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Does School Funding Matter In a Pandemic? COVID-19 Instructional Models and School Funding Adequacy

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The factors that influenced school districts' decisions to offer virtual, hybrid, or in-person instruction during the 2020-21 school year—the first full school year after the emergence of the COVID-19 pandemic—have been the focus of a large body of research in recent years. Some of this research examines the influence of school spending, among other factors; however, these studies do not consider spending in relation to cost, "cost" being the amount needed for a school district to achieve a given outcome. This paper uses a measure of adequacy, which is the amount of spending under or over estimated cost, to determine whether spending correlates with the amount of time a school district offered virtual instruction. We find spending adequacy significantly and substantially predicts time spent in virtual instruction: for every $1,000 positive change in adequacy (closing a gap and/or adding to a surplus), the time spent in virtual schooling decreases 0.6%. A one standard deviation positive change in adequacy, therefore, results in 7.5 fewer days of virtual instruction. While our findings are descriptive, they do require future researchers to consider school spending adequacy, as much as any other factor, as a predictor of pandemic instructional models.

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Abstract

The factors that influenced school districts' decisions to offer virtual, hybrid, or in-person instruction during the 2020-21 school year—the first full school year after the emergence of the COVID-19 pandemic—have been the focus of a large body of research in recent years. Some of this research examines the influence of school spending, among other factors; however, these studies do not consider spending in relation to cost, "cost" being the amount needed for a school district to achieve a given outcome. This paper uses a measure of adequacy, which is the amount of spending under or over estimated cost, to determine whether spending correlates with the amount of time a school district offered virtual instruction. We find spending adequacy significantly and substantially predicts time spent in virtual instruction: for every $1,000 positive change in adequacy (closing a gap and/or adding to a surplus), the time spent in virtual schooling decreases 0.6%. A one standard deviation positive change in adequacy, therefore, results in 7.5 fewer days of virtual instruction. While our findings are descriptive, they do require future researchers to consider school spending adequacy, as much as any other factor, as a predictor of pandemic instructional models.

***Keywords*: COVID-19, school spending, school funding adequacy, pandemic learning models, virtual, hybrid, in-person.**

Does School Funding Matter In a Pandemic? COVID-19 Instructional Models and School Funding Adequacy

The closing of schools at the onset of the COVID-19 pandemic in the spring of 2020 is arguably one of the most consequential events in the history of American education. A research consensus is emerging that finds that remote schooling during the 2020-21 school year had a pronounced effect on the academic progress and mental health of students. School districts, however, varied widely in how they delivered instruction: some districts offered fully remote/virtual schooling, some were fully in-person, and some were a hybrid of the two. In addition, in response to changes in the local COVID-19 case rate or other factors, districts changed their instructional models as the year progressed. Given the consequences of these choices, understanding why school districts offered the instruction that they did is an important policy question.

Over the past two years researchers have explored the correlation between pandemic instruction and variables that might explain school districts' choices: political affiliation, teachers union strength, local COVID-19 prevalence, and student demographics have all been assessed as potential predictors of instructional delivery models. A small number of studies have also included spending per pupil in their models; most have found no correlation between spending and the types of instruction offered. What these studies fail to include, however, is a measure of school spending *adequacy*. Research has established that school districts with different student populations and different economic contexts require different amounts of funding to provide equal educational opportunity. Two school districts spending the same amount per pupil may have very different costs, "cost" being the amount necessary for a district to achieve some common educational goal. A simple measure of spending per pupil will therefore be an

insufficient measure of a district's ability to provide an adequate education—and, potentially, its ability to provide a particular type of schooling during a global pandemic.

During the 2020-21 school year, school districts were advised to implement a variety of mitigations to reduce the spread of COVID-19 if providing in-person instruction. There is reason to believe the ability of districts to implement those mitigations depended on their fiscal capacity. Adequate ventilation requires a building with appropriate and well-maintained HVAC systems. Social distancing requires both a facility large enough to accommodate spacing requirements and enough staff to adequately supervise students. If a district spends less than adequately, it will likely have less capacity to implement these and other mitigations, and therefore opt for virtual instruction.

This paper contributes to the literature on pandemic schooling by examining the correlations between measures of funding adequacy and instructional delivery. Our measure of adequacy, which we have described in a previous study (Baker, Weber, et al., 2021), is based on well-established, empirical methods that determine a school district's cost of achieving national average outcomes, accounting for that district's student population and characteristics. After establishing the difference between a district's estimated adequacy cost and its actual spending—which we refer to as its "adequacy gap/surplus"—we determine the correlation between adequacy and the percentage of time students spent in virtual, hybrid, or in-person schooling during the 2020-21 school year. Because our analysis focuses on spending relative to cost, as opposed to simply spending, we are better able to determine whether fiscal capacity was a relevant factor in districts' responses to the pandemic.

Our paper begins with a review of the literature on pandemic instructional models, including how spending has been measured and used in regression-based and other analyses. We

then recap our previous work in education cost modeling, reviewing both the theoretical underpinnings and methods of our cost estimates. Next, we explain our empirical strategy for determining the correlations between the percentage of time a district's students spent in different types of pandemic instruction and measures of school funding adequacy. As a contrast, we also employ a model, similar to previous research, that uses a simple measure of per pupil spending among a set of other predictors with the percentage of time in virtual instruction as the dependent variable. After presenting our estimates, we discuss the ramifications of our findings for policymaking and future research.

Literature Review

There is little question that the COVID-19 pandemic, the subsequent closing of schools in the spring of 2020, and the deployment of various types of instructional models during the 2020-21 school year had a profound effect on students in the United States. The extent of the "learning loss" suffered by students is still to be determined, but there is ample evidence losses did occur. (Kuhfeld et al., 2022; Pier et al., 2021) In addition, losses were not evenly distributed across student populations, with students in poverty and students of color suffering larger decreases in educational outcomes. (Goldhaber et al., 2022; Kuhfeld et al., 2022) There is also evidence that academic declines were greater in districts with less in-person instruction. (Halloran et al., 2021) Given the consequences of pandemic schooling decisions, it is understandable that education researchers have focused on how and why these decisions were made.

A substantial body of research has emerged that attempts to ascertain which factors predict how a school district delivered instruction during the height of the COVID-19 pandemic. (Singer, Jeremy, 2022) Several studies find correlations between political affiliation and whether a school district delivered in-person instruction. (Flanders, 2020; Grossmann et al., 2021; Harris

& Oliver, 2021; Hartney & Finger, 2021; Kretchmar & Brewer, 2022; Singer, Jeremy, 2022; Valant, 2020) Other research finds teachers union strength correlates with pandemic instruction models; stronger unions predict a greater chance a district delivered remote instruction. (DeAngelis & Makridis, 2021; Flanders, 2020; Grossmann et al., 2021; Hartney & Finger, 2021; Hemphill & Marianno, 2021; Marianno et al., 2022) We note these studies use a wide variety of measures of union strength; none is a direct measure of how much influence a teachers union in a particular district has over COVID-19 related policy. Some studies find increases in the local COVID-19 case rate reduced the likelihood of in-person instruction. (Christian et al., 2022; Harris & Oliver, 2021) Others find correlations between student population demographics and instructional models, with remote learning more likely in districts with higher proportions of students of color. (Camp & Zamarro, 2022; Harris & Oliver, 2021; Oster et al., 2021; Viner et al., 2022)

All of these studies are subject to one important limitation: they are descriptive, which precludes making any claims of causality. As an example: white parents showed a greater preference for in-person instruction than Black and Hispanic parents during the height of the pandemic. (Gilbert et al., 2020) However, it does not necessarily follow that this preference itself is the underlying cause of students of color being more likely to receive remote instruction. It may be that parents' preferences were driven by their perceptions of the ability of their children's schools to provide safe in-person instruction. Black and Latinx parents perceive that schools serving students of color are inadequately funded. (Leadership Conference Education Fund, 2017) Further, research shows Black/African-American and Hispanic/Latinx students are twice as likely as white students to be enrolled in inadequately funded school districts. (Baker, Di Carlo, Reist, et al., 2021) If their children's schools were better funded, it is possible these

parents would feel differently about in-person instruction, as they may also perceive that schools have the staff and facilities needed to educate their children safely. Descriptive research that shows a correlation between student demographics and pandemic instruction types cannot determine whether this is the case, or whether other factors are in play. This is particularly problematic when examining the correlations between pandemic schooling models and political affiliation, which is correlated with student race and ethnicity, poverty, and health. (Harris & Oliver, 2021)

Several of these studies include a measure of spending per pupil within a regression model. (Harris & Oliver, 2021; Hartney & Finger, 2021; Houston, David M. & Steinberg, Matthew P., 2022; Marianno et al., 2022) Only Houston and Steinberg's (2022) study found spending to be a consistent and statistically significant predictor of the percentage of time in in-person learning. The study is, however, limited to a county-level analysis, using: "…the values for the largest district by enrollment in each county" as its fiscal measure. There can be significant heterogeneity in fiscal measures across districts within a county; however, this analysis does not account for that variation.

While the studies above use district-level measures of spending per pupil, they are likely inadequate for the task of determining whether school funding plays a role in pandemic instructional decision making. Variations in student populations and school district contexts can greatly influence educational costs. (Baker, Weber, et al., 2021) Disadvantaged students, for example, require more school resources to attain equal educational opportunity. (Baker & Duncombe, 2004; Duncombe & Yinger, 2005, 2011) Variations between labor markets can raise or lower the relative cost of hiring qualified staffs. (Taylor, 2006) Enrollment sizes can affect economies of scale for school districts. (Baker & Duncombe, 2004) These and other factors are

not captured by simple measures of per pupil spending; two districts with similar expenditures per student may still have very different costs to achieve their educational goals.

There is reason to believe that a school district's funding relative to its costs would affect its decisions to offer various types of pandemic instruction. Schools were advised by public health officials to implement a series of mitigations before opening, including: "…increasing physical distance by dedensifying classrooms and common areas, using hybrid attendance models when needed to limit the total number of contacts and prevent crowding, increasing room air ventilation, and expanding screening testing to rapidly identify and isolate asymptomatic infected individuals." (Honein et al., 2021) A district with greater funding relative to its costs would be more likely to be able to carry out these recommendations, both because its facilities would be better suited to meet ventilation and density standards, and because it would have the numbers of staff necessary to provide smaller class sizes with student cohorts that did not mix. School facilities improvements—particularly improvements in air quality— have been shown to have a positive effect on student outcomes. (Duran et al., 2021; Lafortune & Schönholzer, 2022; Sadrizadeh et al., 2022) Those improvements, which would require increased spending, are likely the same improvements that would improve the chances of adhering to suggested ventilation mitigations against COVID-19. A district that spent less than its adequacy cost, however, would likely be unable to implement these and other mitigations, increasing the chance it would offer only remote instruction.

This study contributes to the research on pandemic schooling by schools by considering funding adequacy, rather than simple measures of school spending, as a possible predictor of the decisions school districts made to offer in-person, hybrid, or remote schooling at the height of the COVID-19 pandemic. What we present are descriptive estimates; we make no claims of

causality, particularly as funding adequacy is highly correlated to student race and ethnicity, a clear predictor of pandemic instructional models. Nevertheless, this research provides a new perspective on why school districts responded as they did to the pandemic. Funding adequacy—as much as political affiliation, teachers union strength, student demographics, or COVID-19 prevalence—should be considered when speculating on why schools made the decisions they made.

Research Questions

Our research addresses two questions:

Q1: Is per pupil spending, adjusted for labor market effects, a predictor of whether schools offered remote instruction during the 2020-21 school year?

Q2: Is school funding adequacy, as measured by how much more or less a school district spends relative to its estimated cost, a predictor of whether schools offered in-person, hybrid, or remote instruction during the 2020-21 school year?

Methodology

Our empirical strategy consists of two models:

1) A regression model where the time spent in virtual (or other types) of instruction is predicted by a set of variables measuring district and student characteristics, COVID-19 prevalence in the region, and school district spending, the focus of our first research question.

2) A regression model where the time spent in virtual (or other types) of instruction is predicted by COVID-19 prevalence and an estimation of how much more or less a school district spends than the predicted cost of providing an education that meets a common educational outcome (average national test scores).

We draw on previous work in educational cost modeling to determine district spending relative to predicted cost, which we refer to as district spending "adequacy." We begin by summarizing this work and briefly describe the methods and data we employ to calculate our adequacy estimates. Next, we explain our two models that predict a district's pandemic instructional model based on its spending, holding other district and student characteristics constant.

Modeling and Estimating Educational Costs

The theoretical underpinnings and methodologies of educational cost modeling have been well established in the school finance literature, dating back to pioneering work from William Duncombe and colleagues in the 1990s. (Duncombe & Yinger, 2000, 2005, 2011) Unlike production models, which use educational outcomes as the dependent variable and spending (along with other covariates) as the independent variable, cost models predict spending with outcomes as an independent variable. A core challenge in cost modeling is producing estimates that are not biased by the endogenous relationship between spending and outcomes. A large and growing body of evidence demonstrates that educational outcomes such as test scores have a positive relationship with educational spending. (Baker et al., 2021; Jackson, 2018; Jackson et al., 2016; Lafortune et al., 2016; Rothstein & Schanzenbach, 2021) Yet a school district with better outcomes will likely have higher property values, creating both incentives and the capacity for taxpayers to spend more on schools, thus protecting their investment in their homes by keep property values high. Researchers employing cost models, therefore, must use methods that address this endogeneity. (Baker et al., 2021; Duncombe & Yinger, 2011; Kolbe et al., 2021)

We use a two-stage, instrumental variables model—a standard econometric method—to address this endogeneity in our approach: the National Education Cost Model (NECM). (Baker,

Weber, et al., 2021) The first stage instruments outcomes on exogenous variables known to influence educational outcomes; the second stage then uses this instrumented outcome variable to estimate educational costs. The first stage is specified as:

$$(Outcome)_{it} = \mathrm{B}_1(Surrounding\ Poverty)_{it} + \mathrm{B}_2(Surrounding\ Black\ or\ Hispanic)_{it} + \Theta X_{it} + \Gamma_t + \mathrm{E}_{it}$$

where *Outcome* is the equated average test scores for district *i* in school year *t* and *X* is a set of student population and district context factors (see below). *Outcome* is instrumented on two variables: *Surrounding Poverty* is the income-to-poverty ratio for all other school districts in a particular district's labor market; *Surrounding Black or Hispanic* is the percentage of students who are Black or Hispanic/Latinx in all other school districts in the same district's labor market. These two variables are plausibly exogenous measures of the competitive context within which a school district operates, and will thus affect educational outcomes.

The second stage is:

$$(Spending)_{it} = \beta(Outcome)_{it} + \theta X_{it} + \gamma_t + \epsilon_{it}$$

where *Spending* is the natural log of total current per pupil spending for school district *i* in year *t*. The set of student population and school district characteristics (*X*) consists of:

- A comparable wage index (ECWI) to account for varying costs across different labor markets. (Taylor & Fowler, 2006)
- The district poverty rate, adjusted to account for the fact that Census poverty rates apply the same income thresholds despite significant variations in the cost of living from district to district and state to state. (Baker, Taylor, etc. 2013)
- District percentage of students with disabilities (SWDs).
- District percentage of students who are English Language Learners (ELLs).

- District percentage of students enrolled in Pre-Kindergarten.
- District percentage of students enrolled in grades 9 to 12.
- A categorical variable for district enrollment size.
- A density measure: log of population per square mile.

In addition to these variables, which will affect district spending, we include three potential measures of district efficiency that serve as predictors of spending differences not directly associated with outcomes; in other words, measures of inefficiency:

- The percentage of the population that is between five and seventeen years old.

The theory here is a higher percentage of school-aged students in the overall population will put greater pressure on policymakers to spend on schooling.

- The ratio of housing values in a district to those in the same labor market.

Districts with relatively higher property values compared to their neighbors may feel less competitive pressure to spend above cost.

- The Herfandahl index, an indicator of competition that, again, may affect the amount of spending over cost.

Outcomes are district-levels averages of state test scores, collapsed by year across all grade cohorts, from the Stanford Education Data Archive (SEDA). (Reardon et al., 2021) These scores are equated and standardized so as to provide a consistent measure of academic outcomes across various states administering different tests. (Fahle et al., 2021) Appendix Table 1 shows the NECM estimates.

We use two versions of the NECM in this paper: the second mirrors the first but adds the percentage of Black students in a district as a covariate. Previous research in cost modeling shows excluding race as a covariate can result in biased estimates. (Baker et al., 2021;

Duncombe & Yinger, 2011; Kolbe et al., 2021) Adding a "pct. Black" variable to the model mitigates against underpredicting the costs for districts with large proportions of Black students to achieve average national outcomes. Appendix Table 2 shows the estimates of a regression of percentage Black and percentage Hispanic/Latinx on the residuals of models using and not using race covariates. The estimates of percentage Black in particular are large and significant in the model without a race covariate, suggesting omitted variable bias is present. Rather than choose either a race-neutral or race-inclusive model to calculate our adequacy gap/surplus estimates, we elect to use both in two separate models.

Using the NECM estimates, we calculate the predicted per-pupil cost of all school districts in our dataset, assuming outcomes and efficiency measures for all districts at the national average. We then calculate how much more or less a district actually spends (total current spending) compared to the estimated adequacy amount it would need to spend to reach national average outcomes, assuming average efficiency. This difference becomes the variable of interest in our second model below.

Pandemic Instruction and School District Spending

Our first model is a simple regression with percentage of time in virtual schooling as the dependent variable, and a set of district characteristics, including current spending per pupil, as the predictors:

$$ShareVirtual_i = \beta_1(CurrentSpendingPP)_i + \beta_2(State_i) + \beta_3(COVIDCaseRate_i) + \beta_4(State_i * CovidCaseRate_i) + \theta X_i + \varepsilon_i$$

where *CurrentSpendingPP* is district current expenditures per pupil; *State* is a categorical variable, interacted with the county-level COVID-19 case rate per 100,000; and *X* is a set of school district and student population characteristics that will affect district spending:

- The natural log of student enrollment.
- The percentage of the district's students who are enrolled in high school (grades 9-12).
- The percentage of students who are English Language Learners (ELL).
- The percentage of Students With Disabilities (SWDs).
- The percentage of 5- to 17-year-olds living within the district's boundaries who are in poverty.

The COVID-19 case rate is included under the theory that a higher regional case rate would make it more likely a school district would move from in-person to hybrid or remote learning. That likelihood, however, is conditioned on public health policy, much of which is under the jurisdiction of the state, particularly regarding COVID-19. (Kaufman et al., 2021) We therefore interact the case rate with the state categorical variable. Because case rates are reported by county, we cluster standard errors for our estimates at the county level.

The second model substitutes our estimation of a district's adequacy gap (or surplus) for the current spending figure:

$$ShareVirtual_i = \beta_1(AdequacyGapPP)_i + \beta_2(State_i) + \beta_3(COVIDCaseRate_i) + \beta_4(State_i * CovidCaseRate_i) + \varepsilon_i$$

This model removes the set of student and district characteristics because they are correlated with the adequacy gap/surplus estimation, and would thus bias the estimates. Appendix Table 3

shows the correlations; poverty in particular is highly correlated with our adequacy gap estimations.

We begin with percentage of time in virtual learning as the dependent variable, as both hybrid and fully in-person learning required a school to be operating and open to at least some of a district's student population. Virtual learning, in contrast, did not require any students to be within school buildings. The facilities requirements and demands on staff of virtual instruction are fundamentally different from both hybrid and in-person learning; in contrast, the difference between hybrid and in-person is only a difference in degree. However, while we believe estimates with percentage of virtual learning as the dependent variable are the most relevant to our policy question, we also produce estimates using percentages of time in hybrid and in-person learning as the dependent variable.

Data

For our measures of time spent in various pandemic instructional modes, we use data from the COVID-19 Data Hub. (*COVID-19 School Data Hub*, 2022) Instructional models are classified as in-person, hybrid, remote/virtual; the data measure the percentage of the 2020-21 school year each district spent offering one of these three models. COVID-19 case rate per 100,000 data are from the Center for Disease Control. (*United States COVID-19 County Level of Community Transmission Historical Changes*, 2022) The countywide average used here is the unweighted mean of all observations for a county, excluding all "0" observations, averaged from August 15, 2020 to June 15, 2021. Total current per pupil spending is for FY2019; the data source is the U.S Census Bureau's Annual Survey of School System Finances (F33). (US Census Bureau, 2022) Spending is adjusted by the Comparable Wage Index for Teachers (CWIFT) for 2019. (National Center for Education Statistics, 2019) The other covariates in the spending

model are from the SY 2018-19 Local Education Agency (School District) Universe Survey Data. (National Center for Education Statistics, 2022) We use FY19 (SY2018-19) as our comparison year for two reasons: first, it is the latest available year for the CWIFT adjuster; second, this is the last year uninterrupted by the pandemic and therefore the best pre-pandemic measure of the underlying fiscal condition of a school district. In all our datasets, variables for New York City are "rolled up" when necessary to the weighted average of its component districts or its five counties.

Table 1 gives summary statistics for variables used in the models; means are unweighted. Notably, the range of values for the two adequacy gap/surplus models varies significantly, with estimates from the model using race as a covariate showing much greater average gaps and greater variation. There are extreme outliers both in adjusted spending per pupil and in the adequacy gap/surplus. For our estimates below, we exclude observations where adjusted spending is over $50,000 or under $4,000. We further exclude observations where the adequacy gap/surplus from the model without race is less than -$50,000 and greater than $50,000.

We have documented the variables used and their sources for the NECM in previous work. (Baker, Weber, et al., 2021)

Results

Table 2 presents the estimates from three models with "percentage of time in virtual schooling" as the dependent variable; we consider this the most important of the three pandemic instructional models as hybrid and in-person would require school buildings to be open, a fundamental difference with virtual. To aid in interpretation, we express both spending per pupil and the adequacy gap/surplus in thousands ($1,000s) of dollars.

The spending model—which is the model closest to those employed in previous research—shows a statistically significant and positive correlation between spending per pupil and the percentage of time a district offered virtual schooling. For every additional $1,000 spent, the time spent in virtual schooling increases 0.4%; assuming a 180-day school year, this is approximately three-fourths of a day (0.72). This positive correlation aligns with findings by Houston and Steinberg (2022) , although the finding is inconsistent across their models, as well as Harris and Oliver (2021), although their finding is not statistically significant.

Contrast this to the estimates in the adequacy gap/surplus models, which find a statistically significant and negative relationship between spending adequacy and virtual schooling. When using the model without race: for every $1,000 positive change in adequacy (closing a gap and/or adding to a surplus), the time spent in virtual schooling decreases 0.6%, a little over a day (1.08). The model using race estimates a similar, statistically significant relationship, with a $1,000 positive change in adequacy decreasing time in virtual schooling 0.4%. Notably, COVID-19 cases per 1000 is not a significant predictor within any of the models.

To further explore the correlation between spending adequacy and pandemic instruction, we next use the first adequacy model (without race) with three different dependent variables: percentage of time in virtual, hybrid, and in-person schooling. The estimates are presented in Table 3. Unsurprisingly, the correlation flips when moving from a virtual to an in-person model: spending adequacy is positively correlated with in-person learning time. The coefficients are almost perfect mirrors of each other: a $1,000 increase leads to 0.06 per less time in virtual instruction and 0.07 percent more time in in-person learning. The percentage of time in hybrid schooling does not significantly correlate with adequacy.

Discussion

Based on previous research, policymakers might assume school funding has little to do with how school districts responded to the pandemic; at most, they would conclude spending has a positive but inconsistent relationship with time spent in virtual instruction. But per pupil spending does not measure school funding adequacy; it fails to account for the different costs school districts have due to their differing student populations, labor market pressures, and other characteristics. Models using our measure of adequacy show that schools that spend more toward or above adequacy were less likely to offer virtual instruction and more likely to offer in-person instruction. The differences are substantial: assuming a 180-day school year and using our adequacy measure that does not include race, a one standard deviation positive change in adequacy results in 7.5 fewer days of virtual instruction. Using our model including race, the same one standard deviation positive change in adequacy predicts 7.3 fewer days in virtual instruction.

The primary limitation of our findings is the same limitation on all of the research on this topic: the estimates are descriptive and do not show a causal connection between school spending adequacy and pandemic instructional models. As noted above, the factors that have been shown to be predictors of variation in instructional models are correlated, making it difficult, if not impossible, to disentangle their effects. This may also be true for school spending adequacy. Teachers union strength, for example, has been shown to be associated with increases in per pupil spending. (Cowen & Strunk, 2015; Marianno et al., 2021; Strunk, 2011) While spending and adequacy are not the same, they are related; if union strength improved a district's adequacy, it may have also improved its chances of providing in-person instruction during the pandemic. Similarly, because adequacy is negatively correlated with poverty and race/ethnicity,

the preferences of parents in urban communities for virtual learning may be driven by their perception that their children's schools are inadequately funded and, therefore, unable to implement recommended mitigations. In addition, many Republican-leaning or "red" states are highly inadequately funded when evaluated by the methods used in our models. (Baker, Di Carlo, Weber, et al., 2021) It may be that the funding inadequacy in these states influenced their decisions to offer in-person instruction, or that the same political preferences manifested themselves both in school spending adequacy and pandemic instructional models; in other words, the effects of school funding adequacy on district decisions during the pandemic may or may not be causal.

Nevertheless, even though we cannot claim for certain a causal relationship between school funding and pandemic instructional models, we believe the findings presented here are important. School spending adequacy has unique advantages as a predictor of school districts' pandemic instructional models. Unlike measures of union strength, which are indirect measures of how unions may be able to influence districts' COVID-19 policies, adequacy can be measured directly. And unlike political affiliation or race, adequacy can be affected by policy: governments can choose to more (or less) adequately fund schools.

Until now, the research consensus has been that school spending has an inconsistently positive association with virtual instruction during the 2020-21 school year. But when spending is measured relative to cost, the opposite is true: more adequate spending is associated with less virtual instruction and more in-person schooling. Given these findings, future research into how and why school districts reacted to the pandemic should include some measure of districts' spending adequacy, with the acknowledgement that simple measures of per pupil spending do not capture districts' costs. Whether school spending adequacy can ever be extricated from other

factors that may have affected pandemic schooling remains an open question; however, adequacy cannot simply be ignored in future analyses.

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Table 1: Descriptive Statistics

	Mean	S.D.
Dependent Variables		
Pct. of school time in:		
Virtual	31.3%	34.5%
Hybrid	53.4%	41.4%
In-person	15.3%	24.7%
Spending Model		
Adjusted Spending per pupil	$15,944	$5,532
Enrollment	3,883	12,383
Pct. Grades 9-12	26.9%	15.8%
Pct. ELL	5.4%	9.1%
Pct. SWD	15.2%	4.7%
Pct. Poverty (age 5-17)	15.1%	8.8%
COVID-19 Cases per 100K (county level)	229.3	91.6
Adequacy Model		
NECM Adequacy Gap/Surplus, no race covariate	$1,423	$6,968
NECM Adequacy Gap/Surplus, w/race covariate	-$8,488	$10,191

Table 2: Spending and Adequacy Models' Estimates

	Dependent Variable		
	Pct. Of Time In Virtual Instruction		
	Spending Model	NECM Adequacy Gap/Surplus Model	NECM Adequacy Gap/Surplus Model, w/race covariate
Spending per pupil ($1,000s)	0.004*** (0.001)	-	-
NECM Adequacy Gap/Surplus per pupil ($1,000s)	-	-0.006*** (0.001)	-0.004*** (0.001)
Enrollment (natural log)	0.046*** (0.004)	-	-
Pct. Enrolled Grades 9-12	-0.008 (0.015)	-	-
ELL Pct.	0.379*** (0.058)	-	-
SWD pct.	0.379*** (0.058)	-	-
SAIPE Poverty pct.	0.520*** (0.065)	-	-
Covid Cases per 1000 (county-level, interacted w/state FE)	-0.025 (0.029)	-0.025 (0.035)	-0.033 (0.036)
Constant	-0.197* (0.112)	0.379*** (0.113)	0.328*** (0.113)
N	11004	11204	11204
R-sq.	*0.514*	*0.436*	*0.439*

Note: SEs clustered at the county level.

Table 3: Adequacy Models with Three Dependent Variables

	Pct. Virtual	Pct. Hybrid	Pct. In-Person
NECM Adequacy Gap/Surplus per pupil ($1,000s)	-0.006*** (0.001)	-0.001 (0.001)	0.007*** (0.001)
Constant	0.379*** (0.113)	0.077 (0.093)	0.544*** (0.167)
N	*11204*	*11204*	*11204*
R-sq	*0.436*	*0.393*	*0.502*

Appendix Table 1: Regression Estimates, NECM

VARIABLES	(1) ln_curexpp	(2) ln_curexpp
Outcome Index	1.543*	1.636*
	(0.091)	(0.100)
Education Comparable Wage Index	0.627*	0.700*
	(0.051)	(0.054)
Adjusted Poverty Rate	2.133*	3.086*
	(0.155)	(0.206)
State Mean Centered SWD Rate	2.693*	2.658*
	(0.126)	(0.134)
% ELL	1.311*	1.014*
	(0.104)	(0.098)
% Black Enrollment	0.860*	
	(0.048)	
% Enrollment in Pre-k	0.238	0.454*
	(0.123)	(0.131)
% Enrollment in Secondary Grades	0.547*	0.559*
	(0.037)	(0.040)
Less than 100 Students	0.587*	0.565*
	(0.076)	(0.077)
101 to 300 Students	0.376*	0.362*
	(0.019)	(0.018)
301 to 600 Students	0.221*	0.205*
	(0.014)	(0.014)
601 to 1200 Students	0.140*	0.124*
	(0.011)	(0.011)
1201 to 1500 Students	0.108*	0.095*
	(0.013)	(0.013)
1501 to 2000 Students	0.100*	0.088*
	(0.012)	(0.012)
Log of Population per Square Mile	-0.044*	-0.025*
	(0.006)	(0.006)
% Population between 5 & 17 yrs of age	-0.617*	-0.090
	(0.128)	(0.091)
Median Housing Value (ratio to Labor Market)	-0.295*	-0.337*
	(0.023)	(0.026)
Herfindhal Index - Enrollment	-0.207	0.330
	(0.356)	(0.371)
Year	0.019*	0.019*
	(0.001)	(0.001)
Constant	8.607*	8.385*
	(0.056)	(0.055)
Observations	124,663	124,663
R-squared	-0.761	-1.042

Robust standard errors in parentheses
* p<0.05
Model 1:
Partial F = 176.62, Hansen J = 0.000
Model 2:
Partial F = 155.22, Hansen J = 0.129

Appendix Table 2: Racial bias in model residuals

DV = Residuals from Appendix Table 1 Regressions	(1) Race Neutral Residuals [All]	(2) Race Neutral Residuals [>20% Pov]	(3) Race Neutral Residuals [<10% Pov]	(4) Race Sensitive Residuals [All]	(5) Race Sensitive Residuals [>20% Pov]	(6) Race Sensitive Residuals [<10% Pov]
% Black	**-0.504***	**-0.433***	**-0.422***	-0.126*	-0.019*	0.012
	(0.004)	(0.005)	(0.020)	(0.004)	(0.005)	(0.020)
% Latinx	-0.091*	0.015*	0.005	-0.176*	-0.042*	-0.062*
	(0.003)	(0.004)	(0.015)	(0.003)	(0.004)	(0.015)
Constant	0.100*	0.015*	0.181*	0.062*	-0.058*	0.151*
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Observations	114,735	42,557	26,152	114,735	42,557	26,152
R-squared	**0.137**	**0.168**	0.017	**0.037**	**0.003**	0.001

Standard errors in parentheses
* $p<0.05$

Appendix Table 3: Correlations Between Adequacy Measures and Variables in Spending Model

	Adequacy Gap/Surplus, No Race	Adequacy Gap/Surplus, With Race
Enrollment(ln)	-0.038	0.077
Pct. Grades 9-12	-0.023	0.012
Pct. ELL	-0.327	-0.361
Pct. SWD	-0.028	-0.148
Pct. Poverty, age 5-17	-0.564	-0.571
Covid Cases per 1000	-0.110	-0.100