself is low: they are efficient at producing relatively low outcomes. Mississippi is the extreme case. It spends 58 percent of predicted cost, has among the lowest outcomes in the sample (-0.26 SD, 37th of 38), and ranks 7th in efficiency.

Massachusetts, New Jersey and Connecticut are the reverse. They spend 50 to 70 percent above predicted cost and rank among the most productive states: Massachusetts has the highest outcomes in the sample ($+0.25$ SD), New Jersey ranks 4th ($+0.15$) and Connecticut 7th ($+0.10$). Yet they rank 28th, 34th and 36th in efficiency. New Jersey spends about twice as much per pupil as Florida (\$19,124 against \$9,636), and its outcomes are 0.20 SD higher. Against a single national frontier, a fully efficient system at New Jersey's

resource level would outperform one at Florida's by 0.49 SD, which would mean New Jersey realizes about 40 percent of the gain its additional resources could produce. That calculation assumes the two states share one frontier, which the functional-form and state fixed effects results below call into question. The productivity comparison does not depend on it: New Jersey spends about twice as much and its outcomes are substantially higher. Spending matters, even where returns are diminishing and even when it is not used as efficiently as possible.

Utah and Idaho come closest to combining the two: very low spending relative to cost (0.82 to 0.83), roughly average outcomes and the highest efficiency ratings. Rhode Island and West Virginia illustrate the weakest combination, with high spending relative to cost (1.42 and 1.16) and below-average outcomes.

Two cautions apply. Cross-state comparisons of outcome levels are exactly the comparisons most exposed to measurement error in the SEDA-linked outcome index, and cross-state comparisons of spending relative to cost are exposed to differences in financial reporting and to cost conditions the NECM may not capture. The same distinction between efficiency and productivity applies among districts within states, where those measurement problems are smaller: a district can rank high on efficiency because it spends little, not because it produces high outcomes.

Is the gap a matter of functional form? Because New Jersey, Connecticut and Massachusetts sit at the high end of spending relative to cost, where the frontier is least densely supported, one possibility is that returns diminish faster than the log form allows, so that the frontier overstates what their resources could buy and understates their efficiency. The evidence points the other way. Across 20 equal-sized bins of spending relative to cost, mean residuals from the log frontier range only from -0.04 to $+0.02$ SD, including the two highest bins, which are 49 and 73 percent New Jersey, Connecticut and Massachusetts district-years. Quadratic, cubic and six-segment spline frontiers trace nearly the same curve and, if anything, bend slightly upward at high spending; state efficiency hardly changes (New Jersey 0.80 to 0.81, Florida 0.87 to 0.88; Appendix Table A5). Within states, the relationship between outcomes and spending relative to cost is steeper, not flatter, in the high-spending states: about 1.2 in New Jersey, Connecticut and Massachusetts, compared with 0.44 in Florida and 0.70 in Texas. Across 35 states, state slopes rise with states' average spending relative to cost (0.38 per log unit, SE 0.12).

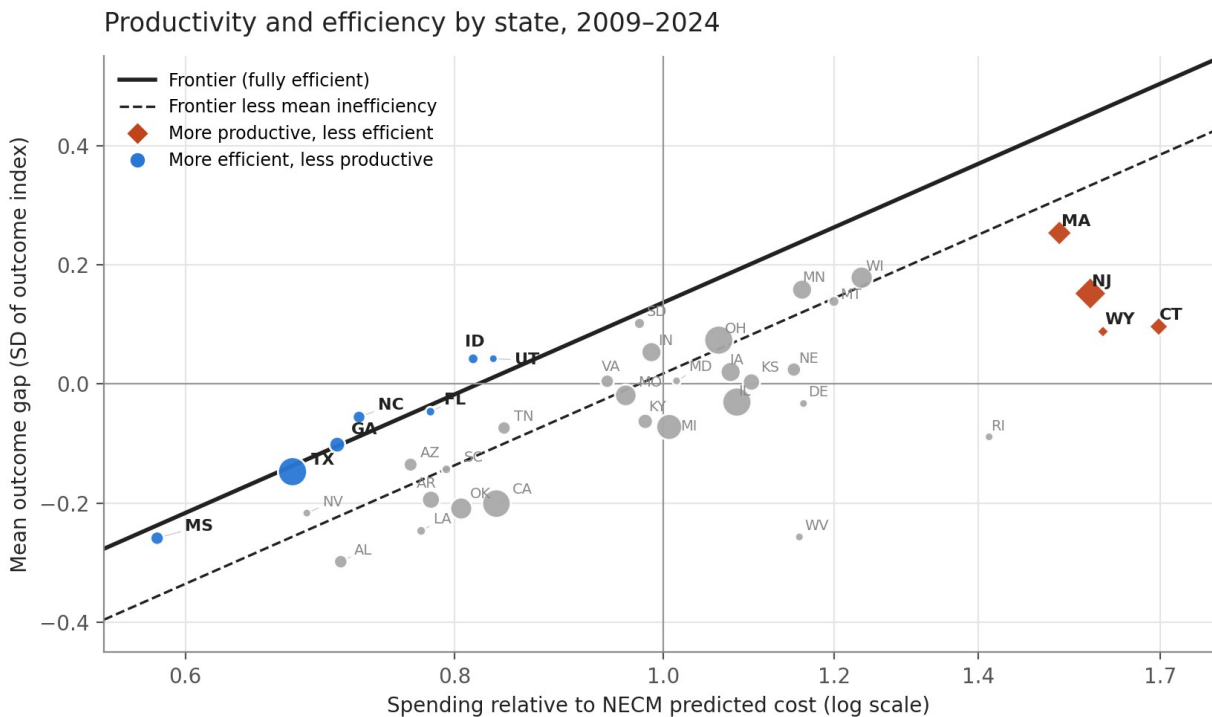
New Jersey's low efficiency is therefore not a product of the frontier's curvature. Its districts sit about 0.3 SD below the pooled frontier across their whole range of spending, a shift in level rather than slope. That is exactly the kind of difference that state fixed effects absorb (Section 3.5), and once they do, New Jersey's mean efficiency (0.905) is essentially the same as Florida's (0.917). Whether New Jersey and Florida belong on a common frontier at all depends on how much of that level difference reflects cross-state measurement error in the outcome index and in spending relative to cost.

Table 4. Productivity and efficiency in selected states, 2009–2024

State	Mean outcome gap (SD)	Outcome rank	Per-pupil spending	NECM predicted cost	Spending ÷ cost	Mean TE	TE rank
More productive, less efficient							
Massachusetts	+0.25	1	\$16,862	\$11,890	1.53	0.838	28
New Jersey	+0.15	4	\$19,124	\$13,159	1.58	0.802	34
Connecticut	+0.10	7	\$18,241	\$11,690	1.70	0.767	36
Wyoming	+0.09	8	\$16,639	\$10,648	1.60	0.792	35
More efficient, less productive							
Florida	−0.05	21	\$9,636	\$12,581	0.78	0.882	4
North Carolina	−0.06	22	\$9,636	\$13,671	0.72	0.884	2
Georgia	−0.10	27	\$10,886	\$16,121	0.71	0.880	5
Texas	−0.15	30	\$9,657	\$15,120	0.67	0.874	8
Mississippi	−0.26	37	\$9,148	\$16,750	0.58	0.875	7
Efficient at roughly average outcomes and low spending							
Utah	+0.04	11	\$7,667	\$9,306	0.83	0.883	3
Idaho	+0.04	12	\$7,868	\$9,671	0.82	0.887	1

Mean outcome gap, spending, cost and spending ÷ cost are enrollment-weighted means over 2009–2024 (restricted sample). Mean TE is the enrollment-weighted three-year TE from the baseline model, 2011–2024. Ranks are among 38 states. Spending ÷ cost is the enrollment-weighted geometric mean of district ratios.

Figure 4. Productivity and efficiency by state, 2009–2024



Enrollment-weighted state means. Frontier: baseline model at the average year effect. Marker size reflects number of districts.

States near the solid line are efficient; states higher on the vertical axis are more productive. The dashed line is the frontier shifted down by mean inefficiency (0.119 SD).

3.4 Staffing and spending profiles

Table 5 compares districts across the four efficiency bands for FY2018–2024. Three patterns stand out.

First, less efficient districts are higher-cost, not underfunded relative to need. Per-pupil spending rises from \$11,858 among the most efficient districts to \$18,237 among the least efficient, but predicted cost rises in parallel, from \$13,676 to \$20,417. Median funding gaps are similar across bands (between +2 and –8 percent). The least efficient districts are not districts with more money than they need; they are districts in higher-need, higher-cost settings whose outcomes fall short of the frontier.

Second, administrative staffing and spending rise steadily as efficiency falls. School administrators per 100 pupils rise from 0.35 to 0.43, LEA administrators from 0.12 to 0.19, and the share of spending on general administration from 1.46 to 2.03 percent. The share on instruction falls from 62.1 to 57.5 percent. These patterns hold within most states (Table 6).

Third, the differences are small in budget terms. The general administration gap between the most and least efficient bands is about 0.6 percentage points of current spending, roughly \$100 per pupil in the least efficient districts. By the frontier estimate, that sum would be associated with an outcome difference of well under 0.01 SD, against a gap of more than a full standard deviation in outcomes between the two bands. School administration shares show no consistent gradient. Teacher staffing is also slightly higher in

less efficient districts, which suggests these districts are more heavily staffed across the board, consistent with higher-need student populations, rather than shifting resources from classrooms to administration.

Table 5. Profile of districts by technical efficiency band, FY2018–2024 (enrollment-weighted)

	Most efficient (≥ 0.90)	Typical (0.80– 0.90)	Less efficient (0.70–0.80)	Least efficient (< 0.70)	All
District-years	6,730	39,038	8,034	2,203	56,005
Mean technical efficiency	0.913	0.863	0.760	0.637	0.852
Per-pupil current spending	\$11,858	\$12,712	\$15,956	\$18,237	\$13,145
NECM predicted cost	\$13,676	\$15,785	\$18,642	\$20,417	\$15,932
Median funding gap	+2%	–8%	–6%	–4%	–7%
Outcome gap (SD)	+0.32	–0.13	–0.50	–0.75	–0.12
School administrators per 100 pupils	0.35	0.39	0.42	0.43	0.39
LEA administrators per 100 pupils	0.12	0.15	0.17	0.19	0.15
Classroom teachers per 100 pupils	6.13	6.40	6.41	6.61	6.36
% of current spending: instruction	62.1	60.1	58.4	57.5	60.2
% of current spending: general administration	1.46	1.83	1.94	2.03	1.79
% of current spending: school administration	5.65	5.69	5.74	5.42	5.68

Staffing: CCD FTE per 100 pupils (zero counts treated as missing). Spending shares: F-33, as a percentage of current elementary-secondary spending. Funding gap = spending ÷ NECM predicted cost – 1.

Table 6. Within-state consistency of differences (26 states with ≥ 20 district-years in both groups)

Measure	States where most efficient < least efficient (≥ 0.90 vs. < 0.80)
School administrators per 100 pupils	26 of 26
LEA administrators per 100 pupils	20 of 26
Classroom teachers per 100 pupils	23 of 26
% of spending on general administration	17 of 26
% of spending on school administration	12 of 26
% of spending on instruction (most efficient higher)	25 of 26

Compares the most efficient band (≥ 0.90) with districts below 0.80, within each state.

3.5 A state fixed effects frontier

The concentration of efficiency by state raises the question of how much of the baseline model’s inefficiency is really a difference between states. To separate the two, the frontier was re-estimated with a full set of state intercepts alongside the year effects (a “true fixed effects” frontier in the sense of Greene, 2005). Each state then has its own frontier height, and a district’s inefficiency is its shortfall from its own state’s frontier. Everything else is unchanged: the same sample, exponential inefficiency, enrollment-weighted pseudo-likelihood, and TE defined as $E[\exp(-u/\beta) \mid \varepsilon]$ averaged over three years. District-clustered robust standard errors are now reported for both models (Table 7).

Table 7. Stochastic frontier estimates with and without state fixed effects

	Baseline (year effects)	State fixed effects
$\beta \ln(\text{spend}/\text{cost})$	0.691 (0.015)	0.906 (0.017)
Frontier gain from +10% resources (SD)	0.066	0.086
σ_v	0.239	0.221
$E[u]$	0.119	0.089
–Pseudo-LL, frontier	12,511	–1,750
–Pseudo-LL, OLS (normal errors)	12,856	–1,599
Skewness of OLS residuals (weighted)	–0.13	+0.04
Median three-year TE	0.859	0.914
Enrollment-weighted mean three-year TE	0.854	0.911
Share of variance in three-year TE between states	19.5%	1.1%

Both models: exponential inefficiency, year fixed effects, $N = 128,713$ district-years, enrollment-weighted pseudo-likelihood (weights normalized to mean 1). Standard errors in parentheses are robust and clustered by district. Variance share is the R^2 from an enrollment-weighted regression of three-year TE on state indicators ($N = 112,215$).

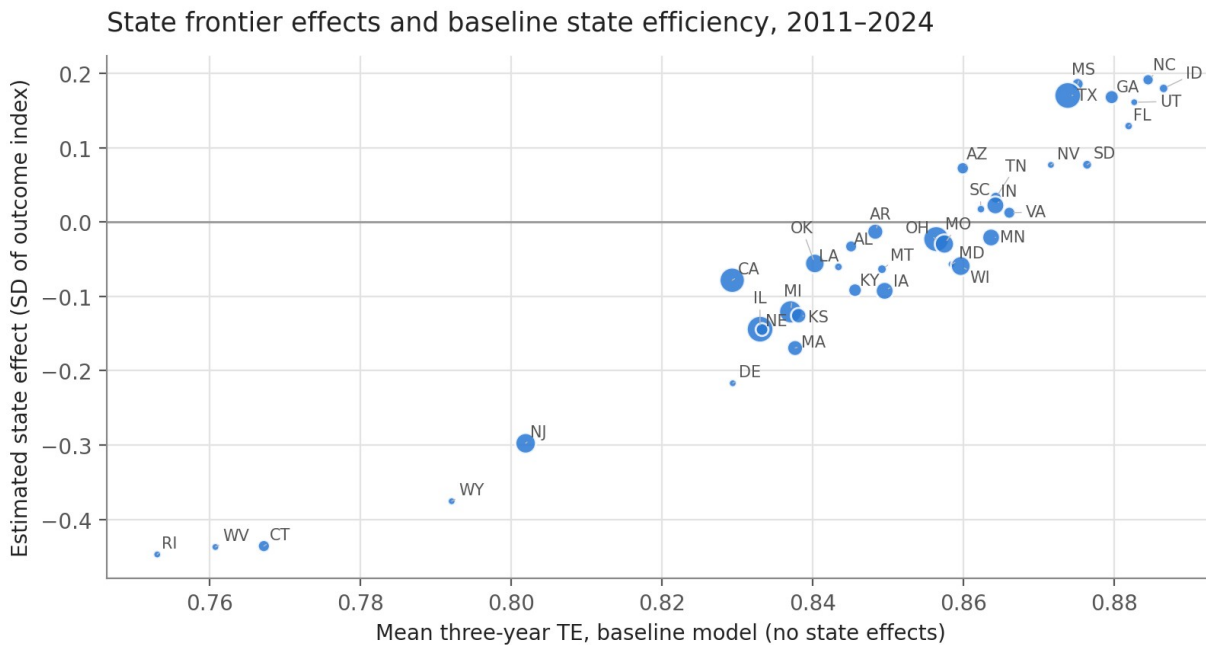
The frontier is steeper within states. The coefficient on log spending relative to cost rises from 0.69 to 0.91. A 10 percent increase in resources relative to cost is associated with a 0.086 SD higher frontier outcome, compared with 0.066 SD in the pooled model. This is the pattern expected if a substantial part of the between-state variation in both measures is measurement error. Error in the spending-to-cost ratio that is common to a state biases the pooled coefficient toward zero, and state-level error in the outcome index adds noise that is unrelated to resources. Within a state, districts share the same assessments and the same financial reporting rules, so those errors largely cancel.

Estimated inefficiency is smaller and less well identified. Mean inefficiency falls from 0.119 to 0.089 SD, and noise from 0.239 to 0.221. Within states, the OLS residuals are no longer negatively skewed overall (weighted skewness +0.04). The frontier model instead identifies inefficiency from a lower tail that is longer than the upper tail: the 1st percentile of standardized residuals is –2.94, against +2.77 for the 99th. The frontier still fits materially better than OLS (the pseudo-log-likelihood improves by 151, against 345 in the baseline), but district TE estimates in this model lean more heavily on the exponential distributional assumption.

State effects absorb almost all of the state ranking. Estimated state intercepts range from +0.19 SD (North Carolina) to –0.45 SD (Rhode Island) relative to the enrollment-weighted mean. They track the baseline state averages of Table 3 almost exactly ($r = 0.96$; Figure 5). States account for 19.5 percent of the variance in baseline three-year TE and 1.1 percent under state effects. The model cannot say whether a state intercept reflects measurement error in the outcome index, measurement error in spending or cost, or genuine state-level efficiency (governance, policy or management practice common to a state’s districts). It treats all three as something other than district inefficiency, the opposite extreme from the baseline model, which treats all three as district inefficiency. Given the known limits of cross-state comparisons of state

assessment results and of reported spending, a sizable portion of the state intercepts is likely measurement error. For comparing districts, the state fixed effects estimates are therefore the more defensible of the two.

Figure 5. State frontier effects and baseline state efficiency, 2011–2024



State effects from the state fixed effects frontier, centered on the enrollment-weighted mean. Marker size reflects number of districts. $r = 0.96$.

State intercepts from the state fixed effects frontier, centered on the enrollment-weighted mean across states.

Efficiency levels are higher, so bands are defined by share. Because β is larger and inefficiency smaller, TE levels rise: median three-year TE is 0.914 compared with 0.859, and 69 percent of district-years exceed 0.90. The fixed cut points of Table 2 therefore do not carry over. For comparison, bands under the state fixed effects model are defined to hold the same shares as the baseline bands (10.9, 73.0, 13.0 and 3.0 percent), which places the cut points at 0.939, 0.880 and 0.816.

Rankings change at the margins, not at the extremes. The rank correlation between the two models' three-year TE is 0.88, and 83 percent of district-years fall in the same band (Table 8). No district-year moves between the most and least efficient bands. Movement is concentrated in states with large state effects. The share of district-years below the typical band falls from 74 to 9 percent in West Virginia, from 48 to 7 percent in Rhode Island and from 46 to 15 percent in Connecticut. It rises from 13 to 33 percent in Texas, from 4 to 19 percent in North Carolina and from 5 to 21 percent in Georgia. These are states whose districts sit high on a common frontier but vary widely around their own (Appendix Table A3).

Table 8. Band assignments with and without state fixed effects (percent of baseline band)

Baseline band	State FE band			
	Most	Typical	Less	Least
Most efficient (≥ 0.90)	72.5	27.5	0.0	0.0
Typical (0.80–0.90)	4.1	89.5	6.3	0.0
Less efficient (0.70–0.80)	0.0	34.4	57.2	8.4
Least efficient (< 0.70)	0.0	4.9	32.1	63.0

Rows sum to 100. District-years with three-year TE, 2011–2024 ($N = 112,215$). State fixed effects bands hold the same shares as the baseline bands.

Growing dispersion is a within-state phenomenon. Under state effects, the share of district-years in the two lower bands rises from 11.5 percent in 2011 to 22.3 percent in 2024, almost exactly the baseline pattern (10.9 to 22.4 percent). The widening gap in outcomes among districts with similar resources relative to cost is therefore not a shift between states. It occurs among districts in the same state, taking the same assessments and reporting spending under the same rules, so it is unlikely to be an artifact of cross-state measurement differences.

3.6 Staffing and budget allocation relative to state averages

The profiles in Table 5 compare districts nationally. Because efficiency is concentrated by state, those comparisons mix differences between districts with differences between states. In the baseline model, the least efficient districts are disproportionately in New Jersey, Connecticut, Rhode Island, California and Illinois, whose staffing and spending patterns differ from the national average for reasons unrelated to district efficiency. This section repeats the comparison in two ways: as enrollment-weighted averages by band (Table 9), and as standard deviations around enrollment-weighted state averages (Table 10 and Figure 6).

For the second, each measure x for district i in state s and fiscal year t is expressed as $z = (x - \mu_{st}) / \sigma_{st}$, where μ_{st} and σ_{st} are the enrollment-weighted mean and standard deviation of x across linked districts in that state and year. Measures are winsorized at the 1st and 99th percentiles before standardizing, and each state-year has at least five districts. Band averages of z are enrollment-weighted, so +0.5 means that the band's pupils attend districts half a standard deviation above their own state's average for that year. The typical band sits near zero by construction. Both sets of comparisons are shown for the state fixed effects bands; Table 10 also shows the baseline bands, so the two sources of state adjustment can be separated.

Table 9. Profile of districts by technical efficiency band, state fixed effects model, FY2018–2024 (enrollment-weighted averages)

	Most efficient	Typical	Less efficient	Least efficient	All
District-years	6,960	38,987	7,928	2,130	56,005
Mean three-year TE	0.946	0.916	0.858	0.772	0.909
Per-pupil current spending	\$12,682	\$12,782	\$15,147	\$16,701	\$13,145
NECM predicted cost	\$13,641	\$15,934	\$17,712	\$18,664	\$15,932
Median funding gap	+1%	–8%	–7%	–5%	–7%
Outcome gap (SD)	+0.38	–0.12	–0.49	–0.72	–0.12
Percent of current spending					
Instruction	61.76	60.31	58.19	56.58	60.15
Pupil support	6.01	5.77	6.40	6.40	5.89
Instructional staff support	4.21	4.80	5.23	5.29	4.79
General administration	1.62	1.73	1.88	2.09	1.75
School administration	5.43	5.49	5.54	5.27	5.48
Operation & maintenance	9.03	9.37	9.60	10.40	9.38
Student transportation	3.52	3.93	3.48	3.40	3.81
Business, central & other support	4.73	4.14	5.07	5.48	4.36
Food service & other non-instruction	3.64	4.38	4.50	4.82	4.32
Staff per 100 pupils					
Classroom teachers	6.13	6.38	6.38	6.74	6.36
Instructional aides	1.53	1.59	1.84	2.06	1.62
Guidance counselors	0.23	0.24	0.25	0.25	0.24
Librarians/media specialists	0.10	0.11	0.10	0.10	0.10
Student support staff	0.71	0.81	0.86	0.98	0.81
School administrators	0.35	0.38	0.41	0.45	0.38
School admin. support staff	0.53	0.54	0.61	0.61	0.55
LEA administrators	0.12	0.15	0.16	0.20	0.15
LEA admin. support staff	0.36	0.38	0.48	0.59	0.39
Other support staff	2.45	2.55	2.79	3.07	2.58
Total staff	12.61	13.23	14.00	15.19	13.29

Bands hold the same shares as the baseline bands (cut points 0.939, 0.880 and 0.816). Spending shares: Census F-33, as a percentage of current elementary-secondary spending; “business, central and other support” is total support services less the categories listed above it. Staffing: CCD FTE per 100 pupils (zero counts treated as missing). Measures winsorized at the 1st and 99th percentiles. Full averages for the baseline bands are in Appendix Table A2.

On raw averages, the state fixed effects bands look much like the baseline bands. The least efficient districts still spend more (\$16,701 against \$12,682) and face higher costs (\$18,664 against \$13,641), but the spending gradient is flatter than in the baseline. Instruction falls from 61.8 to 56.6 percent of current spending; general administration rises from 1.62 to 2.09 percent, and operation and maintenance from 9.0 to 10.4 percent. Total staff rises from 12.6 to 15.2 per 100 pupils.

Table 10. Staffing and budget allocation in standard deviations from the enrollment-weighted state average, FY2018–2024

	Baseline bands				State fixed effects bands			
	Most	Typ.	Less	Least	Most	Typ.	Less	Least
Context								
Per-pupil current spending	–0.40	–0.05	+0.58	+0.82	–0.50	–0.06	+0.66	+1.19
NECM predicted cost	–0.50	–0.02	+0.58	+0.82	–0.51	+0.01	+0.38	+0.40
Funding gap	+0.39	–0.02	–0.33	–0.42	+0.34	–0.05	–0.06	+0.20
Outcome gap	+1.25	–0.06	–0.97	–1.43	+1.32	–0.02	–0.95	–1.42
Enrollment (log)	+0.20	–0.06	+0.10	–0.10	+0.09	+0.02	–0.11	–0.55
Percent of current spending								
Instruction	+0.52	–0.00	–0.52	–0.69	+0.47	+0.04	–0.57	–0.86
Pupil support	–0.03	–0.02	+0.13	+0.16	–0.04	–0.02	+0.16	+0.08
Instructional staff support	–0.30	–0.00	+0.32	+0.34	–0.28	–0.02	+0.33	+0.40
General administration	–0.17	+0.02	+0.07	+0.14	–0.12	–0.02	+0.17	+0.41
School administration	–0.04	+0.00	+0.06	–0.15	+0.00	–0.00	+0.02	–0.07
Operation & maintenance	–0.28	+0.04	+0.13	+0.20	–0.25	–0.01	+0.20	+0.42
Student transportation	–0.05	–0.01	+0.06	+0.17	–0.09	+0.00	+0.06	–0.01
Business, central & other support	+0.04	–0.05	+0.15	+0.35	+0.06	–0.05	+0.15	+0.34
Food service & other non-instruction	–0.59	+0.06	+0.32	+0.51	–0.52	+0.02	+0.31	+0.55
Staff per 100 pupils								
Classroom teachers	–0.25	–0.00	+0.29	+0.25	–0.29	–0.04	+0.41	+0.59
Instructional aides	–0.26	+0.01	+0.21	+0.28	–0.25	–0.03	+0.36	+0.61
Guidance counselors	–0.08	–0.03	+0.27	+0.08	–0.10	–0.04	+0.31	+0.20
Librarians/media specialists	–0.13	+0.04	–0.03	–0.07	–0.06	–0.00	+0.08	+0.07
Student support staff	–0.23	+0.00	+0.27	+0.18	–0.27	–0.02	+0.32	+0.46
School administrators	–0.40	–0.01	+0.44	+0.57	–0.39	–0.02	+0.42	+0.65
School admin. support staff	–0.20	+0.01	+0.16	+0.30	–0.15	–0.01	+0.18	+0.33
LEA administrators	–0.18	+0.00	+0.18	+0.23	–0.21	–0.03	+0.28	+0.48
LEA admin. support staff	–0.33	+0.01	+0.32	+0.48	–0.31	–0.02	+0.31	+0.72
Other support staff	–0.33	+0.02	+0.23	+0.43	–0.34	–0.01	+0.27	+0.67
Total staff	–0.42	+0.00	+0.40	+0.56	–0.44	–0.04	+0.54	+0.99

Entries are enrollment-weighted band means of $z = (x - \mu_{st}) / \sigma_{st}$, with μ and σ the enrollment-weighted mean and SD across linked districts in the same state and fiscal year (264 state-years). Typ. = typical. Baseline bands use the Table 2 cut points; state fixed effects bands hold the same shares.

Relative to their own states, the least efficient districts are more heavily staffed in every category. Under the state fixed effects bands, the least efficient districts are +0.99 SD above their state average in total staff per pupil. That includes classroom teachers (+0.59), instructional aides (+0.61), school administrators (+0.65), LEA administrators (+0.48), LEA administrative support staff (+0.72) and other support staff (+0.67). The most efficient districts are below their state average in every staffing category, by 0.06 to 0.44 SD. The

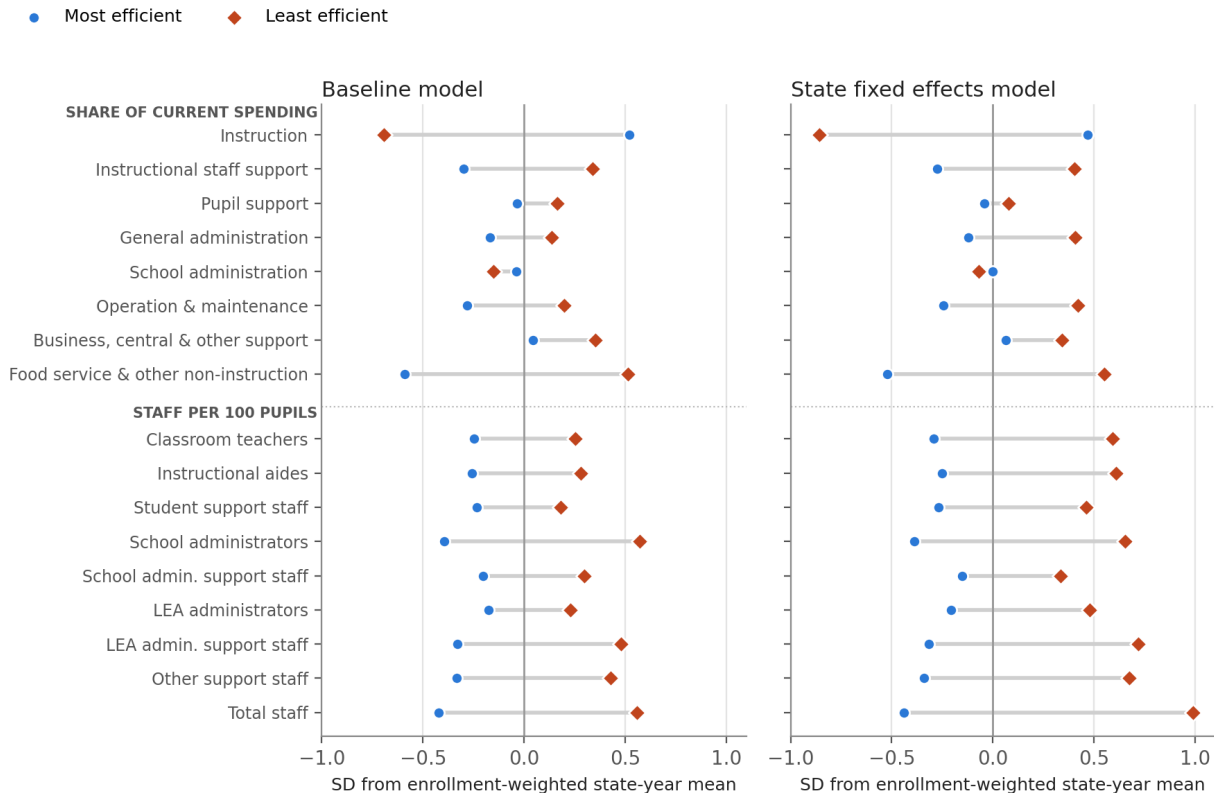
baseline bands show the same pattern, but less sharply: total staff is +0.56 SD in the least efficient band. Removing state effects from the frontier sharpens rather than removes the staffing contrast.

Budget shares shift away from instruction, but not toward school administration. The least efficient districts devote -0.86 SD less of their budgets to instruction than their state peers, and the most efficient +0.47 SD more. The offsetting shares are general administration (+0.41), operation and maintenance (+0.42), instructional staff support (+0.40), business and central services (+0.34) and food service and other non-instructional spending (+0.55). School administration spending shows no difference (-0.07), even though school administrator staffing is higher, consistent with the report's earlier finding.

The contrast is in staffing intensity more than in allocation, and part of it follows district size. The least efficient districts under state effects are smaller than their state peers (-0.55 SD in log enrollment; median enrollment 1,092 against 1,499 in the most efficient band). They spend well above their state average (+1.19 SD) and face somewhat higher predicted costs (+0.40 SD). Small districts carry more staff per pupil for reasons of scale that the NECM treats as cost, so some of the staffing difference is expected given cost. What the comparison adds is that the least efficient districts do not have a thinner classroom workforce: they have more of everything, with the largest excess in central office and support staff. Measured in dollars, the reallocation remains small. The general administration share in the least efficient band is 0.48 percentage points above the most efficient band, roughly \$80 per pupil.

Figure 6. Staffing and budget allocation relative to state averages, most and least efficient districts, FY2018–2024

Staffing and budget allocation relative to state averages, FY2018–2024



Enrollment-weighted mean z-scores by band. Most/least efficient: baseline TE ≥ 0.90 / < 0.70 ; state FE bands matched to the same shares.

Enrollment-weighted mean z-scores (Table 10). The spending shares for general and school administration in Tables 9, 10 and A2 come from a fresh extract of the Census F-33 files and run somewhat lower than those in Table 5 (for example, 1.92 rather than 2.03 percent for general administration in the least efficient band); instruction shares, spending, cost and staffing match Table 5.

4. Relation to the residual-based analysis

A companion analysis flagged districts using the standardized residuals from an ordinary regression of the outcome gap on the log of spending relative to cost. In a stochastic frontier model with a constant distribution of inefficiency, each district's estimated inefficiency is a monotone function of its composed residual. The two approaches therefore rank district-years almost identically (Spearman correlation 0.997 between three-year TE and three-year standardized residuals). Using the cut points above, 96 percent of district-years fall in the same group under both approaches, and no district moves between the top and bottom groups.

The frontier model adds two things. First, it expresses performance as an interpretable rate: the share of resources a frontier-efficient district would need. Second, it measures efficiency on a common scale across years, which reveals the growing dispersion shown in Figure 3. The within-year standardization in the residual approach masks this by construction.

5. Limitations

- **Inefficiency is a residual concept.** Any shortfall from the frontier not explained by spending relative to NECM cost is attributed to inefficiency. That includes unmeasured student needs and cost factors, state measurement differences and any noise the distributional assumptions fail to separate.
- **Noise is large relative to inefficiency.** The modest skewness of residuals means efficiency estimates for individual districts are imprecise and shrunk toward the mean. Band assignments are more reliable than precise TE values, and three-year averaging helps.
- **Distributional assumptions matter for levels, not rankings.** Exponential and half-normal specifications give identical rankings but different average efficiency. Cut points should be read relative to this specification.
- **A common frontier across states.** Cross-state efficiency comparisons assume all states share one frontier. Flexible functional forms do not change the state comparisons, but level differences between states (Section 3.5) may reflect measurement rather than efficiency.
- **Pooled inefficiency.** Inefficiency is treated as independent across years rather than modeled with persistent and transient components. Panel frontier models (for example, with separate persistent and time-varying inefficiency) are a natural extension.
- **Descriptive comparisons.** Staffing and spending differences across bands are associations, not causal effects of administrative choices on outcomes.
- **State effects are an upper bound on state-level differences.** The state fixed effects model attributes all state-level differences in outcomes at a given resource level to the state, including any genuine state-level efficiency. The baseline attributes all of them to districts, including cross-state measurement error in the SEDA-linked outcome index and in reported spending and estimated cost. The truth lies between, and the two models bracket it; because much of the state-level variation is likely measurement error, the state fixed effects estimates are the better guide to district efficiency.
- **Weaker identification within states.** Within states the residual distribution is roughly symmetric apart from a longer lower tail, so district TE under state effects depends more on the exponential assumption.
- **Staffing comparisons are not cost-adjusted.** The state-standardized comparisons remove state composition but not differences in size, sparsity or student need within states, which raise staffing per pupil for reasons the NECM treats as cost.
- **Narrow outcome measure.** The outcome index covers only grade 6–8 reading and mathematics assessments. Efficiency here means efficiency in producing middle-grades test results in those two subjects, not in producing other outcomes that districts also spend on, such as early-grade learning, high school completion, other subjects or non-academic outcomes.
- **Sample.** Excluding 11 states with carried-forward outcome data improves measurement but limits national coverage, notably New York and Pennsylvania.

6. Next steps

- Compare staffing and spending with districts of similar predicted cost and size within the same state (for example, z-scores from a within-state regression on cost factors), to separate staffing that follows cost from staffing beyond it.
- Estimate a panel frontier distinguishing persistent from transient inefficiency, and identify districts persistently in each band.
- Model inefficiency as a function of district characteristics (size, sparsity, student needs, governance) within the frontier, rather than comparing profiles after the fact.
- Bootstrap intervals for district TE under both models (district-clustered robust standard errors for the frontier parameters are now reported in Table 7).

Appendix

Table A1. Technical efficiency by state, 2011–2024 (ordered by mean TE)

State	Districts	Mean TE (enroll.-wt.)	% Most efficient	% Typical	% Less efficient	% Least efficient
ID	82	0.887	27.6	67.7	2.3	2.4
NC	115	0.884	13.2	83.0	3.6	0.2
UT	32	0.883	33.5	64.3	2.2	0.0
FL	66	0.882	11.6	84.8	3.3	0.3
GA	177	0.880	12.1	83.2	4.4	0.3
SD	87	0.876	17.6	79.0	2.8	0.7
MS	128	0.875	15.1	81.4	3.5	0.0
TX	831	0.874	12.8	74.2	10.5	2.5
NV	11	0.872	0.0	75.3	16.2	8.4
VA	129	0.866	2.2	87.3	9.9	0.7
TN	127	0.864	13.2	83.2	3.6	0.1
IN	284	0.864	15.6	77.3	6.3	0.8
MN	283	0.864	10.8	78.4	8.5	2.4
SC	66	0.862	4.7	83.2	9.9	2.2
AZ	137	0.860	13.2	62.5	15.6	8.7
WI	350	0.860	13.1	80.4	5.8	0.7
MD	24	0.858	2.1	80.7	15.5	1.8
MO	331	0.857	10.2	83.4	6.0	0.4
OH	597	0.856	15.3	75.1	8.7	0.9
IA	285	0.850	4.7	87.8	7.2	0.4
MT	85	0.849	17.5	69.7	8.2	4.7
AR	231	0.848	5.7	74.3	17.1	2.9
KY	166	0.846	7.8	83.1	8.5	0.7
AL	129	0.845	8.7	70.4	19.9	1.0
LA	67	0.843	1.2	76.6	18.1	4.2
OK	342	0.840	8.4	74.8	14.4	2.4
KS	212	0.838	8.1	79.9	10.6	1.4
MA	226	0.838	18.3	60.8	17.1	3.9
MI	478	0.837	3.8	75.8	17.6	2.8
NE	145	0.833	6.4	73.4	16.7	3.5
IL	636	0.833	8.1	68.0	19.5	4.3
DE	13	0.829	0.0	72.5	25.3	2.2
CA	575	0.829	16.7	55.0	21.6	6.8
NJ	377	0.802	11.6	59.4	21.7	7.4
WY	42	0.792	1.4	59.5	30.8	8.3
CT	132	0.767	2.0	51.9	29.2	16.9
WV	54	0.761	0.0	26.3	56.0	17.7
RI	31	0.753	4.8	46.8	35.5	12.9

Shares of district-years with three-year TE in each band. Mean TE is enrollment-weighted. Restricted sample; Hawaii is not in the NECM file, and Vermont's single district drops out of the sample.

Table A2. Profile of districts by technical efficiency band, baseline model, FY2018–2024 (enrollment-weighted averages)

	Most efficient	Typical	Less efficient	Least efficient	All
District-years	6,730	39,038	8,034	2,203	56,005
Mean three-year TE	0.913	0.863	0.760	0.637	0.852
Per-pupil current spending	\$11,858	\$12,712	\$15,956	\$18,237	\$13,145
NECM predicted cost	\$13,676	\$15,785	\$18,642	\$20,417	\$15,932
Median funding gap	+2%	–8%	–6%	–4%	–7%
Outcome gap (SD)	+0.32	–0.13	–0.50	–0.75	–0.12
Percent of current spending					
Instruction	62.11	60.11	58.35	57.52	60.15
Pupil support	5.79	5.73	6.62	7.08	5.89
Instructional staff support	4.37	4.85	5.02	4.76	4.79
General administration	1.44	1.79	1.86	1.92	1.75
School administration	5.49	5.50	5.44	5.06	5.48
Operation & maintenance	9.00	9.45	9.44	9.52	9.38
Student transportation	3.62	3.91	3.58	3.66	3.81
Business, central & other support	4.36	4.13	5.21	5.89	4.36
Food service & other non-instruction	3.77	4.44	4.35	4.37	4.32
Staff per 100 pupils					
Classroom teachers	6.13	6.40	6.40	6.59	6.36
Instructional aides	1.43	1.60	1.87	2.05	1.62
Guidance counselors	0.23	0.24	0.25	0.24	0.24
Librarians/media specialists	0.09	0.11	0.09	0.10	0.10
Student support staff	0.74	0.80	0.89	0.94	0.81
School administrators	0.35	0.39	0.42	0.42	0.38
School admin. support staff	0.51	0.54	0.60	0.62	0.55
LEA administrators	0.12	0.15	0.17	0.19	0.15
LEA admin. support staff	0.33	0.38	0.50	0.60	0.39
Other support staff	2.47	2.57	2.68	2.80	2.58
Total staff	12.54	13.28	13.98	14.72	13.29

Baseline bands (Table 2 cut points). Same data and definitions as Table 9.

Table A3. State effects and band shares with and without state fixed effects, 2011–2024 (ordered by state effect)

State	State effect (SD)	Mean TE, state FE	% most efficient: baseline	% most efficient: state FE	% below typical: baseline	% below typical: state FE
NC	+0.19	0.914	13.2	1.0	3.9	18.9
MS	+0.19	0.912	15.1	8.0	3.5	12.6
ID	+0.18	0.913	27.6	11.6	4.7	13.6
TX	+0.17	0.908	12.8	4.4	12.9	33.2
GA	+0.17	0.913	12.1	3.8	4.7	21.3
UT	+0.16	0.912	33.5	11.8	2.2	7.6
FL	+0.13	0.917	11.6	2.3	3.6	13.4
SD	+0.08	0.912	17.6	7.1	3.4	11.9
NV	+0.08	0.918	0.0	0.0	24.7	50.0
AZ	+0.07	0.908	13.2	10.4	24.4	29.1
TN	+0.03	0.913	13.2	11.3	3.7	8.0
IN	+0.02	0.911	15.6	10.2	7.1	12.6
SC	+0.02	0.915	4.7	4.8	12.1	11.8
VA	+0.01	0.913	2.2	1.7	10.5	16.2
AR	-0.01	0.911	5.7	6.6	20.0	18.5
MN	-0.02	0.911	10.8	6.9	10.9	13.6
OH	-0.02	0.910	15.3	10.6	9.6	13.8
MO	-0.03	0.913	10.2	14.1	6.4	7.0
AL	-0.03	0.914	8.7	11.4	20.9	11.4
OK	-0.06	0.910	8.4	14.5	16.8	13.5
MD	-0.06	0.915	2.1	0.9	17.3	20.8
WI	-0.06	0.912	13.1	11.3	6.5	9.6
LA	-0.06	0.913	1.2	4.8	22.2	15.4
MT	-0.06	0.903	17.5	18.7	12.9	14.2
CA	-0.08	0.907	16.7	20.3	28.3	21.0
KY	-0.09	0.912	7.8	15.0	9.1	6.6
IA	-0.09	0.913	4.7	7.7	7.6	6.7
MI	-0.12	0.912	3.8	6.6	20.4	11.3
KS	-0.13	0.911	8.1	14.1	12.0	8.5
IL	-0.14	0.909	8.1	13.6	23.9	17.5
NE	-0.14	0.909	6.4	11.9	20.2	16.4
MA	-0.17	0.908	18.3	17.1	21.0	20.1
DE	-0.22	0.915	0.0	2.7	27.5	6.6
NJ	-0.30	0.905	11.6	20.2	29.0	13.1
WY	-0.38	0.906	1.4	18.4	39.1	11.7
CT	-0.44	0.908	2.0	14.3	46.1	15.0
WV	-0.44	0.915	0.0	5.4	73.7	8.9
RI	-0.45	0.911	4.8	21.7	48.4	7.1

State effect: intercept from the state fixed effects frontier, centered on the enrollment-weighted mean, in SD of the outcome index. Mean TE is enrollment-weighted. "Below typical" = less or least efficient bands. State fixed effects bands hold the same national shares as the baseline bands.

Table A4. Productivity and efficiency by state, 2009–2024 (ordered by mean outcome gap)

State	Mean outcome gap (SD)	Outcome rank	Per-pupil spending	NECM predicted cost	Spending ÷ cost	Mean TE	TE rank
MA	+0.25	1	\$16,862	\$11,890	1.53	0.838	28
WI	+0.18	2	\$11,976	\$10,046	1.24	0.860	16
MN	+0.16	3	\$12,179	\$11,043	1.16	0.864	13
NJ	+0.15	4	\$19,124	\$13,159	1.58	0.802	34
MT	+0.14	5	\$10,415	\$8,913	1.20	0.849	21
SD	+0.10	6	\$9,414	\$9,914	0.97	0.876	6
CT	+0.10	7	\$18,241	\$11,690	1.70	0.767	36
WY	+0.09	8	\$16,639	\$10,648	1.60	0.792	35
OH	+0.07	9	\$11,868	\$12,378	1.06	0.856	19
IN	+0.05	10	\$10,421	\$11,197	0.99	0.864	12
UT	+0.04	11	\$7,667	\$9,306	0.83	0.883	3
ID	+0.04	12	\$7,868	\$9,671	0.82	0.887	1
NE	+0.02	13	\$11,775	\$10,719	1.15	0.833	30
IA	+0.02	14	\$10,852	\$10,500	1.07	0.850	20
MD	+0.01	15	\$15,300	\$16,673	1.01	0.858	17
VA	+0.00	16	\$12,439	\$13,745	0.94	0.866	10
KS	+0.00	17	\$11,140	\$10,616	1.10	0.838	27
MO	-0.02	18	\$10,394	\$11,689	0.96	0.857	18
IL	-0.03	19	\$13,952	\$13,705	1.08	0.833	31
DE	-0.03	20	\$14,769	\$12,922	1.16	0.829	32
FL	-0.05	21	\$9,636	\$12,581	0.78	0.882	4
NC	-0.06	22	\$9,636	\$13,671	0.72	0.884	2
KY	-0.06	23	\$10,808	\$11,241	0.98	0.846	23
MI	-0.07	24	\$11,330	\$12,690	1.01	0.837	29
TN	-0.07	25	\$9,362	\$11,384	0.84	0.864	11
RI	-0.09	26	\$16,125	\$12,372	1.42	0.753	38
GA	-0.10	27	\$10,886	\$16,121	0.71	0.880	5
AZ	-0.14	28	\$8,329	\$11,154	0.76	0.860	15
SC	-0.14	29	\$10,894	\$14,071	0.79	0.862	14
TX	-0.15	30	\$9,657	\$15,120	0.67	0.874	8
AR	-0.19	31	\$10,113	\$13,662	0.78	0.848	22
CA	-0.20	32	\$11,762	\$14,124	0.84	0.829	33
OK	-0.21	33	\$8,723	\$11,273	0.81	0.840	26
NV	-0.22	34	\$9,563	\$14,209	0.68	0.872	9
LA	-0.25	35	\$11,904	\$16,000	0.77	0.843	25
WV	-0.26	36	\$11,988	\$10,586	1.16	0.761	37
MS	-0.26	37	\$9,148	\$16,750	0.58	0.875	7
AL	-0.30	38	\$9,988	\$15,116	0.71	0.845	24

Definitions as in Table 4.

Table A5. Frontier functional form: alternative specifications

	Log (preferred)	Log + log ²	Log + log ² + log ³	Linear spline, 6 segments
-Pseudo-LL	12,511	12,486	12,483	12,384
E[u]	0.119	0.119	0.119	0.118
Rank correlation of state mean TE with log	1.000	0.996	0.996	0.964
Enrollment-weighted mean three-year TE				
Massachusetts	0.836	0.840	0.841	0.840
New Jersey	0.802	0.807	0.808	0.806
Connecticut	0.769	0.775	0.777	0.774
Florida	0.881	0.880	0.879	0.870
Texas	0.874	0.871	0.871	0.868
Mississippi	0.875	0.870	0.872	0.870
Frontier relative to spending = cost (SD)				
Spending ÷ cost = 0.51	-0.472	-0.462	-0.461	-0.456
Spending ÷ cost = 0.81	-0.149	-0.149	-0.147	-0.146
Spending ÷ cost = 1.29	+0.173	+0.176	+0.175	+0.189
Spending ÷ cost = 1.62	+0.335	+0.342	+0.341	+0.352
Spending ÷ cost = 2.05	+0.496	+0.512	+0.514	+0.516

Exponential inefficiency, year fixed effects, N = 128,713 district-years. For the non-log specifications, TE converts inefficiency to input terms using the frontier's local slope at each district's spending relative to cost. Spline knots at the 20th, 40th, 60th, 80th and 95th percentiles of $\ln(\text{spend}/\text{cost})$.

Table A6. Within-state slopes of outcomes on spending relative to cost, selected states

State	Slope on $\ln(\text{spend}/\text{cost})$	Clustered SE	Mean spending ÷ cost	District-years
MA	1.21	0.09	1.53	3,597
NJ	1.20	0.06	1.58	5,987
CT	1.16	0.07	1.70	1,835
FL	0.44	0.15	0.78	1,055
NC	0.86	0.11	0.72	1,840
GA	0.86	0.08	0.71	2,831
TX	0.70	0.05	0.67	13,292
MS	0.77	0.05	0.58	2,007

Enrollment-weighted OLS within each state with year fixed effects; standard errors clustered by district. Across the 35 states with at least 25 districts, a precision-weighted regression of state slopes on log mean spending ÷ cost gives 0.38 (SE 0.12).

Variable definitions

- Outcome gap: NECM outcome index, SD units relative to the national average; based only on SEDA nationally normed state reading and mathematics assessments, grades 6–8.

- Funding gap: actual current spending per pupil $\div$ NECM predicted cost of national-average outcomes (cost model 1, bd) – 1.
- Technical efficiency: $E[\exp(-u/\beta) \mid \epsilon]$ from the exponential stochastic frontier; three-year trailing average.
- Staffing ratios: CCD FTE (school administrators, LEA administrators, classroom teachers) per 100 enrolled pupils.
- Spending shares: F-33 current spending on instruction, general administration and school administration as a percentage of total current elementary-secondary spending.