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Access to Effective Teachers and Economic and Racial Disparities in Opportunities to Learn

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Abstract

This paper provides detailed description of students' access to one critical educational resource, teachers that effectively promote learning. Using large scale administrative data from North Carolina in grades 3-8 and value-added measures of effectiveness, I find disadvantages for poor, American Indian, African American, and Hispanic students, but disparities represent less than 2% of observed achievement gaps. Gaps are driven by differential risks of exposure to especially ineffective teachers, which occur between and within schools. The distribution of teacher-related learning opportunities therefore highlights White and higher SES students' advantaged access to important educational resources as well as apparent limits to those advantages.

Keywords

Educational Inequality; Economic and Racial Achievement Gaps; Teacher Effectiveness; Opportunity to Learn

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Access to a high quality teacher means access to beneficial educational opportunities, and these teacher-related opportunities have long been recognized as a key potential source of educational inequality (Coleman et al. 1966). Research on individual teachers' impacts on student development highlights this point, demonstrating that teachers are among the most important school-based determinants of learning (Nye, Konstantopoulos, and Hedges 2004). It is particularly troubling, therefore, that poor and minority students are less likely to be taught by better credentialed or more experienced teachers (Lankford, Loeb, and Wyckoff 2002; Palardy 2015; Roscigno, Tomaskovic-Devey, and Crowley 2006), and the distribution of teachers with more experience implies both geographic and organizational sources of inequality (Boyd et al. 2005; Kalogrides, Loeb, and Béteille 2013). Given the central role that classroom teachers play in the organization of schooling, these disparities point to important mechanisms of inequalities at school, inequalities that may fundamentally exacerbate social background gaps.

This conclusion is complicated, however, by the inherent difficulty in measuring teacher quality. Most attention to teacher inequalities focuses on traditional measures such as

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experience and credentials. Yet these characteristics are at best weak proxies for the full differences in educational experiences associated with different teachers (Kane, Rockoff, and Staiger 2008; Palardy and Rumberger 2008). This means that evidence based on traditional measures misses most of the potential for educational inequality related to teacher assignments. Well-documented gaps may belie even greater inequalities in access to the most beneficial teachers, if advantaged families effectively secure privileged access to crucial school resources (e.g., Lucas 2001). Conversely, traditional gaps may overstate inequalities in underlying opportunities associated with teachers, just as school quality disparities are less pronounced for measures related to student learning than average achievement (Downey, von Hippel, and Hughes 2008; Hanselman and Fiel 2017).

Given teachers' formative influence on academic development, questions about teacher inequalities have important implications for debates about how formal schooling shapes educational inequality (Downey and Condron 2016). Do substantial gaps serve to reproduce social background inequalities, or does a relatively equitable distribution of teachers mitigate disparities? In addition to *whether* teachers contribute to inequality, details of the allocation of teachers speak to *how* social background advantages may translate into educational advantages. For instance, do advantaged families enjoy universally greater access to more effective teachers, do they seek out especially effective teachers, or are they particularly effective in avoiding especially ineffective teachers? And to what extent are social background differences the result of between-school opportunity hoarding (Fiel 2015) as opposed to within-school influence (Lareau 1989)?

In addressing these questions, this paper focuses on *teacher effectiveness*, the impact on student learning of being assigned to one teacher relative to an average one. Conceptually, this impact summarizes a complex constellation of differences between teachers that shape students' learning opportunities in the classroom, opportunities that are poorly captured by traditional measures of teacher quality. Practically, estimates of teacher effectiveness draw on large-scale administrative data and the growing literature on value-added models of teachers' influence. Yet relatively little research to date has focused on implications for the magnitude and sources of inequality, suggesting the need to incorporate stratification perspectives to growing research on teacher effects.

Teachers, Opportunities to Learn, and Educational Inequality

Inequalities in educational outcomes related to racial/ethnic and economic background are large, persistent, and socially consequential (Jencks and Phillips 1998; Reardon 2011; The National Center for Education Statistics 2013). Yet the role that formal schooling plays in creating these gaps remains a matter of debate. One perspective holds that school practices fundamentally exacerbate background inequalities, providing privileged resources to students from more advantaged backgrounds (Bourdieu and Passeron 1990; Lucas 2001). However, others argue that schooling tends to mitigate inequalities, especially compared to the large disparities present outside of school (Downey, von Hippel, and Broh 2004). Key to assessing these perspectives is understanding the *opportunities to learn* that schooling distributes to students (Grodsky, Warren, and Felts 2008; Sorensen 1989), which depend on the quality of instructional content (e.g., Barr and Dreeben 1983), the delivery of this material (e.g., Herman, Klein, and Abedi 2000), and the social environment of instruction (e.g., Pianta et al. 2007).

Although complex, many of the opportunities to learn at school have a clear source: the classroom teacher. Teachers' work shapes the instructional content, delivery, and the social environment that students experience in the classroom throughout the course of the school year. And the organization of schools into classrooms—discrete instructional groups throughout the year—amplifies the importance of the teacher as the primary adult in the instructional environment. Research on teacher effectiveness suggests that such learning opportunities vary widely among teachers, often even in classrooms across the hall from one another. The impacts of assignment to one teacher versus another are large (Nye et al. 2004; Rivkin, Hanushek, and Kain 2005; Rockoff 2004), are seen in both academic and non-academic development (Jackson 2012; Jennings and DiPrete 2010), and are discernable in adulthood (Chetty, Friedman, and Rockoff 2014b).

Given their importance, unequal access to high quality teachers is a critical potential source of educational inequalities. Yet research on teacher inequalities has typically focused on observable characteristics of teachers (e.g. Clotfelter, Ladd, and Vigdor 2005; Kalogrides and Loeb 2013; Lankford et al. 2002; Peske and Haycock 2006). These measures have little claim to capturing the totality of differences in learning opportunities associated with different teachers, and indeed these characteristics explain little of the variation teachers' impacts on student learning (Goldhaber 2007; Kane et al. 2008; Palardy and Rumberger 2008; Rivkin et al. 2005). Thus, fully understanding how teachers contribute to educational inequalities requires better understanding the distribution of more and less effective teachers. In the following sections, I discuss two key related issues for educational stratification: the magnitude of disparities in access to effective teachers and the potential sources of these differences.

How large are Disparities in Learning Opportunities Related to Teachers?

We typically think of poor and minority students as consigned to lower quality teachers, contributing to persistent inequalities. Yet the role that teacher assignments play in these inequalities remains unclear. Previous research demonstrates gaps in access to teachers with better training, credentials, and more experience, but these factors explain little of social background achievement disparities (Condron 2009; Covay Minor et al. 2015; Desimone and Long 2010; Palardy 2015). Although these highly visible teacher characteristics do not substantially contribute to achievement gaps, they do not rule out the possibility of differences in more consequential, if subtle, distinctions among teachers.

Conclusions from research directly assessing economic and racial/ethnic differences in exposure to effective teachers are mixed. There is evidence that poor and minority students tend to be assigned to less effective teachers in several settings: in North Carolina and Florida (Sass et al. 2012), Washington state (Goldhaber, Lavery, and Theobald 2015), Los Angeles (Bacher-Hicks, Kane, and Staiger 2014), and a sample of 10 large school districts (Glazerman and Max 2011). These gaps point to non-trivial and relatively widespread opportunity gaps related to teachers that may exacerbate inequalities.

However, several features of these findings imply that teacher-related opportunities may not be a substantial source of social background inequalities. For one, the magnitude of these gaps is variable, in some cases suggesting equity in specific grade-level or locations (Glazerman and Max 2011; Isenberg et al. 2013). Among 26 large school districts across the country in one recent report, for instance, there was no evidence of differential exposure to teacher effectiveness (Isenberg et al. 2016). For another, the size of the disparities tends to be substantively small, in many cases less than 0.05 standard deviations of student achievement. While not unimportant, disparities of this size would not support the conventional wisdom that teacher inequalities play a crucial role in exacerbating inequality. Finally, implied teacher effectiveness disparities may be sensitive to the specification of the underlying teacher effectiveness calculation, leading to an overstatement of gaps for measures that do not sufficiently isolate teacher influences (Isenberg et al. 2013).

In short, while at least some economic and racial/ethnic disparities exist in access to effective teachers, there remain important open questions about the size, scope, and ultimate implications of these differences.

Potential Mechanisms of Teacher (In)equality

A stratification perspective on teacher quality focuses attention on two relevant mechanisms through which families from advantaged backgrounds secure privileged access to educational opportunities: parental advocacy and segregated school attendance.

Several theoretical accounts of educational inequality locate disparities in the greater tendency and effectiveness of privileged parents to advocate for better opportunities for their children. These differences can result from class-based differences in cultural capital (Calarco 2018; Lareau 2003) as well as racialized interactions with school officials (Lareau and Horvat 1999). Advantaged parents are much more likely to customize their children's educational experiences, including a greater likelihood of requesting specific teachers (Horvat, Weininger, and Lareau 2003; Robinson 2014). Such interventions may contribute to within-school disparities in access to more experienced teachers (Kalogrides et al. 2013), and may also disproportionately place more advantaged students with more effective teachers.

It is also important to consider potential barriers to advantages, most notably the limited information that parents—and others outside the classroom—possess about the quality of learning opportunities that a teacher provides. In contrast to easily observable characteristics, parents are unlikely to have access to information about effectiveness, especially since principals only reliably distinguish especially effective and ineffective teachers (Jacob and Lefgren 2008). The result of parental advocacy may therefore be to accentuate differences at both tails of the distribution. Given that class-based interventions in school often are reacting to specific problems (Calarco 2014), we may see the largest differences in avoiding exposure to especially ineffective teachers. Relatively little research to date considers such distributional differences; Goldhaber et al. (2015) report similar gaps in access to especially ineffective and effective teachers, while Isenberg et al. (2016) report no differences at any point in the distribution.

Another prominent stratification mechanism is between-school inequalities enabled by segregated attendance patterns (Logan, Minca, and Adar 2012). If the most effective teachers and most advantaged students are concentrated in the same schools, then between-school teacher inequalities would exacerbate inequality. This could be viewed as a form of educational opportunity hoarding (Fiel 2015; Tilly 1998), and some research finds between-school disparities in teacher effectiveness (Goldhaber et al. 2015). However, it is again important to note potential barriers to such opportunity hoarding. For one, family decisions about school attendance tend to be based on general reputation and imperfect information about true school quality (Goyette and Lareau 2014), parental decisions may be more associated with signals of higher status schools, including high-achieving ones, than those with teachers that provide especially rich learning opportunities (Hanselman and Fiel 2017).

In addition to the potentially stratifying actions of advantaged families, organizational and labor market mechanisms may also contribute to teacher inequalities. Most notably, transfer and assignment policies give teachers with greater tenure more influence over their place of work and their courses. Given average preferences for the working conditions associated with more advantaged students, these policies contribute to disparities in access to more experienced teachers between and within schools (Boyd et al. 2010; Kalogrides et al. 2013). However, since staffing policies rarely provide formal benefits to more effective teachers, and because administrators have at best partial information about a teacher's classroom effectiveness, there is less reason to expect similar sorting of teachers based on effectiveness.

More effective teachers are also less likely to exit the profession or transfer from a school (Hanushek et al. 2005; Henry, Bastian, and Fortner 2011). This is consistent with the importance teachers place on non-pecuniary rewards such as a sense of success in the classroom (Johnson and Birkeland 2003), and may limit any tendency for more effective teachers to be concentrated in specific schools. As a result, disparities in access to teachers that provide richer learning opportunities may be most pronounced within rather than between schools.

In sum, while there are many potential sources of economic and racial/ethnic disparities in access to teacher-related opportunities to learn, these differences may be less pronounced and less universal than typically assumed.

Research Questions

This paper asks whether and how teacher allocations create economic and racial disparities in relative learning opportunities at school. Building on previous research on teachers and inequality, I focus on three specific questions: First, how large are mean economic and racial differences in exposure to teacher effectiveness? In this I aim to understand whether substantial disparities serve to reproduce existing gaps or whether an equitable or compensatory distribution mitigates them.

In addition to mean differences, I consider more detailed features of the distribution of effective teachers across students from different social backgrounds. My second research question is: are social background disparities more pronounced for especially effective or ineffective teachers? While theories of educational stratification often consider the advantages of privileged parents to be expansive, the distribution of teachers may reflect specific opportunities for advantages, such as greater information about the quality of exceptional teachers or resources to avoid an especially ineffective teacher.

Third, I ask to what extent teacher effectiveness disparities are located within and between schools and districts, since disparities in learning opportunities may result from between- and within-school processes.

In addition to these primary research questions, I also address additional issues related to how these answers may vary across context (such as grade level and subject) and model specification (such as included covariates), as I describe below.

Methodology

My analytic strategy involves two steps: identifying and describing the allocation of teacher effectiveness. In the first, I estimate individual teachers' effectiveness using value-added models of student achievement (for a review, see: Koedel, Mihaly, and Rockoff 2015). In the second, I use these measures as proxies for teacher-related learning opportunities and assess features of the distribution teacher effectiveness across different types of students. Both steps require extensive data on student achievement and teacher assignments over time. I use administrative data from all public schools in North Carolina between 2006 and 2013 prepared for research use by the North Carolina Education Research Data Center (NCERDC) at Duke University. The data include yearly information on all public school students in the state in grades 3-8: over 5 million student-year observations of more than 1.5 million unique students. The breadth of these data is well suited to characterizing teacher effectiveness across a large population of teachers serving diverse student populations, and in turn describing patterns in students' exposure to more and less effective teachers.

Student Measures

I focus on two facets of students' background included in administrative records for each student: economic disadvantage and race/ethnicity. As a measure of economic disadvantage I use eligibility for free or reduced-price lunch, which indicates family income less than 185% of the federal poverty line. Racial and ethnic information for students is required for reporting to the Unites States Department of Education, and it is typically provided to school officials by parents. Harmonized race/ethnicity values (due to federal reporting changes during the sample period) include the following five focal groups: Hispanic, American Indian or Alaskan Native, Asian, Black or African American, and White.[1] The demography of North Carolina in this period is predominantly White with African American students making up the largest non-White group (see Appendix A). However, given the overall sample size, there are sufficient cases to explore the distribution of teachers among smaller groups as well.

[1]I use the terms "Black" and "African American" interchangeably. Results for multiracial students are not reported due to inconsistency in this category's meaning over time.

Measures of student achievement are taken from the North Carolina End of Grade standardized assessments, which were administered to all students in the state in grades 3-8 in 2006-2013 in the areas of mathematics and reading comprehension/language arts. These pencil and paper, multiple choice (and gridded free response in mathematics in some grades) tests include 50-60 items and are completed in three to four hours for each subject. The tests are designed to assess knowledge and learning in North Carolina learning standards, and results are used to satisfy federal reporting standards and as part of the state accountability system. Reported reliabilities range from 0.888 to 0.922 in mathematics and from 0.875 to 0.925 in reading and are similarly high across demographic subgroups. To facilitate comparisons over time and level, I standardize all outcomes to have a mean of zero and a standard deviation of one within each grade and year. I also exclude the small proportion of alternate assessments from analyses.

Analytic Sample and External Validity

To assess the full distribution of teacher effectiveness, the population of interest is all elementary and middle school students in the state. However, as is typical in teacher value-added effectiveness research, the available analytic sample is restricted in three important ways. First, data are only available for public schools. Private school enrollment in North Carolina accounts for just 7.6% of enrollment among schools serving grades 1-8, but substantially higher rates for White (11.0%) than Black (2.6%) or Hispanic (1.7%) students.[2] Second, teacher effectiveness measures are limited to the grades for which both end of grade and prior achievement tests are administered. In North Carolina during the full sample period, this limits analyses to grades 3-8.[3] Finally, individual teachers' effectiveness is unknown for 10-13% of students across subjects and grades, either because the students' teacher is unknown, or because estimates were not possible, given the criteria described below. Students matched to teachers without value-added information are more likely to be male, Black, and economically disadvantaged, and are lower performing on average.

Appendix A summarizes the characteristics of the students included in analyses for each subject and level of schooling. Taking elementary mathematics as an example, the analytic sample is 50% female, 54% White, 26% Black, 12% Hispanic, 3% Asian, and 2% American Indian. Approximately half of the students (52%) were eligible for free- or reduced-price lunch, and mean test scores were 0.01 standard deviations higher than the population overall. The average student in this sample was taught by a teacher for mathematics instruction with 11 years of experience, and 84% of students had a teacher with at least 2 years of previous teaching experience.

Consistent with other research, economic and racial achievement gaps were apparent in the analytic sample. The economic achievement gap ranged from 0.70 to 0.75 standard deviations across subjects and grade levels; the Black-White gap ranged from 0.75 to 0.80; the Hispanic-White gap was between 0.50 and 0.55 in mathematics and 0.65 and 0.75 in

[2]Author's calculation based on data collected by the National Center for Education Statistics for 2010-2011.

[3]Value-added estimates for grade 3 are only possible for 2007-2010, when pre-tests were administered at the start of grade 3. In those cases I treat pre-tests the same as lagged test scores in other grades (including allowing for interactions between prior achievement and grade level in the full model).

reading; and the American Indian-White gap ranged from 0.60 to 0.70. On average, Asian students in the analytic sample scored higher than White students by 0.30 to 0.45 standard deviations in mathematics and similarly to them in reading. These observed achievement gaps (available in supplementary materials) are used to contextualize the magnitude of reported teacher quality differences.

Course and Teacher Links

A prerequisite for characterizing learning opportunities related to teachers is identifying students' primary teacher(s) in each year. Previous research with older versions of the NCERDC data has made teacher links based on the test proctor for annual testing; these methods present challenges to confidently assessing teacher links for all students (see Sass et al. 2012:106) and have precluded consideration of middle school grades (Clotfelter, Ladd, and Vigdor 2007).[4] A contribution of the current research is that it draws on direct course membership information for all students, which schools were required to report beginning in 2006-2007, to link both students and teachers to classrooms.

Student-teacher linkages proceed in three steps: First, I identify mathematics and reading courses with Classroom Membership roster information. Classrooms are defined by the unique combination of course and section identifiers within school. The resulting enrollment figures correspond closely to those from School Activity Reports, an independent record of course enrollment; the correlation in class size between the two sources ranges from 0.92 to 0.95 across all years and grades.

Second, I link course records to the assigned teachers, combining information from two data sources: School Activity Reports, which record the teacher(s) for each offered course, and Course Membership lists, which NCERDC linked to teacher identifiers when recorded names could be matched unambiguously to personnel files. Both links are available for 81.7% of all course observations; of these, these independent sources agree in 97.9% cases, suggesting high reliability for the teacher links. Combining both methods, all but 2.0% of courses are linked to a teacher. I also drop the 1.7% of classrooms taught by multiple teachers from all analyses.

Third, I identify one primary mathematics and one primary reading/language arts course per student-year. For students with multiple courses that potentially include either mathematics or language arts/reading instruction—only common in elementary grades—I prioritize a subject-specific solo course, then a general self-contained course, then a combination course (often smaller supplemental courses). This procedure leads to highly consistent designations of primary classrooms; over 99% of potential mathematics or language arts/reading classrooms are either the primary classroom for all enrolled students (such as a main mathematics course) or for none (such as a self-contained elementary classroom in which all students are enrolled in a separate math course).

[4]In the current data, I find that test proctors accurately reflect classroom teachers for more than 80% of students in elementary grades, but less than 30% in middle school.

Value-added Estimates of Teacher Effectiveness

Teacher effectiveness is defined as the average causal effect for a typical student of assignment to a particular teacher, relative to assignment to an average teacher. This counterfactual difference is a conceptually clean summary of the constellation of relative opportunities to learn a student experiences when assigned to a teacher. The main challenge for this measure is practical: how can teacher influences on student development be isolated from other influences? My approach draws on the established literature on calculating value-added measures of teacher effectiveness from longitudinal student information available in administrative data (Koedel et al. 2015).

Estimation—Value-added models are based on specifications derived from a cumulative education production function in which current student achievement is a function of school, family, and student inputs. As is typical in value added research, I use a parsimonious estimating equation of the following general form:

$$Y_{ijt} = \beta_0 + f(Y_{i,\,t-1}) + \beta X_{it} + \mu_j + \varepsilon_{it}, \tag{1}$$

where i indexes students, j indexes teachers, and t indexes year. This equation models the student outcome at the end of the school year (Y_{ijt}) as a function of several observable characteristics: a function of prior achievement ($f(Y_{i,t-1})$, which I specify as a third order polynomial), a vector of observable student, classroom, and school characteristics (X_{it}: student prior achievement in the alternate subject, gender, eligibility for free/reduced lunch, race/ethnicity, limited English proficiency designation, disability designation, migrant status, gifted designation in mathematics or reading, an indicator for grade retention, and cubic polynomials of classroom and school-level mean prior achievement in reading and mathematics), and a teacher effect (μ_j). The focal parameter is μ_j, representing the effectiveness of teacher j. It is important to note that by construction, teacher effectiveness includes only teacher influences that are consistent throughout the sample time period; the error term in Equation 1 includes any time-varying teacher effects on achievement, which can be thought of as a classroom or teacher-by-year effect. In addition, μ_j is not indexed by student, meaning that it reflects teacher j's average impact for all students. I relax this assumption by considering subgroup-specific effectiveness in alternate specifications.

I estimate μ_j as a fixed effect using ordinary least squares, for two reasons. Most importantly, this fixed effects approach properly accounts for potential correlations between teacher effects and student characteristics, the key question of this study. By estimating the effects of observed characteristics based on within-teacher variation, between-teacher variation in these variables is not erroneously attributed to the teacher. A random effects approach, for instance, will produce unbiased estimates of μ_j only if the correlation between teacher effects and student characteristics is zero. However, if more effective teachers tend to teach non-poor students, then the influence of poverty will distort inferences about teacher effectiveness and conclusions about inequality (see Chetty et al. (2014a) Online Appendix D and Mansfield (2015:769–70)).[5] In addition, fixed effects estimates from this model, sometimes referred to as dynamic ordinary least squares estimates, perform well in simulations of a variety of plausible underlying data generating processes (Guarino, Reckase, and Wooldridge 2015).

I calculate teacher effects using all years of the data (2007-2013). This allows me to include as many teachers as possible, including those present for only one year; I omit the focal year in an alternate specification. All models include year and grade fixed effects, and parameters are estimated separately for elementary (grades 3-5) and middle school (grades 6-8). I exclude classes with fewer than 10 or greater than 50 students, which are likely to be non-regular courses or data errors, and I additionally exclude classes with fewer than 5 students with valid test scores (outcome and lagged) from value-added estimation. I report raw value-added estimates, which are in the metric of standardized student achievement.[6] The overall standard deviation of teacher effectiveness for mathematics is 0.195 in elementary and 0.162 in middle school (0.132 and 0.090 for reading, respectively); these magnitudes are consistent with prior research (Hanushek and Rivkin 2010).

Limitations and Alternate Specifications—Value-added methods have received substantial scrutiny, especially whether they isolate teachers' effects on student achievement from confounding influences (Everson 2017). While some researchers have raised concerns about potential bias due to systematic school and classroom sorting, most evidence suggests these "do not appear to introduce significant bias in effect estimates, especially when several years of data are included" (Everson 2017:51).[7] This includes studies randomly assigning teachers and students to classrooms (Kane et al. 2013; Kane and Staiger 2008) and quasi-experimental validation exercises (Bacher-Hicks et al. 2014; Chetty et al. 2014a).

Despite these results, one notable potential threat to validity is that annual achievement gains may systematically misattribute differences in summer learning to teachers (Downey et al. 2008). There are several reasons to think that selective summer learning loss is of minimal concern for this study. First, documented overall summer learning biases are only problematic to the extent that they affect teachers of different student groups differently; constant seasonal biases would not alter conclusions about disparities. Second, to be a problem, students would need to be sorted to teachers according to differential summer learning after controlling for prior achievement, a proxy indication of cumulative prior summer setbacks. Third, analogous results from school effects imply small distortions to the association between value-added and student characteristics related to summer learning (Downey et al. 2008, Table 6).

[5]This problem is expected even if student demographic characteristics are omitted from the estimating equation, given the association between these characteristics and prior achievement, which cannot be plausibly omitted. That is, if more effective teachers are assigned to non-poor students, then true effectiveness would be (positively) correlated with prior achievement.

[6]Some research reports adjusted teacher effects estimates, in which raw estimates are "shrunken" toward the mean as a function of estimated reliability. Such adjustments are inappropriate in this context because they would attenuate estimated relationships between social background characteristics and teacher effectiveness (Chetty, Friedman, and Rockoff 2014a, see Appendix D).

[7]Several additional critiques for policy purposes are less relevant here. Most notably, imprecision in effectiveness estimates—while critical to individual teachers—do not threaten the aggregate conclusions here. It may also be unfair to attribute effectiveness solely to the teacher, since they may reflect resources outside her control, such as available curricular resources (see Raudenbush 2004). Since these resources reflect relative learning opportunities, they are valuable components of relative disparities in opportunities to learn. My precise argument is that value-added estimates measure *teacher-related* opportunities, not solely *teacher-caused* opportunities.

In short, like any proxy, teacher effectiveness is neither a perfect nor comprehensive measure of teacher-related learning opportunities. Evidence demonstrates that value-added estimates reflect consequential variation in students' learning experiences in school, but it highlights the need to critically evaluate features of the underlying models.

To assess the sensitivity of conclusions to key features of the value-added model, I also consider three alternate specifications. First, I relax the assumption of homogeneous teacher effects by calculating subgroup-specific estimates of effectiveness. Previous research finds relatively little difference in teacher effects across groups on average (Fox 2015), but even small differences may alter conclusions about inequality. For economic differences, I focus on teachers observed with at least 10 economically disadvantaged and 10 non-economically disadvantaged students (see Appendix A for a summary of alternate specification subsamples). Within this population I calculate: (a) estimates for both types of students, (b) effectiveness based on disadvantaged students only, and (c) effectiveness based on non-disadvantaged students only. I estimate analogous measures for African American and White students, among teachers observed with at least 10 students from each group; sample size limitations preclude similar analyses with smaller racial/ethnic groups.

Second, I assess the importance of contextual covariates (school and classroom achievement) in the model by omitting them in some specifications. Aggregate characteristics are excluded in some value-added implementations but may alter conclusions about inequality (Isenberg et al. 2013). Comparing these omitted covariate specifications to the full model indicates how conclusions about inequality change as teacher-related opportunities are more plausibly isolated, and it indicates the likely direction and possible magnitude of additional biases.

Third, I calculate teacher effectiveness from a "leave out" sample of student records from all other years in the data. For example, the effectiveness estimate for a student assigned to a teacher in 2011 is based only on that teachers' students in 2007-2010 and 2012-2013. This restriction reduces sample sizes by approximately 10%. Because the leave-out results track closely with the main findings, these results are reported only in supplementary materials.

Analytic Strategy

I describe several features of the distribution of exposure to teacher effectiveness across economic and racial groups. Most basically, I compare mean differences by regressing the estimated value-added for the teacher that students experience in each year on indicators for student social background.

To test for distributional differences, I consider whether different students are more likely to experience a teacher at either tail of the distribution. To provide a more detailed description of distributional differences, I employ relative distribution methods, which have been applied most prominently to earnings inequalities (Handcock 1999). This approach estimates the relative share of students from different groups who experience teachers throughout the range of effectiveness, revealing where poor and minority groups are over- or under-represented.

To decompose differences in exposure to teacher effectiveness into components related to between-district, between-school, and within-school components, I follow the procedure described by Clotfelter et al. (2005). This decomposition compares group gaps as observed (gap_{obs}) to those that would were all students to experience a teacher with the mean effectiveness in their district (gap_{dist}) or school (gap_{sch}). Between-district inequality is gap_{dist}; between-school (within-district) inequality is $gap_{sch} - gap_{dist}$; and within-school inequality is $gap_{obs} - gap_{sch}$. By construction these component gaps sum to observed inequality, and I focus on the proportion of the total attributable to each component.

Results

Mean Differences in Exposure to Teacher Effectiveness

Table 1 presents mean differences in exposure to teacher effectiveness for economic disadvantage (relative to students not eligible for free or reduced-price lunch) and for racial/ethnic groups (relative to the White reference group) for the preferred specification, which includes data from all years and controls for individual, classroom, and school characteristics. Overall, gaps in mean teacher effectiveness imply fewer opportunities to learn for poor, American Indian, Black, and Hispanic students; however, these disparities are substantively small and precisely estimated. For instance, the economic disadvantage gap in elementary school mathematics is 0.012, implying that teacher allocations increase economic disparities by 1.2% of a standard deviation in student achievement, or contribute 1.7% toward the observed achievement gap in a given year. This difference is substantively small; it represents 0.055 of a standard deviation in observed teacher quality or about one week (0.89) less of typical learning throughout the school year.[8] Patterns are similar with respect to reading.

Patterns for Black and Hispanic students imply even smaller disparities in opportunities to learn related to teachers. Teacher effectiveness for these groups in elementary school grades is not meaningfully different from Whites, and estimates diverge for mathematics and reading teachers in later years. There are minor opportunity gaps related to teacher effectiveness in mathematics in middle school, but they contribute less than 2% toward the Black-White and Hispanic-White achievement gap and less than a week difference in average learning throughout the year. However, estimates imply that Black and Hispanic students experience slightly more effective teachers in English Language Arts in middle school.

American Indian and Asian students, by contrast, have diverging experiences. American Indian elementary students receive the least effective teachers of any group, corresponding to two weeks less of learning during the year in both mathematics and reading, but estimates imply no difference in middle school. Conversely, Asian students are the group that tends to be assigned teachers with the highest estimated effectiveness, with especially large advantages in the middle school grades. While both results are based on small

[8]The metric of standard deviations of teacher effectiveness correspond roughly to that of an effect size for the disparity. Weeks of learning are calculated using the benchmarks provided by Hill et al. (2008) based on typical growth in standardized achievement scores.

subpopulations, these results suggest that teacher assignments may lead to important differences in the learning opportunities for these groups.

Figure 1 summarizes the key results for the largest student groups and presents alternative specifications gauging sensitivity to two features of the teacher effectiveness measure. The first is the assumption that a teacher's effectiveness is the same for each subgroup. To relax this assumption, I consider a subpopulation of students taught by teachers with sufficient observations for subgroup measures, with value-added estimates based on all students or only among specific subgroups. Conclusions about teacher effectiveness gaps are similar across all subgroup specifications.

The second set of supplementary analyses omits classroom and/or school aggregate control variables from the teacher effectiveness models to provide some indication of the direction and size of potential bias of omitting key variables. In general, group differences are more pronounced in models that do not account for these characteristics, and therefore inappropriately attribute characteristics of students and classrooms to teacher impacts. Disadvantaged students attend schools where teachers seem less effective if we do not control for lower starting achievement. A similar dynamic is present at the classroom level in middle school, where curricula tends to be differentiated, but not in elementary school. When these influences are ignored, disparities are three times as large, yet still less than 0.03 standard deviations in elementary grades and 0.05 in middle school.

Since omitting basic contextual control variables tends to increase the estimated advantage of non-poor and White students modestly, it is reasonable to presume that controlling for additional unobserved confounders might further reduce economic and racial disparities. In other words, the results from the preferred specification may provide an upper bound estimate of privileged groups' advantages. However, the covariate-omitted differences may also point to a component of disparities in learning opportunities that are related to classroom composition rather than teacher allocations per se.

In total, there are small estimated differences in the mean teacher effectiveness experienced by most economic and racial minority groups, and there is reason to think that the true disparities in related opportunities to learn may be smaller.

Distributional Differences in Teacher Effectiveness

Mean differences may obscure background advantages in exposure to especially effective or ineffective teachers. I now turn to a more nuanced description of the distribution of students' exposure to teacher effectiveness, focusing on the three largest focal groups: economically disadvantaged students, African American (relative to White) and Hispanic (relative to White).

To visualize the distributional differences between groups, I calculate relative distribution statistics for economically disadvantaged and minority racial/ethnic students relative to the more advantaged reference groups. Intuitively, this approach estimates the relative share of the focal group population (such as poor students) at each percentile of the reference group population (non-poor students). A uniform relative distribution at a value of one would represent perfect similarity in the chances of exposure to all levels of teacher effectiveness. Values greater than one at the bottom of the distribution would reflect disadvantages (higher concentration among especially ineffective teachers), while values greater than one at the top of the distribution would reflect advantages (higher concentration among the most effective teachers).

The relative distribution results (Figure 2) reveal that disadvantages in access to teacher effectiveness for poor and minority students consist primarily of a greater risk of exposure to the least effective teachers. Taking elementary mathematics as an example, economically disadvantaged students are over-represented in the bottom quartile and by 25% among the least effective teachers. Poor students are somewhat less likely to be assigned to teachers in the middle of the distribution, and there is little difference at the very top of the effective distribution. A similar pattern holds for other groups, with the exception of racial inequalities in teacher effectiveness related to reading in middle school. Consistent with mean differences, repeating these calculations with alternate specifications (see Appendix D) implies larger differences overall, including disparities in exposure to the most effective teachers, but gaps remain most pronounced at the bottom of the distribution.

A complementary way to describe access to different types of teachers is to collapse the teacher effectiveness measure into categories. To correspond with an indicator of a minimally experienced teachers (at least two years of experiences, approximately 85% of the teacher workforce), I consider teachers above the 15th percentile of the teacher effectiveness distribution (“minimally effective”) and those above the 85th percentile (“exceptionally effective”). Figure 3 summarizes the group differences in exposure to these types of teachers.[9] In mathematics, poor, African American, and Hispanic students are all more likely to be assigned to a particularly ineffective teacher, while there are no differences for exceptionally effective ones. In reading, these groups are also relatively disadvantaged in somewhat greater likelihoods of experiencing a very ineffective teacher, compared to small estimated advantages in access to especially effective teachers for all groups.

Even where effectiveness disparities exist—in access to minimally effective teachers—these differences tend to be smaller than those implied by exposure to minimally experienced teachers. This suggests that previous research focusing on teacher characteristics overstates background inequalities in learning opportunities related to teachers. An exception is elementary gaps by economic disadvantage, where inexperience gaps are nearly identical to those for especially ineffective teachers.

In summary, distributional patterns imply that racial and economic advantages related to teachers are not universal. They reflect better chances of avoiding an especially ineffective teacher, but these advantages do not extend to exposure to especially effective teachers. This difference may result from parental efforts to avoid especially poor learning environments. However, it is important to note that social advantages in exposure to a minimally effective teacher tend to be smaller than the well-documented advantages in exposure to an inexperienced teacher. This suggests that the family and school organizational pressures that

[9]All corresponding estimates and those for alternate specifications are available in supplementary materials.

place more advantaged students in the classes of more experienced teachers do not apply in the same way to effectiveness.

Decomposing Teacher Effectiveness Disparities across Schools and Districts

Disparities in exposure to especially ineffective teachers suggest that poor and minority students are at greater risk of relatively poor learning opportunities at school. At what levels of educational organization do these disparities occur? To answer this question, I decompose the overall gaps into components due to between-districts sorting of teachers, between-school sorting (within-district), and between-classroom assignments within schools (Table 2). Negative values have the interpretation that sorting at a particular level works against the overall disparity. For example, in elementary mathematics, poor students are 3.4 percentage points less likely to have a minimally effective teacher overall. About a third of this difference (31.5%) is due to the districts that poor students attend, more than a third (38.3%) is attributable to teacher sorting between schools within district, and almost a third (30.2%) is related to classroom assignments within schools.

For the largest background groups, decompositions reveal that substantial portions of the differences are driven by both within- and between-school processes. Poor, Black, and Hispanic students attend schools with more struggling teachers but are also more likely to be taught by the ineffective teachers within these schools. No less than a quarter of disparities for these groups is attributable to within-school processes. It is not surprising that within-school differences play a bigger role in the middle school grades, when schools are larger and the curricula becomes more diverse. It is important to remember that overall disparities are generally small. Nonetheless, these differences point to multiple underlying mechanisms of inequality. District differences also play a role, especially for the smaller racial/ethnic groups. Asians are well-represented in districts with fewer ineffective teachers, while the reverse is true for American Indian students.

Comparable decompositions of the disparities in access to minimally experienced teachers (estimates reported in supplementary materials) show that a larger share of disparities in exposure to novice teachers is due to between-school and between-district sorting. This suggests that the organizational forces that lead to concentrations of teacher experience do not concentrate more effective teachers to the same degree. Traditional measures of educational resources may overstate the concentration of poor, Black, and Hispanic students in schools with drastically lower opportunities, at least in elementary and middle schools.

In sum, these variegated patterns of disparities in access to effective teachers suggest that different processes create and constrain educational advantages in access to opportunities to learn at school. Because these processes affect different social groups at different levels of educational organization, providing equal opportunities to learn for all students will require a multifaceted understanding of the problem and response. Moreover, traditional measures of teacher quality may mischaracterize some of the location and therefore sources of inequalities, especially those inequalities that exist between classrooms within schools.

Discussion

To what extent and how do social advantages translate into access to learning opportunities at school? Answering these questions is key to resolving debates about whether formal schooling tends to reproduce or equalize social background inequalities (e.g., Downey et al. 2004), but measuring consequential learning opportunities is a fundamental challenge. This paper highlights a valuable approach to exploring these questions, drawing on the burgeoning literature on the impacts of individual teachers. Like curricular tracks in later grades (see Kilgore and Pendleton 1993), teacher assignments are one of the most consequential determinants of a constellation of the learning opportunities that students experience in school throughout the academic year. Therefore, the distribution of students across more and less effective teachers provides a new perspective for stratification research about if, where, and how students from advantaged background enjoy greater access to the learning opportunities provided by school.

The general picture that emerges from recent cohorts of elementary and middle school students in North Carolina is that non-poor and White students tend to be assigned more effective teachers, but the magnitude of these differences suggests limited contributions to inequality. The estimated disparities in learning opportunities for poor and non-poor students, extrapolated across grades K-8, are less than ten weeks of learning in mathematics and less than five in reading.[10] These disparities are important, and should motivate efforts to redress them. However, the magnitude of these contributions pales in comparison to growth in achievement gaps over this period. The implication is that inequalities are driven largely by other factors, not the effectiveness of teachers to whom different groups of students are assigned. The results for alternate specifications are consistent with this finding: the less precisely teacher influences are separated from other influences on learning, the more unequal teacher assignments seem to be. This implies that outside influences play a more critical role in generating achievement gaps than the provision of teachers.

On the whole, given how influential teachers are in shaping the learning opportunities that students experience in school, these results complement seasonal learning comparisons in supporting the notion of *relative* equity in school learning experiences in school, compared to disparities in non-school environments (Alexander, Entwisle, and Olson 2007; Downey et al. 2004). This is not because schooling does not matter; in fact, teachers have strong impacts on students' learning, and allocations at schools could certainly be more equalizing. Rather, there is large variety in the teachers experienced by all types of students, and relatively small systematic differences between groups.

The goal of these analyses was to provide a detailed descriptive picture of the distribution of teacher effectiveness. The results do not reveal precisely how or why students experience different access to effective teachers, but they highlight several important theoretical

[10]This calculation is based on a simple combination of the weeks of learning estimates in Table 1 from Kindergarten to 8th grade (6 elementary, 3 middle). The cumulative effects of teacher assignments on achievement at the end of grade 8 may be less, given decay in observed teacher effects over time. Although outside the scope of this paper, one important area for future research is how teacher-related learning opportunities impact students over time, especially for schooling influences on the development of within-group inequality.

questions for future research on equity in access to school learning opportunities. Most basically, substantively small group differences are surprising in light of many documented educational advantages enjoyed by non-poor and White families. Additional research is needed to illuminate the social mechanisms that constrain or counteract these advantages. Moreover, the current results highlight the importance for research and policy focused on numerical assessments of educational quality to engage more deeply with school-based enthographers to better understand the meanings, choices, and processes that shape student placements between different schools and classrooms.

One notable pattern in the current analyses is the relatively small variation in teacher effectiveness between schools, which mutes the impacts of persistent economic and racial school segregation among students. The forces that systematically sort teachers to schools seem to be weakly related to teachers' effectiveness, and we need a greater understanding of links between effectiveness and particular staffing decisions (Boyd et al. 2010). Another area for attention is the within-school allocation processes for teachers and students. Here an important theoretical distinction to explore is between *limits on parental advantages*, such as imperfect information about the quality of local learning opportunities, and *active efforts to promote equity*, such as educators' commitments to creating balanced classrooms. Tracing these dual processes will be important to understanding implications for equity in a changing policy context that is placing greater emphasis on teacher value-added scores.

Future research should also explore the causes of the specific social advantages observed in these data: the tendency of non-poor and White families to avoid especially ineffective teachers. There are several theoretically distinct sources for this difference. One relates to information, as parents may only be able to identify particularly struggling schools or teachers. However, we should also consider how parents make sense of teacher quality and school resources more generally. Just as parents construct a particular conception of a good school (Goyette and Lareau 2014), how do parents make sense of a "good teacher"? For instance, since teacher quality is multidimensional, advantaged parents may prioritize other qualities than effectiveness at raising student achievement, at least above a certain threshold. Parent-school interactions around teacher assignments are also important. An explanation for the distributional results presented here is that middle class parents' interventions primarily arise as reaction to perceived problems (Calarco 2014), rather than maximizing all advantages in all ways.

Further, the distribution of teacher effectiveness highlights important and diverging patterns by economic background and race/ethnicity. The patterns for poor, African American, and Hispanic students are similar, showing generally modest disadvantages in access to effective teachers, implying broad consistency in how these aspects of social background translate to access to high quality teachers. Yet the sources of these disparities suggest potentially different underlying processes. Economic disparities are most evident in within-school sorting, while racial disparities are also the result of between-school (Black and Hispanic) and between-district (American Indian) segregation. The large and geographically concentrated disparities faced by American Indian students highlight the need for greater attention to this group. Conversely, Asian students' disadvantages in greater assignments to inexperienced teachers belie mean advantages in teacher effectiveness, driven by a particularly low likelihood of assignment to a low quality teacher.

Finally, to place these interpretations in context, it is important to highlight several limits of teacher value-added measures as indicators of the opportunities to learn provided by schools. First, value-added estimates reflect only learning opportunities related to the measured outcome, standardized achievement in mathematics and reading. These results do not speak to potential inequalities related to schools' and teachers' important influences on other formative outcomes, such as social and emotional skills (Jennings and DiPrete 2010). An important next step for research is to provide a similarly detailed accounting of access to teachers who effectively promote social and emotional skills, successfully integrate students into their classes, and inspire students' motivation in school.

Second, the focus on learning opportunities at the teacher-level elides broader determinants of learning opportunities—such as content standards, common curricular materials, and the structure of differentiated courses—and smaller-scale variation in learning opportunities within the classroom, such as those related to dyadic teacher-student interactions. Both require devoted attention, as they enable potentially different stratifying mechanisms.

Third, teacher effectiveness estimates do not provide information about the learning opportunities of all students. For instance, these methods do not speak to learning opportunities in early grades, which could have formative impacts on educational disparities. Within tested grade levels, not all students can be linked to a teacher with an effectiveness estimate; the broad inclusion criteria employed here covered roughly 90% of all public school students, but an observably less advantaged, and potentially unique, subpopulation was omitted.[11] Alternate data sources or methods will be necessary to characterize the learning opportunities of the set of roughly 15% of all children omitted here (including those in private schools).

Lastly, this teacher-effectiveness approach may misrepresent disparities in opportunities to learn if value-added biases differ systematically for teachers of particular types of students. Alternate specifications highlight this potential problem. When fewer control variables are included in the value-added model, economic and racial inequities seem larger, because outside influences are misattributed to teachers. As in any observational design, even the best available model may omit important unobserved confounders of teacher effects. As discussed above, differential summer learning is one potential threat to the validity of these estimates, although the magnitude of any distortions is unknown. Because these possible biases would likely work in the favor of teachers of advantaged students, the current results may be viewed as conservative estimates of the relative equality of teacher-related learning opportunities between different student groups.

[11]Manfield's (2015) detailed analysis of disparities in teacher effectiveness in high schools illustrates a trade-off between leverage for identifying teacher effectiveness and how wide a population can be considered. A strength of the study is that it capitalizes on teacher transfers to identify parameter estimates, but as a result, analyses of inequality are based on 386 of 1000 total schools. It is notable that the general conclusion of that paper, small disparities in the expected directions, are similar to the current design, which includes a larger proportion of students.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Appendices

Appendix A:: Sample Characteristics

Table A1.

Sample Characteristics for Mathematics Elementary Analyses

	Full Sample	No Teacher Link	No VA Estimate	Analysis Sample	Leave-out Sample	EDS-specific Sample	Black-White Sample
Sample Size							
Students (millions)	1.981	0.147	0.059	1.776	1.573	1.322	0.833
Prop. of Full Sample	1.000	0.074	0.030	0.896	0.794	0.667	0.420
Schools	1976	1056	1738	1593	1580	1537	1308
Districts	219	151	198	211	210	192	165
Demographics							
Female	0.490	0.483	0.382	0.494	0.494	0.494	0.494
American Indian	0.015	0.014	0.015	0.015	0.014	0.014	0.011
Asian	0.025	0.033	0.023	0.025	0.024	0.023	0.025
Black	0.266	0.266	0.384	0.261	0.256	0.238	0.302
Hispanic	0.122	0.126	0.108	0.123	0.122	0.116	0.123
Pacific Islander	0.000	0.000	0.000	0.000	0.000	0.000	0.000
White	0.532	0.516	0.428	0.537	0.545	0.570	0.495
Multiracial	0.040	0.045	0.042	0.039	0.039	0.040	0.043
EDS	0.516	0.408	0.636	0.521	0.518	0.510	0.525
Achievement							
Mathematics	0.000	0.014	−0.409	0.007	0.025	0.032	0.001
Standard Deviation	*1.000*	*1.030*	*1.138*	*0.994*	*0.991*	*0.978*	*0.991*
Reading	0.000	0.036	−0.354	0.004	0.018	0.028	−0.001
Standard Deviation	*1.000*	*1.022*	*1.130*	*0.995*	*0.993*	*0.979*	*0.989*
Teachers							
N			6147	25229	17868	13037	7299
Experience (years)			11.7	11.0	11.3	11.5	11.6
Standard Deviation			*9.3*	*8.7*	*8.6*	*8.5*	*8.5*
Minimally Experienced[(a)]			0.819	0.837	0.857	0.873	0.876
VA Estimate				0.000	0.010	0.010	0.010

	Full Sample	No Teacher Link	No VA Estimate	Analysis Sample	Leave-out Sample	EDS-specific Sample	Black-White Sample
Standard Deviation				*0.195*	*0.185*	*0.183*	*0.179*
VA Estimated Reliability				0.919	0.935	0.943	0.950
Standard Deviation				*0.066*	*0.047*	*0.036*	*0.031*

(a) at least 2 years of teaching experience

EDS = Economically Disadvantaged; VA = Value-added

Note: Full sample includes all students in grades 3-5 between 2006-2007 and 2012-2013 (excluding 3rd graders for 2009-2013) with non-missing demographic information (economic disadvantage and race/ethnicity).

Table A2.

Sample Characteristics for Mathematics Middle School Analyses

	Full Sample	No Teacher Link	No VA Estimate	Analysis Sample	Leave-out Sample	EDS-specific Sample	Black-White Sample
Sample Size							
Students (millions)	2.398	0.214	0.064	2.120	1.942	1.989	1.698
Prop. of Full Sample	1.000	0.089	0.027	0.884	0.810	0.829	0.708
Schools	1859	781	1743	882	866	846	748
Districts	218	171	199	212	206	197	174
Demographics							
Female	0.488	0.454	0.340	0.496	0.497	0.497	0.498
American Indian	0.015	0.016	0.019	0.015	0.015	0.015	0.012
Asian	0.024	0.023	0.015	0.024	0.025	0.024	0.026
Black	0.278	0.314	0.412	0.270	0.264	0.265	0.287
Hispanic	0.109	0.120	0.091	0.108	0.107	0.107	0.110
Pacific Islander	0.000	0.000	0.000	0.000	0.000	0.000	0.000
White	0.540	0.488	0.431	0.549	0.555	0.554	0.528
Multiracial	0.034	0.038	0.031	0.034	0.034	0.034	0.036
EDS	0.498	0.497	0.694	0.492	0.487	0.490	0.481
Achievement							
Mathematics	0.000	−0.265	−0.921	0.031	0.052	0.042	0.041
Standard Deviation	*1.000*	*1.007*	*1.080*	*0.991*	*0.989*	*0.983*	*0.988*
Reading	0.000	−0.234	−0.859	0.028	0.041	0.037	0.036
Standard Deviation	*1.000*	*1.037*	*1.161*	*0.988*	*0.986*	*0.981*	*0.984*
Teachers							
N			5787	9417	6671	7410	5810
Experience (years)			11.6	11.9	12.1	12.1	12.0
Standard Deviation			*8.9*	*8.9*	*8.8*	*8.9*	*8.8*
Minimally Experienced(a)			0.860	0.856	0.872	0.867	0.871
VA Estimate				−0.003	0.004	0.001	0.000
Standard Deviation				*0.162*	*0.156*	*0.157*	*0.154*
VA Estimated Reliability				0.968	0.976	0.974	0.976
Standard Deviation				*0.049*	*0.035*	*0.030*	*0.026*

[(a)] at least 2 years of teaching experience

EDS = Economically Disadvantaged; VA = Value-added

Note: Full sample includes all students in grades 6-8 between 2006-2007 and 2012-2013 with non-missing demographic information (economic disadvantage and race/ethnicity).

Table A3.

Sample Characteristics for Reading Elementary Analyses

	Full Sample	No Teacher Link	No VA Estimate	Analysis Sample	Leave-out Sample	EDS-specific Sample	Black-White Sample
Sample Size							
Students (millions)	1.981	0.148	0.085	1.749	1.538	1.293	0.810
Prop. of Full Sample	1.000	0.074	0.043	0.883	0.776	0.653	0.409
Schools	1976	1113	1811	1567	1559	1521	1282
Districts	219	152	199	210	209	191	165
Demographics							
Female	0.490	0.484	0.408	0.494	0.494	0.494	0.495
American Indian	0.015	0.017	0.015	0.014	0.014	0.014	0.011
Asian	0.025	0.033	0.020	0.025	0.025	0.023	0.025
Black	0.266	0.267	0.339	0.262	0.256	0.237	0.302
Hispanic	0.122	0.127	0.107	0.123	0.122	0.115	0.123
Pacific Islander	0.000	0.000	0.000	0.000	0.000	0.000	0.000
White	0.532	0.512	0.478	0.537	0.544	0.571	0.496
Multiracial	0.040	0.045	0.040	0.039	0.039	0.040	0.044
EDS	0.516	0.412	0.618	0.520	0.516	0.508	0.523
Achievement							
Mathematics	0.000	0.009	−0.315	0.010	0.027	0.035	0.001
Standard Deviation	*1.000*	*1.033*	*1.062*	*0.994*	*0.991*	*0.977*	*0.991*
Reading	0.000	0.028	−0.295	0.008	0.023	0.034	0.003
Standard Deviation	*1.000*	*1.024*	*1.080*	*0.994*	*0.992*	*0.977*	*0.988*
Teachers							
N			7068	25130	17958	13012	7292
Experience (years)			11.9	11.0	11.3	11.6	11.7
Standard Deviation			*9.5*	*8.8*	*8.7*	*8.6*	*8.7*
Minimally Experienced[(a)]			0.829	0.836	0.857	0.872	0.876
VA Estimate				0.001	0.005	0.004	0.006
Standard Deviation				*0.132*	*0.122*	*0.117*	*0.112*
VA Estimated Reliability				0.829	0.857	0.870	0.885
Standard Deviation				*0.120*	*0.092*	*0.082*	*0.070*

[(a)] at least 2 years of teaching experience

EDS = Economically Disadvantaged; VA = Value-added

Note: Full sample includes all students in grades 3-5 between 2006-2007 and 2012-2013 (excluding 3rd graders for 2009-2013) with non-missing demographic information (economic disadvantage and race/ethnicity).

Table A4.

Sample Characteristics for Reading Middle School Analyses

	Full Sample	No Teacher Link	No VA Estimate	Analysis Sample	Leave-out Sample	EDS-specific Sample	Black-White Sample
Sample Size							
Students (millions)	2.398	0.236	0.067	2.095	1.892	1.947	1.649
Prop. of Full Sample	1.000	0.098	0.028	0.874	0.789	0.812	0.688
Schools	1859	791	1626	880	859	839	752
Districts	218	156	190	211	204	192	172
Demographics							
Female	0.488	0.452	0.330	0.497	0.498	0.499	0.500
American Indian	0.015	0.016	0.019	0.015	0.014	0.014	0.012
Asian	0.024	0.028	0.015	0.024	0.024	0.024	0.025
Black	0.278	0.295	0.397	0.272	0.266	0.267	0.291
Hispanic	0.109	0.129	0.112	0.106	0.105	0.104	0.108
Pacific Islander	0.000	0.000	0.000	0.000	0.000	0.000	0.000
White	0.540	0.493	0.425	0.549	0.557	0.556	0.528
Multiracial	0.034	0.037	0.031	0.034	0.034	0.034	0.036
EDS	0.498	0.496	0.704	0.491	0.486	0.488	0.481
Achievement							
Mathematics	0.000	−0.207	−0.911	0.030	0.045	0.040	0.034
Standard Deviation	*1.000*	*1.025*	*0.965*	*0.990*	*0.989*	*0.982*	*0.988*
Reading	0.000	−0.217	−0.982	0.031	0.046	0.043	0.040
Standard Deviation	*1.000*	*1.055*	*1.106*	*0.985*	*0.982*	*0.975*	*0.979*
Teachers							
N			5669	10075	6911	7738	5947
Experience (years)			11.9	11.6	11.8	11.7	11.7
Standard Deviation			*9.1*	*9.0*	*8.9*	*8.9*	*8.9*
Minimally Experienced[(a)]			0.858	0.853	0.868	0.863	0.866
VA Estimate				−0.002	0.000	0.000	0.000
Standard Deviation				*0.090*	*0.082*	*0.082*	*0.079*
VA Estimated Reliability				0.917	0.935	0.930	0.936
Standard Deviation				*0.092*	*0.066*	*0.064*	*0.055*

[(a)] at least 2 years of teaching experience

EDS = Economically Disadvantaged; VA = Value-added

Note: Full sample includes all students in grades 6-8 between 2006-2007 and 2012-2013 with non-missing demographic information (economic disadvantage and race/ethnicity).

Appendix B:: Distributions of Teacher Effectiveness

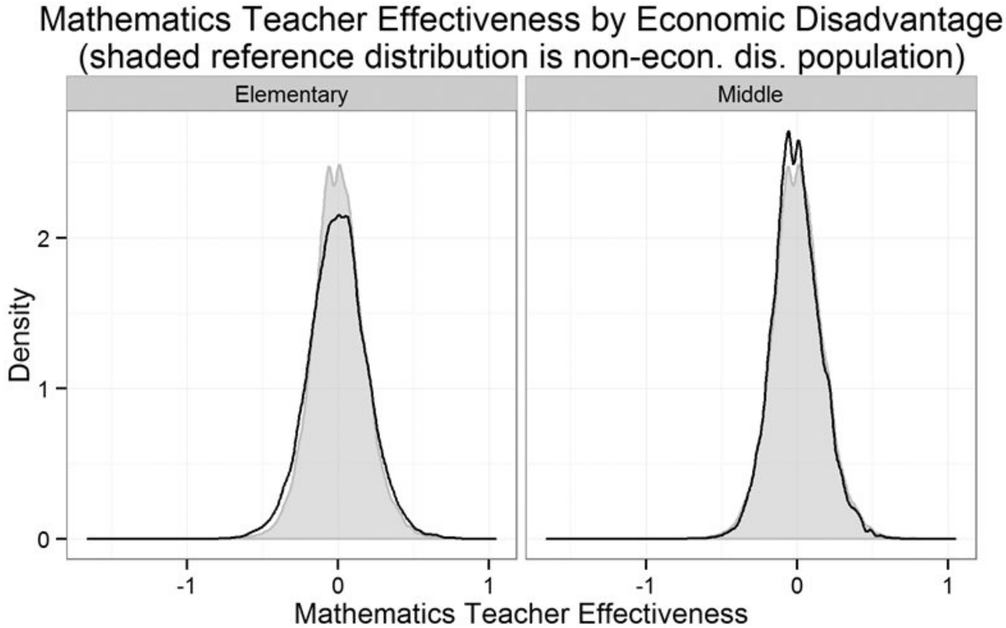

Figure B1.
Distribution of Mathematics Teacher Effectiveness by Economic Disadvantage

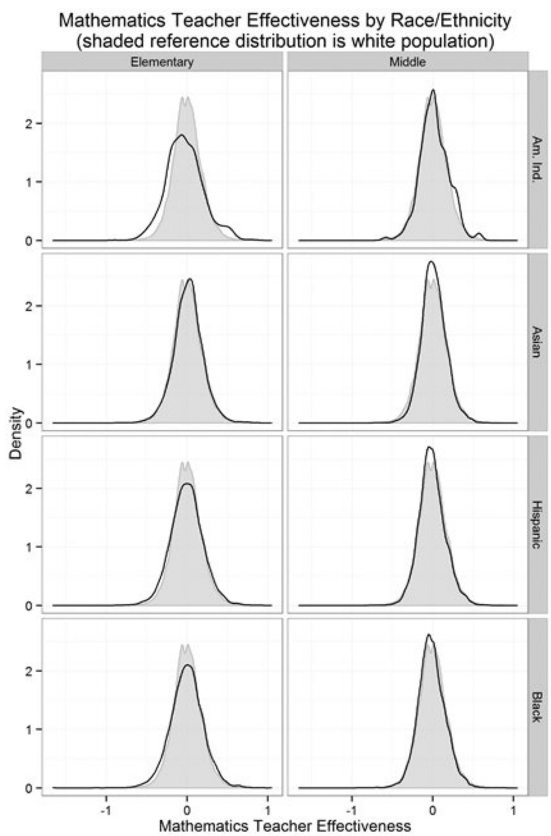

Figure B2.
Distribution of Mathematics Teacher Effectiveness by Race/Ethnicity

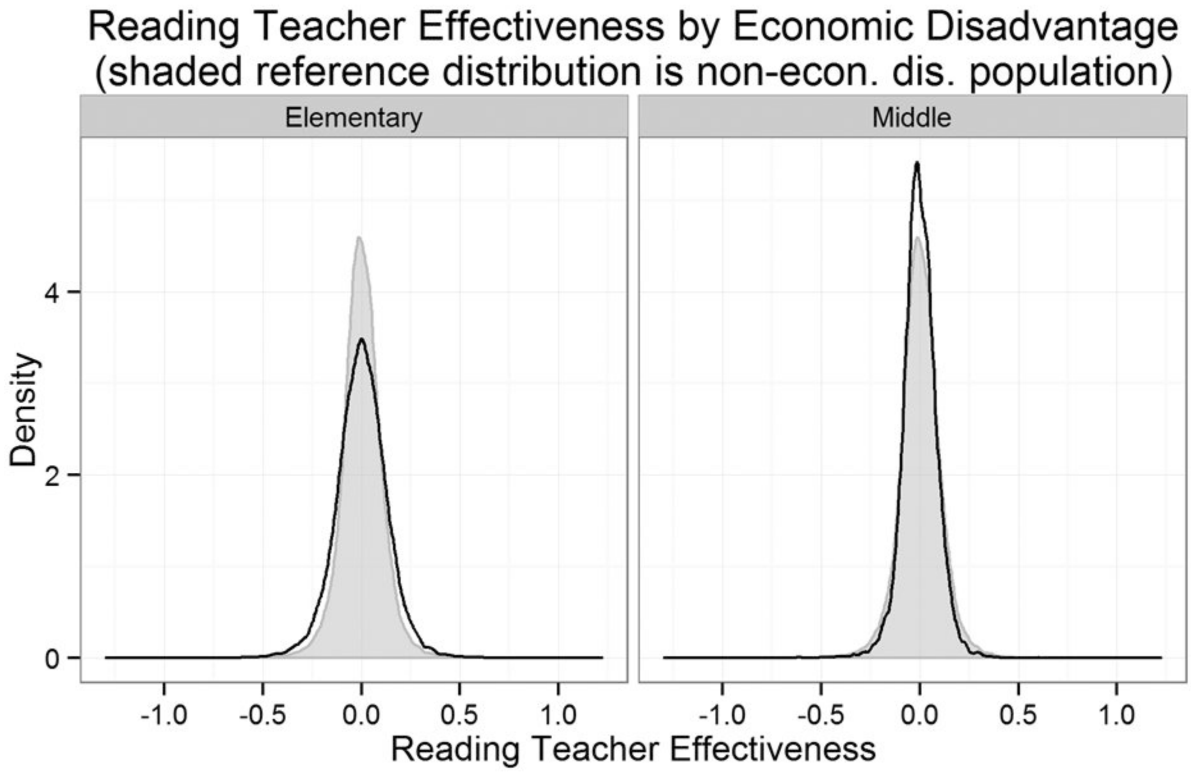

Figure B3.
Distribution of Reading Teacher Effectiveness by Economic Disadvantage

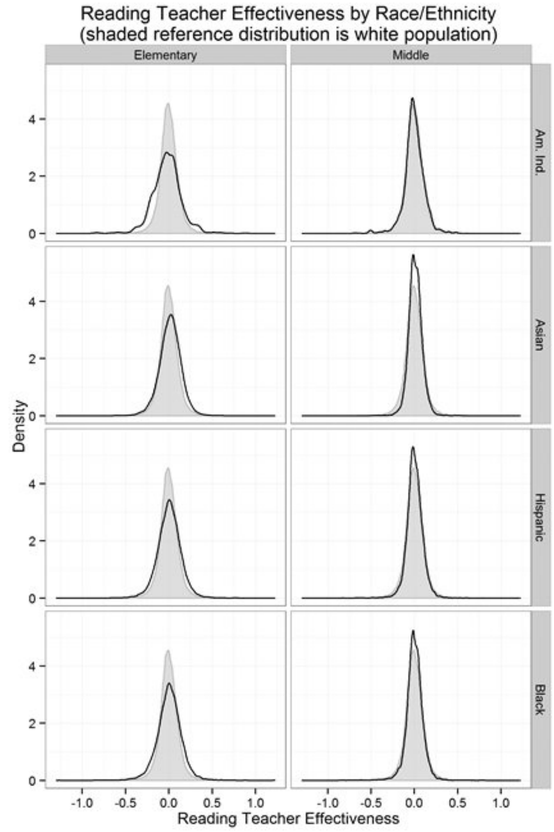

Figure B4.
Distribution of Reading Teacher Effectiveness by Race/Ethnicity

Appendix C:: Corresponding Plots for Reading

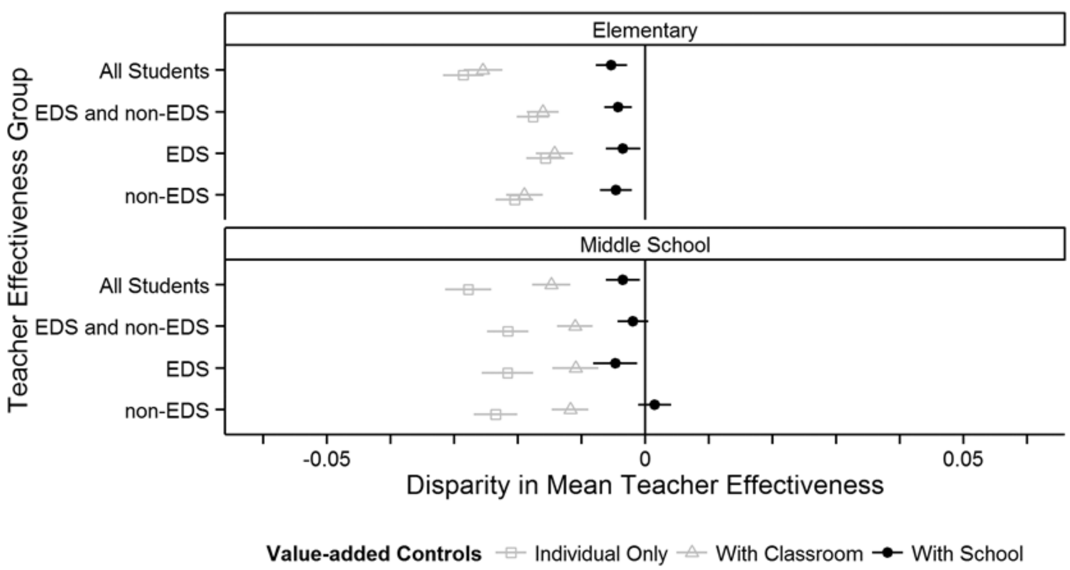

Figure C1.
Economic Disadvantage, Mean Disparities (Analogous to Figure 1A)

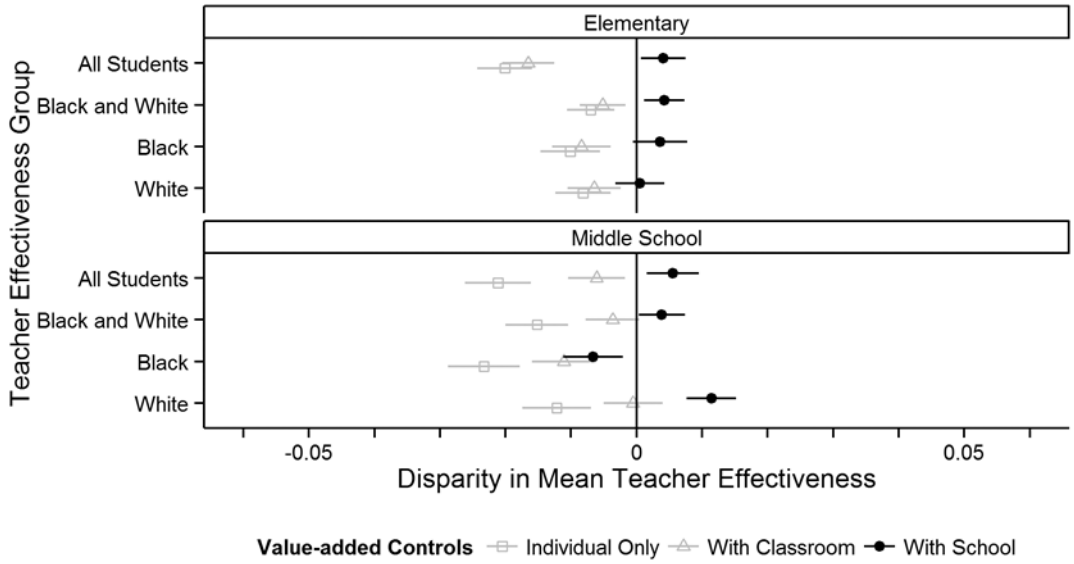

Figure C2.
Economic Disadvantage, Mean Disparities (Analogous to Figure 1B)

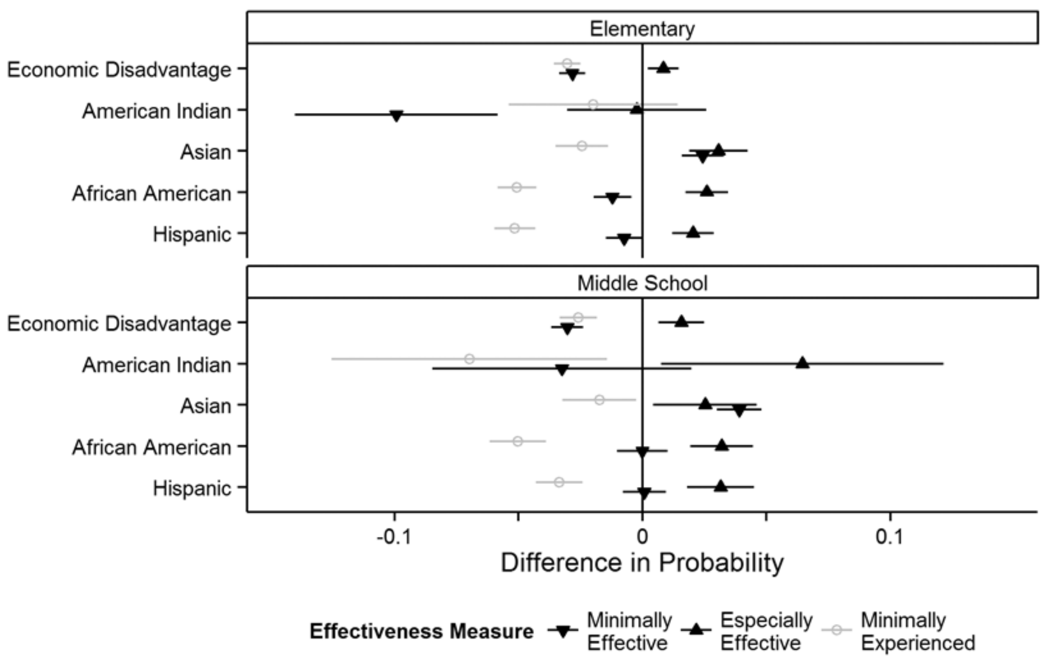

Figure C3.
Economic and Racial/Ethnic Disparities in Access to Minimally Effective, Especially Effective, and Minimally Experienced Reading Teachers (Analogous to Figure 3)

Appendix D:: Relative Distributions for Alternate Value-added Specifications

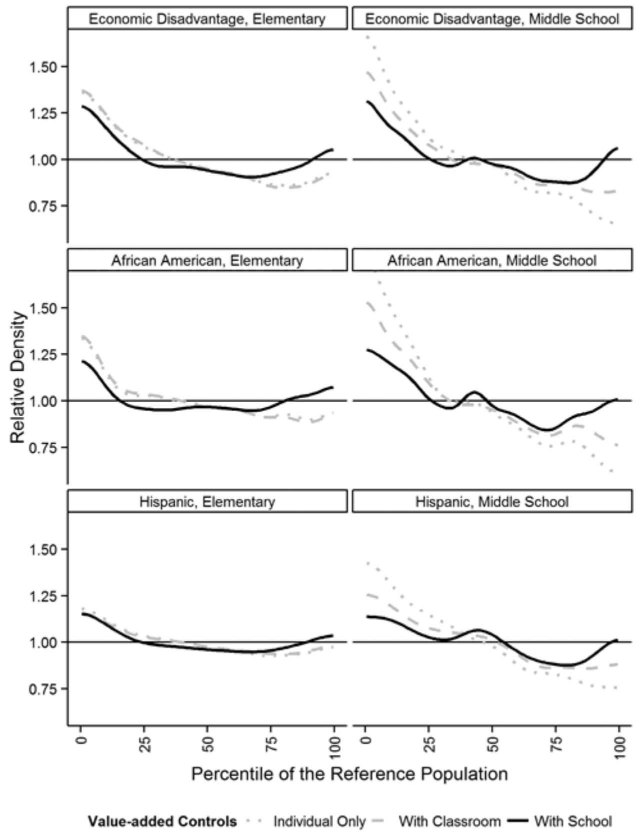

Figure D1.
Relative Distributions for Mathematics Teacher Effectiveness

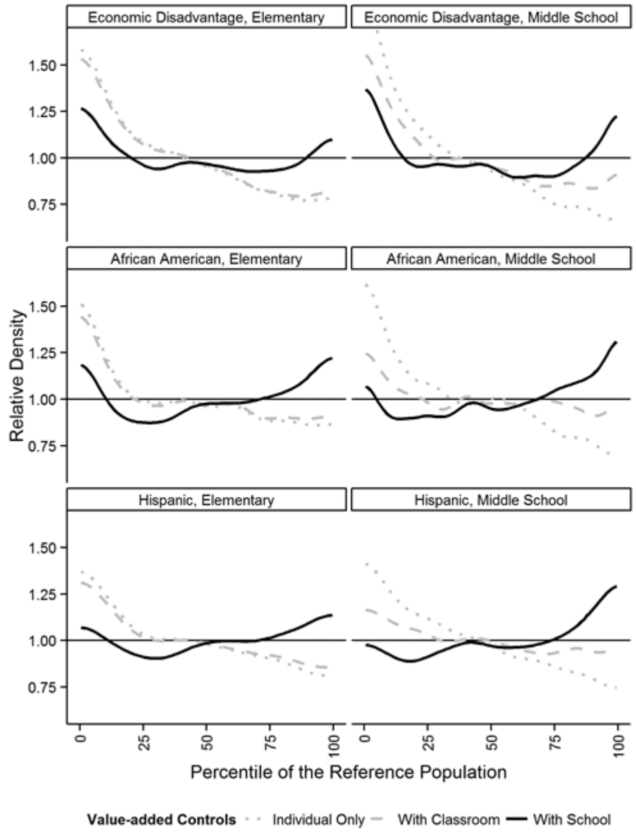

Figure D2.

Relative Distributions for Reading Teacher Effectiveness

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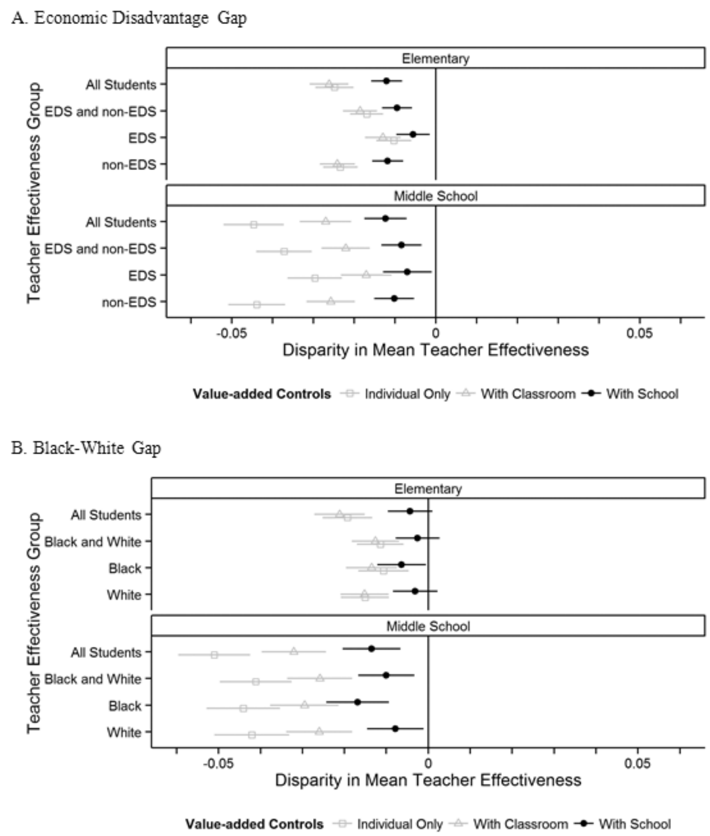

Figure 1.

Estimated Mean Mathematics Teacher Effectiveness Gaps for Alternate Teacher Value-added Specifications

Notes: Intervals represent 95% confidence intervals.

Preferred specifications are represented by filled circle estimates for the “All students” effectiveness measure

The “All students” effectiveness measure is based on the full analytic sample value-added estimates based on all students. All other estimates are based only on the sample of students taught by teachers observed with at least 10 students in each subgroup (EDS and non-EDS for Panel A and Black and White for Panel B). Teacher effectiveness estimates are based only on the listed sub-groups.

“Individual Only” control specifications include individual student characteristics and prior achievement in the value-added model. The “With Classroom” specification adds classroom-level aggregate prior achievement. “With School” specification adds school aggregate prior achievement.

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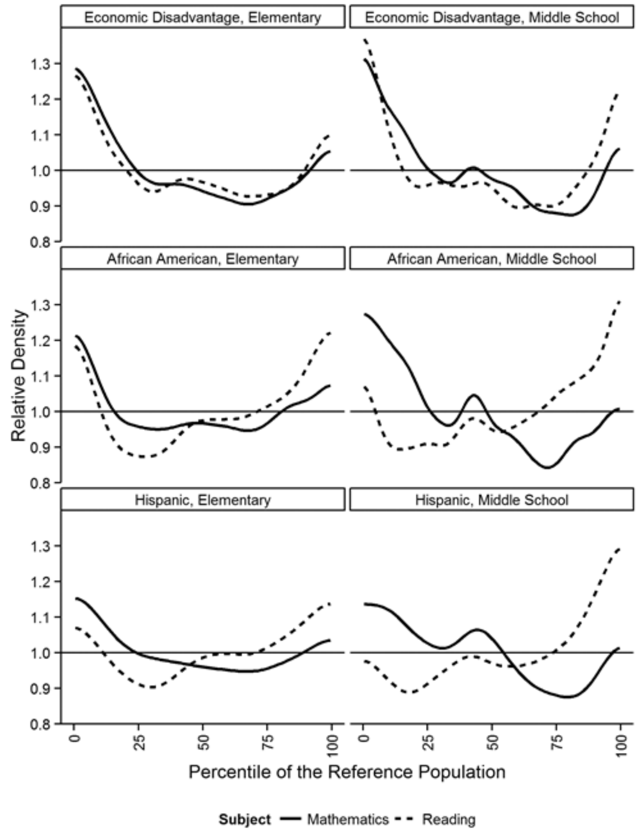

Figure 2.

Relative Distribution of Teacher Effectiveness by Social Background Groups

Note: The reference group for economically disadvantage students ("Econ. Dis.") is non-economically disadvantaged students; the reference group for race/ethnicity groups is White students.

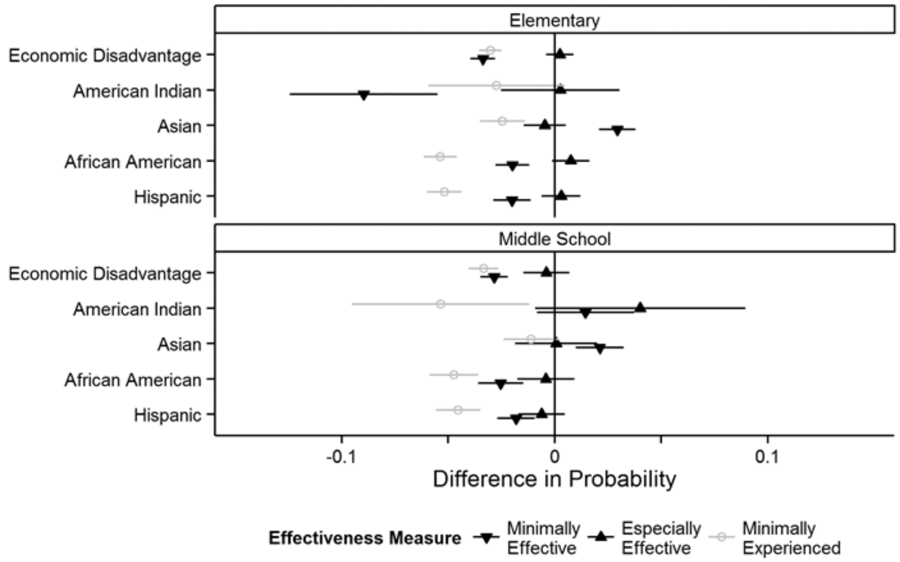

Figure 3.
Economic and Racial/Ethnic Disparities in Access to Minimally Effective, Especially Effective, and Minimally Experienced Mathematics Teachers

Notes: Intervals represent 95% confidence intervals. All comparisons are relative to either non-EDS (for EDS group) or White (for racial/ethnic groups) students.

"Minimally Effective" reflects above the 15th percentile in the teacher effectiveness distribution.

"Especially Effective" reflects above the 85th percentile in the teacher effectiveness distribution.

"Minimally Experienced" refers to at least 2 years of teaching experience.

Table 1.

Estimated Economic and Racial/Ethnic Disparities in Mean Teacher Effectiveness in Four Metrics

Subject/Level	Group	(1) Raw Estimate	SE	(2) Prop. of Ach. Gap	(3) Prop. of SD	(4) Weeks of Learning
Mathematics						
Elementary	EDS	−0.012	0.002	0.017	0.055	−0.89
	American Indian	−0.029	0.009	0.045	0.131	−2.14
	Asian	0.012	0.003	0.037	0.053	0.87
	Black	−0.006	0.003	0.012	0.028	−0.46
	Hispanic	−0.004	0.003	0.006	0.020	−0.32
Middle School	EDS	−0.012	0.003	0.017	0.064	−1.44
	American Indian	0.021	0.011	0.033	0.107	2.41
	Asian	0.011	0.005	0.026	0.057	1.29
	Black	−0.009	0.003	0.017	0.046	−1.05
	Hispanic	−0.014	0.004	0.018	0.070	−1.58
Reading						
Elementary	EDS	−0.005	0.001	0.007	0.034	−0.56
	American Indian	−0.022	0.007	0.033	0.139	−2.30
	Asian	0.015	0.002	1.703	0.093	1.54
	Black	0.004	0.002	0.006	0.026	0.43
	Hispanic	0.004	0.002	0.005	0.026	0.43
Middle School	EDS	−0.003	0.001	0.005	0.027	−0.51
	American Indian	0.001	0.012	0.001	0.008	0.15
	Asian	0.014	0.002	0.275	0.108	2.03
	Black	0.007	0.002	0.011	0.055	1.03
	Hispanic	0.006	0.002	0.007	0.044	0.82

EDS = Economically Disadvantaged; SE = Standard Error

Note: All comparisons are relative to either non-EDS (for EDS group) or White (for racial/ethnic groups) students. "Raw estimate" (1) is in the metric of standard deviations in student achievement within each grade and year. "Prop. of Ach. Gap" (2) is the proportion of the observed achievement gap (EDS vs. non-EDS or minority group vs. White). "Prop. of SD" (3) is the proportion of a standard deviation in the teacher effectiveness distribution. "Weeks of Learning" (4) is based on benchmarks for typical annual growth (Hill et al. 2008), assuming a 40 week school-year (Weeks Difference = Raw Difference / Annual Growth * 40). Annual growth values are 0.54 (0.34) for mathematics in elementary (middle) school, and 0.38 (0.27) for reading.

Table 2.

Decomposition of Disparities in Access to Minimally Effective Teachers, Between Districts, Between Schools, and Classrooms

Subject/Level	Group	Overall Gap	District	School	Classroom
Mathematics					
Elementary	EDS	−0.034	31.5%	38.3%	30.2%
	American Indian	−0.090	77.1%	15.5%	7.4%
	Asian	0.029	84.8%	11.8%	3.4%
	Hispanic	−0.020	−11.0%	76.8%	34.2%
	Black	−0.020	13.2%	59.9%	26.9%
Middle	EDS	−0.028	12.5%	35.5%	51.9%
	American Indian	0.014	162.8%	−33.6%	−29.2%
	Asian	0.021	39.0%	24.7%	36.3%
	Hispanic	−0.018	1.1%	51.1%	47.8%
	Black	−0.025	9.7%	49.2%	41.2%
Reading					
Elementary	EDS	−0.028	42.5%	26.5%	31.0%
	American Indian	−0.099	95.6%	−2.1%	6.5%
	Asian	0.024	83.6%	18.5%	−2.0%
	Hispanic	−0.007	−7.4%	22.2%	85.2%
	Black	−0.012	29.6%	34.8%	35.6%
Middle	EDS	−0.030	34.6%	13.8%	51.6%
	American Indian	−0.033	49.6%	27.2%	23.2%
	Asian	0.039	57.6%	33.5%	8.9%
	Hispanic[(a)]	0.001	-	-	-
	Black[(a)]	0.000	-	-	-

[(a)] Decompositions omitted because overall gap is near zero.

Note: All comparisons are relative to either non-EDS (for EDS group) or White (for racial/ethnic groups) students.