School Funding Effectiveness

Evidence From California's Local Control Funding Formula

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LEARNING POLICY INSTITUTE

AUGUST 2023

Acknowledgments

The author thanks the California Department of Education (CDE); Policy Analysis for California Education (PACE); and Linda Darling-Hammond, President and CEO of the Learning Policy Institute (LPI), for their partnership and support. The author is grateful for excellent research assistance provided by Joaquin Fuenzalida. In addition, the author thanks the members of the LPI Communications team for their invaluable support in editing, designing, and disseminating this report. Without their generosity of time and spirit, this work would not have been possible.

This research was supported by the William T. Grant Foundation; PACE; and a University of California, Berkeley (UC Berkeley) Population Center pilot grant. Core operating support for LPI is provided by the Heising-Simons Foundation, William and Flora Hewlett Foundation, Raikes Foundation, Sandler Foundation, and MacKenzie Scott. LPI is grateful to them for their generous support. The ideas voiced here are those of the author and not those of our funders.

The restricted-use administrative data used for this project was obtained under a special data-use agreement with the CDE, LPI, and UC Berkeley.

This study benefited from the insights and helpful feedback received from David Card, Avi Feller, Austin Land, Anne Podolsky, Sophia Rabe-Hesketh, Sean Reardon, Sarah Reber, Jesse Rothstein, and other UC Berkeley economics seminar participants, as well as those at Dartmouth College, Duke University, Harvard University, Princeton University, the University of Pennsylvania, the University of Texas at Austin, and Yale University.

Suggested citation: Johnson, R. C. (2023). *School funding effectiveness: Evidence from California's local control funding formula*. Learning Policy Institute. https://doi.org/10.54300/529.194

This report can be found online at https://learningpolicyinstitute.org/product/school-funding-effectiveness-ca-lcff.

Document last revised August 28, 2023

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Executive Summary

In 2013, California implemented an ambitious school funding reform, the Local Control Funding Formula (LCFF), which allocates state funding by the proportion of unduplicated "high-need" students in the district: those from low-income families, English learners, and those in foster care. The goal of LCFF was to reduce academic achievement gaps between socioeconomically disadvantaged children and their more advantaged counterparts by committing $18 billion in increased state support, allocated based on pupil needs, to be incrementally distributed over 8 years. This reform was distinctive in two ways. First, its multiyear design pre-committed funds, so districts were assured this would not be a temporary, reversible change. This commitment enabled districts to plan long-term, transformative initiatives rather than one-off expenditures. Second, the funding came with minimal restrictions on how schools could use it, giving fiscal sovereignty to districts.

This study investigates the impacts of LCFF-induced increases in per-pupil spending on student achievement and behavioral and attainment outcomes. To examine the impact of increased funding on student outcomes, I linked district- and school-level information on school resources and per-pupil spending with longitudinal student data for the full universe of public school students in California who were first observed in kindergarten and followed as they progressed through the K–12 school system. This student-level data included 6.2 million K–12 students in each year studied. My analyses span the school years 1995–96 through 2018–19 across the 10,000 schools and 1,000 districts in the state but focus particular attention on the rollout period of LCFF implementation from 2013 through 2019.

I exploited the staggered timing of implementation of the progressive funding formula to isolate policy-induced changes in school spending across cohorts and districts at each grade (K–12). Using quasi-experimental methods (2SLS-IV, difference-in-difference, and regression kink designs) to facilitate causal inference, I analyzed the causal effects of public K–12 school spending on student achievement. This is the first comprehensive study of LCFF impacts on student outcomes across all grades. Results include impacts on math and reading achievement on standardized tests in grades 3–8 and 11, grade repetition, high school graduation rates, college readiness, and suspensions and expulsions. It also investigates which uses of funding are most strongly associated with improved student outcomes.

This analysis resulted in the following five key findings:

1. **LCFF improved students' math and reading achievement.** Analyses find positive and significant effects of LCFF-induced increases in per-pupil spending on academic achievement in math and reading in every grade assessed (3rd–8th and 11th) and for every school that experienced this new infusion of state funds, which targeted lower-income districts and students from low-income families. The positive impacts on student achievement increased with school-age years

of exposure to the greater funding and with the amount of increased funding that occurred due to LCFF. The results indicate that a $1,000 increase in per-pupil spending experienced for 3 consecutive years led to a full grade-level improvement in both math and reading achievement, relative to what the average student achieved prior to the funding increases. These results are consistent across modeling strategies, providing confidence in the results. Further, a causal interpretation of the results is supported by the lack of significant spending effects found for "Basic Aid" districts (which were not subject to state school funding formulas) and the lack of any similar pattern found in the years preceding LCFF's implementation.

2. **LCFF reduced the probability of grade repetition.** LCFF-induced increases in school spending also led to significant reductions in the probability that a student would need to repeat a grade, particularly during elementary school. The results indicate that a $1,000 increase in per-pupil spending experienced for 3 consecutive years led to a 5 percentage-point reduction in the probability of students experiencing grade repetition by 3rd grade, a corresponding 5.1 percentage-point reduction by 4th grade, and a 5.3 percentage-point reduction in the likelihood of grade repetition by the end of elementary school (5th grade). These grade progression effects were likely enhanced by the coincident introduction of transitional kindergarten over this period.

3. **LCFF increased the likelihood of high school graduation and college readiness.** Analyses find the increase in school spending subsequently increased the likelihood of graduating from high school and college readiness. Students exposed to LCFF concentration funding displayed an increased likelihood of graduating from high school. For all student groups, a $1,000 increase in the average per-pupil spending experienced throughout one's high school years (grades 9–12) increased the likelihood of graduating from high school by 8.2 percentage points, on average. The estimated effect is strongest for Black students but is not statistically distinguishable from the large significant effects found for other subgroups.

   Furthermore, LCFF-induced increases in spending led to substantial improvements in college readiness among students in high school. In particular, the results indicate that a $1,000 increase in per-pupil spending experienced in 3 consecutive years of high school (grades 9–11) led to a 9.8 percentage-point increase in the likelihood of meeting college readiness standards in math and a 14.7 percentage-point increase in the likelihood of meeting college readiness standards in reading.

4. **LCFF decreased suspensions and expulsions.** LCFF-induced increases in school spending led to significant reductions in the annual incidence of suspensions and expulsions across all grades (3rd–10th), with effects greater for boys than girls and with larger effects in high school relative to elementary and middle

school. In particular, the results indicate, on average, that a $1,000 increase in per-pupil spending experienced for 3 consecutive years was associated with a 5 to 6 percentage-point reduction in the likelihood of being suspended or expelled in a given year of high school for boys and a 3 percentage-point reduction for girls. The impacts for Black students are striking and are the most pronounced. The evidence reveals that a $1,000 increase in per-pupil spending experienced for 3 consecutive years (grades 8–10) was associated with an 8 percentage-point reduction in the likelihood of suspension or expulsion in high school (10th grade) among Black boys and a 5 percentage-point reduction in the probability of suspension or expulsion for Black girls.

5. **LCFF-induced investments in instructional inputs were associated with improved student achievement.** Analyses find that increases in instructional expenditures appear to be the input associated with the largest consistent boost in student performance. The results reveal that roughly 84% of the variation in school spending effectiveness can be explained and is predominantly driven by the trio of combined funding impacts of class size reductions, teacher salary increases, and reductions in teacher turnover. Comporting with prior research, this analysis found these three school inputs—each related to the sustainment of a strong, stable teacher workforce—mattering the most.

The results garnered through this study show meaningful outcomes when sustained, multiyear funding reaches the classroom, particularly in high-need communities. The robustness of the significant positive effects of multiyear per-pupil spending on all student outcomes measured for each grade and subject across different models and subgroups provides compelling causal evidence that the estimated impacts are not driven by any single group of students or districts, nor confined to a single outcome, but rather reflect a general pattern that school spending matters. For student success, instructionally focused dollars matter more than others, and systematic spending practices of school districts can shape student achievement trajectories.

These findings from one of the nation's largest and most diverse state public education system may be instructive for other states looking to improve education outcomes. They show that long-term, increased funding matters and can improve student achievement and attainment and increase the benefits of providing additional resources to districts and schools serving high-need students.

Introduction

In 2013, California implemented one of the most ambitious school funding reform efforts the state had experienced in a generation, the Local Control Funding Formula (LCFF). The goal of LCFF was to reduce academic achievement gaps between children from socioeconomically disadvantaged families and their more advantaged counterparts by committing $18 billion in increased state support, distributed incrementally over 8 years, based on pupil needs. This reform was distinctive in two ways. First, its multiyear design pre-committed funds, so districts were assured this would not be a temporary, reversible change and could plan long-term, transformative initiatives rather than one-off expenditures. Second, the funding came with minimal restrictions on how schools could use it, giving more fiscal sovereignty to districts.

Positive and Significant Effects

This study investigates the causal impacts of LCFF-induced increases in per-pupil spending on student achievement and school conditions, measuring how per-pupil spending over multiple years affects student achievement trajectories and assessing the extent to which school resource equity narrows socioeconomic achievement gaps. This is the first comprehensive investigation of LCFF's impacts on student outcomes across all grades, presenting a unique opportunity to assess the relative impacts of various school inputs, school practices and conditions, and student characteristics on differences in the effectiveness of K–12 funding across schools.

The research finds positive and significant effects of LCFF-induced increases in per-pupil spending on academic achievement in math and reading in every grade assessed (3rd–8th and 11th) and for every school that experienced this new infusion of state funds, which targeted lower-income districts and students from low-income families. The impacts on student achievement grew with the number of years of exposure to increased funding and with the amount of the increase that occurred due to LCFF.

Furthermore, the study finds that increased school spending led to reductions in the probability of students repeating grades and subsequently increased the likelihood of students graduating from high school and the likelihood of meeting college-readiness standards in both math and reading. Equally important, the results indicate a significant narrowing of the average achievement gap by district socioeconomic status and race. While most studies of educational interventions focus solely on test scores, this study is among the first to provide causal evidence that also shows that school spending increases led to significant improvements in student behavioral outcomes and substantial reductions in the annual incidence of suspensions and expulsions across all grades.

California School Spending and the Local Control Funding Formula

Across the country, about 90% of public school funding is provided through a blend of state and local dollars. States vary in how they distribute funding and how much funding schools receive. Nearly all school funding in California is determined centrally under state funding formulas. Prior to the creation of the LCFF system, districts' school funding was derived from local property taxes supplemented by the state to bring each district up to a "revenue limit," a mostly uniform per-pupil funding allotment. In other words, for districts whose property tax wealth was insufficient to meet the revenue limit, the state supplemented local property taxes until the limit was reached so that funding was equalized across districts. The system allowed for some monetary differentiation for particular purposes, such as transportation or special education, but contained little explicit weighting for student demographic characteristics.

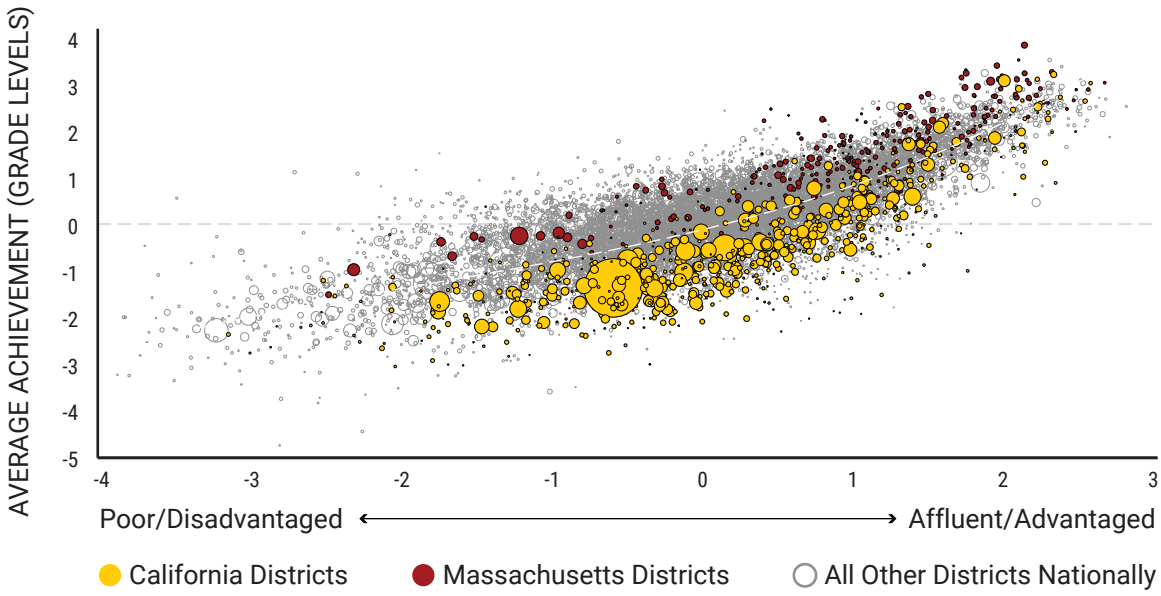
In 2011, California ranked last nationwide in average per-pupil spending adjusted for differences in cost of living (based on data of states' wages and salaries).[1] In the 10 years leading up to LCFF, the state consistently ranked in the bottom 15 among state systems in both per-pupil spending and the capacity to spend on education, defined as local and state revenues spent as a percentage of taxable resources. In the year immediately preceding LCFF passage, data from the National Assessment of Educational Progress (NAEP)[2] revealed California had among the largest socioeconomic achievement gaps in the nation.

Figure 1 illustrates the strong relationship between student achievement and socioeconomic status in California districts from 2009 to 2013, pre-LCFF. It also shows that while districts in a high-education spending state with a highly progressive funding formula, such as Massachusetts, routinely delivered above-average achievement on standardized test scores, only a small proportion of California districts, all of them serving students from more affluent families, did so. Most, including California's largest districts, had below-average academic achievement.

In 2013, California passed LCFF and enacted a temporary sales tax hike to increase and better equalize funding and to counteract school budget shortfalls, partially a result of the Great Recession and home foreclosures. Under LCFF, funding is not allocated based on district property wealth but by the proportion of unduplicated "high-need" students in the district. LCFF defines high-need students as those who are from low-income families, living in foster care, experiencing homelessness, eligible for free or reduced-price lunch programs, or English learners.

Under LCFF, funding is not allocated based on district property wealth but by the proportion of "high-need" students in the district.

Figure 1
Relationship Between Academic Achievement and Socioeconomic Status in California and Massachusetts, 2009–2013



Note: Achievement is based on a composite of math and reading test scores (pooled across grades 3–8) that have been NAEP-normed, standardized, and converted into grade-level-equivalent units, following methods developed by Sean Reardon and colleagues, where 1 represents student achievement that is one grade level above the national average achievement for that grade, and -1 represents achievement that is one grade level below the national average for that particular grade. The size of the dot is proportional to district enrollment size. The definition of district socioeconomic status (SES) used along the x-axis is a district SES composite index computed as the first principal component factor score of the following measures: median income, percentage with a bachelor's degree or higher, poverty rate, Supplemental Nutrition Assistance Program (SNAP) rate, single mother–headed household rate, and unemployment rate.

Source: Author analysis of data from Reardon, S., Fahle, E., Ho, A., Shear, B., Kalogrides, D., Jang, H., Chavez, B., & Saliba, J. (2021). *Improving educational equity* [Data set]. Stanford Educational Data Archive.

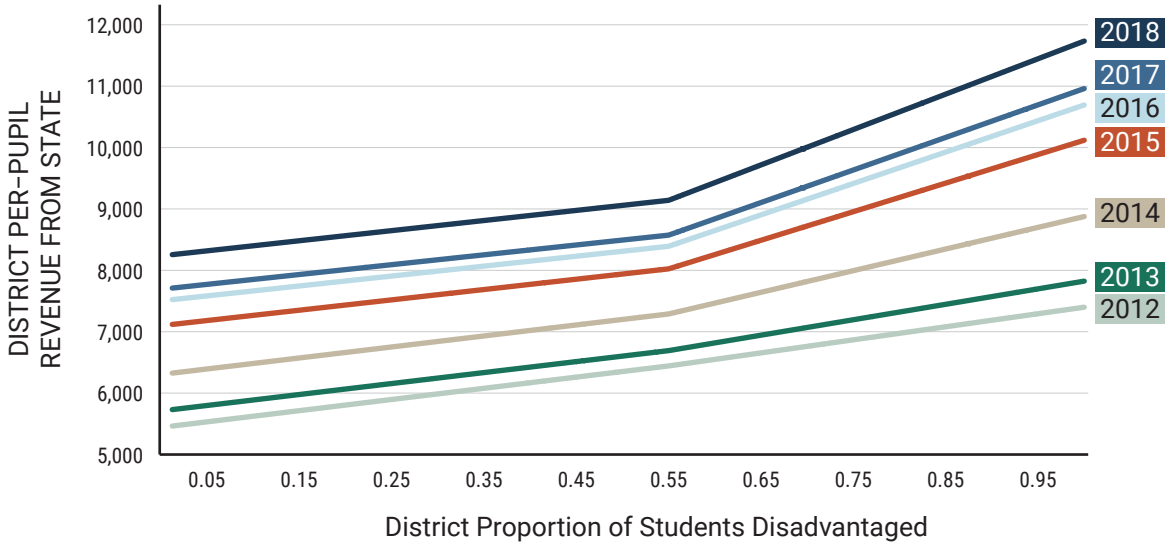
The LCFF funding formula is characterized by three components: (1) base grant, which varies based on the grade span of the students; (2) supplemental grant, which is equal to 20% of the adjusted base grant for each high-need student; and (3) concentration grant, which is equal to 50% of the adjusted base grant per high-need student in districts with more than 55% high-need students. There was a rollout phase-in period of LCFF implementation from 2013 through 2019, wherein target funding levels did not approach fully funded status until the 2017–18 school year, and LCFF became fully funded in the 2018–19 school year. In 2018–19, funding allocations totaled:

- **Base grant**: approximately $8,000 per pupil (depending on grade level)
- **Supplemental grant**: $1,600 for each high-need student
- **Concentration grant**: $5,300 per high-need student in districts with more than 55% high-need students

The concentration grant is explicitly designed to address the substantially greater resource needs of students living in poverty and concentrated poverty, schools with high proportions of students who are English learners, and student populations that are disadvantaged in multiple ways. The greater progressivity of the funding formula caused by the concentration grant for districts with more than 55% high-need students is depicted in Figure 2, with the slope increasing with each year of LCFF implementation. By comparison, there was no kink (nonlinearity) in the funding formula (at 55% disadvantage or elsewhere) in the years before LCFF implementation.

This staggered rollout and pre-reform and post-reform change in funding due to LCFF as a function of district percent student disadvantage is also depicted in Figure 2.

Figure 2
Funding Formula Amounts Before (2012) and During (2013–2018) the Rollout of LCFF



Notes: Figure 2 was constructed by computing per-pupil revenues for each school district in each year based on the funding formula and its elements before and after LCFF-induced formula changes. This figure excludes Basic Aid districts, which are not subject to the LCFF funding formula, as discussed later in the text. Total per-pupil revenue from the state is defined as the total revenue from all state sources, divided by enrollment and adjusted for inflation to represent 2015 dollars. Pre-LCFF is 2012, and post-LCFF is 2013–2018.

Source: Author analysis of data from the California Department of Education for 2012 through 2018–19 in the Standardized Account Code Structure.

In addition to the tiered allocation system based on student demographics, there are two other notable qualities of LCFF. Under LCFF, districts have greater discretion in the use of funds than in the previous model, in which a large share of funding was for categorical aid, which made allocation options more rigid. While the LCFF policy mandates that each district devise a Local Control Accountability Plan—which can be thought of as the recipe and ingredients it will use to prepare a nutritious, equitable learning "meal" for every student, from preschool to graduation—there are minimal

reporting requirements overall. Schools that serve 40% or more high-need students can spend these resources schoolwide, and districts with more than 55% high-need students may spend these resources districtwide. The accountability plan must identify how these resources are principally directed to high-need students, but such decisions can be made based on the specific needs of each district or school.

A second notable quality of LCFF is its guaranteed multiyear distribution.[3] Traditionally, the uncertainty of available funding from year to year precludes a district's ability to enact bold, transformative reforms. This is the case for many districts, but it is particularly common for urban and low-income districts. Such fiscal uncertainty in a district, which is similar to the instability experienced by families who live paycheck to paycheck, leads to suboptimal investments rather than the sustained, high-quality investments that lead to continual improvement. The architects of LCFF aimed for it to be a stark contrast to this uncertainty.

Importantly, roughly 100 Basic Aid districts have local revenue per pupil in excess of LCFF targets, do not receive state funding, and are not subject to LCFF requirements. So, irrespective of the proportion of student disadvantage, these Basic Aid districts are not eligible for additional revenue via LCFF, and they are held "harmless" as their local revenue is not taken away. As discussed in the Empirical Strategy section, because the LCFF formula is not applied to Basic Aid districts, these districts provide an additional placebo test and control group in the post-LCFF period. Basic Aid districts and the issuance of bonds are the only sources of local discretion, with bond revenue restricted to capital investments.[4] Roughly 10% of state funding is outside the LCFF, including funding for special education, Home-to-School Transportation and Targeted Instructional Improvement Block Grants, and school lunch programs.

Empirical Strategy

I linked district- and school-level information on school resources and per-pupil spending with longitudinal student-level data for the full universe of public school students in California to analyze the determinants of student achievement trajectories throughout their K–12 years. This student-level data included 6.2 million students across K–12 each year. My analyses span the school years 1995–96 through 2018–19 across the 10,000 schools and 1,000 districts in the state but focus particular attention on the rollout period of Local Control Funding Formula (LCFF) implementation from 2013 through 2019.

LCFF was a multidimensional reform that included substantial funding increases overall, greater funding explicitly targeted to socioeconomically disadvantaged districts (via concentration grants), elimination of many state categorical programs, and increased local control and local accountability. The empirical approach isolates the effects of increased spending via the pre-post changes in the funding formula, accounting for other coincident changes.

I exploited quasi-experimental variation in school spending induced by changes in California's school funding formula, and its 7-year staggered rollout interacted with the timing of an individual's school-age years of exposure. The quasi-experimental variation in school spending arises from policy nonlinearities in the funding formula, which were nonexistent in the former state funding formula. In particular, the LCFF funding formula involves concentration grants for districts whose enrollment comprises more than 55% disadvantaged students (those with limited English proficiency, living in foster care, experiencing homelessness, and/or enrolled in the free or reduced-price lunch program).

This funding rule creates a kink in the LCFF funding received as a function of the district proportion of disadvantaged students. The significant increase in funding, its staggered rollout, and substantially greater progressivity of funding for districts with greater than 55% disadvantage caused otherwise similar students across cohorts from the same districts to be exposed to different amounts of school funding. Particularly, the nonlinearity (kink) beyond 55% disadvantage also caused observationally similar districts to have different levels of per-pupil spending on students in their respective districts. Since it is unlikely that other factors changed exactly at the funding formula kink point at 55%, this research design offered highly credible estimates of causal effects of school spending.

This study identifies the impact of LCFF-induced increases in per-pupil spending on a range of student outcomes. The empirical analysis is complicated by the dynamic nature of student achievement trajectories and how current learning outcomes are influenced by both the history of school resources and resources in the current assessment year. The modeling approach used accounts for the cumulative nature of learning and considers how early learning begets future learning (often in

compounding ways). Using population student-level longitudinal administrative data for the full universe of public school students in California, I was able to follow the same students over time. The analysis sample was restricted to students who were first observed in a California public school in kindergarten and followed thereafter.[5]

The primary empirical challenge in estimating the effects of school spending on student outcomes was that spending and school quality tend to be highly correlated with child family and neighborhood socioeconomic factors due to parental choices and residential location constraints (e.g., zoning policies and availability of affordable housing). Analyses of the impact of school finance reforms allow researchers to isolate the effect of increases in school funding on children whose non-school factors remained the same before and after the reform.

If school spending is the treatment that helps cure what ails under-resourced districts, then one would expect the efficacy of treatment (i.e., the extent to which spending boosts achievement) to depend on two factors: (1) the number of school-age years a student is exposed to the funding reform (duration of exposure); and (2) the amount of LCFF-induced increased spending (the dosage). Exposure is cohort-specific, while dosage is district-specific. Applying that principle to this case, dosage is a function of district percent disadvantage (kink at 55%), and there is negligible differential dosage for students from the same cohort in districts between 0 and 55% disadvantage.

The reform of California's school funding formula generates two sources of variation that I used to identify the causal impacts of per-pupil spending: (1) rollout timing, which generates differences in the duration of exposure by a given grade, and which is amenable to a difference-in-difference design; and (2) variation created by the change in the slope of the funding aid–district disadvantage formula, which allowed me to use a regression kink design, and which solely determines the greater progressivity of the funding formula above the 55% threshold.[6] I exploited the timing of reform, its implementation rollout, and parameters of the funding formula.

This strategy aims to isolate exogenous policy-induced variation in school spending—driven by the timing of funding reforms to LCFF and the respective funding formula in effect in each year—as distinct from the endogenous variation driven by residential sorting and changes in the tax base, and independent from increased district autonomy in how to use the funding. Because LCFF eliminated many state categorical programs, the changes in funding must be analyzed based on both the pre-LCFF and post-LCFF formulas that were in effect each year over time.

I identified the causal impact of per-pupil spending increases on student achievement using variation induced by the staggered timing of LCFF implementation and by the kink in the relationship between state funding and district disadvantage at the 55% threshold for concentration grant eligibility. The empirical strategy analyzes differences in student achievement across adjacent cohorts in the same school, leveraging their differential exposure to funding reform–induced increased spending over time, beyond statewide time trends. (See Appendix A.)

The research design compares the change in student achievement outcomes after school funding reform–induced increases in per-pupil spending across cohorts within districts that were more (or less) exposed to funding increases due to the timing when the students reached particular ages and the type of district (i.e., defined by district disadvantage, wherein districts with greater than 55% disadvantage experienced larger increases in school spending). I used two complementary strategies (2SLS-IV-DiD and 2SLS-IV-difference-in-RKD) that yield similar patterns of results.

As discussed in the following section, the results clearly demonstrate a dose-response such that the longer students are treated for the symptoms of poorly funded schools, and the higher the doses of school funding reform they are administered, the better their outcomes are found to be. Finally, the empirical investigation aims to go beyond addressing questions of *whether* money matters to contribute to an understanding of which types, how, when, why, and for whom school funding matters most.

Funding increases resulting from LCFF are significantly associated with improved math and reading achievement. Before moving into the findings, I first discuss why we should have confidence in them. The identification strategy used in the study relies on the assumption that the reason for the systematic association between per-pupil spending and student achievement is a school spending effect driven by LCFF-induced changes in district revenues that is distinct from other coincident policy changes. The estimated causal effects of school spending isolated in the analyses are also independent of the potential effects of the increased autonomy districts were granted over how funding could be used (i.e., reductions of categorical restrictions on aid).

Funding increases resulting from LCFF are significantly associated with improved math and reading achievement.

If the results are to be interpreted causally, it is important that the effects work through the proposed funding channels from state sources and are not driven by any effects of other coincident changes (e.g., Common Core standards implementation, changes in local economic conditions and rebound from the Great Recession, Every Student Succeeds Act Title I funding, imposition of new state testing assessment, mean reversion). I conducted several empirical tests that support a causal interpretation. I found supportive evidence consistent with the proposed funding mechanisms, as the results revealed that the pre- and post-LCFF changes in the funding formula (used as the instrumental variables to identify causal impacts) operate through their systematic impacts on state revenues (arising from LCFF's staggered rollout) and are not associated with significant changes in local and federal revenue sources. There also is not a significant change in the proportion of funding subject to restrictions (relative to the 2014 reference year).

I considered other factors occurring at the same time as LCFF implementation that would be expected to have differential impacts by district socioeconomic status (SES), as these may provide a counter-explanation for the results. A coincident education policy reform that overlaps LCFF is the state's implementation of more rigorous Common Core standards since 2014. The research design, and robustness of both 2SLS-IV-RKD and 2SLS-IV-DiD results, insulates us from (or, at the very least, minimizes) potential bias arising from the coincident implementation of Common Core standards over this period, and the model accounts for common statewide trends (by grade and cohort). As an *unfunded* mandate, the lessons drawn from other states' implementation of Common Core standards have raised awareness that, to achieve those uniform standards, one must invest in schools more equitably. Equal dollars are not equal if the costs of providing high-quality education that meets standards are not the same across districts. When we finance those expectations unequally, we undermine the value of the Common Core standards themselves.

There may still be concerns that the estimated spending effects are, in part, attributable to other district-level changes or state-level factors with differential effects by district SES, such as the change to a new state testing assessment (the California Assessment of Student Performance and Progress) in 2014 for all California public schools, Common Core standards implementation in all California public schools, and changes in local economic conditions. If that were the case, one would observe similar patterns both in public schools subject to state school finance formulas and in Basic Aid districts, the latter of which are ineligible to receive funding from state sources. However, if the effects operate through LCFF-induced increases in per-pupil spending, one should observe improvements in achievement among students from schools that experienced LCFF funding increases, but not for students from Basic Aid districts. The results show this is indeed the case (as discussed in the following section).

Instead of thinking of individual policies in a vacuum (that is, in isolation), one should also consider the potential interactive effects of greater school resource equity and ways in which that may support adoption of school practice reforms that are equity enhancing (e.g., reforms of school disciplinary practices intended to reduce exclusion from school), which may lead to positive multiplier effects that may not have been possible without the funding increases. For example, LCFF funding allocations that helped support teacher professional development in the implementation of Common Core standards may enhance the impact of improvements in curricular standards and their alignment from prekindergarten to 12th grade.

Impacts of LCFF-Induced Spending Increases on Student Outcomes

The Local Control Funding Formula (LCFF) was enacted to reduce academic achievement gaps between children from socioeconomically disadvantaged families and their more advantaged peers. Earlier, I showed that LCFF increased state funding to districts, particularly to districts that received an LCFF concentration grant due to having a concentration of more than 55% of high-need students. This section presents causal evidence of how LCFF-induced increased spending influenced student outcomes in California, including math and reading achievement on standardized tests in grades 3–8 and 11, grade repetition, high school graduation rates, college readiness, and suspensions and expulsions.

Math and Reading Achievement Results

LCFF resulted in significantly improved achievement in math and reading for all grade levels tested. Students in districts that received LCFF concentration grants had the largest achievement boost. As an example, the analysis compares the achievement of students from the same elementary school across successive cohorts that were exposed to different funding levels as LCFF was incrementally rolled out. For grades 3 through 5, Figures 3 and 4 show the change in math achievement between 2014 (the first year after LCFF passed before significant spending had been allocated) and 2018 (when LCFF became fully funded) across districts with different proportions of student disadvantage. It shows that 3rd- through 5th-grade math achievement significantly improved for students in all districts in which the progressivity of the funding formula kicked in (districts receiving LCFF concentration grants). The kink at 55% concentration of high-need students shows that larger achievement gains were made under higher LCFF funding levels through the LCFF concentration grants. Among students from the same school, student achievement growth across successive grades was also significantly higher for those exposed to greater LCFF-induced per-pupil spending increases; this pattern was found across all districts that received LCFF funding (not just those that received LCFF concentration grants). These results shown for math and reading achievement in grades 3 through 5 (see Figures 3–5 and Appendix Figure B1), were also found for math and reading achievement in middle school grades 6 through 8 (see Figure 6). Taken together, the pattern found for both math and reading, and across grades, was one of significantly improved achievement with LCFF exposure years (relative to 2014), with differentially greater achievement growth for students in "high-dosage" districts (relative to "low-dosage" districts).

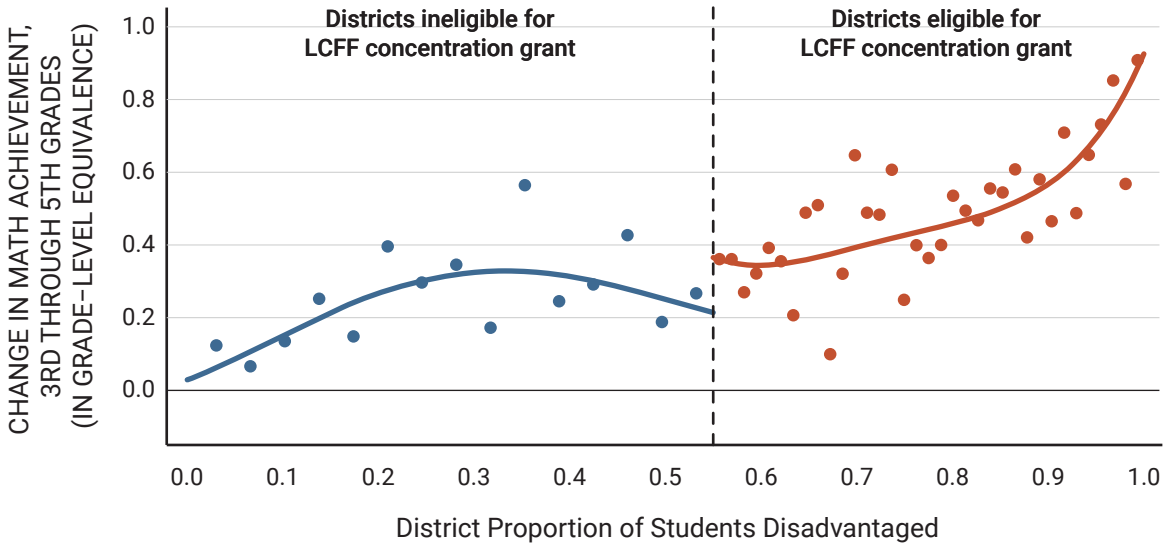
In contrast, and as a falsification check, there is no positive kink relationship in either per-pupil revenues (at 55%) or student achievement (at 55%) for pre-LCFF cohorts; the relationship is indeed flat and statistically insignificant (see Figures 7–8 and Appendix Figure B2). Causal impacts of per-pupil spending can be identified (using the difference-in-regression kink design) under the assumption that, absent the additional

LCFF revenue, there would be no associated kink in student outcomes beyond a district's 55% threshold of disadvantage; and thus, any kink in outcomes beyond that point can be interpreted appropriately as consistent with being attributable to the causal effects of per-pupil funding on student outcomes.

I found this is indeed the case, as the graphical results for post-LCFF cohorts show that the kink and resultant improvements in both math and reading achievement are more pronounced for cohorts that have been exposed to the increased resources for more of their school-age years and for whom the dosage was higher (i.e., as represented by the steeper upward-sloping kink beyond 55% shown for both math and reading achievement in elementary school grades 3 through 5 presented in Figures 3, 4, and 5. Similar graphical patterns are found for achievement in middle school grades 6 through 8 (see Figure 6). The timing and evolution of per-pupil spending increases induced by LCFF are mirrored by the increased growth in student achievement in both math and reading in each grade for successive cohorts with greater LCFF exposure.

The timing and evolution of per-pupil spending increases induced by LCFF are mirrored by the increased growth in student achievement in both math and reading in each grade for successive cohorts with greater LCFF exposure.

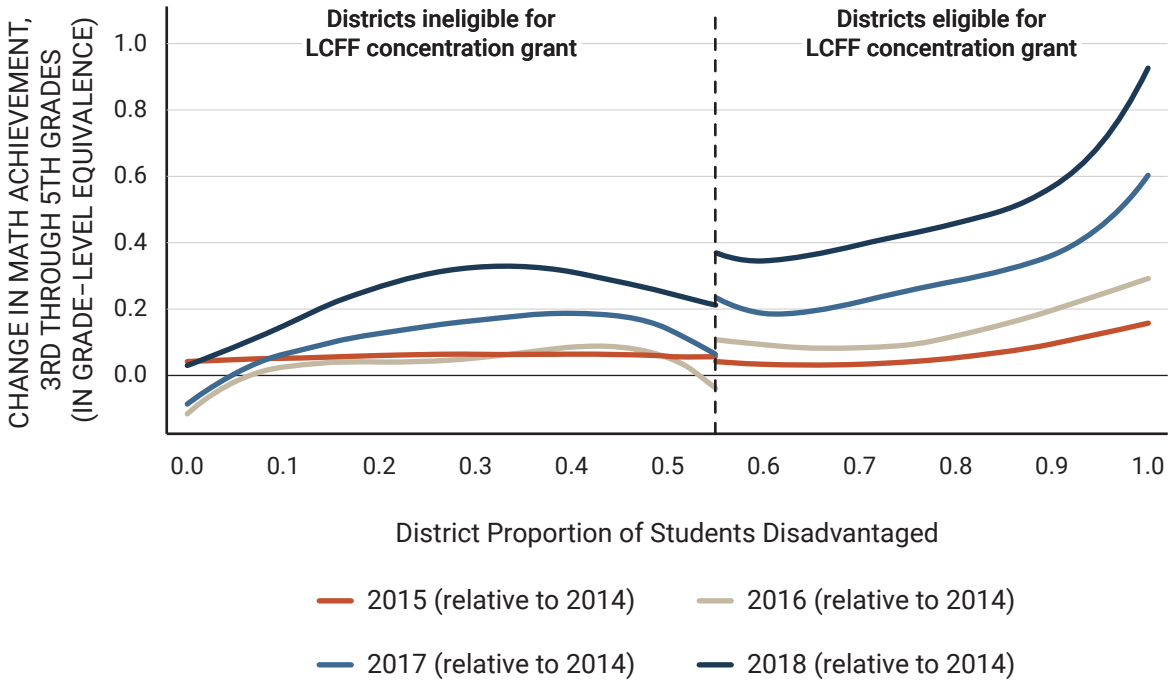
Figure 3
Increase in Math Achievement From 2014 (Before) to 2018 (After) LCFF, Grades 3 Through 5



Note: Lines represent the change in math achievement between 2014 and 2018.

Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

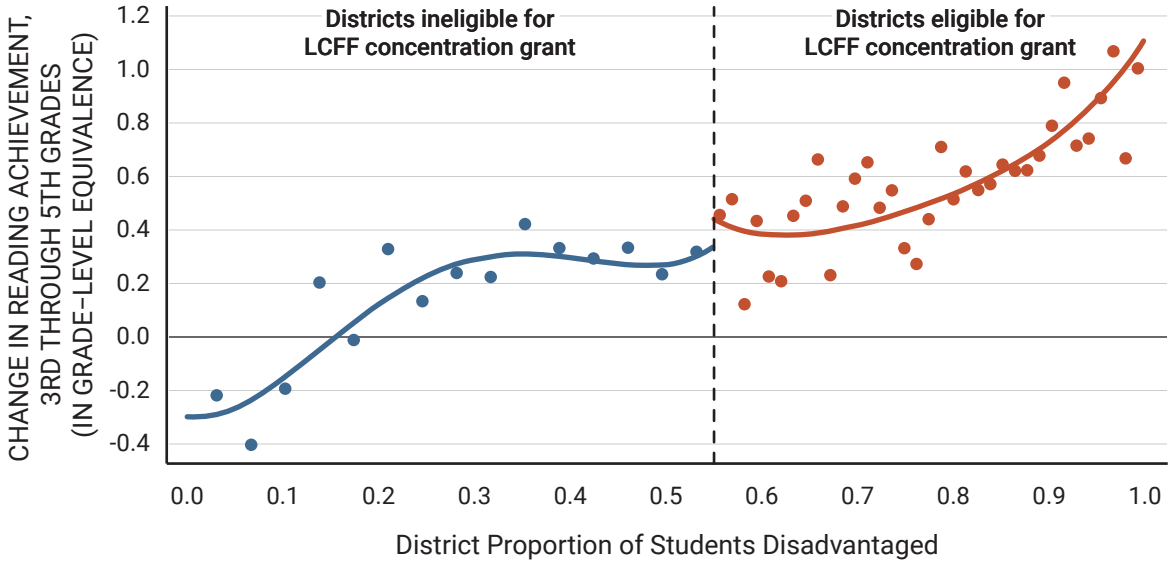
Figure 4
Increase in Math Achievement Before and After LCFF, by Year, Grades 3 Through 5



Note: Lines represent the change in math achievement relative to 2014.

Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

Figure 5
Increase in Reading Achievement From 2014 (Before) to 2018 (After) LCFF, Grades 3 Through 5



Note: Lines represent the change in reading achievement between 2014 and 2018.

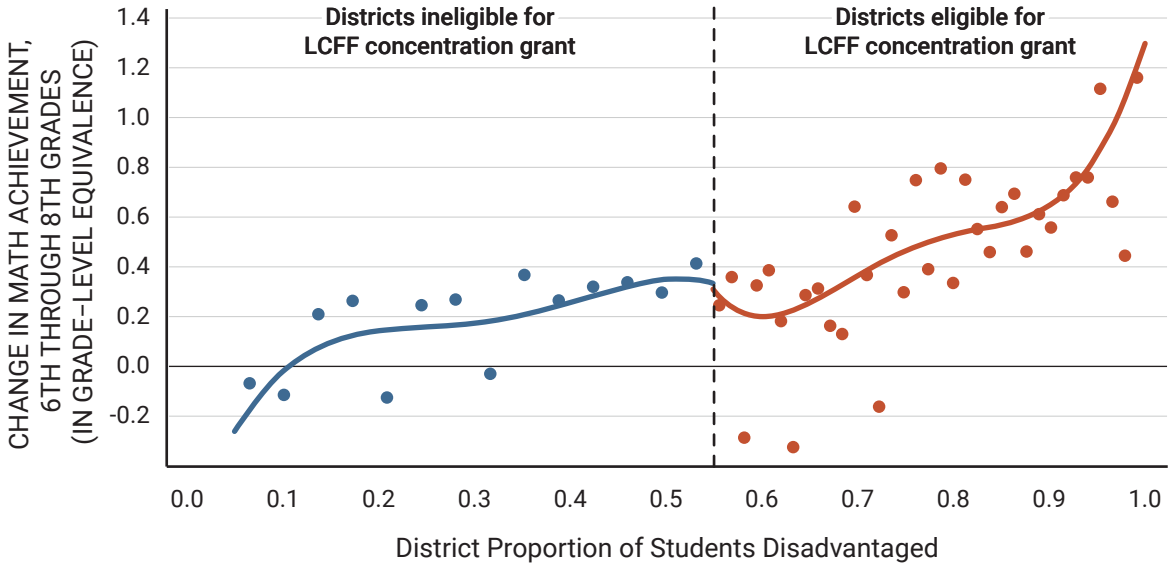
Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

Conversely, as a placebo test, no significant effects or comparable patterns were found among students from Basic Aid districts, which were not subject to state school funding formulas and did not receive a new infusion of state dollars via LCFF, as all their funding was raised locally (see Appendix Figure B2).

Furthermore, as an additional falsification test, no comparable pattern was found in the years immediately preceding LCFF passage, and, in fact, socioeconomic achievement gaps were widening (see Figures 7 and 8) and did not begin to narrow until after the targeted LCFF-induced spending increases occurred. No such positive kink relationship was found for pre-LCFF cohorts' math and reading achievement, nor for the probability of graduating from high school (see the High School Graduation Results section).

While we have shown a discontinuity in the slope of the funding–district percent disadvantage relationship profile at the kink point, there were no other discontinuities at other points, and no discontinuities found for other covariates that could provide a counter-explanation for the results. For example, based on institutional rules and funding formulas, federal Title I funding did not change around this kink.

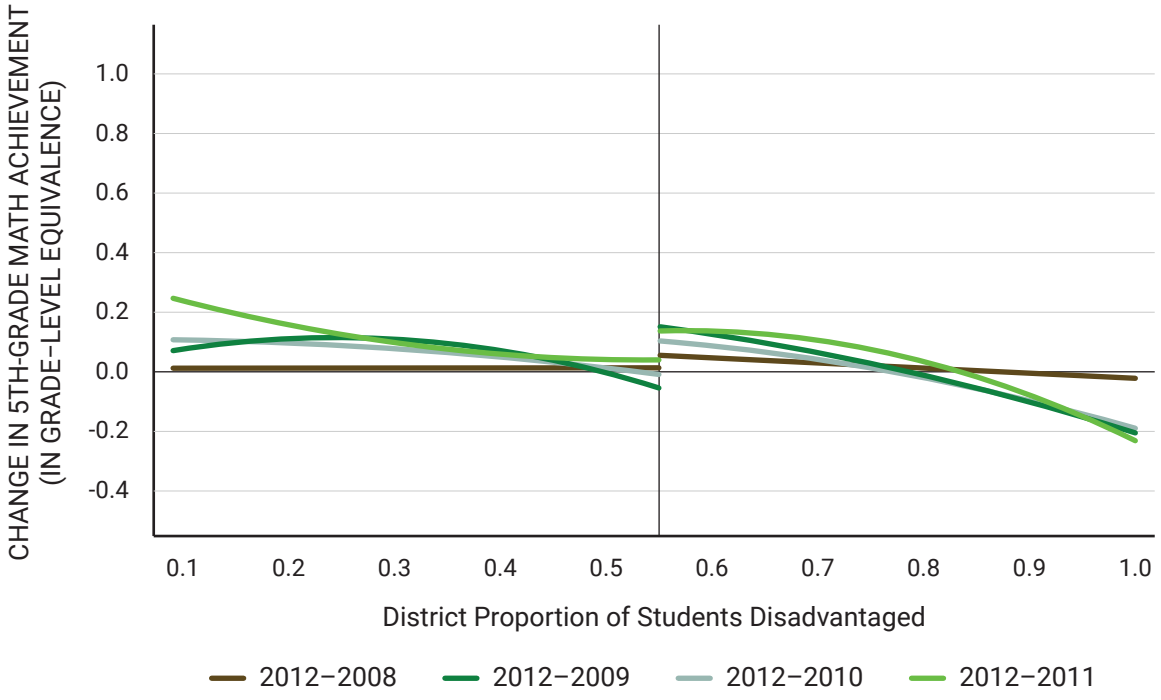
Figure 6
Increase in Math Achievement Before and After LCFF, Grades 6 Through 8



Note: Lines represent the change in math achievement between 2014 and 2017.

Sources: Author analysis of data from the California Department of Education for 2014 through 2017–18 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

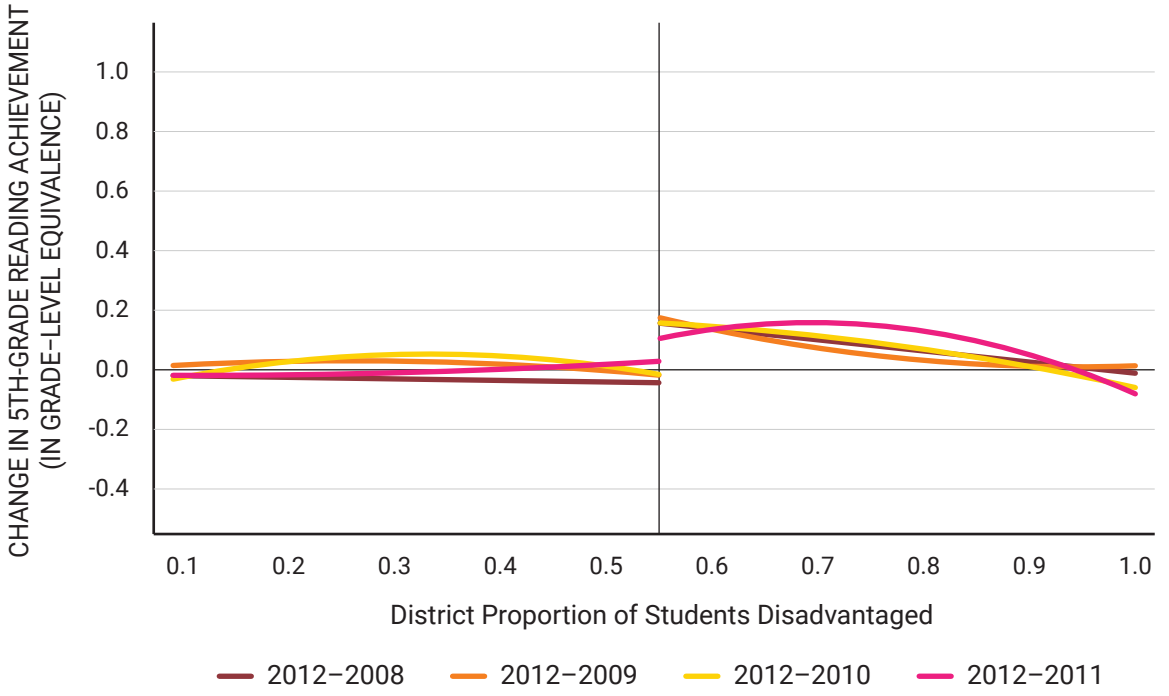
Figure 7
Change in 5th-Grade Math Achievement in Years Before LCFF, Placebo Test



Note: Lines represent the change in math achievement between years.

Sources: Author analysis of data from the California Department of Education for 2008–2012 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

Figure 8
Change in 5th-Grade Reading Achievement in Years Before LCFF, Placebo Test



Note: Lines represent the change in reading achievement between years.

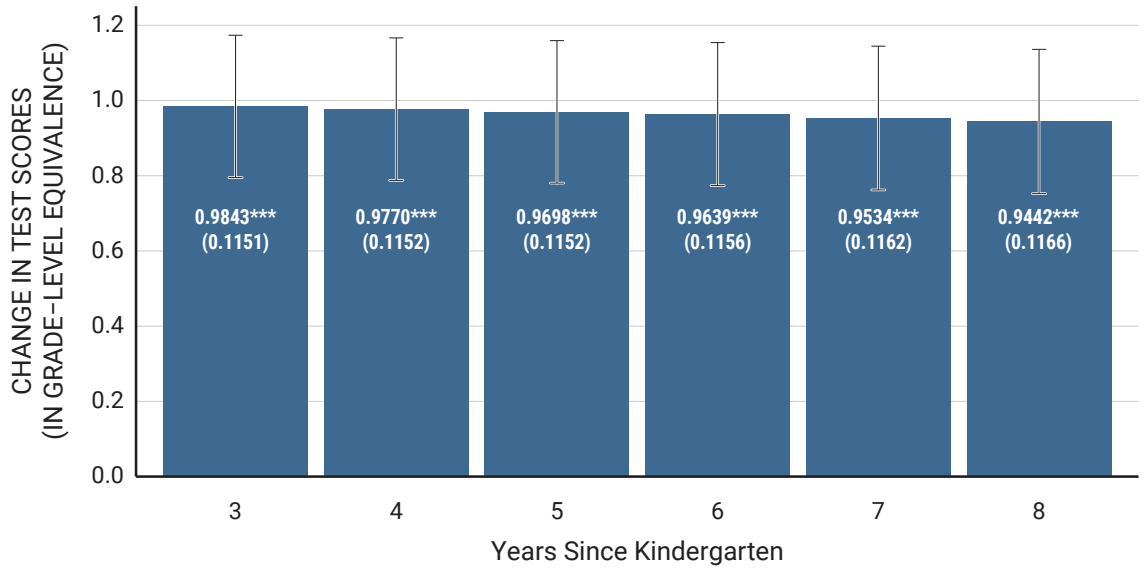
Sources: Author analysis of data from the California Department of Education for 2008–2012 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

Improvements in math and reading achievement were more pronounced for students who were exposed to the increased resources for more of their school-age years. As shown in Figure 9, the results indicate that a $1,000 increase in per-pupil spending experienced in 3 consecutive years led to roughly a full grade-level increase in math achievement in grades 3–8, relative to what the average student achieved prior to the funding increases.

Improvements in math and reading achievement were more pronounced for students who were exposed to the increased resources for more of their school-age years.

The corresponding figure for reading (Figure 10) shows that the estimated LCFF-induced effects of a $1,000 increase in per-pupil spending experienced in 3 consecutive years also resulted in a full grade-level increase in reading in elementary school and middle school grades. Figures 11 and 12 depict the estimated impacts of per-pupil spending on math and reading achievement in Basic Aid districts.

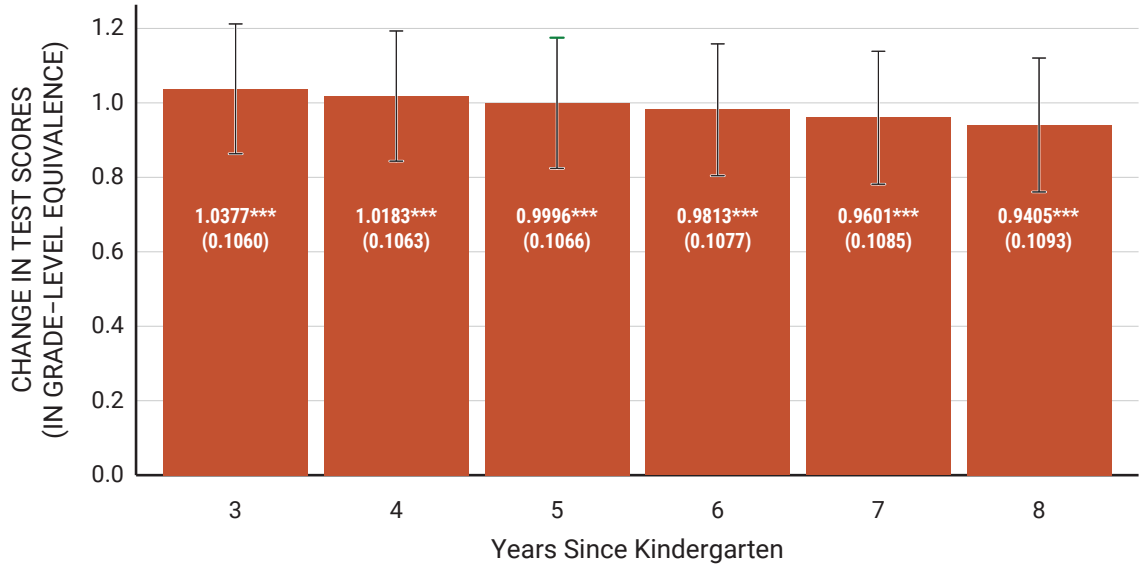
Figure 9
Estimated Impacts of $1,000 Increase in Per-Pupil Spending for 3 Years on Math Achievement, All Students



Note: *** indicates statistical significance at the .001 level.

Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

Figure 10
Estimated Impacts of $1,000 Increase in Per-Pupil Spending for 3 Years on Reading Achievement, All Students

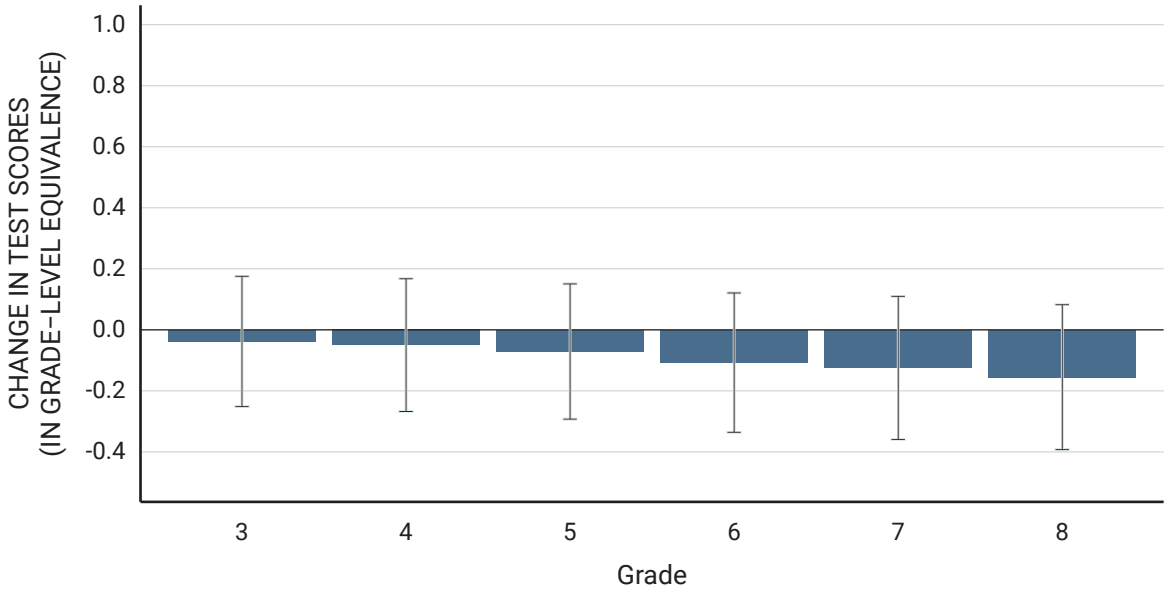


Note: *** indicates statistical significance at the .001 level.

Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

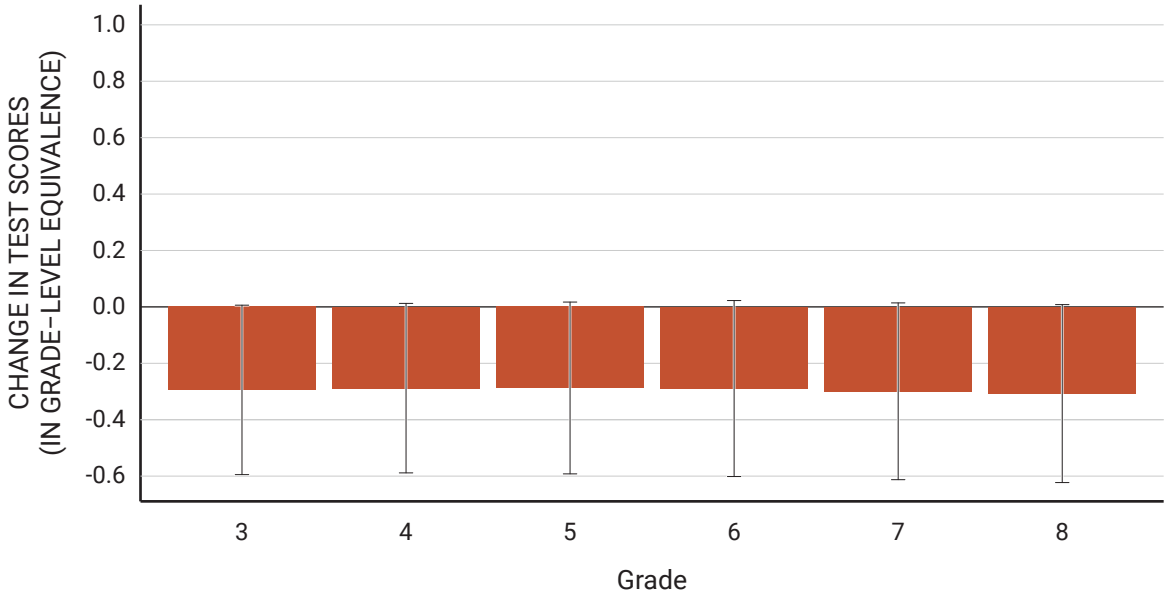
Analyses show that the improvements in both math and reading achievement are more pronounced for cohorts of students who have been exposed to the increased resources for more of their school-age years and for whom the dosage was higher. While there was a sharp uptick in achievement gains after LCFF was implemented, Figures 11 and 12 show there was no significant improvement in math and reading achievement in Basic Aid districts (which were ineligible for LCFF funding).

Figure 11
Estimated Impacts of $1,000 Increase in Per-Pupil Spending for 3 Years on Math Achievement, Basic Aid Districts Not Receiving LCFF Funding



Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

Figure 12
Estimated Impacts of $1,000 Increase in Per-Pupil Spending for 3 Years on Reading Achievement, Basic Aid Districts Not Receiving LCFF Funding



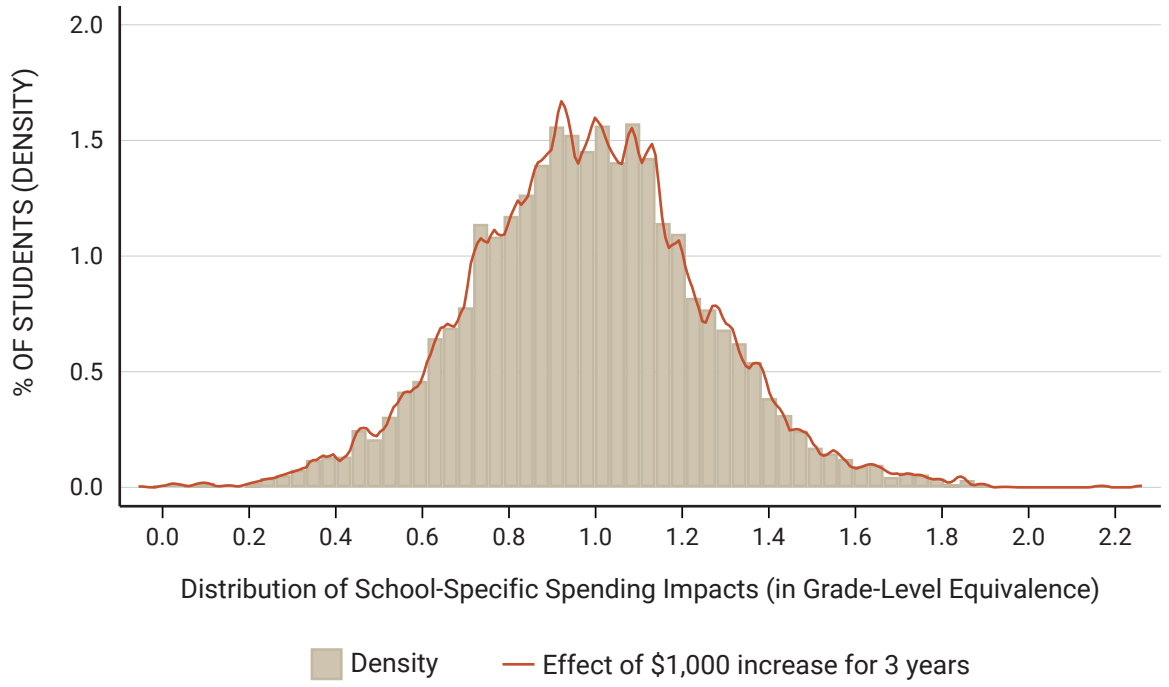
Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

Heterogeneity of Spending Effects and Distributional Impacts

I analyzed the degree of heterogeneity in causal effects of funding across schools separately by grade and subject. This is implemented by estimation of multilevel 2SLS-IV-DiD random coefficients models with the inclusion of school fixed effects, year fixed effects, and controls for a student's baseline 3rd-grade achievement.[7] I documented the distribution of the estimated effects of a $1,000 increase in school spending for 3 consecutive years on student achievement across all public schools in California.

Figure 13 presents a kernel density plot of the distribution of spending effects across schools for 6th-grade math achievement. Most importantly, while it reveals heterogeneity of spending effects, it shows improvements in achievement for every school that experienced this infusion of state funds.

Figure 13
Distribution of School-Level Changes in 6th-Grade Math Achievement From $1,000 Increase in Per-Pupil Spending for 3 Years



Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

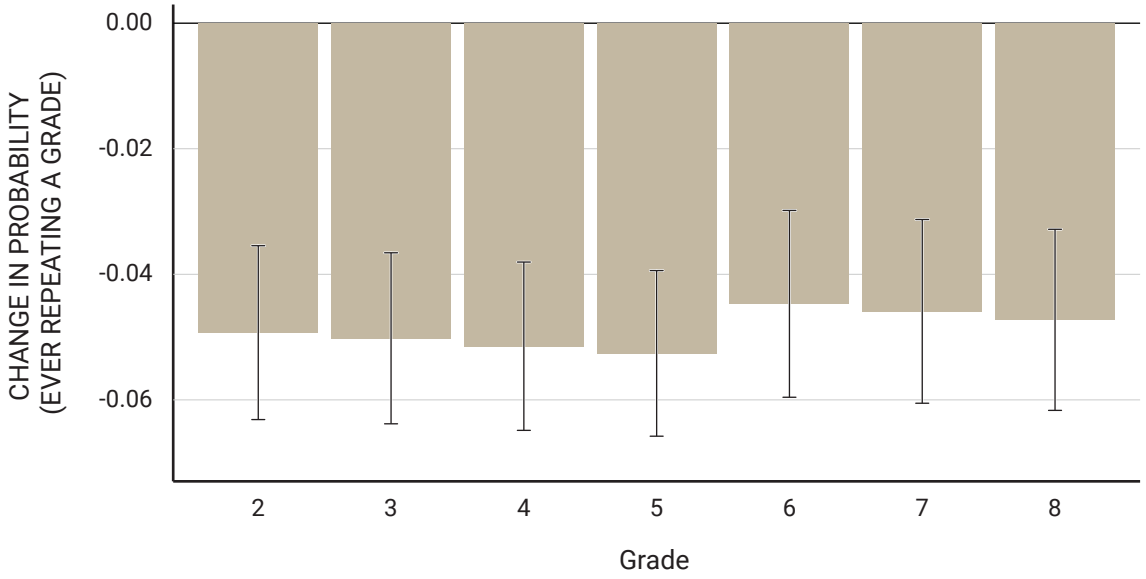
Grade Repetition Results

I examined the impacts of per-pupil spending on students' progression through grades since kindergarten in recognition that grade progression (and grade repetition) are potential outcomes influenced by the quality of learning conditions in schools, and thus a student's grade in school may in part be endogenous to the school funding reforms enacted. To shine a light on this, I investigated the effects of school funding on the likelihood of a student ever experiencing grade repetition since kindergarten (grades 2–8).

As shown in Figure 14, the 2SLS-IV results indicate that LCFF-induced increases in school spending led to significant reductions in the probability of grade repetition, particularly during elementary school. Specifically, a $1,000 increase in per-pupil spending experienced for 3 consecutive years resulted in a 5 percentage-point reduction in the probability of students experiencing grade repetition by 3rd grade, a corresponding 5.1 percentage-point reduction by 4th grade, and a 5.3 percentage-point reduction in the likelihood of grade repetition by the end of elementary school (5th grade). These grade progression effects were enhanced by the coincident

introduction of transitional kindergarten (TK) over this period. This is a finding that would not have been uncovered without access to the student-level longitudinal data following the same children since kindergarten (or TK) as they progress through California public schools. It is missed using aggregate school-level data and may contribute to the reason the estimated spending effects documented are larger than prior study estimates in the literature.

Figure 14
Estimated Impacts of $1,000 Increase in Per-Pupil Spending (for 3 Years) on the Likelihood of Repeating a Grade



Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

High School Graduation Results

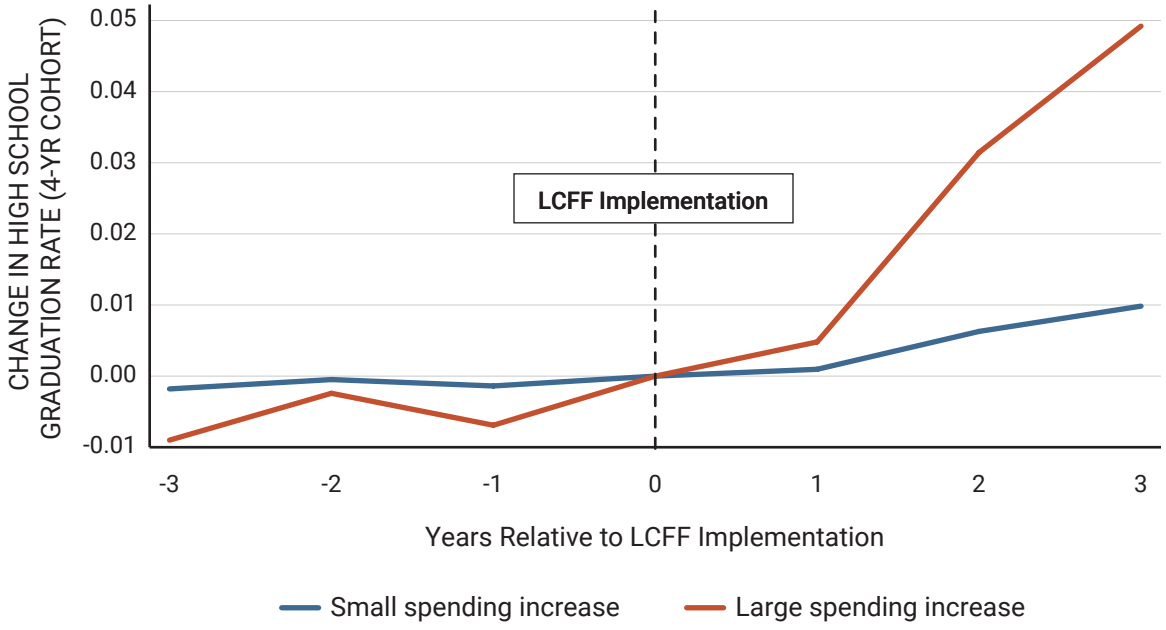
Likewise, cohorts exposed to LCFF concentration funding displayed an increased likelihood of graduating from high school. For all student groups, a $1,000 increase in the average per-pupil spending experienced throughout one's high school years (grades 9–12) expands the likelihood of graduating from high school by 8.2 percentage points, on average. The estimated effect for Black students is strongest but not statistically distinguishable from the large significant effects found for other subgroups.

Similar to other outcomes, effects are strongest for students exposed to larger spending increases, and the longer the exposure to additional funding, the greater the improvements in achievement—in this case, the probability of graduating from high school. Figure 15 shows this dynamic for students from low-income families. At the time LCFF was implemented, students from low-income families in schools that

received either large or small increases in LCFF funding had equivalent graduation rates. After 1 year of LCFF funding, little had changed. However, after 3 years of additional funding, graduation rates among students from low-income families increased by 1 percentage point in schools with small spending increases and increased by 5 percentage points in schools with large spending increases.

Figure 15
Effects of LCFF on High School Graduation Rates for Students From Low-Income Families

Large (vs. small) school finance reform–induced spending increase



Note: "Small spending increase," as defined here, corresponds with the typical change in LCFF districts not eligible for a concentration grant, whereas "large spending increase" corresponds with the typical change in LCFF districts eligible for a concentration grant.

Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

College-Readiness Results

The analyses include models that estimate the effects of per-pupil spending experienced over 3 consecutive years on the likelihood of a student meeting college readiness standards on the state tests in math and reading. College readiness is defined here with a dichotomous indicator for achievement levels Standard Met or Standard Exceeded (college ready) vs. Standard Not Met or Standard Nearly Met (not college ready) for each subject.[8] That is, students who are ready for college or able to become ready by taking specific courses or assessments prior to enrollment have a college readiness indicator of 1, and students who are not considered college ready

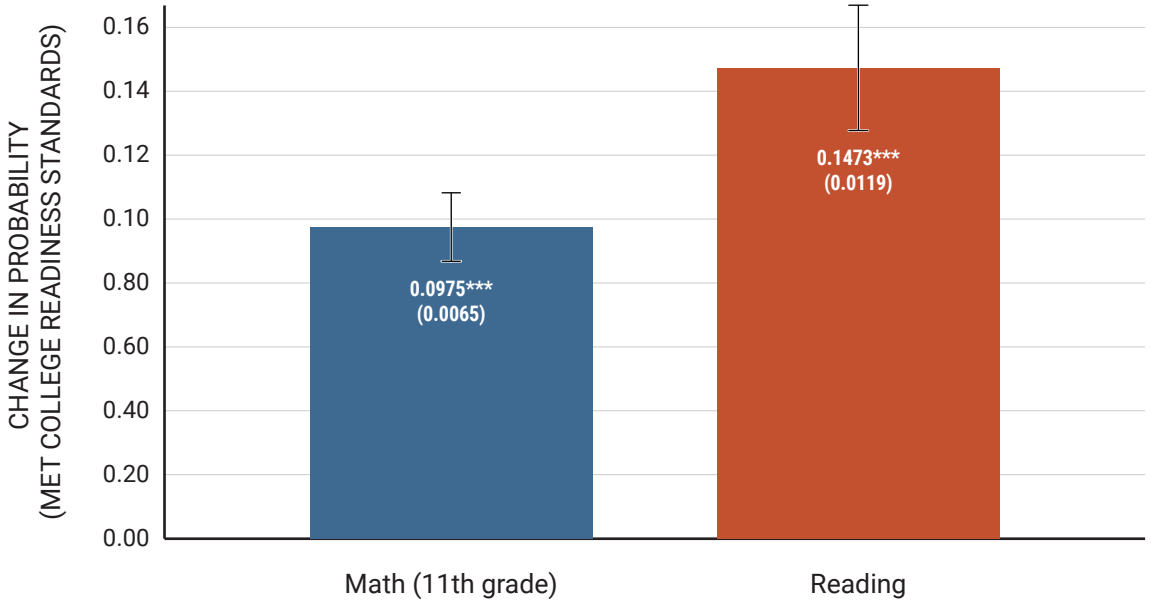
and have few options to demonstrate college readiness in high school have a college readiness indicator of 0. The college readiness signals that are attached to these achievement levels are used by colleges and universities.[9]

The college readiness gaps in 2014, prior to significant LCFF implementation, were substantial by socioeconomic status and by race and ethnicity. In particular, 49% of students from socioeconomically disadvantaged families met neither math nor reading standards for college readiness as measured by the California Assessment of Student Performance and Progress, compared with roughly 25% of non-disadvantaged students. In 2014, roughly 50% of Hispanic students and 57% of Black students met neither math nor reading standards for college readiness, compared with roughly 27% of white students and 20% of Asian students.

LCFF-induced spending led to substantial improvements in college readiness among socioeconomically disadvantaged and other high-need students.

While significant college readiness gaps by socioeconomic status and by race and ethnicity remain, the results reveal that LCFF-induced spending led to substantial improvements in college readiness among socioeconomically disadvantaged and other high-need students. In particular, the results indicate that a $1,000 increase in per-pupil spending experienced in 3 consecutive years of high school (grades 9–11) led to a 9.8 percentage-point increase in the likelihood of meeting college readiness standards in math and a 14.7 percentage-point increase in the likelihood of meeting college readiness standards in reading. These college readiness standards have been found to be significantly predictive of college success.[10] Figure 16 captures the estimated impacts of LCFF-induced increases in spending during grades 9–11 on the likelihood of meeting college readiness standards in math and reading, respectively.

Figure 16
Estimated Impacts of $1,000 Increase in Per-Pupil Spending for 3 Years (9th–11th Grades) on College Readiness, All Students



Note: *** indicates statistical significance at the .001 level.

Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

Student Behavior and Disciplinary Incident Results

Prior research has highlighted many dimensions of student learning and skills developed in school, including socioemotional development and student behaviors, that significantly influence later-life success but are not well captured by student performance on standardized achievement tests.[11] Overcrowded classrooms and under-resourced schools may create learning environments that are more vulnerable to disruptive behavior problems and disengagement in school due to greater difficulty in providing students with individualized attention.

I extended the investigation of the role of school spending to examine causal impacts on the annual incidence of suspensions and expulsions and other related disciplinary incidents. Prior evidence has demonstrated that, relative to using only test score measures, using effects on both test score and student behavioral outcomes (including suspensions and other markers of noncognitive skills) more than doubles value-added estimates of school quality and teacher quality impacts on longer-run outcomes.[12]

Los Angeles Unified School District (LAUSD) is excluded from the analyses of suspensions and expulsions because LAUSD's disciplinary policy and restorative justice reforms were quite different than most other districts in California, and suspension

rates in LAUSD fell by roughly 90% between 2003 and 2014 (prior to significant LCFF implementation).[13] As a result, their pre-existing time trends were notably different than all other districts in California. Because of LAUSD's large size, including these data in the study might have distorted the underlying relationships of interest.

In 2013, districts in California began including suspensions in the accountability system, and there has been a growing movement to rethink exclusionary zero-tolerance school disciplinary policies, prohibiting suspension for subjective behavior (e.g., willful defiance). Related research from Chicago Public Schools and California public schools has shown that restorative justice practices in schools (as an alternative to exclusionary discipline policies) have led to enhanced school climates, improved academic performance, and academic engagement, particularly for Black students.[14]

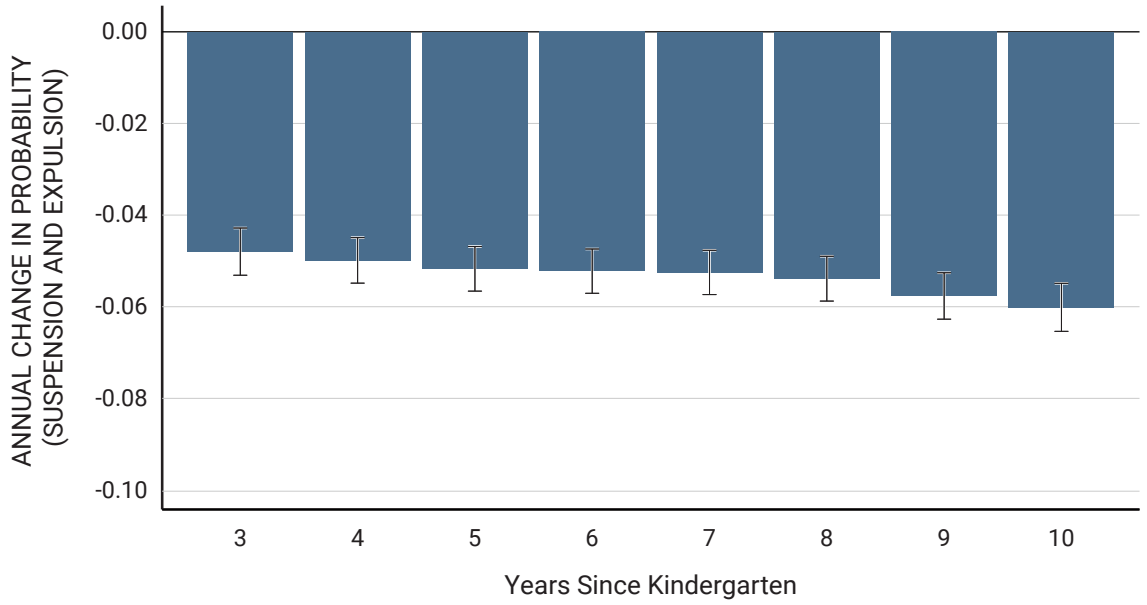
To ensure I was isolating the impacts of school resources, independent of school practice, the models I estimated account for statewide trends (by grade and cohort), and a subset of models also include controls for these markers of California schools' adoption of restorative justice practices.[15] It is important to bear in mind that there may be developmental multiplier effects of funding on the efficacy of these school practice reforms (i.e., positive synergies between school resources and school practices that are equity enhancing).

I examined the role of school spending in elementary school, middle school, and high school (grades 3–11) to account for child developmental stage–specific factors. I present results for all students, and separately for boys, girls, students from low-income families, and—in light of the well-documented racial disparities in suspension rates—for Black boys and Black girls. Prior work has shown that boys tend to exhibit greater externalizing behavior problems ("acting out"), while girls tend to exhibit greater internalizing behavior problems ("acting in").[16] The research design utilized enables one to disentangle the influence of baseline student proclivities for in-school behavior problems to isolate the independent effects of school resources.

As shown in Figures 17–20, LCFF-induced increases in school spending were associated with significant reductions in the annual incidence of suspensions and expulsions across all grades (3rd–10th), with effects greater for boys than girls, and with larger effects in high school relative to elementary and middle school. In particular, the results indicate that a $1,000 increase in per-pupil spending experienced for 3 consecutive years led to, on average, a 5 to 6 percentage-point reduction in the likelihood of boys being suspended or expelled in a given year of high school and a 3 percentage-point reduction for girls.

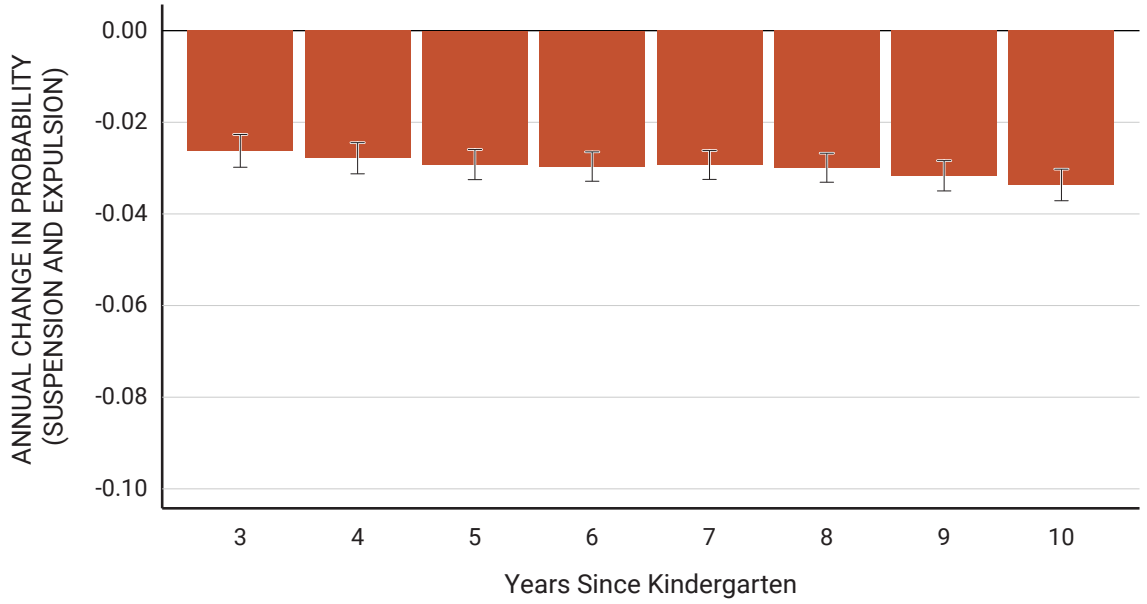
The impacts are striking and are the most pronounced for Black boys and Black girls. The evidence reveals that a $1,000 increase in per-pupil spending experienced for 3 consecutive years (grades 8–10) was associated with an 8 percentage-point reduction in the likelihood of suspension or expulsion in high school (10th grade) among Black boys and a 5 percentage-point reduction for Black girls.

Figure 17
Estimated Impacts of $1,000 Increase in Per-Pupil Spending (for 3 Years) on Likelihood of Suspension and Expulsion, Boys



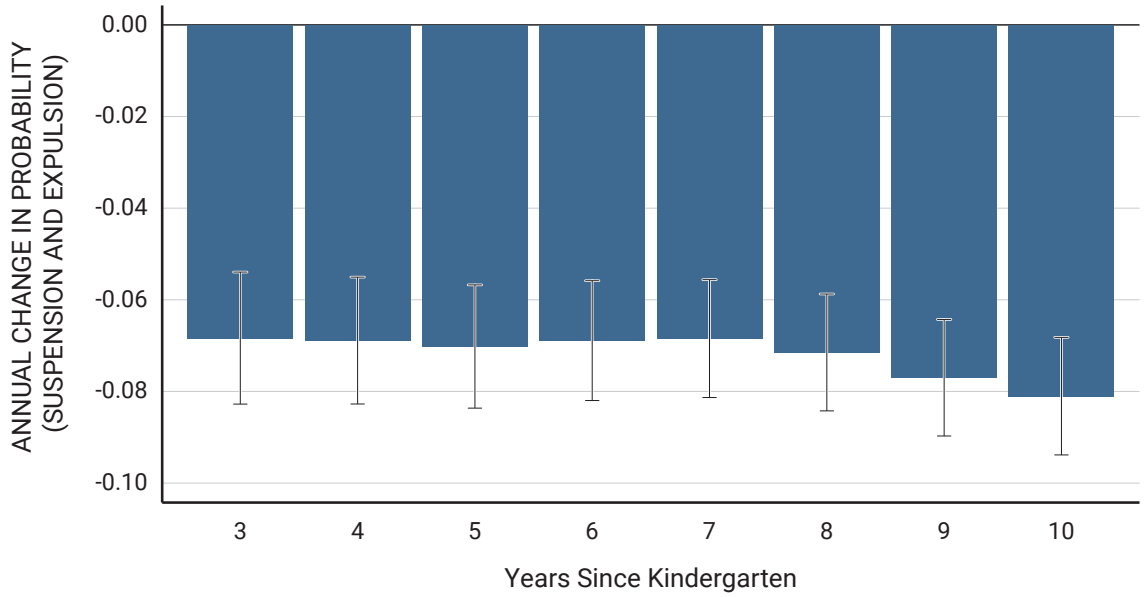
Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

Figure 18
Estimated Impacts of $1,000 Increase in Per-Pupil Spending (for 3 Years) on Likelihood of Suspension and Expulsion, Girls



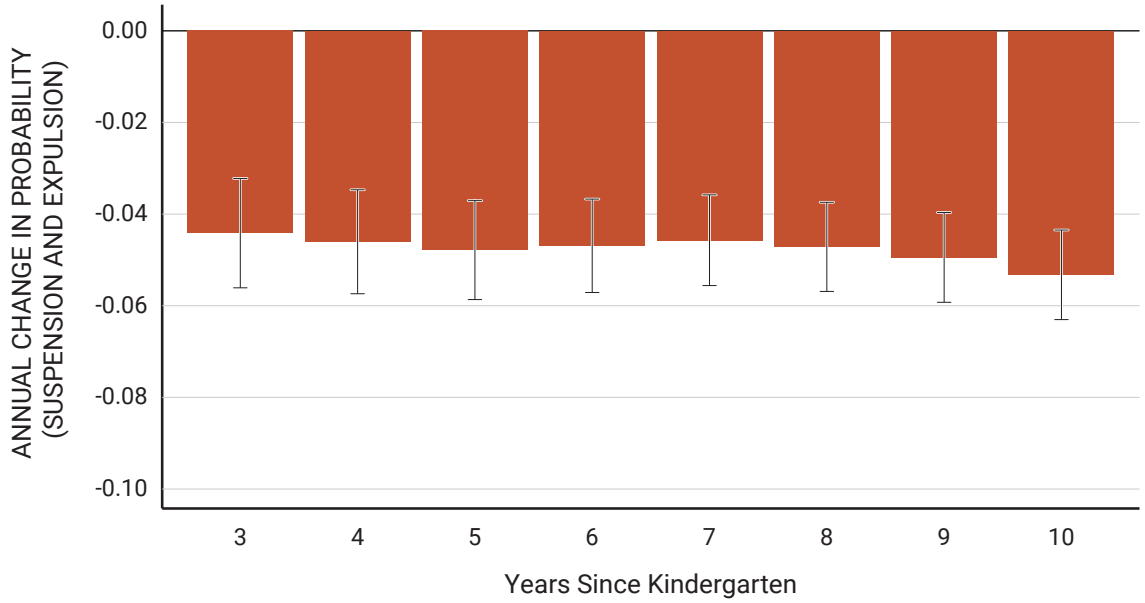
Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

Figure 19
Estimated Impacts of $1,000 Increase in Per-Pupil Spending (for 3 Years) on Likelihood of Suspension and Expulsion, Black Boys



Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

Figure 20
Estimated Impacts of $1,000 Increase in Per-Pupil Spending (for 3 Years) on Likelihood of Suspension and Expulsion, Black Girls



Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

These results contribute additional hard evidence that soft skills matter and that school resources can play an influential role in their development, in this case potentially replacing a school-to-prison pipeline with a school-to-life success one. The findings highlight how disciplinary practices interact with school resource environments in ways that can either mitigate inequitable outcomes or reinforce and exacerbate them. These results are part of a larger project in which I am investigating the causal impacts of school resources on a suite of socioemotional development and academic, disciplinary, behavioral, school climate, and mental health outcomes throughout the K–12 school career.

What Type of Spending Matters Most?

The Local Control Funding Formula's (LCFF) emphasis on funding high-need students and districts appears to have contributed to improved achievement, graduation rates, and college readiness. This raises additional questions: How did districts invest the additional resources? And which investments resulted in the largest improvement in student outcomes? To investigate which types of school inputs and resource allocations are systematically most productive in boosting student achievement, this study looked at the array of different spending categories, student achievement measures, student-to-teacher ratios, and teacher characteristics.

I employ multilevel models and hierarchical variance decomposition methods to decompose the sources of school spending effectiveness into district-level factors (e.g., teacher salary schedules are typically set at the district level) vs. between-school within district processes (e.g., teacher turnover, student-to-teacher ratios, and the distribution of teacher quality across schools within the district) and within-school processes (e.g., distribution of teachers and resources among classes). Our goal is to identify at what levels of the system educators and policymakers can most productively address educational inequities and which opportunity-to-learn factors provide the most leverage for boosting student performance and reducing disparities in student outcomes. Somewhat surprisingly, I find that among middle school grades, upward of 40% of per-pupil spending effects vary between middle schools within districts, while roughly 60% of school spending effects vary across districts.

The results indicate that increases in instructional expenditures appear to be the input associated with the largest consistent boost in student performance. School input changes can explain roughly 84% of the variation in school spending effectiveness, with three school inputs seeming systematically to matter most: reductions in class size, increases in teacher salaries, and reductions in teacher turnover. Increases in guidance counselors, health services, and funding for teacher professional development were also significantly and positively associated with higher school spending effectiveness.

The pattern of results, on average, broadly echoes those reported by Jackson, Johnson, and Persico,[17] who demonstrate that court-ordered school finance reforms that increased spending resulted in disproportionately higher increases in both instructional spending and support services. Spending increases on school facility construction and building maintenance, as well as increases in school-level administrative salaries or graduate degrees for teachers, were not significantly associated with measurable improvements in academic achievement over the study period. (However, they may present other benefits, as discussed in "Funding Inputs and Their Effects on Student Outcomes.") In sum, greater school investments devoted to instructional expenditures that reduce class sizes, increase teacher salaries, and reduce teacher turnover—associated with a stronger, more stable teaching force—promote higher student academic achievement.

Funding Inputs and Their Effects on Student Outcomes

The Local Control Funding Formula (LCFF) serves as an example of an unrestricted funding scheme, as funds can be put to use within schools and districts as leaders see fit. While keeping in mind that no one-size-fits-all solution exists, the following information outlines possible applications of school funds and how they may (or may not) benefit school achievement. It presents data from original research and other sources but does not make recommendations on uses of funding.

Positive outcomes have been observed when funding is put toward:

- **Class size reductions**: Class size reductions often correspond with improved social environments in schools and fewer students exhibiting problem behaviors. Inversely, higher student-to-teacher ratios negatively impact teachers' instructional effectiveness by placing greater demand on classroom management and impairing teachers' ability to offer individualized attention to students with higher and lower levels of preparation and learning. One commonly cited experiment found that smaller class sizes lead to significant improvements in students' math and reading achievement (about 0.15 standard deviations in terms of average math and reading scores measured after each grade for 4 years).[18]
- **Teacher salaries**: Teacher compensation influences recruitment and retention and is associated with the level of teacher skill that districts can maintain—the capacity of a school's instructional staff to effectively execute classroom curricula and support learning. Low levels of teacher compensation, especially common in high-poverty schools, are associated with economic adversity, which in turn can negatively impact teachers' "psychological load"—including incidences of depression, stress, and emotional exhaustion—and inhibit their classroom performance.
- **Teacher retention**: Approximately 1 in 5 teachers leaves the profession within the first 5 years, and that proportion is as high as 1 in 2 in high-poverty districts.[19] Teacher–student relationships—a critical element of classroom quality and active learning—are disrupted when teachers leave schools during the school year.[20] Additionally, teachers hired to replace those who leave typically have lower levels of experience and are less effective than the teachers they replace.[21] Higher salaries, professional development opportunities, and adequate staffing can contribute to teacher retention.[22]
- **Other instructional expenditures**: Other instructional expenditures, such as teacher professional development and trainings, can enhance the content that students are taught and how (e.g., through active learning methods), the skills and knowledge that teachers bring to instruction, and instructional consistency and coherence.[23]

- **Facilities**: School facilities are among the most important public infrastructure investments, yet many schools in the United States are in need of renovation, expansion, modernization, and repair. Inferior school environmental conditions, disproportionately present among high-poverty schools, can negatively influence both students' and teachers' performance.[24] While this study did not find that expenditures on facilities themselves increased students' academic outcomes, improved facilities can increase well-being and improve classroom instruction, indirectly influencing achievement outcomes.

However, data from the California State Teachers' Retirement System indicate that some districts had accrued substantial teacher pension debt and allocated portions of the LCFF funding to pay down the debt. The analysis conducted for this study suggests districts that used increased funding to pay down previously accrued pension liabilities (or put it toward other related spending that does not make it to the classroom) generally did not experience improved student achievement.[25]

In conclusion, the results of this research and related literature indicate that increases in instructional expenditures appear to be the single biggest school input associated with the largest consistent boost in student performance. In fact, school input changes may account for upward of 84% of the variation in school spending effectiveness, with reductions in class size and teacher turnover and increases in teacher salaries appearing to matter most systematically. It is also worth noting that many of these inputs are interrelated. For example, teacher salaries can affect teacher retention; facilities can partially inform class size; and so on.[26]

Increases in instructional expenditures appear to be the single biggest school input associated with the largest consistent boost in student performance, with reductions in class size and teacher turnover and increases in teacher salaries appearing to matter most systematically.

Key Findings

Analysis of data in this study resulted in the following five key findings:

1. **LCFF improved students' math and reading achievement.** Analyses find positive and significant effects of LCFF-induced increases in per-pupil spending on academic achievement in math and reading in every grade assessed (3rd–8th and 11th) and for every school that experienced this new infusion of state funds, which targeted lower-income districts and students from low-income families. The positive impacts on student achievement increased with school-age years of exposure to the greater funding and with the amount of increased funding that occurred due to LCFF. The results indicate that a $1,000 increase in

per-pupil spending experienced for 3 consecutive years led to a full grade-level improvement in both math and reading achievement, relative to what the average student achieved prior to the funding increases. These results are consistent across modeling strategies, providing confidence in the results. Further, a causal interpretation of the results is supported by the lack of significant spending effects found for Basic Aid districts (which were not subject to state school funding formulas) and the lack of any similar pattern found in the years preceding LCFF's implementation.

2. **LCFF reduced the probability of grade repetition.** LCFF-induced increases in school spending also led to significant reductions in the probability that a student would need to repeat a grade, particularly during elementary school. The findings indicate that a $1,000 increase in per-pupil spending experienced for 3 consecutive years resulted in a 5 percentage-point reduction in the probability of students experiencing grade repetition by 3rd grade, a corresponding 5.1 percentage-point reduction by 4th grade, and a 5.3 percentage-point reduction in the likelihood of grade repetition by the end of elementary school (5th grade). These grade progression effects were likely enhanced by the coincident introduction of transitional kindergarten over this period.

3. **LCFF increased the likelihood of high school graduation and college readiness.** Analyses find the increase in school spending subsequently increased the likelihood of graduating from high school and college readiness. Students exposed to LCFF concentration funding displayed an increased likelihood of graduating from high school. For all student groups, a $1,000 increase in the average per-pupil spending experienced throughout one's high school years (grades 9–12) increased the likelihood of graduating from high school by 8.2 percentage points, on average. The estimated effect is strongest for Black students but is not statistically distinguishable from the large significant effects found for other subgroups.

   Furthermore, LCFF-induced increases in spending led to substantial improvements in college readiness among students in high school. In particular, the results indicate that a $1,000 increase in per-pupil spending experienced in 3 consecutive years of high school (grades 9–11) led to a 9.8 percentage-point increase in the likelihood of meeting college readiness standards in math and a 14.7 percentage-point increase in the likelihood of meeting college readiness standards in reading.

4. **LCFF decreased suspensions and expulsions.** In addition to the effects of California's accountability reforms aimed at reducing suspensions, LCFF-induced increases in school spending enabled significant reductions in the annual incidence of suspensions and expulsions across all grades (3rd–10th), with effects greater for boys than girls and with larger effects in high school relative to elementary and middle school. In particular, the results indicate, on average,

that a $1,000 increase in per-pupil spending experienced for 3 consecutive years was associated with a 5 to 6 percentage-point reduction in the likelihood of being suspended or expelled in a given year of high school for boys and a 3 percentage-point reduction for girls. The impacts for Black students are striking and are the most pronounced. The evidence reveals that a $1,000 increase in per-pupil spending experienced for 3 consecutive years (grades 8–10) was associated with an 8 percentage-point reduction in the likelihood of suspension or expulsion in high school (10th grade) among Black boys and a 5 percentage-point reduction in the probability of suspension or expulsion for Black girls.

5. **LCFF-induced investments in instructional inputs were associated with improved student achievement.** Analyses find that increases in instructional expenditures appear to be the input associated with the largest consistent boost in student performance. The results reveal that roughly 84% of the variation in school spending effectiveness can be explained and is predominantly driven by the trio of combined funding impacts of class size reductions, teacher salary increases, and reductions in teacher turnover. Comporting with prior research, this analysis found these three school inputs—each related to the sustainment of a strong, stable teacher workforce—mattering the most.

Conclusion

In the decade leading up to passage of the Local Control Funding Formula (LCFF), California consistently ranked among the lowest 15 state systems in average per-pupil spending adjusted for cost of living, with persistently large educational opportunity gaps across district socioeconomic status divides left unaddressed. LCFF resulted in substantial increases in public education investments in transitional kindergarten through 12th grade and a transformative funding formula overhaul that has been sustained in recent years, as reflected in the fact that the funding K–12 public schools received in the 2022–23 state budget is nearly triple the funding received in 2011.

The empirical strategy in this paper used the staggered timing of LCFF implementation, coupled with the kink in the funding formula at 55% district disadvantage, to approximate a true experiment for the examination of the effects of increased school spending. This study finds LCFF-induced increases in school spending led to profound improvements in student achievement trajectories and significant reductions in student achievement gaps by district socioeconomic status and race, with achievement improvements most pronounced for students from low-income families and students of color at higher-poverty schools where spending increases were most targeted.

Because of the cumulative nature of learning, dynamic models that consider the cumulative effects of multiple years of funding embody the idea that early learning begets later learning.[27] Therefore, higher baseline achievement is a conduit that enables students to take greater advantage of subsequent learning opportunities afforded in school, further augmenting achievement growth.

The robustness of the significant positive relationship between multiyear per-pupil spending on all student outcomes measured for each grade and subject across different models and subgroups provides compelling causal evidence that the estimated impacts are not driven by any single group of students or districts, nor confined to a single outcome, but rather reflect a general pattern that school spending matters. A causal interpretation of these results is further supported by the lack of significant spending effects found for Basic Aid districts (which were not subject to state school funding formulas) and the lack of any similar pattern found in the years preceding LCFF's implementation, as documented in the placebo tests and falsification exercises.

In sum, the results garnered through this study show meaningful outcomes when sustained, multiyear funding reaches the classroom, particularly in high-need communities. For student success, instructionally focused dollars matter more than others, and systematic spending practices of school districts can shape student achievement trajectories. In particular, dollars spent on smaller class sizes and higher teacher salaries that reduce turnover proved to be most significant in predicting achievement gains. Moreover, insights from a study of one of the nation's largest and most diverse state public education system may also be instructive for other states.

While achievement gains and policy momentum have been substantially slowed and, potentially, reversed for many students and communities due to school closings and remote learning during the pandemic, this study provides some lessons on how to target resources to ensure schools regain the traction to boost performance for students of all backgrounds.

Appendix A: Methods and Data

All analyses were restricted to students first observed in a California public school beginning in kindergarten (or earlier, in the case of those who attended transitional kindergarten or a California State Preschool Program) and followed thereafter. Quasi-experimental methods were used to isolate the causal effects of Local Control Funding Formula (LCFF)-induced increases in per-pupil spending on a variety of student achievement outcomes. Two approaches were used: difference-in-difference and difference-in-regression kink design within a two-stage least squares instrumental variables framework.

Research Design 1: Difference-in-Difference

The difference-in-difference (DiD) model compares the differences in student achievement growth after LCFF spending increases across districts with a high percentage of student disadvantage (55% or greater) while accounting for lagged achievement 3 years prior to assessment (*t*–3) and statewide time trends (year-specific factors). The difference-in-difference approach analyzes achievement growth and only relies on within-district variation over and above common statewide time trends.

Research Design 2: Difference-in-Regression Kink Design

The research design utilized to produce the main results presented in this study is a difference-in-regression kink design (Diff-in-RKD) that exploits both variation induced by the staggered rollout timing of LCFF implementation and variation induced by the kink in the funding formula at 55% district disadvantage via the state aid's concentration grant eligibility cutoff. These two sources of variation allow for the use of both DiD and regression kink designs to be combined in a unified framework. The Diff-in-RKD approach accounts for both persistent factors (observable and unobservable) that lead to differences in student achievement levels across districts and differences in achievement growth by district percent disadvantage. Specifically, the Diff-in-RKD approach allows for the existence of differences in achievement growth by district percent disadvantage before the LCFF state finance reform, and it imposes a "common trend" assumption that such differences in achievement growth would remain the same if districts had not received LCFF-funded concentration grants. Importantly, this approach accounts for other policy changes and the potential relative to pre-existing differences in achievement growth by district percent disadvantage. The empirical strategy exploits only the kink in the funding formula at 55% district disadvantage to isolate the causal impacts of spending and simulates the counterfactual funding that would have occurred in the absence of LCFF concentration grants. The main model specification controls for the following:

- Schools and districts ("fixed effects")
  - E.g., Berkeley High School vs. Skyline High School (Oakland, CA)

    - Charter school type vs. traditional public school

- Kindergarten cohort fixed effects
    - Grade

- District % of students disadvantaged (2013) * Grade
    - Captures differences in the (baseline grade–specific) average growth rate of learning by district (linear) % disadvantage

- District % of students disadvantaged (2013) * Year fixed effects
    - Captures Diff-in-RKD counterfactual had there been no kink in LCFF funding formula at 55% (as was the case pre-LCFF)

- Proportion of funding subject to restrictions

The results are also robust to control for school (and district) responses to the economy.

The simulated instrumental variables approach instruments for a student's average per-pupil spending that prevailed in (*t, t*-2) in their district (i.e., average spending during the relevant 3-year period—which is the key explanatory variable of interest—to examine their impacts on the student's assessed outcome in year *t*). It also allows estimated spending effects to differ across grades. The excluded instruments are the pre–post LCFF-induced change in a district's per-pupil funding in each year at ages *t*, *t*-1, *t*-2, and *t*-3. This is computed using the relevant funding formula in effect in each year (pre- and post-LCFF) and evaluated using 2013 district percent disadvantage (not endogenous changes due to school compositional changes from parental responses to LCFF). This modeling approach accounts for the fact that current learning outcomes are influenced by school resources in the current and previous years. This empirical strategy isolates exogenous policy-induced variation in school spending—driven by the timing of funding reforms to LCFF and the respective funding formula in effect each year—and distinguishes it from the endogenous variation driven by residential sorting and changes in the tax base. Because LCFF eliminated many state categorical programs, one must analyze the changes in funding based upon both the pre-LCFF and post-LCFF formulas that were in effect each year over time.

Causal impacts of per-pupil spending are identified by comparing the changes in student achievement growth across cohorts within districts with differential exposure to LCFF-induced increases in per-pupil spending (due to rollout timing) and between districts with higher percent disadvantage (0–55% vs. >55%) among those from the same cohort (due to kink in funding formula beyond 55% from concentration grant). To compare changes in each district's outcomes to time trends for districts with similar percent disadvantage, I include the district-specific percent disadvantage (linearly specified) interacted with year fixed effects and district-specific percent disadvantage interacted with grade (in the first and second stage, respectively). This accounts for pre-LCFF (pre-existing) time-trend differences between districts with higher (vs. lower) percent disadvantage, as the Great Recession caused socioeconomic

achievement gaps (by district socioeconomic status) to increase significantly in the years leading up to LCFF implementation through 2014–15.[28] Because this model includes year fixed effects interacted with district percent disadvantage, the excluded instruments are differential increased funding due to the kink in the formula at 55% interacted with rollout timing. Over and above common statewide year-specific trends, if the only reason for a differential post-LCFF change in the student achievement growth in math and reading across districts with higher (>55%) and lower (<=55%) percent disadvantage is the differential effect of the funding formula's kink at 55% from concentration grant on public K–12 spending across these districts, then the research design credibly identifies causal impacts of per-pupil spending (i.e., instrument is valid). I perform many empirical tests showing that this condition is likely satisfied.

The school funding formula rules have a somewhat arbitrary threshold cutoff—in this case, for eligibility for concentration grants at 55% district disadvantage—and thereby provide a natural experiment in which changes in funding levels (at the kink) are determined in a way that is uncorrelated with unobservables (conditional on district and year fixed effects). Essentially, even if many other factors influence student achievement, as long as the relationship between these factors and district disadvantage evolves continuously across the concentration grant eligibility threshold (55% disadvantage), regression kink designs will approximate random assignment in the neighborhood of the kink.[29]

The student-level outcome is either (1) math or reading standardized achievement (National Assessment of Educational Progress–normed, adjusted in grade-level equivalents) in year *t*; (2) probability of graduating from high school for 17- and 18-year-olds who were expected to graduate from high school in district *d* in year *t*; or (3) probability of suspension and/or expulsion in year *t.*

The rationale for using 2014 as the reference year is threefold:

1. Progressivity of the new funding formula does not take effect in the first post-LCFF year, so there is no sizable identifying variation independent of common statewide funding increases (i.e., independent of year fixed effects); also, lingering effects of the Great Recession persist through 2014.

2. The research design must distinguish LCFF features of more discretion/autonomy of how to spend funding vs. more funding (7-year staggered rollout of funding, but the proportion of funding that is subject to restrictions does not change after 2014).

3. The same testing assessments of reading and math achievement were used from 2014 through 2019 (California Assessment of Student Performance and Progress).

Note that the similarity and robustness of estimated LCFF-induced spending effects across both DiD and diff-in-RKD research design approaches address omitted variable bias concerns and effectively rule out plausible alternative explanations for the results. Furthermore, the falsification exercises and placebo tests performed show:

- insignificant effects found for Basic Aid districts (which were not eligible for LCFF funding), and
- insignificant effects found during pre-LCFF years (achievement gaps were widening, and those patterns only reversed after LCFF was implemented).

Moreover, the results are robust to counter alternative explanations (e.g., coincident changes), including Common Core standards implementation, rebound from the Great Recession and mean reversion, and change to new testing instruments.

Data Sources

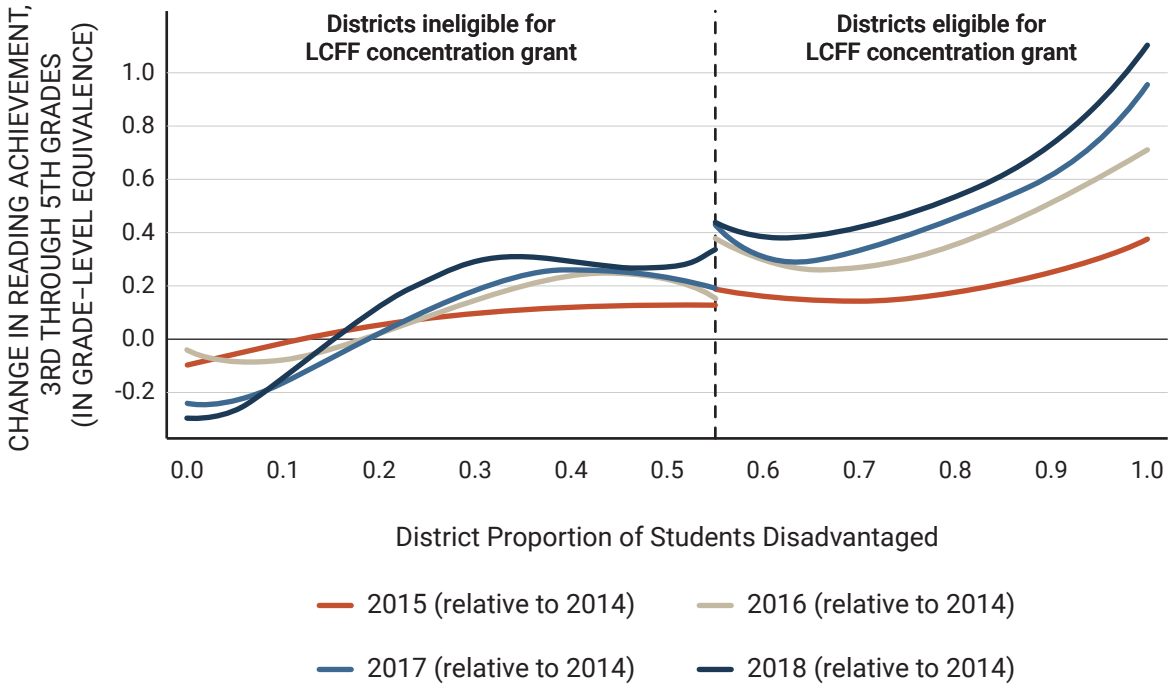
I use student-level longitudinal data matched with the publicly available annual school-level and district-level finance data, spanning 1995 through 2019, to identify the impacts of changes in district expenditures and school inputs (student-to-teacher ratio and teacher quality) on student achievement. The analyses in this study largely draw on data from LCFF's rollout period between 2013 and 2019. (LCFF began in 2013 and became fully funded in the 2018–19 school year.) Various data sources of school-level conditions and student achievement are considered.

- **School district records.** The student-level K–12 data from the California Longitudinal Pupil Achievement Data System (2004–2019), administered by the California Department of Education, is used to produce individual-level data, including demographics, course data, and discipline. The school district finance records for 1995–2019 capture a school-by-birth cohort panel of school resource data matched in each year of students' K–12 tenure.
- **District spending.** Annual district financial records are available in aggregate from the Standardized Account Code Structures (SACS), which are unaudited actual data files from 2003 forward. Each SACS file contains data on all general-ledger financial records (both expenditures and revenues) for public school districts in a given year. School-level teacher salary measures, which comprise the lion's share of school budget items, are compiled by combining information from the district-level salary schedules and school-level staffing data over time.
- **High school graduation.** The analyses that examine the likelihood of students graduating from high school use longitudinal data of all public school students in California and apply the state's adjusted 4-year cohort graduation rate definition to track high school attendance patterns through potential graduation (or dropout), which can be consistently measured over the 2009–2019 period.

- **Academic achievement.** California's Smarter Balanced test serves as the basis for students' academic achievement measures. The Smarter Balanced test is designed to evaluate students' progress toward mastery of the Common Core State Standards, and scores fall into four achievement levels: Standard Not Met, Standard Nearly Met, Standard Met, and Standard Exceeded.
- **College readiness.** Students' achievement levels on the 11th-grade math and reading portions of the Smarter Balanced test serve as markers for college readiness. For each subject, students who earn a score classified as Standard Exceeded are identified as college ready, and students whose score earns the achievement level of Standard Met are identified as conditionally ready for college.
- **Teacher quality and instructional expenses.** The data that include markers of teacher quality come from the California Department of Education. The state maintains an annual file of all teaching staff in each public school, which contains the staff members' education level, years of experience, and years working in the district, among other variables.

Appendix B: Additional Figures

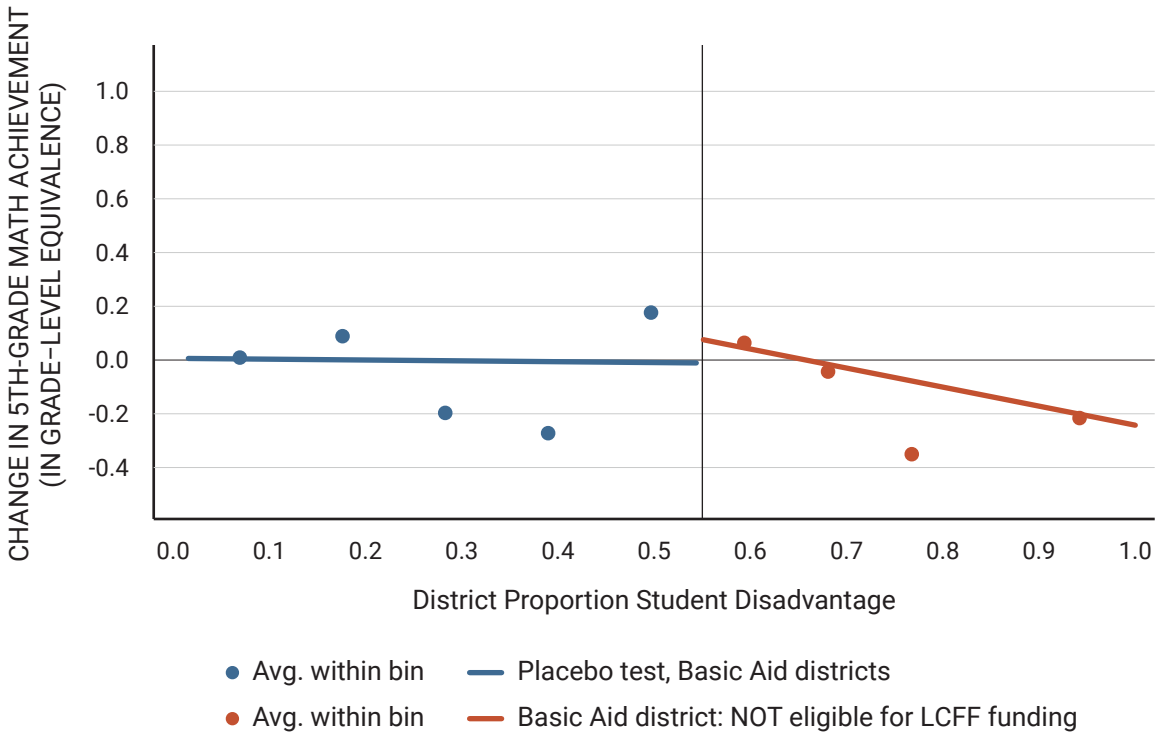
Figure B1: Increase in Reading Achievement Before and After LCFF, by Year, Grades 3 Through 5



Note: Lines represent the change in reading achievement relative to 2014.

Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

Figure B2: Change in 5th-Grade Math Achievement Before (2014) and After (2018) LCFF for Basic Aid Districts Not Receiving LCFF Funding



Sources: Author analysis of data from the California Department of Education for 2014–2018 in the Standardized Account Code Structure and California Longitudinal Pupil Achievement Data System.

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2. The Nation's Report Card. *California student groups and gaps* [Data set]. https://www.nationsreportcard.gov/profiles/stateprofile/overview/CA?cti=PgTab_GapComparisons&chort=1&sub=MAT&sj=CA&fs=Grade&st=MN&year=2013R3&sg=National%20School%20Lunch%20Eligibility%3A%20Eligible%20vs.%20Not%20Eligible&sgv=Difference&ts=Single%20Year&tss=2013R3&sfj=NP

3. If a district experiences a change in either annual enrollment (average daily attendance) or socioeconomic composition of students in terms of the proportion disadvantaged, then the district's state funding allotment for that year changes accordingly in alignment with the formula. Since 2013 there has been an incentive for a district to endogenously classify its students as disadvantaged, such as through an increased effort to collect a student's socioeconomic status or retaining students in the limited English proficiency category. To insulate estimates from this potential bias and to avoid using any classification of district percent disadvantage that could have been affected by LCFF itself, I use each district's percent disadvantage in 2013 (before initial LCFF implementation) in all years.

4. Cellini, S. R., Ferreira, F., & Rothstein, J. (2010). The value of school facility investments: Evidence from a dynamic regression discontinuity design. *Quarterly Journal of Economics*, *125*(1), 215–261. https://doi.org/10.1162/qjec.2010.125.1.215

5. This also includes children observed earlier than kindergarten for those who attended transitional kindergarten (TK) and/or a California State Preschool Program. I use the earliest school identifier to match prevailing school spending during their school-age years and for the school- and district identifiers for the school and district fixed effects to circumvent potential bias from endogenous parental residential mobility (e.g., cohorts first observed in kindergarten using earliest school identifier). Any measurement error from using the earliest school identifier (i.e., not incorporating information on school moves that may be endogenous) will likely lead resultant estimates to be diluted, yielding more conservative estimates of school spending effects, assuming classical measurement error.

6. This variation allows for the use of both difference-in-difference and regression kink designs to be combined in a unified framework.

7. Bloom, Raudenbush, Weiss, & Porter (2017) refer to this type of multilevel fixed-effect, random coefficient model as a "fixed intercept random coefficient" (FIRC) model. See: Bloom, H. S., Raudenbush, S. W., Weiss, M. J., & Porter, K. (2017). Using multisite experiments to study cross-site variation in treatment effects: A hybrid approach with fixed intercepts and a random treatment coefficient. *Journal of Research on Educational Effectiveness*, *10*(4), 817–842. https://doi.org/10.1080/19345747.2016.1264518

8. The Smarter Balanced Assessment Consortium (SBAC) is designed to evaluate students' levels of college- and career readiness. Smarter Balanced Assessment scale scores fall into four achievement levels: Standard Not Met, Standard Nearly Met, Standard Met, and Standard Exceeded, the purpose of which is to describe students' progress toward mastery of the Common Core State Standards. Moreover, the achievement level on the 11th-grade math and reading Smarter Balanced Assessment determines the markers for college readiness. For each subject, students earning the achievement level of Standard Exceeded are identified as college ready and students earning the achievement level of Standard Met are identified as conditionally ready for college, which also directs students and schools to a set of 12th-grade courses students can take to satisfy the conditionally ready signal. Earning a Standard Nearly Met or Standard Not Met comes with a signal that students are not yet ready for college-level work.

9. For example, the proficiency determination of students based on these achievement tests is used for California state universities (CSUs) and California community colleges to exempt students from any additional remedial coursework. Moreover, Kurlaender and Cohen (2019) show that these college readiness markers are highly predictive of college success as measured by first-year college GPAs and second-year persistence rates, and at least as well as other commonly used assessments for predicting college success, such as SAT scores, for students enrolled in the CSU system and at University of California (UC) campuses. See: Kurlaender, M., & Cohen, K. (2019). *Predicting college success: How do different high school assessments measure up?* Policy Analysis for California Education. https://edpolicyinca.org/sites/default/files/R_Kurlaender_Mar-2019.pdf

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