Austerity, Disaster and the Distribution of School Resources

Evidence from Puerto Rico, 2009–2026

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ABSTRACT

Between 2014 and 2018 Puerto Rico's public schools absorbed a sovereign-debt crisis, a federal fiscal oversight regime, the most destructive hurricane in the island's modern history, two waves of mass school closures and a comprehensive reform law. This paper assembles a school-level panel covering 2008–09 to 2025–26 and an island-level finance series for FY2009–FY2022 to ask what these shocks did to the adequacy and the distribution of school resources. Nominal spending relative to the states fell sharply, from 75% of the U.S. average per pupil in 2013–14 to 52% in 2017–18, and recovered only on temporary federal funds. Census microdata show that teacher base pay was frozen in nominal terms for thirteen years, but also that teachers were paid more, relative to comparable local college graduates, than U.S. teachers (0.83 vs. 0.70 in 2023), so much of the nominal spending gap reflects lower labor costs rather than fewer resources. A risk analysis shows that the economically disadvantaged share of students alone explains more than 40% of the variation in secondary school proficiency. Yet the distribution of resources relative to that need barely moved. In every year, schools at the 90th percentile of need had between 1% and 7% more teachers per pupil than schools at the 10th percentile, and the pooled change after 2017–18 is indistinguishable from zero. School closures selected on size and rurality rather than need. Exploiting municipal variation in hurricane damage, I find that María reduced enrollment by about 5% per standard deviation of exposure, a loss that persisted for seven years, while staffing and test results did not change once pre-existing municipal trends are accounted for. Secondary outcome gaps between high- and low-need schools, already large, widened by more than half during the fiscal crisis that preceded the storm. The results suggest that a flat, non-compensatory allocation regime survived every shock and every reform. I discuss implications for cost modeling and for the enforcement of Puerto Rico's constitutional right to education.

Keywords: school finance; adequacy; equity; natural disasters; austerity; school closures; teacher pay; Puerto Rico; right to education

JEL codes: H52, H75, I22, I24, J45, Q54

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1. Introduction

Few school systems have absorbed as many simultaneous shocks as Puerto Rico's did in the second half of the 2010s. The Commonwealth defaulted on its debt, and in June 2016 Congress enacted the Puerto Rico Oversight, Management, and Economic Stability Act (PROMESA), placing the island's budgets under a federally appointed board. In May 2017 the Department of Education (PRDE) announced the closure of 179 schools. Four months later, on September 20, 2017, Hurricane María made landfall, destroying the electric grid and accelerating an out-migration that was already emptying classrooms. In March 2018 the legislature adopted a sweeping reform law, Ley 85-2018, which authorized charter-like "Alianza" schools and vouchers and required per-student budgeting. That summer roughly 260 more schools closed. Public school enrollment, more than half a million in 2008–09, fell below a quarter of a million by 2024–25.

This paper asks what these shocks did to two distinct properties of a school finance system. The first is adequacy: whether the level of resources is sufficient for students to reach common outcome goals. The second is equity in the distributional sense: whether resources are allocated in proportion to student need, so that schools serving students who face greater obstacles receive more. The two can move independently. A system can cut spending across the board while preserving its distribution, or redistribute a fixed budget toward high-need schools. Distinguishing them matters for policy, because they call for different remedies, and for law, because constitutional education clauses have been interpreted to reach one, the other or neither.

Puerto Rico is a revealing case for three reasons. First, the island is a single school district. All public schools are funded and staffed by one central department, so the distribution of resources across schools is a direct policy choice rather than the residue of local tax bases. Second, the shocks varied in their geography. Fiscal austerity was island-wide, but María's damage varied substantially across the 78 municipios. That variation allows the local effects of the hurricane to be separated from island-wide trends. Third, Puerto Rico's constitution guarantees "every person" a right to an education, in a Bill of Rights clause modeled on Article 26 of the Universal

Declaration of Human Rights (Const. P.R. art. II, §5). The island's Supreme Court has adjudicated that right only against closures and vouchers, never against adequacy or equity.

I assemble a school-by-year panel from the NCES Common Core of Data, EDFacts assessment files, PRDE's public accountability and school spending data, and FEMA's registry of individual disaster assistance, and pair it with the National Public Education Financial Survey for island-wide finance. Following the risk-and-resources framework of Baker, Atchison and Levin (2026), I first estimate a student-need index from the relationship between school outcomes and student characteristics, and then track, year by year, how staffing and spending vary with that index, how outcome gaps between high- and low-need schools evolved, which schools were closed, and how María's damage affected enrollment, staffing and outcomes. I then measure teacher pay against comparable workers in Puerto Rico and the states.

Five findings stand out. First, spending relative to the states collapsed in nominal terms. Puerto Rico spent 75% of the U.S. average per pupil in 2013–14 and 52% in 2017–18; the subsequent recovery to 72% in 2021–22 rested on federal pandemic aid, which raised the federal share of revenue to 48%. Second, teacher pay tells a more nuanced story. The base salary was frozen at $1,750 a month from about 2009 until July 2022, and teacher pay fell from 0.85 to 0.78 of the pay of comparable local college graduates before a $1,000 monthly raise, initially funded largely with federal pandemic aid, restored it to 0.83. Yet that ratio is higher than for U.S. teachers, and Puerto Rico employs about 37% more teachers per pupil than the states: the nominal spending gap is mostly a price gap, not a quantity gap. Third, the distribution of resources was flat throughout. Staffing was only marginally more generous in high-need schools in every year, and neither austerity, the closures, the hurricane nor Ley 85 changed that. School-site spending, observable from 2019–20, shows the same pattern, and in secondary schools resources are, if anything, slightly regressive. Fourth, the closures selected on size: closed schools had about half the enrollment of those kept open, and need did not consistently predict closure once size was held constant. Fifth, María reduced enrollment by about 5% per standard deviation of municipal damage, a loss that persisted for seven years, but had no detectable effect on staffing or test results once pre-existing municipal trends are absorbed. An apparent post-storm rise in test scores in hard-hit areas reflects convergence that began years before the storm.

The paper contributes to three literatures. It adds a case of deep, sustained austerity to the literature on whether school spending cuts matter (Jackson, Wigger & Xiong, 2021), with the unusual feature that the distribution of resources across schools is observable directly. It extends work on the educational consequences of natural disasters, which has focused on displaced students and receiving schools (Sacerdote, 2012; Imberman, Kugler & Sacerdote, 2012; Özek, 2023), to the sending system itself. And it applies a cost-and-equity framework developed for national systems to a U.S. jurisdiction whose constitutional right, fiscal constraints and adequacy indicators resemble those of a middle-income country more than a U.S. state.

Section 2 describes the institutional background. Section 3 reviews related literature and the analytical framework. Section 4 describes the data and Section 5 the empirical strategy. Section 6 presents results and Section 7 robustness checks. Section 8 discusses implications for cost modeling and constitutional enforcement, Section 9 sets out limitations and Section 10 concludes.

2. Institutional Background

2.1 Fiscal crisis and federal oversight

Puerto Rico's economy entered a prolonged contraction in 2006, and public debt grew as the government borrowed to cover operating deficits. By 2015 the governor had declared the debt unpayable, and the Commonwealth began defaulting on its obligations. Because Puerto Rico is excluded from Chapter 9 of the federal Bankruptcy Code, Congress enacted PROMESA in June 2016 (48 U.S.C. §2101 et seq.). The Act created the Financial Oversight and Management Board, which certifies multi-year fiscal plans and annual budgets for the Commonwealth and its instrumentalities, including PRDE, and it opened a court-supervised debt restructuring under Title III. Education budgets since FY2017 have therefore been set within board-certified fiscal plans that called for consolidation of the school network and reductions in operating costs.

PRDE is the only local education agency on the island. It operates every public school, employs every public school teacher, and receives all federal formula aid. Before Ley 85-2018, school budgets were set centrally through staffing allocations; the law required the department to move to per-student and per-school budgeting "by equity standards" (art. 2.04(b)(11)) and to devote at least 70% of its budget to direct school services (art. 2.02).

2.2 Hurricane María and migration

Hurricane María struck Puerto Rico on September 20, 2017, two weeks after Hurricane Irma had passed to the north. It destroyed much of the electric grid, and power and water outages lasted months in many municipios. A study commissioned by the Commonwealth estimated 2,975 excess deaths in the six months that followed (Milken Institute School of Public Health, 2018). FEMA's disaster declaration (DR-4339) covered all 78 municipios, but damage was uneven: in the data used here, verified household damage per resident ranges from about $90 to more than $2,300 across municipios.

Out-migration, already high during the economic contraction, accelerated. Using school enrollment data from receiving states, the Center for Puerto Rican Studies (2018) estimated that more than 135,000 people had relocated to the mainland within six months of the storm. Florida's schools alone absorbed thousands of displaced Puerto Rican students (Özek, 2023). On the island, public school enrollment fell from 544,138 to 306,652 between 2007–08 and 2017–18, a decline of 44% (Hinojosa, Meléndez & Severino Pietri, 2019).

2.3 School closures and Ley 85-2018

PRDE closed about 150 schools between 2010 and 2015. In May 2017 it announced the closure of 179 more, the largest single wave in the island's history to that point. In April 2018, after María, it announced another 283 closures, leaving 828 schools for the 2018–19 year; Hinojosa et al. (2019) count 265 public schools, or 24% of the network, closed by 2018–19. Ley 85-2018, signed March 29, 2018, gave the Secretary authority over facilities and closures, created Alianza public schools and the Libre Selección voucher program, and restated the constitutional right to education in its statement of motives.

2.4 The constitutional right to education

Article II, §5 of the 1952 Constitution provides that every person has a right to an education directed to the full development of the personality and to strengthening respect for human rights, and requires a free, wholly non-sectarian public system. Elementary and secondary instruction is free, and elementary attendance is compulsory "to the extent permitted by the facilities of the state." A broader social-rights clause (§20), which began with "the right of every person to

receive free elementary and secondary education," was struck by Congress as a condition of approval (Pub. L. 82-447, 66 Stat. 327, 1952).

The Supreme Court of Puerto Rico has treated §5 as justiciable, but its enforcement has run on three narrow tracks. The no-aid clause was enforced against vouchers in Asociación de Maestros v. Torres, 137 D.P.R. 528 (1994), and then effectively set aside when the Court upheld Ley 85's charter and voucher provisions in Asociación de Maestros v. Departamento de Educación, 2018 TSPR 150. A special-education class action, Rosa Lydia Vélez v. Departamento de Educación (stipulated judgment, February 14, 2002), has operated under court supervision for more than two decades. And in Meléndez León v. Keleher (2018), the Court vacated an injunction against nine 2018 closures, holding that the closures did not "directly and substantially interfere" with the right to education. No litigant has asked the Court whether the level or distribution of school funding satisfies §5. The empirical questions in this paper are, in that sense, questions the constitutional right has not yet been asked to answer.

3. Related Literature and Analytical Framework

3.1 School spending and student outcomes

A large body of quasi-experimental work now finds that school spending affects student outcomes, and that effects are larger for low-income students. Jackson, Johnson and Persico (2016) show that court-ordered finance reforms that raised spending improved educational attainment and adult earnings, especially for children from low-income families. Lafortune, Rothstein and Schanzenbach (2018) find that post-1990 finance reforms raised achievement in low-income districts. In a meta-analysis of quasi-experimental studies, Jackson and Mackevicius (2024) estimate that $1,000 more per pupil sustained for four years raises test scores by about 0.03 standard deviations and increases college-going.

The evidence on cuts is directly relevant here. Jackson, Wigger and Xiong (2021) show that per-pupil spending fell by about 7% nationally during the Great Recession and that cohorts exposed to larger cuts had lower test scores and college-going, with larger effects for children in poor neighborhoods. Goldstein and McGee (2021) dispute the robustness of those estimates. Puerto Rico's nominal spending per pupil fell by about a fifth between 2013–14 and 2017–18, and by

nearly a third relative to the states, several times the national recessionary decline, in a system whose students were already far poorer.

3.2 Disasters, displacement and schooling

Most evidence on disasters and schooling comes from Hurricanes Katrina and Rita. Sacerdote (2012) finds that students forced to switch schools suffered sharp test-score declines in the first year, followed by gains among students from the lowest-performing schools. Imberman, Kugler and Sacerdote (2012) study effects on students in receiving schools. For María, Özek (2023) finds that the influx of Puerto Rican students into Florida schools had short-lived negative effects on incumbent students. Less is known about the sending system: how the schools left behind, and the students who remained in them, fared when a large share of their peers left. That is the margin studied here.

3.3 School closures

Closures in shrinking districts can harm displaced students in the short run, with longer-run effects depending on the quality of the receiving school (Engberg, Gill, Zamarro & Zimmer, 2012; Brummet, 2014). A recurring concern is that closures fall disproportionately on schools serving poor and minority students. In a single-district system facing a collapse in enrollment, the question is whether closure decisions followed need, size, or facility condition.

3.4 Framework: risk, resources and cost

The analysis follows the framework for evaluating school finance systems in Baker, Atchison and Levin (2026). The framework starts from the purpose of a finance system: to provide the resources schools need for every child to have an equal opportunity to reach common outcome goals. It proceeds in steps. A risk analysis (Step 1a) asks which student characteristics predict lower outcomes. A resource analysis (Step 1b) asks whether resources rise with those needs, after accounting for cost factors that are not need, such as school size and rurality. Cost modeling (Step 2) estimates what it would cost schools serving different students to reach a common goal (Duncombe & Yinger, 2005). This paper applies Steps 1a and 1b over time and draws out the implications for Step 2.

4. Data

The analysis combines eight sources (Table 1). The unit is the school-year, with years labeled by the spring of the academic year (2009 = 2008–09).

Table 1. Data sources and coverage

Component	Years	Level	Source
Enrollment, teacher FTE, free/reduced-price lunch, operating status	2008–09 to 2024–25	School	NCES Common Core of Data
Proficiency (Spanish, mathematics); economically disadvantaged share of tested students	2008–09, 2010–11 to 2017–18	School	EDFacts
Proficiency (Spanish, mathematics, English); shares of tested students by subgroup	2018–19, 2021–22 to 2025–26	School	PRDE accountability files (META-PR)
Spending per pupil by level (school site; regional and central allocated to schools) and source of funds (federal, Commonwealth, Title I schoolwide); official enrollment	2019–20 to 2024–25	School	PRDE Perfil Escolar
Child poverty; school locations and distances	ACS 2019–2023	Census tract; municipio	American Community Survey; TIGER/Line; NCES and PRDE coordinates
Revenue by source; current spending per pupil	FY2009 to FY2022	Island; U.S. total	NCES National Public Education Financial Survey
Hurricane María household damage and registrations	DR-4339 (2017)	Municipio (78)	FEMA Individuals and Households Program; ACS population
Annual wages, occupation, education, hours, class of worker	2009–2019, 2021–2024 (U.S.: 2014, 2023)	Worker	American Community Survey and Puerto Rico Community Survey 1-year PUMS

Note: There were no statewide assessments in 2019–20 or 2020–21, and EDFacts contains no Puerto Rico assessment file for 2009–10. The Census Bureau did not release standard 1-year PUMS files for 2020.

4.1 Risk analysis and the need index

The need index comes from a risk analysis, the first step of the framework, estimated on the 2019–20 to 2024–25 data. The outcome is a school proficiency index: for each year from 2021–22 to 2025–26, the percentages proficient in Spanish, mathematics and English on META-PR, Puerto Rico's assessment, are standardized within year and phase and averaged, and the school's index is the mean over years, weighted by students tested. Eight candidate need measures are considered: the shares of tested students who are economically disadvantaged, have disabilities, are Spanish learners, are homeless, or are Hispanic but not Puerto Rican; the free or reduced-price lunch share of enrollment; and child poverty in the school's census tract and municipio. For primary and secondary schools separately, measures are added by forward selection, keeping a measure only if it raises five-fold cross-validated R^2, with folds grouped by municipio so that

schools in the same place are never split between estimation and validation, and only if its coefficient has the expected sign.

The need index is the predicted proficiency shortfall from the selected secondary-school model, the phase in which need predicts outcomes most strongly (Section 6.1), applied to every school's own students and standardized across pupils, so that primary and secondary schools share one scale. The long panel requires a version of the index for years before the current assessment. Because EDFacts flags nearly all tested students as economically disadvantaged from 2010–11 to 2012–13, a reporting artifact, the preferred long-panel index (need_fix) applies the same coefficients to each school's average inputs over valid years and re-standardizes within each year. Section 7 shows results with a year-specific index (need_t) and with an index built from pre-2017 data only (need_pre).

4.2 Outcomes

The outcome measure is a school proficiency index: the average of the standardized percentages proficient in Spanish and mathematics, re-standardized within year and school phase and weighted by students tested. Because Puerto Rico changed assessments several times over the period, levels are not comparable across years, but the relative position of schools within a year is. Gaps are therefore expressed in within-year standard deviations.

4.3 Hurricane exposure

Exposure to María is measured at the municipio level from FEMA's individual assistance records for DR-4339. The baseline index (maria_z) averages the standardized number of owner and renter registrations per resident and the standardized Individuals and Households Program assistance per resident. Alternative measures use FEMA-verified damage per resident, registrations per 100 residents, and an indicator for the top tercile of the baseline index. Registrations range from 29 to 44 per 100 residents across municipios. The baseline index is essentially uncorrelated with school need ($r = -0.07$), which limits the scope for exposure to proxy for pre-existing disadvantage.

4.4 School spending

School-level spending comes from PRDE's Perfil Escolar, which reports, for every school, expenditures from the department's audited financial statements for each school year from 2018–19 onward. Spending is reported at two levels: direct spending at the school site, and regional and central office spending that PRDE assigns to schools by its own method. The same total is also reported by source of funds (federal programs, Commonwealth funds and Title I schoolwide funds) and by object (personnel and non-personnel), and each decomposition sums exactly to the total. I divide each amount by the school's official enrollment count (M1). Total spending per pupil, the sum of school-site, regional and central spending per pupil, equals PRDE's reported figure. The 2018–19 year is dropped because enrollment counts are available for only 199 schools. These are measures of spending, not cost: they record what was spent at each school, not what it would cost a school to reach a given outcome goal, which is the object of the cost modeling discussed in Section 8.2. PRDE also reports spending that it does not assign to any school, which grew from about $106 million in 2019–20 to about $525 million in 2024–25, about a seventh of what was assigned to schools that year; school-level totals therefore understate the department's total spending and are not directly comparable with the island-level figures in Table 5.

4.5 Teacher wages

Teacher pay is measured from the 1-year public-use microdata of the Puerto Rico Community Survey, the island's version of the American Community Survey, for 2009–2019 and 2021–2024, with U.S. files for 2014 and 2023 for comparison. The sample is wage and salary workers aged 22–64 with at least a bachelor's degree who worked full time (35 or more usual hours) and full year (50 or more weeks), with positive wage income. Public school teachers are those in elementary and middle school, secondary and special education teaching occupations who work for government; private school teachers are those in the same occupations working for private employers. The comparison group is all other workers in the sample outside education, training and library occupations. Samples are small: between 101 and 236 public school teachers a year, so results are reported for pooled periods. Wages refer to the 12 months before the interview, so the July 2022 raise first appears fully in the 2023 file.

4.6 Sample

Table 2 describes the panel in three periods: before the 2017 closures, the year of the storm and the first closure wave, and the post-María period.

Table 2. Descriptive statistics by period, schools in the Common Core of Data

	2008–09 to 2015–16	2016–17	2017–18 to 2024–25
School-years	11,565	1,283	7,093
Schools (unique)	1,535	1,283	1,143
Pupils per year (mean)	446,329	365,181	276,155
Mean school enrollment	311	287	314
Teachers per 100 pupils (pupil-weighted)	7.60	7.86	8.86
Free/reduced-price lunch, % (pupil-weighted)	91.1	87.0	91.0
Secondary schools, %	23.7	24.7	32.2
Rural schools, %	11.8	6.9	7.3
Closed after year, %	2.3	12.6	4.6

Note: Teachers per 100 pupils excludes school-years outside 1–40. Closure rates in the final period reflect the 2018 wave; the 2024–25 value is undefined and excluded.

5. Empirical Strategy

5.1 Staffing and spending progressivity

For each year t, I estimate the relationship between staffing and need within municipios:

$$ln\ T_{st} = \alpha + \beta_t\ N_s + X'_{st}\ \gamma + \mu_m + \varepsilon_{st} \quad (1)$$

where T_{st} is teachers per 100 pupils in school s, N_s is the need index, X_{st} includes log enrollment and its square, a secondary-school indicator and a rural indicator, and μ_m are municipio fixed effects. Regressions are weighted by enrollment, and standard errors are clustered by municipio. Following the framework, I summarize β_t as a progressivity ratio, the predicted resource level at the 90th percentile of need relative to the 10th: $R_t = \exp[\beta_t(N_{90} - N_{10})]$. A ratio of 1 means resources are flat with respect to need; ratios above 1 indicate progressive allocation. The same specification, in four nested forms (S1, need and year only; S2, adding size; S3, adding rurality and isolation; S4, adding municipio fixed effects), is applied to school-level spending in 2019–20 to 2024–25. To test whether progressivity changed after the shocks, I pool all years:

$$ln\ T_{st} = \alpha + \beta\ N_s + \delta\ (N_s \times Post_t) + X'_{st}\ \gamma + \lambda_t + \mu_m + \varepsilon_{st} \quad (2)$$

where $Post_t$ indicates 2017–18 and later and λ_t are year fixed effects. The coefficient δ measures the change in the need gradient.

5.2 Outcome gaps

Outcome gaps are estimated year by year and separately for primary and secondary schools as $Y_{st} = a + \theta_t N_s + e_{st}$, weighted by students tested, with the gap reported as $\theta_t(N_{90} - N_{10})$ in standard deviations of the proficiency index.

5.3 Closures

For schools open in 2016–17 or 2017–18, I model the probability of closure after that year:

$$Pr(C_{st} = 1) = \Lambda(\varphi_1 N_s + \varphi_2 \ln Enr_{st} + \varphi_3 Rural_s + \varphi_4 E_m + \varphi_5 1[t = 2018]) \quad (3)$$

where E_m is municipal hurricane exposure. I report average marginal effects from a logit and coefficients from a linear probability model, with standard errors clustered by municipio.

5.4 Teacher wages relative to comparable workers

Following the approach used to estimate the U.S. teacher pay penalty (Allegretto, 2024), I estimate a weighted regression of log annual wages on a teacher indicator and controls:

$$\ln W_{it} = \alpha + \rho\, Teacher_i + \delta_1 Age_i + \delta_2 Age_i^2 + \delta_3 Female_i + Degree_i'\kappa + \delta_4 \ln Hours_i + \lambda_t + u_{it} \quad (5)$$

where Degree indicates a master's, professional or doctoral degree (a bachelor's degree is the omitted category) and λ_t are survey-year effects within each pooled period. Person weights are used, with heteroskedasticity-robust standard errors. The adjusted wage ratio exp(ρ) is the pay of a teacher relative to a comparable college graduate in another occupation in the same labor market; 1 indicates parity. The same model is estimated for the United States as a whole and for each state with at least 100 public school teachers in the sample.

5.5 Hurricane María

To identify María's local effects, I compare schools in more and less damaged municipios before and after the storm in an event-study design with school and year fixed effects:

$$y_{st} = \Sigma_{k \neq 2017} \pi_k (E_m \times 1[t = k]) + \alpha_s + \lambda_t + \varepsilon_{st} \quad (6)$$

The outcomes are log enrollment, log teachers per 100 pupils and the proficiency index. School fixed effects absorb permanent differences across schools; year fixed effects absorb everything common to the island in a given year, including austerity, PROMESA budgets, the closure policy

and Ley 85. The coefficients π_k therefore capture the differential evolution of outcomes in more damaged municipios relative to 2016–17. The identifying assumption is that, absent the storm, outcomes in more and less damaged municipios would have followed parallel paths; the pre-period coefficients provide a direct test. For summary and robustness, I also estimate a pooled version replacing the event-time interactions with $E_m \times Post_t$, with and without municipio-specific linear trends.

Two features of the design deserve emphasis. First, it identifies the local, differential effects of the hurricane, not its total effect, which is common to all municipios and absorbed with austerity in the year effects. Second, closures shift students between schools; enrollment effects at surviving schools reflect both migration and consolidation, and outcome effects can reflect changes in student composition as well as changes in learning.

6. Results

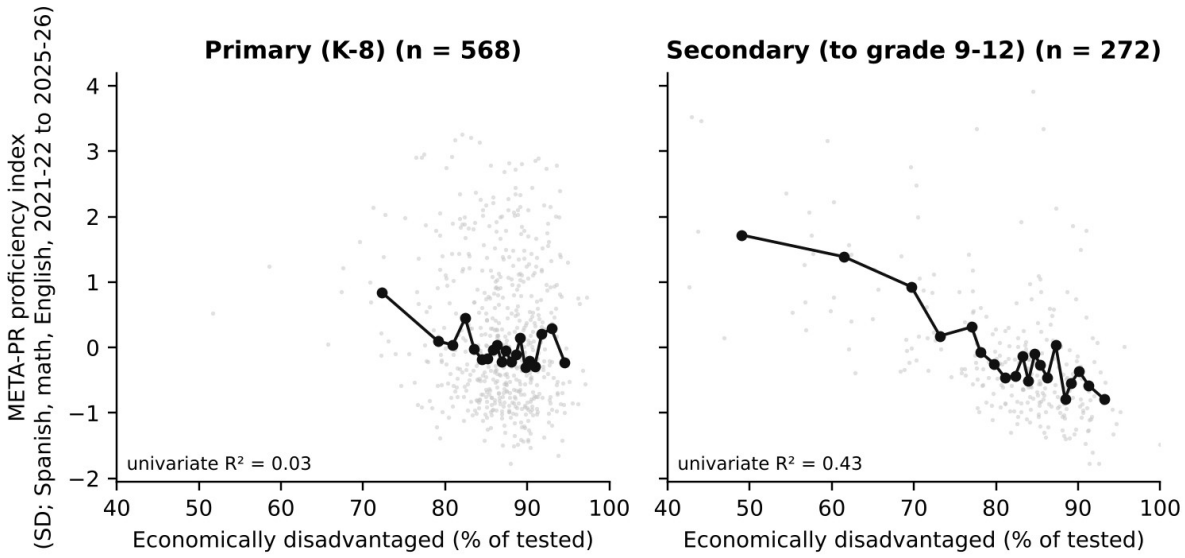
6.1 Risk: which schools are furthest from the goals?

Table 3. Share of variation in school proficiency explained by each candidate need measure

Measure	Primary R^2	Primary CV R^2	Secondary R^2	Secondary CV R^2
Economically disadvantaged (% of tested)	0.028	0.010	0.428	0.416
Students with disabilities (% of tested)	0.012	0.001	0.126	0.098
Hispanic, not Puerto Rican (% of tested)	0.009	-0.006	0.042	-0.027
Spanish learners (% of tested)	0.000	-0.016	0.010	-0.026
Child poverty, census tract of school	0.001	-0.015	0.005	-0.031
Child poverty, municipio	0.014	0.003	0.001	-0.039
Free or reduced-price lunch (% of enrollment)	0.044	0.018	0.000	-0.035
Homeless (% of tested)	0.001	-0.016	0.000	-0.047
Selected model	**0.061**	**0.035**	**0.434**	**0.421**

Note: 568 primary and 272 secondary schools with at least ten students tested; weighted by students tested. Outcome: mean of the within-year, within-phase standardized percentages proficient in Spanish, mathematics and English, 2021–22 to 2025–26. CV R^2: five-fold cross-validation with folds grouped by municipio (negative values indicate predictions worse than the mean). Selected models: secondary, economically disadvantaged share and free or reduced-price lunch share; primary, free or reduced-price lunch share and share with disabilities.

Figure 1. School proficiency and the share of tested students who are economically disadvantaged, 2021–22 to 2025–26



Note: Each grey dot is a school; black points are means of twenty equal-sized groups of schools, weighted by students tested.

Table 4. Percent proficient by need decile, 2024–25

	Spanish	Mathematics	English	Economically disadvantaged, %
Secondary, lowest-need tenth	73	57	67	58
Secondary, highest-need tenth	35	25	24	92
Primary, lowest-need tenth	63	61	50	76
Primary, highest-need tenth	53	51	40	93

Note: Weighted by students tested; deciles of the need index within phase.

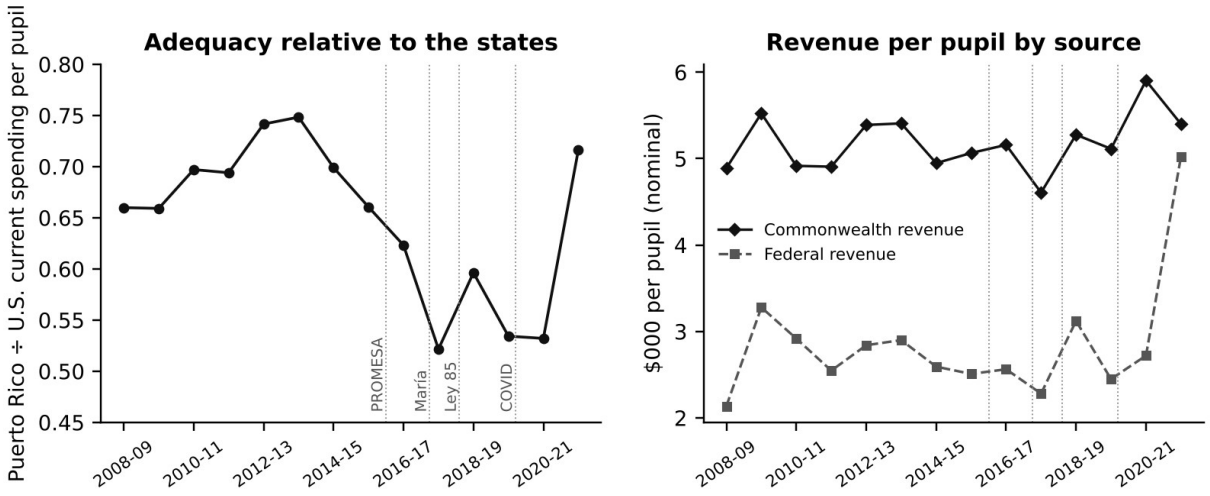
In secondary schools, the economically disadvantaged share of tested students is the dominant predictor of results (Table 3, Figure 1). On its own it explains 43% of the variation in school proficiency, and 42% out of sample; adding the free or reduced-price lunch share raises cross-validated fit only to 42%. The share of students with disabilities adds explanatory power on its own (13%) but not once poverty is included. Child poverty around the school explains almost nothing: in a system where about 85% of tested students are economically disadvantaged, who is enrolled matters more than the neighborhood. The gaps are large in absolute terms. In the lowest-need tenth of secondary schools, 57% of students were proficient in mathematics in 2024–25; in the highest-need tenth, 25% (Table 4). The gap in the proficiency index between schools at the 90th and 10th percentiles of need is 1.57 standard deviations.

Primary results are different. The economically disadvantaged share explains 3% of the variation, the selected model 3% out of sample, and the highest-need tenth of primary schools

reports proficiency close to the middle of the distribution. Three explanations are possible and none can be ruled out here: primary schools are more homogeneous, with most between 80% and 91% disadvantaged; some school-reported results may be unreliable; or primary outcomes depend on factors the data do not capture. Weak primary prediction is unusual; in England, for example, poverty and special educational needs strongly predict primary results. Because the need index applies the secondary model to all schools, it measures need in the sense that matters where need demonstrably predicts outcomes. Its 10th and 90th percentiles are -1.15 and 0.87 standard deviations.

6.2 Island spending relative to the states

Figure 2. Current spending per pupil relative to the U.S. average, and revenue per pupil by source, FY2009–FY2022



Note: NCES National Public Education Financial Survey; current expenditures per member, nominal dollars. U.S. = 50 states and DC. Vertical lines mark PROMESA (June 2016), Hurricane María (September 2017), Ley 85-2018 (March 2018) and the COVID-19 school closures (March 2020).

Table 5. Island-level adequacy indicators, selected years

Year	PR spending per pupil	U.S. spending per pupil	PR ÷ U.S.	Commonwealth revenue per pupil	Federal revenue per pupil	Federal share	Pupils
2008–09	$6,955	$10,540	0.66	$4,890	$2,137	30%	503,635
2011–12	$7,403	$10,667	0.69	$4,907	$2,547	34%	452,740
2013–14	$8,281	$11,066	0.75	$5,407	$2,900	35%	423,934
2015–16	$7,821	$11,841	0.66	$5,065	$2,509	33%	379,818
2016–17	$7,639	$12,258	0.62	$5,159	$2,563	33%	365,181
2017–18	$6,598	$12,649	0.52	$4,607	$2,281	33%	346,096
2018–19	$7,877	$13,212	0.60	$5,276	$3,121	37%	307,282
2019–20	$7,223	$13,520	0.53	$5,113	$2,449	32%	292,518
2020–21	$7,610	$14,302	0.53	$5,903	$2,720	32%	276,413
2021–22	$11,186	$15,618	0.72	$5,401	$5,022	48%	259,535

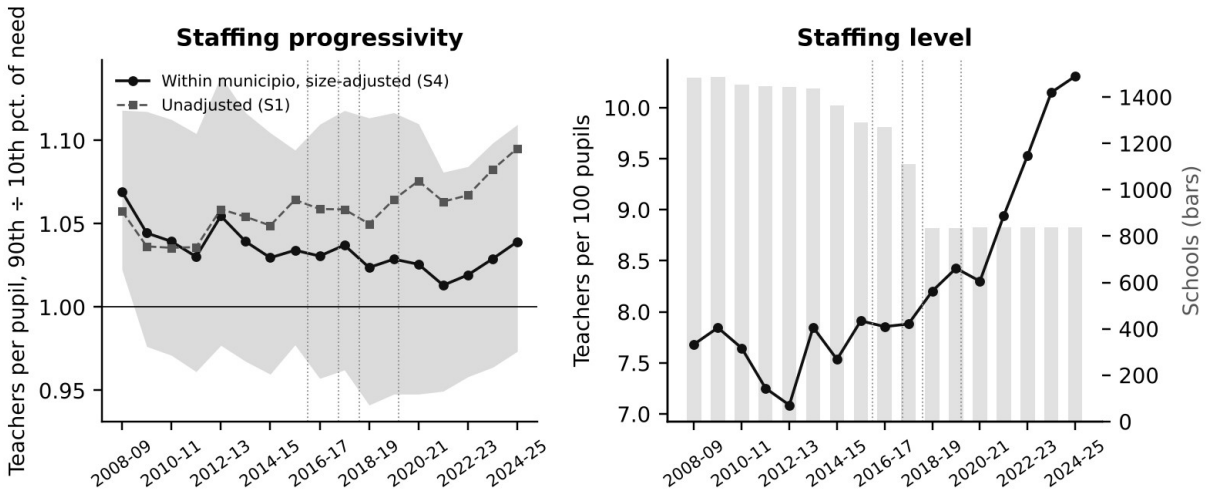
Note: Current expenditures and revenues per member, nominal dollars. Source: NCES National Public Education Financial Survey.

Puerto Rico spent 66% of the U.S. average per pupil in 2008–09 (Figure 2, Table 5). The ratio rose to 75% in 2013–14, mostly because enrollment fell faster than spending, and then declined for four consecutive years, to 66% in the year PROMESA was enacted and 52% in 2017–18. In nominal terms, spending per pupil fell from $8,281 to $6,598 while the U.S. average rose from $11,066 to $12,649. Commonwealth revenue per pupil fell from $5,159 to $4,607 in the hurricane year, despite the loss of nearly 20,000 pupils.

Spending remained near 53% of the U.S. level through 2020–21 and then jumped to 72% in 2021–22. The increase was federal: federal revenue per pupil nearly doubled to $5,022, and the federal share of revenue reached 48%, against 14% in the states. The school-level spending data in Section 6.3 show the same pattern continuing after 2021–22, with federal funds accounting for most of the growth in spending through 2023–24. Much of that federal money was temporary pandemic and disaster aid, so the recovery is fragile. These comparisons are in nominal dollars and are not adjusted for differences in labor costs between Puerto Rico and the states; Section 6.7 shows that this matters a great deal.

6.3 The distribution of resources

Figure 3. Staffing progressivity and staffing levels, 2008–09 to 2024–25



Note: Left, ratio of predicted teachers per pupil at the 90th and 10th percentiles of need, with 95% confidence band (S4: municipio fixed effects, size, phase and rurality) and the unadjusted ratio (S1). Right, pupil-weighted mean teachers per 100 pupils; bars show the number of schools.

Table 6. Staffing progressivity by year: teachers per pupil at the 90th relative to the 10th percentile of need

Year	S1 ratio	S4 ratio	95% CI (S4)	Teachers per 100	Schools	Pupils
2008–09	1.058	1.069	[1.022, 1.118]	7.68	1,482	501,327
2009–10	1.036	1.044	[0.976, 1.117]	7.84	1,486	492,922
2010–11	1.036	1.039	[0.971, 1.113]	7.64	1,454	472,923
2011–12	1.036	1.030	[0.961, 1.104]	7.25	1,448	452,556
2012–13	1.059	1.055	[0.977, 1.138]	7.09	1,442	434,532
2013–14	1.054	1.039	[0.967, 1.117]	7.85	1,437	423,827
2014–15	1.049	1.030	[0.960, 1.105]	7.53	1,364	410,748
2015–16	1.064	1.034	[0.977, 1.094]	7.91	1,292	378,102
2016–17	1.059	1.031	[0.957, 1.110]	7.86	1,271	365,134
2017–18	1.059	1.037	[0.962, 1.118]	7.88	1,111	346,074
2018–19	1.050	1.024	[0.941, 1.114]	8.20	836	307,202
2019–20	1.065	1.029	[0.948, 1.117]	8.43	836	292,138
2020–21	1.076	1.026	[0.948, 1.110]	8.30	838	276,130
2021–22	1.063	1.013	[0.950, 1.081]	8.94	837	258,308
2022–23	1.067	1.019	[0.958, 1.084]	9.53	839	248,099
2023–24	1.083	1.029	[0.964, 1.098]	10.15	838	237,682
2024–25	1.095	1.039	[0.973, 1.110]	10.31	839	230,835
Pooled, 2008–09 to 2016–17		**1.036**				
Pooled, 2017–18 to 2024–25		**1.041**				
Change in need gradient, δ (s.e.)		**0.0023 (0.0047)**	**p = 0.63**			

*Note: S1 controls for phase only. S4 adds log enrollment and its square, a rural indicator and municipio fixed effects. Regressions weighted by enrollment; standard errors clustered by municipio. Pooled rows from equation (2), evaluated at the 2016–17 need distribution. * p<0.05, ** p<0.01, *** p<0.001.*

Teacher staffing was barely related to need in any year (Figure 3, Table 6). The size-adjusted S4 ratio ranged from 1.013 to 1.069; only in 2008–09 does the 95% confidence interval exclude 1. In pooled estimates, the ratio was 1.036 before 2017–18 and 1.041 after, and the change in the need gradient is small and statistically insignificant (p = 0.63). The shocks of 2016–2018 changed the level of staffing, not its distribution. As enrollment fell faster than the teaching force, teachers per 100 pupils rose from 7.86 in 2016–17 to 10.31 in 2024–25, a 31% increase that was spread evenly across schools regardless of need.

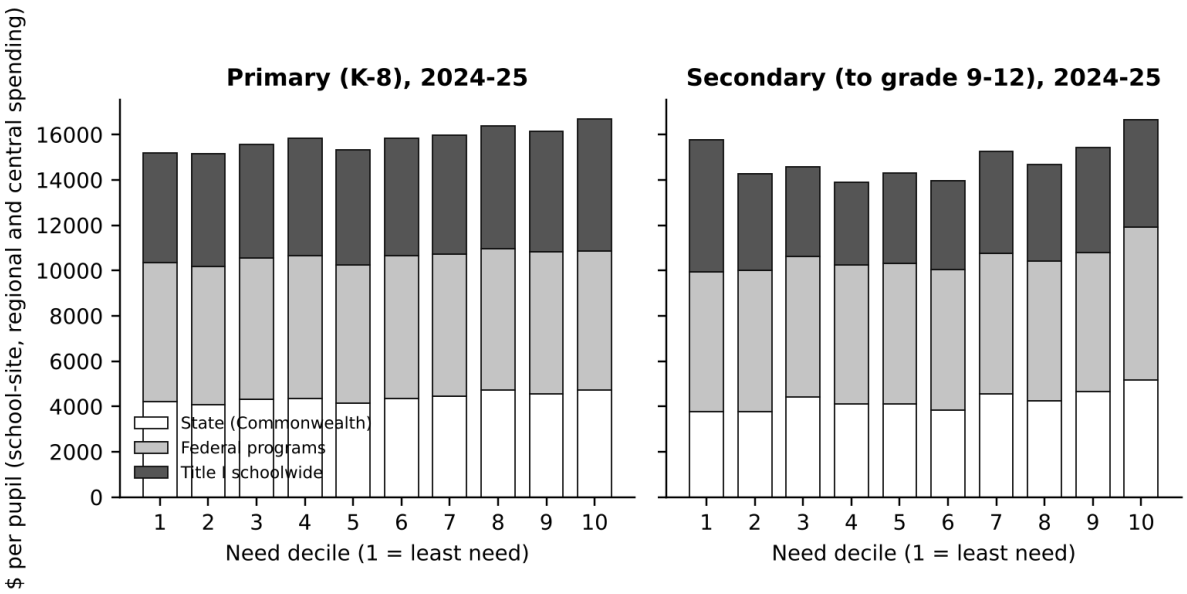
Table 7. Spending and staffing progressivity, 2019–20 to 2024–25: ratio at the 90th relative to the 10th percentile of need

Resource	S1	S2	S3	S4	S4 primary	S4 secondary
Total spending per pupil	1.030*	1.013	1.011	1.016	1.047***	0.990
School-site spending per pupil	1.084**	1.047	1.043	1.052	1.107***	0.984
Commonwealth-funded spending per pupil	1.030	1.014	1.012	1.010	1.070***	0.967
Federally funded spending per pupil	1.012*	1.009	1.009	1.011	1.015**	0.994
Title I schoolwide spending per pupil	1.067**	1.033	1.029	1.043	1.057**	1.046
Personnel spending per pupil	1.044*	1.018	1.014	1.024	1.070***	0.993
Non-personnel spending per pupil	1.011*	1.008	1.008	1.006	1.013**	0.990
Teachers per 100 pupils	1.072***	1.042*	1.040*	1.039	1.089***	1.038

*Note: 860 schools, 5,072 school-years. S1: need and year; S2: adds log enrollment and its square; S3: adds rurality and distance to the third-nearest school of the same phase; S4: adds municipio fixed effects. All models include Alianza, specialized and vocational indicators; all-school models include a secondary indicator. Significance of the need coefficient: * p<0.05, ** p<0.01, *** p<0.001.*

School-level spending, observable only from 2019–20, tells the same story (Table 7). Once size is held constant, total spending per pupil at the 90th percentile of need is only 1.6% higher than at the 10th, and school-site spending 5.2% higher; neither is statistically distinguishable from zero. Modest progressivity in primary schools (4.7% in total spending, 10.7% at the school site) is offset in secondary schools, where Commonwealth-funded resources are slightly lower in high-need schools (ratio 0.967). This is the sector where need most strongly predicts outcomes. Much of the apparent unadjusted progressivity reflects the fact that high-need schools are smaller; once size is controlled (S2), most of it disappears.

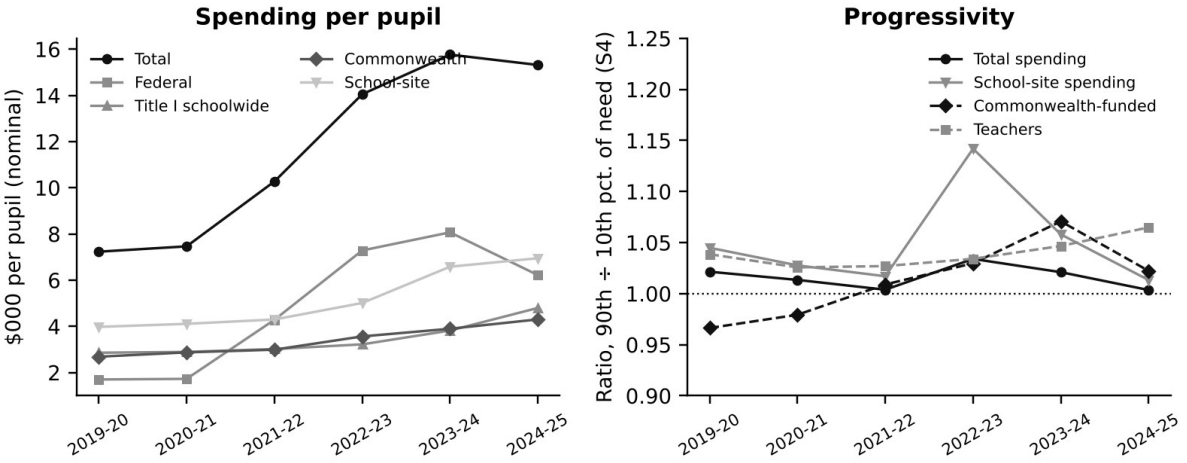
Figure 4. Spending per pupil by need decile and source of funds, 2024–25



Note: Pupil-weighted means. Total spending includes regional and central spending allocated to schools by PRDE.

No funding source is meaningfully targeted (Figure 4). Federal program funds, the largest source in 2024–25 at $6,219 per pupil, are spread almost evenly (S4 ratio 1.01). Title I schoolwide funds ($4,797) are mildly progressive (1.04). Commonwealth funds ($4,301) are progressive in primary schools (1.07) and regressive in secondary schools (0.97). Without controls for size, every source looks more progressive, because high-need schools are smaller: the highest-need tenth of schools averages 273 students, against 411 in the lowest-need tenth, and small schools spend more per pupil whatever their students' needs.

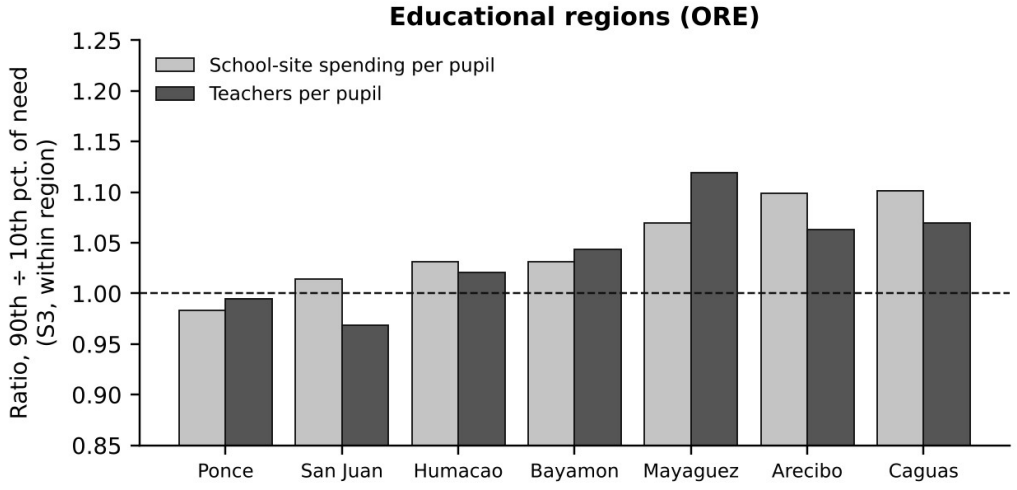
Figure 5. School spending per pupil and progressivity by year, all schools, 2019–20 to 2024–25



Note: Left, pupil-weighted mean spending per pupil by source of funds, nominal dollars. Right, ratio of predicted resources at the 90th and 10th percentiles of need, S4.

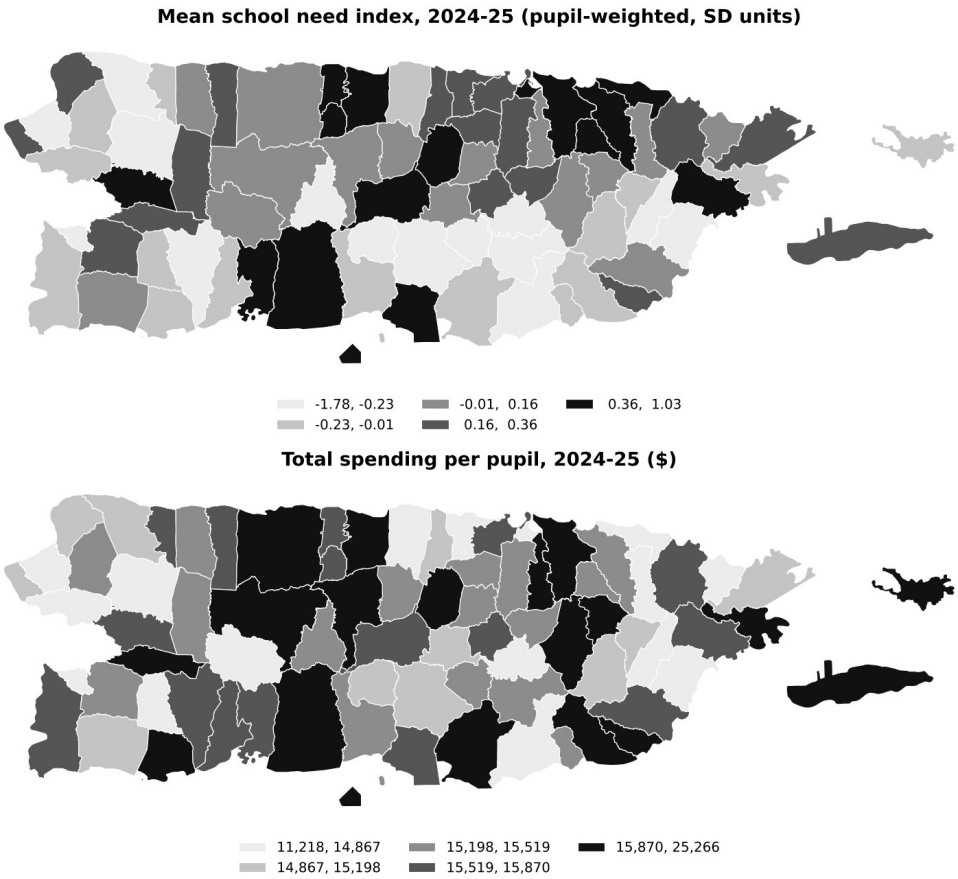
Spending per pupil more than doubled in six years, from $7,233 in 2019–20 to $15,764 in 2023–24, as federal relief arrived and enrollment fell from 292,518 to 235,819 (Figure 5). Federally funded spending per pupil rose from $1,700 to $8,069; Commonwealth-funded spending from $2,686 to $3,896. The S4 ratio for total spending was 1.02 in 2019–20 and 1.00 in 2024–25, and never exceeded 1.03. The largest infusion of resources in the system's recent history was distributed without regard to need.

Figure 6. Progressivity of school-site spending and teachers per pupil by educational region (S3), 2019–20 to 2024–25



The pattern holds within each of PRDE's seven educational regions (Figure 6). The school-site spending ratio ranges from 0.98 in Ponce to 1.10 in Caguas, and total spending per pupil differs little between regions. Holding need and location constant, vocational schools spend 2.5% less per pupil than regular schools and specialized schools 1.3% less. The 14 Alianza schools report 22% lower total spending, though some operator spending may sit outside PRDE's accounts. Geographically, the municipios with the highest mean need are not those with the highest spending (Figure 7).

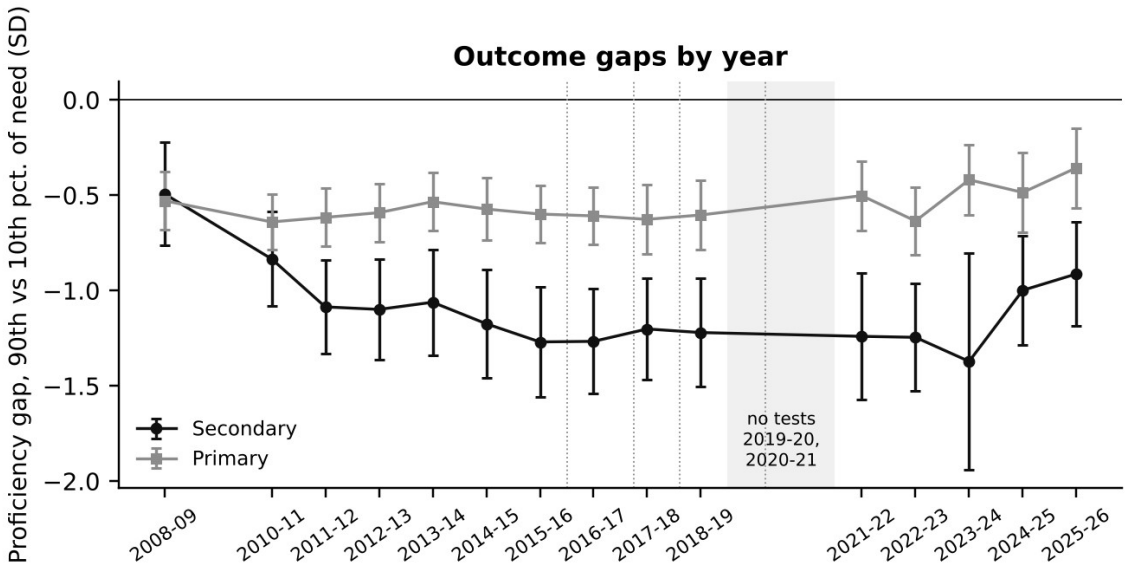
Figure 7. Mean school need and total spending per pupil by municipio, 2024–25



Note: Pupil-weighted means of schools in each municipio, in quintiles. Mona Island is omitted.

6.4 Outcome gaps

Figure 8. Proficiency gap between schools at the 90th and 10th percentiles of need, by phase, 2008–09 to 2025–26



Note: Gap in within-year standard deviations of the school proficiency index (Spanish and mathematics), with 95% confidence intervals. Shaded area marks years without statewide testing.

Table 8. Outcome gaps between high- and low-need schools by year (standard deviations)

Year	Primary gap (s.e.)	Primary schools	Secondary gap (s.e.)	Secondary schools
2008–09	-0.53 (0.08)	1,151	-0.49 (0.14)	333
2010–11	-0.64 (0.07)	1,110	-0.83 (0.13)	324
2011–12	-0.62 (0.08)	1,111	-1.09 (0.13)	329
2012–13	-0.59 (0.08)	1,106	-1.10 (0.13)	325
2013–14	-0.53 (0.08)	1,048	-1.06 (0.14)	314
2014–15	-0.57 (0.08)	996	-1.17 (0.15)	308
2015–16	-0.60 (0.08)	963	-1.27 (0.15)	303
2016–17	-0.61 (0.08)	801	-1.27 (0.14)	282
2017–18	-0.63 (0.09)	565	-1.20 (0.14)	269
2018–19	-0.60 (0.09)	563	-1.22 (0.15)	229
2021–22	-0.50 (0.09)	563	-1.24 (0.17)	269
2022–23	-0.64 (0.09)	566	-1.25 (0.14)	271
2023–24	-0.42 (0.09)	562	-1.37 (0.29)	113
2024–25	-0.49 (0.11)	565	-1.00 (0.15)	267
2025–26	-0.36 (0.11)	563	-0.91 (0.14)	264

Note: Gap = $\theta_t(N_{90} - N_{10})$ from a weighted regression of the proficiency index on need, by year and phase. Heteroskedasticity-robust standard errors. Schools with at least 10 students tested.

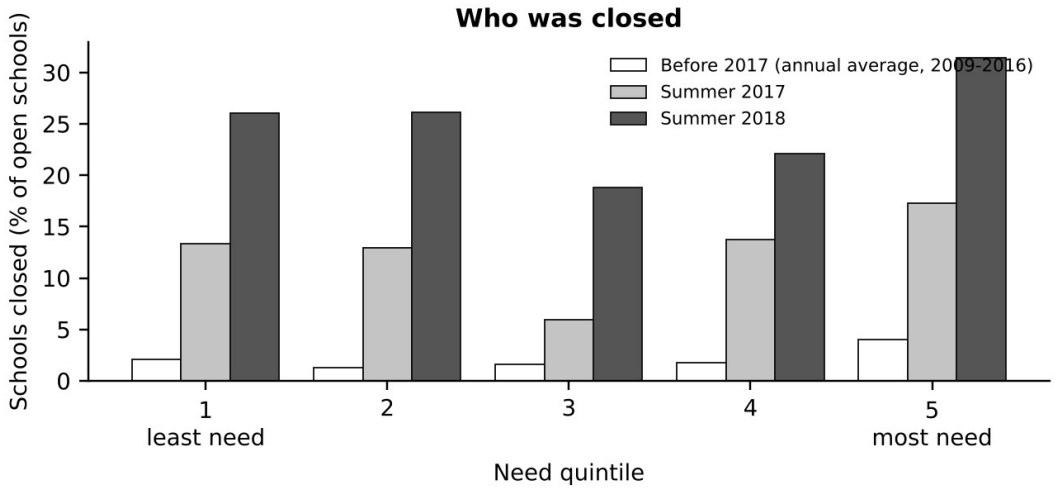
Outcome gaps behaved differently by phase (Figure 8, Table 8). In secondary schools the gap between high- and low-need schools widened from 0.49 standard deviations in 2008–09 to 1.09 in 2011–12 and 1.27 in 2015–16, an increase of more than half that took place during the fiscal crisis and before the hurricane. It then held between 1.2 and 1.4 standard deviations through 2023–24 and narrowed to 0.91 in 2025–26. Primary gaps were smaller and stable, between 0.36

and 0.64. The 2008–09 secondary estimate rests on a different test and on need measured largely from later years, so the magnitude of the early widening should be read with caution, but its direction is consistent across the 2010–11 to 2015–16 estimates, which share a test.

The timing matters for interpretation. The secondary gap widened while spending relative to the states first rose and then fell, and while the distribution of staffing across schools did not change. It did not widen further after María, the closures or Ley 85. Whatever drove the widening, it was not a shift in how resources were allocated across schools.

6.5 Who was closed

Figure 9. Share of schools closed by need quintile: annual average before 2017 and the 2017 and 2018 waves



Note: Closure is recorded when a school open in year t is closed or absent from the Common Core of Data in year t+1.

Table 9. Predictors of closure after 2016–17 and 2017–18

	Logit AME, need_fix	LPM, need_fix	Logit AME, need_t	LPM, need_t
Need index (SD)	-0.006 (0.010)	-0.018* (0.009)	0.021*** (0.006)	0.017** (0.006)
Log enrollment	-0.300*** (0.015)	-0.311*** (0.014)	-0.299*** (0.015)	-0.301*** (0.014)
Rural school	-0.094*** (0.029)	-0.095*** (0.029)	-0.093** (0.030)	-0.089** (0.030)
María exposure (SD)	-0.038*** (0.010)	-0.039*** (0.009)	-0.034*** (0.010)	-0.035*** (0.009)
2018 wave	0.150*** (0.012)	0.152*** (0.014)	0.145*** (0.012)	0.149*** (0.014)
Schools-years	2,385	2,385	2,385	2,385

*Note: Dependent variable = 1 if the school closed after the year. Average marginal effects (logit) and coefficients (linear probability model); standard errors clustered by municipio in parentheses. need_fix: school-average need; need_t: year-specific need. * p<0.05, ** p<0.01, *** p<0.001.*

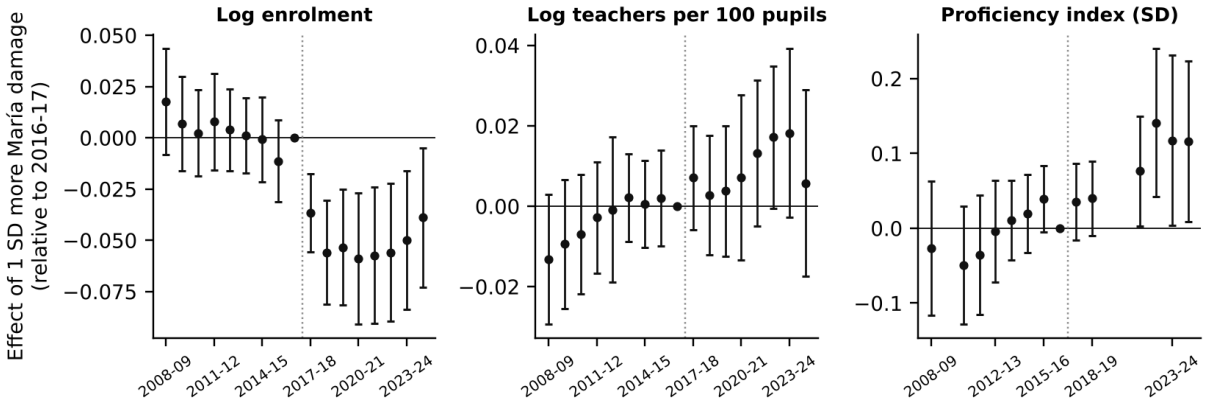
Before 2017, between 1% and 4% of schools closed each year. The Common Core of Data records 161 closures after 2016–17 and 277 after 2017–18 (official announcements differ slightly

because of reporting timing). In raw terms the highest-need quintile had the highest closure rates in both waves (17% and 31%; Figure 9), but high-need schools were also smaller. Closed schools averaged 171 students in 2017–18, against 358 in schools kept open.

Size dominates the multivariate models (Table 9). Each log point of enrollment reduced the probability of closure by about 30 percentage points. Rural schools were about 9 points less likely to close, consistent with the absence of nearby consolidation options, and schools in more damaged municipios were about 4 points less likely to close per standard deviation of exposure. The need coefficient is small and its sign depends on the measure: slightly negative with the school-average index (-0.6 points in the logit, $p = 0.55$) and slightly positive with the year-specific index (2.1 points, $p < 0.001$). The closures were not targeted at high-need schools, but neither were high-need schools systematically protected; the consolidation was driven by building utilization.

6.6 Hurricane María

Figure 10. Event-study estimates: differential change in more damaged municipios relative to 2016–17



Note: Coefficients π_k from equation (6) with 95% confidence intervals. School and year fixed effects; weighted by enrollment (proficiency: students tested); standard errors clustered by municipio.

Table 10. Event-study coefficients: effect of one standard deviation more María exposure, relative to 2016–17

Year	Log enrollment	Log teachers per 100 pupils	Proficiency index (SD)
2008–09	0.018 (0.013)	-0.013 (0.008)	-0.027 (0.046)
2009–10	0.007 (0.012)	-0.009 (0.008)	—
2010–11	0.002 (0.011)	-0.007 (0.008)	-0.050 (0.040)
2011–12	0.008 (0.012)	-0.003 (0.007)	-0.036 (0.041)
2012–13	0.004 (0.010)	-0.001 (0.009)	-0.004 (0.035)
2013–14	0.001 (0.009)	0.002 (0.006)	0.011 (0.027)
2014–15	-0.001 (0.011)	0.001 (0.006)	0.020 (0.026)
2015–16	-0.011 (0.010)	0.002 (0.006)	0.039 (0.023)
2017–18	-0.037*** (0.010)	0.007 (0.007)	0.035 (0.026)
2018–19	-0.056*** (0.013)	0.003 (0.008)	0.040 (0.026)
2019–20	-0.053*** (0.014)	0.004 (0.008)	—
2020–21	-0.059*** (0.016)	0.007 (0.010)	—
2021–22	-0.057*** (0.017)	0.013 (0.009)	0.077* (0.037)
2022–23	-0.056** (0.017)	0.017 (0.009)	0.141** (0.050)
2023–24	-0.050** (0.017)	0.018 (0.011)	0.117* (0.058)
2024–25	-0.039* (0.017)	0.006 (0.012)	0.116* (0.055)
Schools	1,524	1,524	1,462

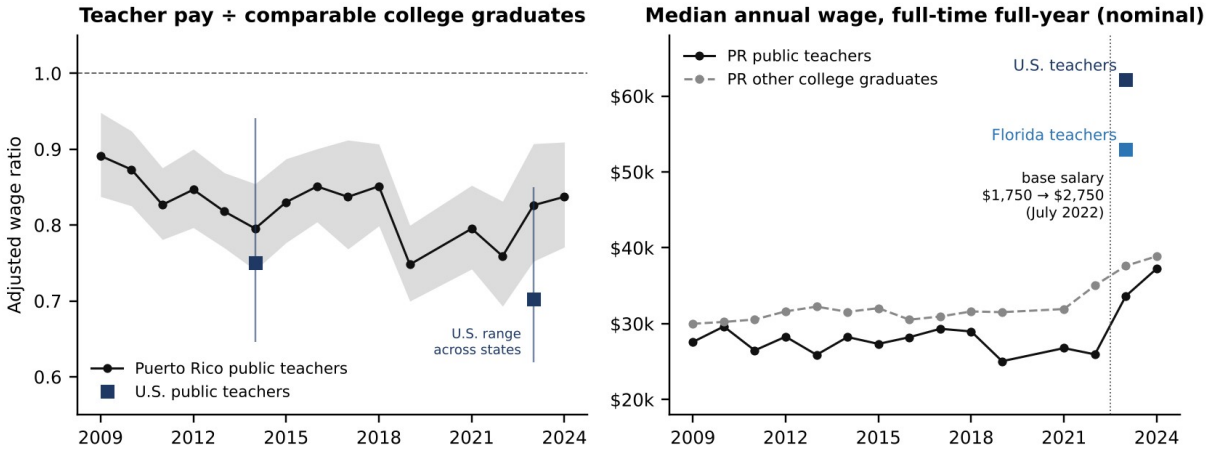
*Note: Omitted year 2016–17. Standard errors clustered by municipio in parentheses. — = no assessment. * p<0.05, ** p<0.01, *** p<0.001.*

María's damage left a sharp and lasting mark on enrollment (Figure 10, Table 10). Before the storm, enrollment trends in more and less damaged municipios were close to parallel; the pre-period coefficients are small and individually insignificant, though they drift down slightly. After the storm, schools in a municipio one standard deviation more damaged lost an additional 3.7% of enrollment in 2017–18 and 5.6% by 2018–19. The gap persisted through 2024–25, when it was still 3.9%. The pattern is consistent with permanent out-migration from the hardest-hit areas rather than temporary displacement.

Teachers per pupil did not change differentially. Because enrollment fell more in damaged areas while staffing fell proportionately, the coefficients are close to zero in every year, with a slight upward drift that predates the storm. Proficiency rose in more damaged municipios after the storm, by 0.14 standard deviations by 2022–23. But the pre-period coefficients rise steadily from -0.05 in 2010–11 to 0.04 in 2015–16, signaling convergence that began years before María. Section 7 shows that this apparent effect disappears once municipal trends are absorbed.

6.7 Teacher wages and the competitive-wage benchmark

Figure 11. Teacher wages relative to comparable college graduates, and median wages, 2009–2024



Note: Left, adjusted ratio exp(ρ) from equation (5) for Puerto Rico public school teachers by survey year, with 95% confidence band; squares show U.S. public school teachers, and vertical lines the range across states with at least 100 sampled teachers. Right, weighted median annual wages of full-time, full-year workers with a bachelor's degree or more, nominal dollars. No standard 1-year file was released for 2020. Source: ACS and PRCS 1-year PUMS.

Table 11. Public school teacher wages relative to comparable college graduates, Puerto Rico and the United States

Period	Public teachers (n)	Median public teacher wage	Median other college graduate wage	Raw ratio	Raw ratio to professional occupations	Adjusted ratio (s.e.)	Private teachers, adjusted ratio
2009–2013	1,067	$27,586	$30,547	0.90	0.77	0.852 (0.012)	0.67
2014–2016	480	$28,212	$31,540	0.89	0.78	0.827 (0.016)	0.69
2017–2019	430	$27,880	$31,347	0.89	0.77	0.812 (0.017)	0.63
2021–2022	268	$26,058	$33,354	0.78	0.66	0.779 (0.023)	0.60
2023–2024	254	$34,868	$38,334	0.91	0.78	0.829 (0.027)	0.68
United States, 2014	22,150	$50,421	$68,573	0.74	0.67	0.750 (0.003)	0.70
United States, 2023	27,111	$62,191	$88,698	0.70	0.64	0.702 (0.003)	0.64

Note: Full-time, full-year wage and salary workers aged 22–64 with a bachelor's degree or more. Medians pool survey years in each period and are in each year's dollars. Raw ratio: median public teacher wage ÷ median wage of college graduates outside education occupations. Professional occupations: management, business, science and arts occupations outside education. Adjusted ratio: exp(ρ) from equation (5) with survey-year effects; delta-method standard errors. Source: ACS and PRCS 1-year PUMS.

Teacher pay followed the austerity timeline closely (Figure 11, Table 11). The statutory base salary for public school teachers was $1,750 a month and did not change for thirteen years (NBC News, 2022). Median annual wages of full-time public school teachers were essentially flat in nominal terms, $27,586 in 2009–2013 and $26,058 in 2021–2022, a real decline of roughly a quarter given U.S. consumer price inflation of about 25% between the midpoints of the two periods. Wages of other college graduates in Puerto Rico also stagnated, but less, so the adjusted ratio of teacher pay to that of comparable college graduates fell from 0.85 to 0.78.

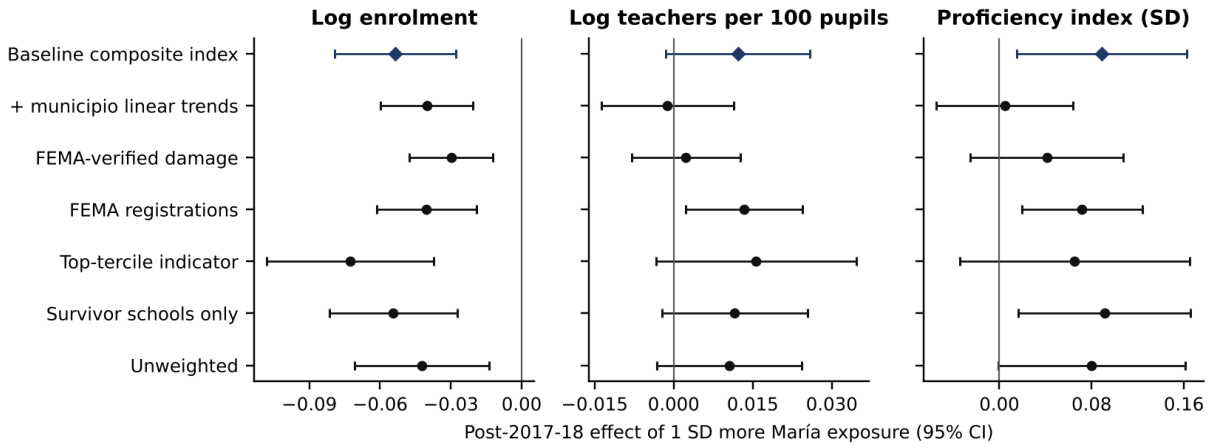
In February 2022, after a walkout by most of the island's public school teachers, the governor announced a $1,000 monthly raise, effective July 2022, lifting the base salary from $1,750 to $2,750; for its first months, $765 of the $1,000 came from federal ESSER pandemic funds (Guillama, 2022), and legislation enacted in March 2022 made the higher base permanent. The raise is visible in the microdata: the median rose to $34,868 in 2023–2024, and the adjusted ratio recovered to 0.83. Like the recovery in spending, the recovery in pay was initially financed with temporary federal money.

Two comparisons put these ratios in context. Relative to their own labor market, Puerto Rico's public school teachers fare better than U.S. teachers. The adjusted U.S. ratio was 0.75 in 2014 and 0.70 in 2023, close to the 26.6% teacher wage penalty estimated by Allegretto (2024) from different data, and across states it ranged from 0.62 to 0.85 in 2023, with a median of 0.73; Puerto Rico's 0.83 would place it near the top. Private school teachers on the island, who make up about 30% of teachers in the sample, earn far less (0.68), so public teaching is the better-paid option locally. In absolute terms, however, the gap is enormous. The median public school teacher in Puerto Rico earned $34,868 in 2023–2024, against $62,191 in the United States and $53,015 in Florida, a leading destination of Puerto Rican migrants after María. Puerto Rican teachers are U.S. citizens and can move to mainland classrooms without restriction, so the local market is not the only one that matters for recruitment and retention.

The wage evidence changes how the island-level spending comparison in Section 6.2 should be read. In 2021–22 Puerto Rico spent 72% of the U.S. average per pupil, but it employed 8.9 teachers per 100 pupils against about 6.5 in the states, roughly 1.37 times as many. Spending per teacher was therefore about 0.52 of the U.S. level, close to the ratio of median teacher pay (0.56). The nominal shortfall is a price gap, not a quantity gap. Wages of comparable college graduates in Puerto Rico are about 43% of the U.S. level. If the labor share of current spending is about 80% and labor costs are adjusted by that comparable-wage ratio, Puerto Rico's spending per pupil would be about 1.31 times the U.S. average rather than 0.72. That calculation is illustrative, not a cost estimate, and adequacy depends on the cost of reaching outcome goals given students' needs, which are far greater in Puerto Rico than in the states. But it means the island's problem is less a shortage of resources at local prices than the combination of resources that do not follow need, outcome gaps that are very large, and teacher pay that is competitive locally but not with the mainland.

7. Robustness

Figure 12. Pooled post-María estimates across specifications



Note: Coefficient on exposure × post-2017–18 with school and year fixed effects; 95% confidence intervals; standard errors clustered by municipio.

Table 12. Pooled difference-in-differences estimates under alternative specifications

Specification	Log enrollment	Log teachers per 100	Proficiency (SD)
Baseline composite index	-0.054*** (0.013)	0.012 (0.007)	0.089* (0.038)
Baseline + municipio linear trends	-0.040*** (0.010)	-0.001 (0.006)	0.005 (0.030)
FEMA-verified damage per resident	-0.030*** (0.009)	0.002 (0.005)	0.041 (0.034)
FEMA registrations per 100 residents	-0.040*** (0.011)	0.013* (0.006)	0.072** (0.027)
Top-tercile exposure indicator	-0.073*** (0.018)	0.016 (0.010)	0.065 (0.051)
Surviving schools only (open 2015–16 to 2024–25)	-0.054*** (0.014)	0.012 (0.007)	0.091* (0.038)
Unweighted	-0.042** (0.015)	0.011 (0.007)	0.080 (0.041)

*Note: Coefficient on exposure × Post$_t$ (2017–18 and later), school and year fixed effects, standard errors clustered by municipio in parentheses. Continuous exposure measures standardized across municipios. Surviving-school sample: 813 schools. * p<0.05, ** p<0.01, *** p<0.001.*

Table 12 and Figure 12 report pooled estimates under alternative specifications. The enrollment effect is robust. It is negative and significant under every exposure measure, ranging from -0.030 (verified damage) to -0.073 (top-tercile indicator), survives the inclusion of municipio-specific linear trends (-0.040), and is essentially unchanged in the sample of schools that remained open throughout (-0.054), so it is not an artifact of closures.

The staffing estimates are small throughout and lose any hint of significance once municipal trends are included (-0.001). The proficiency estimates are fragile. The baseline pooled effect of 0.089 falls to 0.005 with municipio trends; it is insignificant with verified damage and with the top-tercile indicator; and in the surviving-school sample the event-study coefficients rise from -

0.05 in 2010–11 to 0.05 in 2015–16 before the storm. The evidence does not support a causal effect of María on relative test performance in either direction.

Effects did not differ detectably by school need. In models adding exposure × post × need, the triple interaction is small and insignificant for enrollment (-0.020, s.e. 0.013), staffing (0.004, s.e. 0.008) and proficiency (-0.025, s.e. 0.037) (Appendix Table A2). The same models show that, island-wide, high-need schools lost more enrollment after 2017–18 than low-need schools (-0.058 per SD of need), gained slightly in teachers per pupil (0.022) and gained in relative proficiency (0.072), the last consistent with the narrowing of secondary gaps in the final years.

Finally, the staffing results do not depend on how need is measured (Appendix Table A1). With the year-specific index, the S4 ratio ranges from 0.969 to 1.104 across years and the pooled change after 2017–18 is -0.0028 ($p = 0.53$); with the pre-2017 index the ratios are 1.054 before and 1.055 after ($p = 0.95$).

8. Discussion

8.1 Adequacy and distribution moved independently

The central pattern is a sharp contrast between levels and distribution. Over a decade in which island-wide spending relative to the states fell by nearly a third in nominal terms and then recovered on federal money, in which teacher base pay was frozen for thirteen years, in which half the school network closed and half the students left, and in which the governing statute was rewritten to require per-student budgeting "by equity standards," the relationship between resources and need across schools barely moved. In a single-district system this is a policy choice. PRDE allocates teachers and budgets centrally; nothing in local tax bases constrains how it distributes them. The persistence of a flat gradient through every shock suggests that it is the default output of an allocation process driven by enrollment and building utilization, not a deliberate distributive choice, and that neither crisis nor reform was used to change it.

The flat gradient matters because need is unusually predictive in Puerto Rico's secondary schools. The economically disadvantaged share alone explains more than 40% of the variation in secondary proficiency, and the gap between schools at the 90th and 10th percentiles of need is about 1.6 standard deviations in recent years. Resources that do not rise with need cannot be

expected to narrow gaps of that size. That the secondary gap widened substantially during the fiscal crisis, while resources stayed flat, is consistent with a system in which high-need schools bore the consequences of declining adequacy without any compensating allocation, though the design here cannot establish that link causally.

8.2 Implications for cost modeling

The findings bear on Step 2 of the framework, estimating the cost of common outcome goals, in five ways. First, a cost model needs a goal expressed in measured outcomes, and the current gaps frame the choice. In 2024–25, 57% of students in the lowest-need tenth of secondary schools were proficient in mathematics, against 25% in the highest-need tenth. The goal could be the outcomes currently achieved by low-need schools, which defines equal opportunity within Puerto Rico; a fixed proficiency rate, which defines adequacy in absolute terms; or a benchmark shared with other systems, which would place Puerto Rico on the cross-national adequacy scale. The choice is a policy and potentially a constitutional judgment: §5's goal of "the full development of the personality" is broader than any test, but proficiency on META-PR is its measurable core.

Second, weights should be derived from the outcome relationship, not from counts of eligible students. Poverty weights, the usual instrument, are blunt in a population where nearly every student is poor: the economically disadvantaged share ranges only from about 77% at the 10th percentile of need to 91% at the 90th, so a weight on disadvantaged students would add almost as much to low-need schools as to high-need ones. A cost function does this systematically: it estimates how much more it costs to reach the goal as need rises, and the resulting cost index can be used directly as an allocation weight.

Third, the size of outcome gaps implies costs that exceed any plausible reallocation. Taking the Jackson and Mackevicius (2024) estimate of about 0.032 standard deviations per $1,000 per pupil sustained for four years at face value, closing half of the secondary gap of about 1.6 standard deviations would require on the order of $24,831 more per pupil in the highest-need schools. That is a crude extrapolation of a linear average effect, and a dollar buys more teacher time in Puerto Rico than in the states (Section 6.7), but it indicates the scale of the problem. Equity in outcomes cannot be achieved by redistribution alone at Puerto Rico's current level of spending; adequacy and equity have to be addressed together.

Fourth, the post-2018 period offers a warning about cost estimation in shrinking systems. Teachers per pupil rose by about a third as enrollment fell, mechanically raising measured resources without any policy decision. Cost functions estimated on such data will attribute to resources what is in part the fixed cost of a network that has not fully adjusted to demographic decline. School size and isolation must be modeled explicitly, as they are here, and estimates should be cautious about treating the most recent spending levels, inflated by temporary federal funds, as a baseline.

Fifth, any cost model for Puerto Rico must take a position on the relevant labor market. Measured against comparable local college graduates, public school teachers earn about 0.83 of the pay of similar workers, above the U.S. ratio and close to 0.84, the average ratio of teacher to professional wages among countries at or above the global median in learning-adjusted years of schooling, which serves as a global benchmark in cross-national estimates of the cost of a minimum education package (extending Baker, Angel-Urdinola & Zhorayev, in press), although the occupational definitions differ. A cost model that prices teachers at local competitive wages would find that labor in Puerto Rico costs roughly half what it does on the mainland. But the island's teachers can move to Florida or Texas and earn half again to nearly twice as much, and in 2019 the department identified positions in the island municipalities of Vieques and Culebra as hard to fill (Metro Puerto Rico, 2023). A defensible cost estimate should therefore model teacher pay explicitly, test whether shortages and turnover respond to the mainland wage gap, and treat the competitive wage as a range bounded by local and mainland benchmarks rather than a single number. Because Puerto Rico has a single island-wide salary scale, pay cannot be differentiated by school need or location without a policy change; staffing levels are the only lever the current system uses, and Section 6.3 shows they are not used progressively.

Puerto Rico's open data meet some requirements of an education cost function well and others poorly (Table 13). A cost function models spending per pupil as a function of outcomes, student need, input prices and structural cost factors, with controls for inefficiency and with outcomes treated as endogenous.

Table 13. Data requirements for an education cost function in Puerto Rico

Requirement	What is available openly	Assessment
Outcomes	META-PR proficiency rates by school and subgroup, 2018–19 and 2021–22 to 2025–26; no scale scores or growth measures published	Weak to moderate. Proficiency rates, not scores; primary results need an audit
Spending	PRDE audited spending per pupil by school, level and source of funds, about 850 schools, 2019–20 to 2024–25	Strong; allocated central and regional spending follows PRDE's method, and some spending is not assigned to schools
Need	Shares of tested students economically disadvantaged, with disabilities, Spanish learners, homeless; FRL; tract child poverty	Moderate. FRL is near its ceiling; the disadvantaged share is the usable measure
Input prices	Single island-wide teacher salary scale; no school-level pay published; Census microdata on local and mainland wages (Section 6.7)	Little variation within the island; the relevant labor market must be chosen
Structural costs	Enrollment, grades, rural zone, distance to nearest schools of the same phase, island municipios	Strong
Spending variation	With need, size, rurality, sparsity and municipio held constant, residual variation in school-site spending per pupil is about 20% (1 SD)	Sufficient
Instruments	The 2017–2018 consolidation (receiving-school enrollment shocks), federal relief allocation rules, Ley 85-2018 budgeting, hurricane damage	Promising but untested

Four steps would make a credible model possible: obtaining school-level scale scores and, ideally, student-level growth, and auditing primary results; estimating a secondary-school cost function first, where outcomes behave as expected, using the consolidation and federal relief rules as sources of variation in spending plausibly unrelated to school outcomes; modeling teacher pay against both local and mainland benchmarks; and expressing the resulting cost index as allocation weights to compare the cost of the chosen goal with current spending, school by school.

8.3 Implications for the constitutional right

Puerto Rico's §5 jurisprudence has addressed access: whether a closure "directly and substantially interferes" with a student's ability to attend school, and whether public funds may flow to private schools. The evidence here suggests that access was not where the system failed. Closures followed size, not need; the hurricane displaced students but did not change staffing relative to enrollment; and resources per pupil rose as the system shrank. The failures were in adequacy, where nominal spending fell to about half the U.S. level and teacher pay was frozen for thirteen years, and in distribution, where resources did not rise with need even as outcome gaps widened. Neither has been put to the Court.

A §5 adequacy or equity claim would face distinctive obstacles. The text's qualifier, "to the extent permitted by the facilities of the state," and Congress's deletion of §20 both cut against reading §5 as a guarantee of a particular resource level. Any remedy would run into a budget

certified by a federal oversight board under PROMESA, whose authority over Commonwealth budgets has been treated as paramount. And because federal funds now make up close to half of school revenue, the adequacy of the system depends heavily on federal formula decisions that Congress may make on a rational basis (Harris v. Rosario, 446 U.S. 651, 1980; United States v. Vaello Madero, 596 U.S. 159, 2022). The distributive question is different. The allocation of resources across schools is entirely within PRDE's control, is already required by statute to follow "equity standards," and could be measured and enforced using data the department already publishes. If §5 is to have content beyond access, the distribution of resources relative to need is the most tractable place for it to start.

9. Limitations

Several limitations qualify these conclusions. School-level spending is observable only from 2019–20, so the long-run distributional evidence rests on teacher staffing, which captures the largest component of school spending but not all of it. The need index relies on administrative poverty flags that were unreliable for three years and, in a population where most students are poor, discriminates over a narrow range. The proficiency measure spans several changes of assessment, so only within-year comparisons are meaningful. Hurricane exposure is measured at the municipio level, so the event study estimates average effects across schools within municipios, and schools near municipal boundaries may be misclassified. The enrollment effects at surviving schools combine out-migration and consolidation. The wage analysis rests on small survey samples of teachers, measures annual wages rather than total compensation (pensions, which were restructured during the crisis, are not observed), and uses nominal medians because no consistent Puerto Rico price index is applied; the labor-cost-adjusted spending comparison is an illustration, not a cost estimate. PRDE allocates central and regional spending to schools by its own method and leaves part of its spending unassigned to any school, and Alianza schools' spending may be incomplete; school-site spending is less affected. Need is measured among tested students, so untested grades and students taking alternate assessments are not represented, and the spending calibration in Section 8.2 is an illustration of scale, not a cost estimate. Finally, the design identifies María's differential local effects; the total effects of the hurricane and of austerity, which were island-wide, are not separately identified.

10. Conclusion

Between 2014 and 2022 Puerto Rico's public schools passed through fiscal collapse, federal oversight, a catastrophic hurricane, the closure of a third of the school network and a comprehensive reform statute. Nominal spending relative to the states fell from three-quarters to about half and recovered only on temporary federal funds, and teacher base pay was frozen for thirteen years until a raise financed at first with federal pandemic aid. Because labor is far cheaper on the island, much of that nominal gap reflects prices rather than resources: Puerto Rico employs more teachers per pupil than the states, and pays them well relative to local college graduates but far below what they could earn on the mainland. Enrollment in the hardest-hit municipios fell by an additional 5% per standard deviation of hurricane damage and did not recover. Through all of it, the distribution of teachers and spending across schools remained almost entirely unrelated to student need, and the large outcome gaps between high- and low-need secondary schools, which widened during the fiscal crisis, did not narrow until the most recent years. For a single-district system with a constitutional right to education and a statutory mandate for equity-based budgeting, the most immediately actionable finding is the last one: the distribution of resources is a choice, and it is one the system has not yet made.

Data Availability

All data used in this paper are public. A replication package with the analysis datasets (Stata .dta and CSV), extracts of the ACS and PRCS microdata used for the wage analysis, a codebook, Stata do-files reproducing every table and figure, and the Python scripts used to assemble the panel from source files accompanies this manuscript.

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Appendix

Table A1. Staffing progressivity under alternative need measures

Need measure	Ratio, pre	Ratio, post	δ (s.e.)	Range of annual S4 ratios	School-years
School-average need (baseline)	1.036	1.041	0.0023 (0.0047)	1.013 – 1.069	19,650
Year-specific need	1.035	1.029	-0.0028 (0.0045)	0.969 – 1.104	19,650
Pre-2017 need	1.054	1.055	0.0003 (0.0047)	1.030 – 1.099	19,643

Note: Equation (2) with S4 controls; ratios evaluated at the 2016–17 need distribution. Annual ratios from equation (1).

Table A2. Heterogeneity of María effects by school need

	Log enrollment	Log teachers per 100	Proficiency (SD)
Exposure × post	-0.054*** (0.013)	0.013 (0.007)	0.096* (0.037)
Need × post	-0.058*** (0.012)	0.022*** (0.007)	0.072** (0.025)
Exposure × post × need	-0.020 (0.013)	0.004 (0.008)	-0.025 (0.037)
School-years	19,653	19,649	15,505

*Note: School and year fixed effects; standard errors clustered by municipio. * p<0.05, ** p<0.01, *** p<0.001.*

Table A3. Hurricane exposure measures across municipios

Measure	Mean	SD	Min	Max
FEMA-verified damage per resident ($)	616	376	93	2,340
IHP assistance per resident ($)	495	220	119	1,000
Registrations per 100 residents	34.5	2.9	29.5	44.2

Note: 78 municipios, unweighted. Correlations: damage–registrations 0.31; damage–IHP 0.94; registrations–IHP 0.35. Source: FEMA OpenFEMA Housing Assistance (owners and renters), DR-4339; ACS 2017 population.