What Influences Students' Need for Remediation in College? Evidence from California

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Abstract

This paper examines the relationship between students' need for remediation in college and the attributes of their high school. The analysis indicates reduced remediation need by students from high schools with more educated and experienced teachers, and higher remediation need by students with teachers operating on emergency credentials or waivers.

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I. Introduction

According to the U.S. Department of Education, 75 percent of postsecondary institutions in the United States offer remedial courses in mathematics and English, catering to the 28 percent of first-time college freshmen at both two- and four-year postsecondary institutions who lack the skills necessary to perform college-level work (Parsad & Lewis, 2003). By the time students reach college, their ability to handle college-level coursework is based not only on their academic ability and effort, but on a cumulative set of influences from family, teachers, peers, and schools. This paper examines the relationships between these influences and students' need for remedial coursework in college. I focus especially on those factors influencing remediation need that are potentially under public policymakers' control, namely, attributes of students' high schools and teachers. Because minority and low socioeconomic status college students participate in remedial course-taking in greater proportions than their representation in higher education would suggest (Ignash, 1997; Attewell, Lavin, Domina, & Levey, 2006), a secondary research question explored in this paper is whether the factors influencing remediation need differ by secondary school racial composition.

Some blame students' under-preparedness for college on the shortcomings of the public schools that are the primary supplier of college-bound students. The *No Child Left Behind (NCLB) Act of 2001* is the federal response to public demands that schools and teachers should be held accountable for what goes on in the classroom. I explore how one of the main tenets of NCLB, the requirement that all teachers are "highly qualified", is related to students' academic preparation for college study. Specifically, I examine three teacher quality measures that are explicitly discussed in the NCLB definition of a "highly qualified" teacher: years of experience, educational attainment, and credential status. If these measures of teacher quality are unrelated to

the need for remedial math and/or English by college-bound students, after controlling for other influences, then the intended effects of NCLB may not be realized.

This paper addresses the education policy issues above with evidence from higher education in California. The California State University (CSU) system enrolls approximately 400,000 students each year and faces extremely high rates of remediation. Figure 1 shows that the proportion of first-time CSU freshmen in remediation is historically between 40 and 50 percent in both English and math, with some improvement in math during recent years. Figure 1 actually understates the CSU system-wide remediation problem, however, because many students require remedial coursework in both subjects. In 1998, 68 percent of first-time CSU freshmen required remedial education in English and/or math, and the improvements in math remediation rates evident in Figure 1 only lowered the combined remedial course-taking rate to 58 percent in 2003. This is *more than double* the 26 percent national average remedial course-taking rate among first-time freshmen at all four-year institutions in the United States (Adelman, Daniel, Berkovits, & Owings, 2003). The CSU system is attractive to study for three additional reasons. First, remediation need is straightforward to quantify and determined consistently throughout the CSU system. Based on a student's high school coursework and GPA, SAT or ACT score, and CSU-specific math and English placement test scores, every graduate from a California high school can be classified as needing remediation at CSU or not. This consistent definition of remediation within the CSU system avoids some sample selection issues that would otherwise complicate the analysis. Second, a 1994 attempt by CSU to eliminate remedial education entirely and subsequent pressure to reduce remediation need in the system make it likely that this topic will be the focus of future educational policy debates and actions in California. The findings of this study will help guide CSU in collaborative endeavors with

California high schools regarding strategies for improved student preparedness. Finally, the institutions that comprise the 23-campus system are not elite colleges that are frequently the focus of education research, but instead represent the "every-man" of four-year public colleges. Like many public four-year colleges in the U.S., many CSU campuses are less- or non-selective in their admissions processes and serve a large proportion of the state's students. CSU's representativeness allows the findings of the proposed study to be applicable to national debates on college preparedness and alignment between secondary and postsecondary education.

II. Literature

This research benefits from and contributes to three strands of education literature; educational production functions, racial/ethnic differences in postsecondary attendance and success, and curricular alignment between K-12 and higher education. I discuss these three branches of the literature, and emphasize this paper's contributions, in turn.

A. Education Production Functions

The research question addressed in this paper falls within a well-established literature on educational production functions, in which researchers examine the link between school inputs and student outcomes. This literature was brought to the forefront of public education policy nearly 40 years ago in *Equality of Educational Opportunity*, commonly referred to as the "Coleman Report" for its lead author, James Coleman (1966). The Coleman Report concludes that family background characteristics, rather than school attributes, are the primary determinants of student academic achievement. In his review of educational production function studies spawned by the Coleman Report, Hanushek (1986) summarizes the empirical puzzle that continues to attract researchers' attention today, "… that the constantly rising costs and quality

of the inputs of schools appear to be unmatched by improvement in the performance of students." In this paper, I provide new empirical evidence on this puzzle by examining a student performance measure that has been ignored in the educational production function literature – students' need for remedial coursework in college.

Most educational production function studies focus on student test scores (or gains in test scores) as the student outcome of interest (*e.g.*, Akerhielm, 1995; Ferguson & Ladd, 1996; Loeb & Bound, 1996; Hanushek, Rivkin, & Taylor, 1996; Goldhaber & Brewer, 1997), although some papers also examine how school inputs influence students' future earnings (Card & Krueger, 1992) and school dropout probabilities (Ehrenberg & Brewer, 1994). This paper is the first to examine the influence of school and teacher inputs on students' need for remedial coursework as first-time freshmen at four-year colleges. Remediation need is arguably a better student performance measure than a single standardized test score. Being classified as "remedial" in college is based on a student's cumulative performance on *many* tests, which is, in turn, influenced by exposure to a cumulative set of school inputs (classes of various sizes, teachers of various qualities, etc.).

B. Racial/Ethnic Differences in Postsecondary Outcomes

Minority college students participate in remedial course-taking in greater proportions than their representation in higher education would suggest (Ignash, 1997; Attewell et al., 2006), thus, this research is also relevant to the literature on racial differences in postsecondary attendance and degree attainment. Some studies in this literature examine whether policies like affirmative action and financial aid are effective ways of increasing minority representation in higher education (Card & Krueger, 2005; Kane, 2004). As Greene and Forster (2003) clarify, however, affirmative action and financial aid only open "…the spigot at the end of the

[educational] pipeline wider." If there is a dearth of college-ready minority students available to continue on in that pipeline, those policies may not have the intended positive effect on minority college enrollment. Remedial college courses may catch those minority students that would otherwise leak out of the system. Moreover, there is evidence that remediated students experience increases in college persistence and four-year degree completion (Bettinger & Long, 2008). It is, therefore, imperative to understand how remediation need among minority students might influence their postsecondary enrollment choices and options. To address these issues, I examine the extent to which differences in student body racial composition correlate with college readiness, again paying careful attention to the role of teacher and school attributes in these student decisions.

C. Alignment Between K-12 and Higher Education

It is possible that high college remediation rates signify a disconnect between K-12 curricula and the expectations and requirements of postsecondary study. To help regulate those discrepancies between student and postsecondary academic preparedness perceptions, many states have implemented or are considering K-16 initiatives, albeit with a wide range of purposes, relationships, and end goals. Generally described, these efforts involve aligning secondary and postsecondary curriculum as well as the curriculum within the elementary and secondary system itself (Martinez & Klopott, 2005). Oregon, for example, had the nation's first K-16 set of standards against which it marks progress at elementary, secondary, and college entry checkpoints (Borden et al., 2006). Other states have instituted dual enrollment programs, allowing high school students to enroll concurrently in high school and postsecondary coursework to earn college credit (Hughes, Karp, Bunting, & Friedel, 2005). A small body of research, largely descriptive case studies, has suggested that dual enrollment programs may

ultimately enhance a high school student's academic experience by creating closer ties between high schools and colleges, expanding curricular offerings available to high school students, and fostering a better understanding of college expectations (Bailey, Hughes, & Karp, 2003; Robertson, Chapman, & Gaskin, 2001; Venezia, Callan, Finney, Kirst, & Usdan, 2005). Particularly for students of color, this approach has been shown to be an effective recruiting mechanism, as "dual-enrollment programs may help by involving high school students of color in the two-year college experience and may help 'warm up' their educational aspirations to pursue postsecondary education at the two-year college" (Opp, 2001, p. 82). The present study does not directly address alignment between secondary and postsecondary systems, but the empirical results have implications for the role of alignment in alleviating postsecondary remediation need.

III. Background on Higher Education and Remediation in California

Post-secondary education in California is provided within a structured three-tiered system initially outlined in the *1960 Donohoe Higher Education Act*, but better known as the collection of constitutional amendments, legislation, and documents called the *Master Plan for Higher Education in California*.[1] The *Master Plan* clearly divides higher education in California into three segments with unique missions:

(1) The University of California (UC) colleges provide undergraduate, graduate, and professional education, with exclusive jurisdiction over doctoral degrees,

(2) The California State University (CSU) colleges provide undergraduate, graduate, and professional education through master's degrees and teacher education, and

(3) The California Community Colleges (CCC) provide academic and vocational instruction in lower-division undergraduate education.

The *Master Plan* further differentiates student access to these segments by guaranteeing the top one-eighth of the statewide high school graduating class a place in the UC system, the top one-third a place in the CSU system, and any high school graduate who could plausibly benefit from postsecondary study a place in the CCC system. Clearly, college access is a priority in California.

Part of the stated mission of the community colleges is to provide remedial instruction, in addition to English as a Second Language (ESL) courses, adult non-credit instruction, and workforce training. Despite the fact that remediation is explicitly mentioned in the CCC mission statement but not in the CSU mission, a great deal of remediation occurs among first-time freshmen in the CSU system.[2] In 2003 at 19 of the 23 CSU campuses, the proportion of first-time freshmen who required one or more remedial classes exceeded 50 percent (see Figure 2). 2003 is not an outlier; in fact, the second panel of Figure 2 indicates that even more CSU campuses exceeded the 50 percent threshold in prior years. System-wide, 58 percent of first-time CSU freshmen required English and/or mathematics remedial coursework in 2003, compared to 68 percent in 1997. Although the need for remedial education appears to be declining at CSU, it is still extremely high compared to the national average at all four-year colleges of 26 percent in 2000 (Adelman et al., 2003).

Incoming CSU freshmen are classified as remedial according to the guidelines in *Executive Order No. 665*, issued by the CSU Chancellor's office in the spring of 1997 and effective for the fall of 1998. Each entering undergraduate must demonstrate competence in English and math by passing the English Placement Test (EPT) and the Entry Level Mathematics

(ELM) exam, respectively. Students may be exempt from taking these exams if they can demonstrate competence through their performance on the SAT, the ACT, or on relevant Advanced Placement (AP) exams. For example, students are exempt from taking the ELM and assumed to be proficient in math if they score 560 or above on their math SAT (equivalently, 25 or above on their math ACT) and exempt from taking the EPT if they score 470 or above on their verbal SAT (equivalently, 25 or above on their English ACT).[3] Students who are not exempt and who fail either the ELM or EPT are placed in remedial courses and required to achieve general education proficiency within one year in order to continue at CSU. This requirement is biting; students who are not remediated within one year are disenrolled.[4] As one might expect, failure rates on these exams vary substantially by race/ethnicity. In 1993, for example, failure rates on the ELM were 90 percent for black students and 81 percent for Hispanic/Latino students, compared to 68 percent for white students (Irving, 1995).

California and the CSU system produce an appealing sample to investigate collegiate remediation for a variety of reasons. In addition to being the most populous state and the world's fifth largest economy, California also boasts a great deal of racial and ethnic diversity. This diversity is evident in the large variation in student body racial composition at California public high schools and will be useful in examining the differential impact of school inputs by race. Based on empirical evidence that some school inputs are more important for certain types of students (Akerhielm, 1995) and that these differential effects are related to race (Coleman, 1966; Ehrenberg & Brewer, 1995; Hanushek, Kain, & Rivkin, 2002), I interact characteristics of the student body with school and teacher attributes in the empirical analysis to capture these differential effects. For example, teacher quality may not be statistically related to remediation need by students at predominantly white high schools, but may be strongly related to remediation

need for students at schools with large minority student populations. Interacting teacher characteristics with student body racial composition will identify these differential effects, which may be instructive for crafting targeted teacher quality policies.

IV. Data

The data utilized in this paper come from two sources. The first source is the Division of Analytic Studies at the California State University. The CSU data contain mathematics and English proficiency reports for first-time freshmen from each California high school that sent at least five students to a CSU campus between 1997 and 2003. For each of these high schools, which I refer to as CSU-feeder schools, I observe the total number of seniors that become first-time freshmen at a CSU campus, how many of those students require math remediation, and how many require English remediation. According to Table 1, approximately half (54.5 percent) of the students sent to CSU by the average CSU-feeder high school required at least one remedial course in mathematics in 1997. This figure declined substantially over the seven year sample period to 39.7 percent of students. The average CSU-feeder high school sent 46.9 percent of its students to CSU requiring remedial coursework in English, and this proportion grew slightly to 51.3 percent over the sample period.

This data on remediation need at CSU is linked to a second data source from the California Department of Education (CDE). The CDE collects and maintains the California Basic Educational Data System (CBEDS), which is a database containing extensive survey information for all public schools in California. By matching each CSU-feeder high school in the CSU data to their CBEDS survey each year, I link the characteristics of high schools (*i.e.*, attributes of teachers, student body, etc.) to the proportion of each high school's CSU-bound

students that need remediation. The unit of analysis is a school, specifically a public California high school that is a feeder school for the CSU system, thus the summary statistics are annual averages across schools. Because the vast majority of students that required remediation in the fall of 2003 were high school seniors in the previous year (2002-2003), the high school characteristics that I assume to be relevant are those from the previous academic year.[5] Table 2 summarizes the average characteristics of CSU-feeder high schools from 1997 – 2002, which comprise the final sample of schools used in the analysis.[6]

The average high school in the data enrolled approximately 2000 students and graduated about 20 percent of all enrolled students each year. The number of students headed to CSU as first-time freshmen ranged from an average of 30 in 1997 to an average of 39 in 2002. This number of CSU-bound students represented 9-10 percent of the average high school's senior class. The racial composition of students in the sample, while fairly stable over time, is somewhat different from the primary and secondary school population in California. According to the 2002-2003 Common Core of Data, public school students in California are 32.9 percent white, 8.2 percent black, 46.7 percent Hispanic, and 11.3 percent Asian/Pacific Islander. CSU-bound students are disproportionately white compared to all school children in California, although still a racially diverse group relative to many U.S. colleges.

The University of California (UC) and California State University systems are fairly transparent about which high school courses are required for entry into both systems. High school students who complete those courses with a grade of "C" or better are consider UC- and/or CSU-eligible upon graduation. In this sample, 35 – 37 percent of non-GED high school graduates at these feeder schools complete the requirements each year. An even larger proportion of the graduates, approximately 43 percent on average, take the SAT test. Both the

SAT-taking rate and average score of test-takers (approximately 980) are proxies for student body academic performance.

The CBEDS database also contains a survey called the Personal Assignment Information Form (PAIF) that chronicles every teacher in these high schools, making it possible to construct school-level composite measures of various teacher attributes.[7, 8] These composite measures are simply averages over all teachers within a school and proportions of teachers in each school falling into various categories. The average CSU-feeder high school employs approximately 80 teachers with 14 years of teaching experience. The vast majority of these teachers have full teaching credentials, but 10 – 13 percent hold an emergency credential or have a teaching waiver, which allows a teacher to work for one year in a public school before they have earned their teaching credentials. Schools with large proportions of emergency credentialed teachers or teachers with waivers are often among the poorest schools and suffer from high teacher turnover rates. Finally, the PAIF survey makes it possible to construct the distribution of teachers' educational attainment. Each teacher's educational attainment falls into one of six categories based on degree completion and hours of additional coursework. I calculate the proportion of teachers at each school who fall into each of the six categories. Table 2 reports averages across CSU-feeder schools and indicates that teachers at these schools are most likely to have a bachelor's degree with an additional 30 credit hours of college work. The proportion of teachers with degrees (bachelor's and master's) combined with additional college credit hours declines slightly over time.

Table 2 reveals that at least some attributes of CSU-feeder schools and students are changing over the sample period. Before I utilize this variation and variation across schools in the dataset summarized above, I address the representativeness of the sample schools/students by

examining the composition of schools included in the sample compared to those that are not in the sample. Table 3 indicates that approximately 92 percent of all high school students in California are enrolled at public schools and 8 percent are enrolled in private schools, and that these proportions are stable over time. Examining the students from feeder high schools in the CSU data reveals that 85 percent of students come from public high schools and 15 percent come from private high schools. The greater proportion of private school students in the college-going population is not surprising and again, these proportions are stable over the sample period. Each year between 1997 and 2003, 900-1000 high schools sent five or more students to a CSU campus. According to Table 3, 78 percent of these feeder schools are public, 22 percent are private, and this composition is quite stable over the sample period. Table 3 also reveals a decrease in the proportion of all public California high schools that are CSU-feeder schools. In 1997, 85 percent of all public high schools sent five or more students to a CSU campus, but by 2003 only 74 percent of all public high schools were sending five or more students to the CSU.

According to the bottom of Table 3, math proficiency at CSU campuses rose by more than 15 percentage points over the sample period. Only 44.4 percent of first-time CSU freshmen demonstrated math proficiency in 1997 compared to 60 percent in 2003. The pattern for English proficiency moves in the opposite direction, decreasing from 55 to 50 percent of first-time freshmen over the sample period. Table 3 also reports the average proportion of students who are math and English proficient from public versus private feeder schools. The average proportion of CSU students from public high schools in California who are math proficient exceeds the average proportion from private high schools in all seven years of the sample.[9] It may be the case that math proficient private school students are going to the UC system, so these statistics do not necessarily indicate that public high schools are better at producing good math

students. In contrast, private schools sent, on average, a greater proportion of English proficient students to the CSU system than public schools in all sample years.[10] Despite the differential proficiency of first-time CSU freshmen from public versus private high schools, Table 3 demonstrates that there were no major shifts between 1997 and 2003 in enrollments in public and private high schools in California, and no shifts in the public/private composition of CSU-bound students or CSU-feeder schools.

V. Methodology

Following the educational production literature, I employ regression models to investigate the relationship between math and English remediation need in college (student outcomes) and average school, teacher, and student body characteristics (inputs). I estimate separate regression models for math and English remediation need, where the NCLB policy-relevant independent variables in the model measure teacher experience, educational attainment, and credential status. I include additional independent variables to control for differences in the students at each high school, such as racial composition of the student body, and peer quality measures like average SAT scores. The estimated coefficients from these regression models quantify the relationship between teacher quality measures and student remediation need, holding other remediation influences constant, and are used to address the potential impact of one of the main tenets of NCLB, the requirement that all teachers are "highly qualified."

The dependent variable is the proportion of students from each high school that need remedial math (English) upon entering a CSU campus. Positive coefficients indicate variables that are associated with greater proportions of college-bound students requiring remediation. Although suppressed in the tables presented below, year fixed effects are included in all

regressions to account for any changes over the sample period that would have influenced all students and schools. Consistent with Figure 1, the year fixed effects indicate a clear downward trend in math remediation over the sample period and a slight upward trend in English remediation rates in 2002 and 2003.

VI. Results

In Table 4, I present regressions of math and English remediation rates that control for student body characteristics and measures of teacher experience, educational attainment, and credential status. The top half of Table 4 indicates that the racial composition and academic performance of the student body are statistically related to remediation need in expected ways. High schools with greater black and Hispanic representation have higher rates of math and English remediation at CSU campuses, all else constant. A high school's Asian and other race/ethnicity proportion are both positively related to English remediation rates, but negatively related to math remediation rates at CSU.

These racial composition measures are likely proxies for the socioeconomic status of the families with students at each school as well as for other attributes of the surrounding community, insofar as these things are correlated with race. Additionally, the English results are likely picking up the correlation between English as a Second Language students and race/ethnicity. The CBEDS survey also collects information on English as a Second Language (ESL) students and students that participate in the National School Lunch Program (NSLP). These data are retrieved for high schools in the 2002-2003 academic year and linked to the 2003 CSU remediation rates. Fitting regressions similar to those presented in Table 4 on this single year of linked data but with the inclusion of 'proportion ESL' and 'proportion NSLP' yields

several interesting results. The ESL variable, which should be especially important to English remediation need, adds little to the analysis after controlling for student body racial composition.[11] ESL and Hispanic representation are likely capturing similar aggregate student attributes. The NSLP program participation variable, a proxy for socioeconomic status of the student body, is positively related to remediation need, although the effect is not statistically significant for English remediation once the average student body SAT score is also included.

The analysis in Table 4 also sheds light on the relationship between student remediation need and high school teachers' education, credential status, and experience while controlling for student body characteristics.[12] Several of the teacher variables are statistically related to remediation need, but significance varies somewhat between the math and English regressions. The greater the proportion of teachers who possess a master's degree, the lower the rates of math remediation by their CSU-bound students. A ten percentage point increase in the proportion of teachers with a master's degree (with no additional coursework) is associated with a 0.63 percentage point decrease in math remediation rates among CSU-bound students in the same high school. While the effect of master's degrees alone is statistically insignificant in English, more teachers with master's degrees *combined with* additional coursework surprisingly appears to be associated with slightly higher rates of English remediation at CSU.[13]

Teachers operating under emergency credentials or teaching waivers are associated with greater remediation rates at CSU, and the magnitude of the coefficient in both the math and English regressions indicate that credential status is an economically significant variable. A ten percentage point increase in the proportion of teachers with an emergency credential or waiver is associated with a 1.05 percentage point increase in math remediation need and a 0.66 percentage point increase in English remediation need at CSU. Having teachers with emergency credentials

is likely (negatively) correlated with other school quality measures, such as teacher turnover and school resources. Thus, the positive coefficient estimates on emergency credential or waiver are likely capturing some of these effects. Although not statistically significant in the English regression, greater teacher experience has a very small but statistically significant negative association with math remediation need.

In summary, those attributes of high school teachers that are potentially under public policymakers' control have somewhat mixed influences on college remediation rates. Only math remediation need among CSU-bound students appears to be related to all three teacher quality measures that are explicitly discussed in the NCLB definition of a "highly qualified" teacher – years of experience, educational attainment, and credential status. In contrast, the results in Table 4 indicate that English remediation need in college is not statistically related to high school teacher experience and is positively associated with higher teacher educational attainment, if at all, after controlling for various attributes of a school's student body.

Although student body racial/ethnic composition is not a NCLB policy lever, one cannot help but be struck by the fact that the race/ethnicity coefficient estimates in the top panel of Table 4 are among the largest effects of all explanatory variables included in the regression. A ten percentage point increase in the black student population is associated with an increase of approximately 2.5 percentage points in both math and English remediation rates at CSU, on average and holding everything else constant. Similarly, a ten percentage point increase in the Hispanic student population is associated with a 2.8 percentage point increase in English remediation rates among CSU-bound students. Because there is some evidence in the literature that minority students are more sensitive to school inputs than their non-minority peers, I explore

the potentially differential impact of teacher inputs on remediation rates among black and Hispanic student populations by adding several interaction terms to the regressions in Table 4.

First, I condense the teacher educational attainment variables in Table 4 into fewer categories by combining all teachers with master's degrees regardless of whether additional coursework has been completed. Next, I interact the proportion of teachers with master's degrees and student body racial/ethnic composition measures. The regression results, displayed in Table 5, indicate that those high schools with larger black and Hispanic student bodies and also larger proportions of teachers with master's degrees have lower remediation rates at CSU in English (relative to schools with smaller proportions of master's degree holding teachers), but there is no statistically significant difference in math. Because the interaction of two continuous variables is somewhat cumbersome to interpret, I summarize the Table 5 results through graphical depictions of the combined effect of student body race/ethnicity and teacher education on English remediation rates among CSU-bound students. I focus on the English regression results in Table 5 because the relevant variables (proportion black, proportion Hispanic, proportion of teachers with master's degrees, and the interactions of these variables) are all statistically significant at conventional levels, which is not the case in the math regressions.

Figure 3 shows that the predicted proportion of CSU-bound students needing English remediation increases as the proportion of the black student body increases. The three separate lines in Figure 3 are drawn under different assumptions about the proportion of teachers with a master's degree. In particular, I consider the model's prediction of English remediation need when the proportion of teachers with master's degrees is at its average value of 35 percent as well as one standard deviation above (47 percent) and below (22 percent) this mean value. The dashed line in Figure 3 shows that the proportion of CSU-bound students predicted to need

English remediation rises from just under 50 percent to 75 percent as the black student body proportion rises from 0 to 100 percent, conditional on the proportion of teachers with master's degrees being equal to its mean value of 35 percent. Reducing the proportion of teachers with a master's by one standard deviation to 22 percent makes the line steeper (see solid line in Figure 3), while increasing the proportion by one standard deviation to 47 percent makes the line flatter (see triangle-marked line in Figure 3). Thus, predicted English remediation need is lower when more teachers have master's degrees, and this effect grows as the black student body proportion grows. In predominantly black high schools, there is as much as a 7 percentage point lower rate of English remediation among CSU-bound students when one compares one standard deviation above and below the mean proportion of teachers with master's degrees. This result is consistent with the analyses of Ehrenberg & Brewer (1994), who find evidence of a statistically significant relationship between black student achievement and teachers with master's degrees.

Figure 4 shows how the predicted proportion of CSU-bound students needing English remediation changes as the proportion of the Hispanic student body increases, conditional on various values for teacher educational attainment. The same basic pattern emerges as is evident in Figure 3; in predominantly Hispanic high schools, having more teachers with master's degrees reduces the proportion of CSU-bound students who need English remediation relative to schools with fewer teachers with master's degrees. The effect on English remediation need is much more modest for Hispanics than for blacks – a 2.5 percentage point reduction in college remediation rates at high schools that have all Hispanic students – and the point at which these gains begin to be realized is quite different than what we see in Figure 3. Figure 3 indicates that more teacher education begins to benefit English remediation rates at schools with black student body proportions as small as 35 percent. In contrast, the intersection of lines in Figure 4 occurs

much further out in the distribution of Hispanic student body proportion, indicating that more teacher education is only predicted to produce lower English remediation rates at schools with roughly 60 percent or more Hispanic students.

There are several reasons why the results in this paper should be interpreted somewhat cautiously. First, some researchers have concerns about the biases introduced by aggregating individual student and teacher characteristics up to the school level (Hanushek et al., 1996; Betts, 1995). Most of these concerns are voiced about a greater degree of aggregation than what I employ here (*e.g.*, up to the district or state level) and there is some plausible benefit to aggregating up to the school level in this case. The student outcome of interest in the present study is the need for remediation in college, which is a function of students' cumulative educational experiences in a school. This is in contrast to educational production function studies where the student outcome of interest is student test score gains, which are arguably a function of the student inputs and a single teacher's input. Aggregated measures of school characteristics are likely to be a better measure of the cumulative inputs received by students over the course of their schooling (Loeb & Bound, 1996) and help to mitigate the noise associated with excessive variation in classroom-level data (Ferguson & Ladd, 1996). Second, many of the independent variables included in the regressions are potentially endogenous because teachers and students' families sort themselves across schools in a non-random manner. Endogenous variables are a common problem in education production function studies because good instruments for the endogenous schooling inputs are difficult to identify (Goldhaber & Brewer, 1997). I rely on the Card and Krueger (1995) finding that aggregating data up to the school level may reduce endogeneity problems due to the nonrandom assignment of teachers and students within schools.

VII. Conclusion

The provision of college remediation is costly; Breneman and Haarlow (1997) estimate the annual cost of remediation to CSU was more than $9 million in the mid-1990s and that estimate has grown to $30 million in 2001 and continues to grow with rising education costs (California Business for Education Excellence, 2005). Current estimates of the cost of remediation suggest that public four-year colleges and universities spent in the range of $435-543 million dollars in 2004-05 on remedial instruction, and that the total cost to students attending two-year or four-year institutions in the same year was about $708-886 million in remedial education tuition and fees.[14] The empirical findings in this study are, therefore, likely to be especially interesting to taxpayers and policy-makers who want to avoid paying twice to educate these students as well as to the students who seek to reduce their own college expenses and time to degree completion. In this paper I identify factors that influence students' need for remediation in mathematics and English upon entering college at the California State University. By focusing on a previously-ignored educational outcome measure that affects 30 percent of college freshmen nationwide and costs taxpayers dearly – remedial course-taking in college – this study contributes new empirical evidence to the educational production function literature spawned by the Coleman Report over 40 years ago. After controlling for student body characteristics, I find that attributes of secondary school teachers, such as credential status, experience, and educational attainment have statistically significant effects on the remediation rates of college-bound students. Although there is some variation in the results across college subject and empirical specification, making it difficult to issue sweeping policy prescriptions aimed at successfully reducing college remedial course-taking, there are policy-relevant consistencies that emerge.

Across all specifications and subjects, the results indicate that reducing reliance on emergency teaching credentials and waivers decreases remediation need in both math and English. Additionally, across both specifications of the model, more experienced teachers are associated with lower rates of remedial course-taking in math. These results have real policy significance for educators of teachers and those responsible for formulating teaching certification policy at the state level. Because teacher experience is also consistently related to improvements in other student outcomes in the literature (e.g. test scores), these results suggest that policy-makers should continue to explore teacher retention tools as a means of creating and maintaining an experienced teacher workforce with less turnover and attrition from the profession, which could also serve to reduce the use of emergency credentials and waivers. Teacher retention policies would also benefit from careful attention to distributing teacher experience more equitably across schools and districts than occurs naturally.

The most compelling evidence on the issue of teacher educational attainment from the analyses in this research indicates that the greater the proportion of teachers in a high school with a master's degree, the lower the English remediation need by that school's students in college, and that this effect is stronger for those students who attend high schools with larger minority student populations. This result suggests that the teacher quality requirements of *No Child Left Behind* may improve students' college preparedness, although the effects are likely to differ by secondary school racial composition and those socioeconomic factors that are correlated with race and ethnicity. It is tempting in light of these results to encourage more teachers to complete master's degrees, but it is important to recognize that the analysis is not able to control for unobservable teacher attributes that may be important determinants of both master's degree acquisition and skill in the classroom. If those teachers who are more talented in the classroom

are also more likely to complete a master's degree, perhaps because of an underlying high level of motivation or some other hard-to-quantify characteristic, then policies that mandate or subsidize additional college coursework and/or master's degrees for teachers may not have the desired effect on student outcomes.

Crafting well-targeted education policies, especially in a state as racially and ethnically diverse as California where regular budget shortfalls have detrimental effects on education funding, requires an understanding of the factors that influence college remediation need and how those influences vary with important student characteristics like race and ethnicity. Although this study identifies several important student and teacher characteristics that influence college remediation need and may be manipulated by policy-makers, it is clear that there is still work to be done. Perhaps a preferred direction, for future research and policy, is a better understanding of classroom activities unique to experienced, fully-credentialed teachers with master's degrees. Presumably some teacher practices would emerge in such studies as activities that could be replicated through appropriate policies and programs – for example, teacher mentoring programs, which show evidence of improving both teacher performance and retention (Rockoff, 2008). Another area for future research on potential policy remedies for the remediation epidemic is the disconnect between K-12 curricula and the requirements of postsecondary study. Among first-time freshmen at California State University who find themselves in remedial courses, the average high school GPA is an astonishingly high 3.1, better than a B.[15] These students are receiving positive feedback about their academic performance from their high school teachers that does not match what they hear from colleges once they arrive on campus. Interventions that improve the quality of information students have about their academic preparation for college, such as the CSU Early Assessment Program, which

provides an early signal of college readiness to all participating high school juniors in the state as well as professional development activities for teachers, have the potential to remedy the information asymmetry caused by the disconnect between the secondary and postsecondary systems. Quantitative analyses of these types of interventions and K-16 programs designed to better align secondary and postsecondary curricula are clearly needed.

Notes

[1] See http://sunsite.berkeley.edu/uchistory/archives_exhibits/masterplan/ for an overview of the *Master Plan*.

[2] Many CSU students complete coursework at community colleges and then transfer those credits to a four-year CSU degree program. These students are only allowed to transfer if they are deemed "transfer-ready," which means, in practice, that they have already been successfully remediated by the community colleges if necessary. Thus, transfer students into the CSU system are not eligible for remedial course-taking.

[3] Because of changes in the SAT and ACT tests, the relevant thresholds vary according to the year in which the test was taken. See Addendums A and B to *Executive Order No. 665* (California State University, Office of the Chancellor, 1997) for these specifics.

[4] At the end of the 2001-2002 school year, CSU dismissed 8.2 percent of its freshman class for failing to complete their remediation requirements, an increase from 6.7 percent in 2000 and 5.1 percent in 1999 (Trounson, 2002).

[5] There is some concern that first-time freshmen at CSU campuses are not traditionally-aged college students who were recently high school seniors, which would make it potentially inappropriate to look for a connection between high schools and student's remediation needs. The distribution of CSU first-time freshmen by age indicates that 80 percent of these students are 18 or younger and 98 percent of these students are 19 or younger. Thus, it is reasonable to assume that most first-time freshmen at CSU were in high school one or two years ago.

[6] Technically, since the CSU remediation data is available beginning in 1997, the high school data from CDE should begin in 1996. As is apparent in Table 2, the CDE data is missing important variables prior 1998, so the empirical analysis excludes the first year of CSU data.

[7] The PAIF survey enables instructional staff to be distinguished from administrators, counselors, and other non-instructional staff. The term 'teacher' throughout this paper refers to instructional staff only.

[8] Although aggregation bias is a concern with this type of data, I rely on the Card and Krueger (1995) finding that aggregation may actually reduce endogeneity problems due to the nonrandom assignment of teachers and students within schools, as well as the Loeb and Bound (1996) and Ferguson and Ladd (1996) validations of aggregation as a means of reducing errors-in-variables and the noise associated with excessive variation in classroom-level data.

[9] The differences are only statistically significant in 1997, 1998, and 2001.

[10] The differences are statistically significant in all years.

[11] The lack of statistical significance of the ESL variable does not imply that the activities in ESL classrooms are unimportant to understanding remedial English needs in college. In fact, English proficiency is widely regarded as a significant indicator of successful integration by immigrants. Given the simultaneous decrease in ESL funding and national shortage of ESL programs in recent years (Gonzalez, 2007) in conjunction with the NCLB goals regarding reclassifying students as 'Fluent English Proficient' (Jepsen & de Alth, 2005), it would be beneficial to further explore the relationship between ESL and remediation in future research.

[12] The proportion of teachers with doctorates ranges from zero percent to forty percent in the data, although the average is only 1.5 percent and the vast majority of schools have less than 5 percent teachers with doctoral degrees. I exclude outliers by restricting the sample to those high schools with fewer than 5 percent of teachers with doctorates, which omits 180 school-year observations or 36 schools. All coefficient estimates are robust to this restriction except for the

effect of doctoral teachers on remediation need, which becomes statistically insignificant as a result.

[13] There is some evidence of a negative relationship between master's degree attainment by teachers and student achievement at the elementary education level. For example, see Murnane and Phillips (1981).

[14] http://www.scribd.com/doc/8534051/Diploma-To-Nowhere-Strong-American-Schools-2008

[15] http://www.asd.calstate.edu/remediation/07/Rem_Sys_fall2007.htm

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Tables and Figures

Table 1

Remediation Need by Students From Average CSU-Feeder High School

	1997	1998	1999	2000	2001	2002	2003
Proportion requiring remedial mathematics	0.545	0.560	0.498	0.482	0.489	0.402	0.397
Proportion requiring remedial English	0.469	0.480	0.476	0.479	0.481	0.518	0.513

Table 2

Characteristics at Average CSU-Feeder High Schools

	1997	1998	1999	2000	2001	2002
Student characteristics at the average CSU-feeder high school						
Total Enrollment	1,867	1,902	1,919	1,924	1,970	2,014
Total Grade 12 Enrollment	364	375	385	388	396	410
Number of CSU-bound freshman	30.51	33.29	35.47	37.71	38.39	39.06
Proportion of total high school enrollment:						
White	0.462	0.458	0.453	0.447	0.434	0.427
Black	0.071	0.070	0.069	0.069	0.071	0.069
Hispanic	0.328	0.334	0.339	0.344	0.355	0.361
Asian	0.100	0.100	0.099	0.098	0.097	0.099
Other race/ethnicity	0.039	0.038	0.040	0.042	0.043	0.044
High school graduates	0.184	0.187	0.189	0.189	0.189	0.191
Graduates UC and/or CSU eligible	0.075	0.075	0.074	0.076	0.073	0.074
Dropouts	0.019	0.018	0.017	0.016	0.015	0.017
Proportion of grade 12 enrollment:						
Taking SAT	-	0.419	0.417	0.423	0.429	0.431
(Average score)	-	(985)	(987)	(987)	(981)	(987)
Graduating	0.917	0.920	0.917	0.914	0.916	0.914
Graduating UC and/or CSU eligible	0.373	0.366	0.357	0.364	0.352	0.351
Enrolling in CSU campus	0.086	0.090	0.093	0.098	0.099	0.097
Teacher characteristics at the average CSU-feeder high school						
Number of teachers	-	80.22	82.94	84.97	85.44	86.50
Years of teaching experience	-	14.74	14.35	14.09	13.88	13.72
Proportion:						
Fully credentialed	-	0.900	0.880	0.871	0.866	0.873
Emergency credentialed & waivers	-	0.100	0.120	0.129	0.134	0.127
First- or second-year teachers	-	0.139	0.142	0.147	0.137	0.124
Doctoral degree	0.014	0.014	0.014	0.015	0.016	0.016
Master's degree + 30 additional credits	0.220	0.206	0.193	0.180	0.175	0.174
Master's degree	0.155	0.156	0.159	0.170	0.169	0.172
Bachelor's degree + 30 additional credits	0.467	0.453	0.443	0.440	0.436	0.436
Bachelor's degree	0.131	0.154	0.175	0.181	0.190	0.188
No Bachelor's degree	0.007	0.010	0.008	0.008	0.009	0.008

Table 3

Composition of California and CSU-Feeder High School Enrollment

	1997	1998	1999	2000	2001	2002	2003
Total CA High School Enrollment	1,589,476	1,627,388	1,679,927	1,714,220	1,747,978	1,803,398	1,850,244
Public Enrollment	1,453,810	1,490,309	1,538,497	1,568,526	1,602,909	1,655,754	1,700,913
(proportion of total)	0.91	0.92	0.92	0.92	0.92	0.92	0.92
Private Enrollment	135,666	137,079	141,430	145,694	145,069	147,644	149,331
(proportion of total)	0.09	0.08	0.08	0.08	0.08	0.08	0.08
Total Number of Students in CSU Data	23767	26518	29269	31680	34220	35346	35685
Number from Public High Schools	20296	22514	24903	27027	29077	30210	30660
(proportion of total)	0.85	0.85	0.85	0.85	0.85	0.85	0.86
Number from Private High Schools	3471	4004	4366	4653	5143	5136	5025
(proportion of total)	0.15	0.15	0.15	0.15	0.15	0.15	0.14
Total Number of High Schools in CSU Data	912	937	958	980	994	1009	991
Number Public	729	738	748	762	771	787	785
(proportion of total)	0.80	0.79	0.78	0.78	0.78	0.78	0.79
Number Private	183	199	210	218	223	222	206
(proportion of total)	0.20	0.21	0.22	0.22	0.22	0.22	0.21
Total Number of Public High Schools in CA	860	871	908	934	969	1005	1059
Proportion CSU-feeder schools	0.85	0.85	0.82	0.82	0.80	0.78	0.74
Average Proportion of Students Math Proficient	0.444	0.434	0.500	0.516	0.503	0.597	0.600
From Public High Schools	0.455	0.440	0.503	0.518	0.511	0.599	0.603
From Private High Schools	0.399	0.411	0.489	0.509	0.474	0.593	0.587
difference	**0.056**	**0.030**	0.014	0.010	**0.037**	0.005	0.017
Average Proportion of Students English Proficient	0.546	0.531	0.536	0.539	0.532	0.503	0.501
From Public High Schools	0.531	0.520	0.524	0.522	0.519	0.483	0.487
From Private High Schools	0.609	0.573	0.577	0.598	0.578	0.575	0.554
difference	**-0.078**	**-0.053**	**-0.053**	**-0.076**	**-0.059**	**-0.092**	**-0.067**

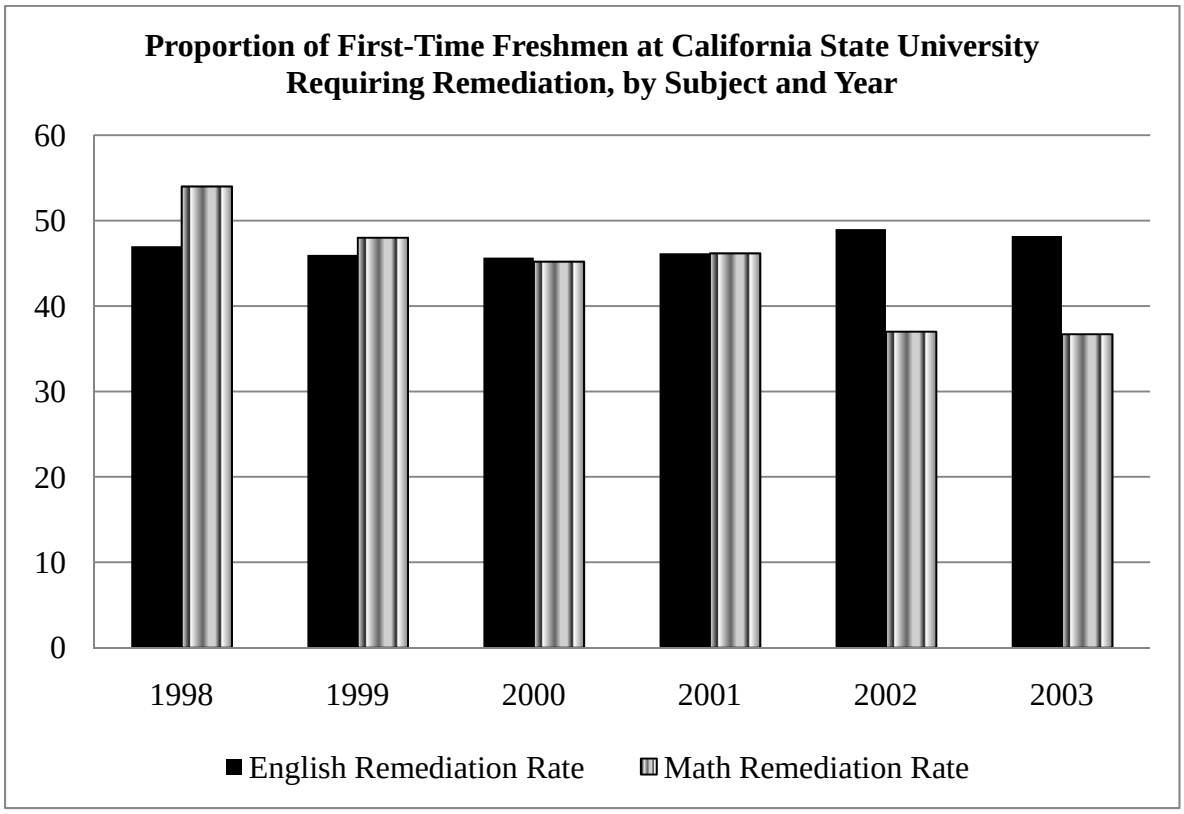
Table 4: Regression Results						
	Math Regressions			**English Regressions**		
	Estimate	Std. Error	Signif.	Estimate	Std. Error	Signif.
Student Characteristics						
Average SAT score	-0.001	0.000	***	-0.001	0.000	***
Proportion						
Asian students	-0.072	0.019	***	0.459	0.017	***
black students	0.251	0.029	***	0.240	0.026	***
Hispanic students	0.043	0.015	**	0.283	0.013	***
other race/ethnicity students	-0.243	0.043	***	0.123	0.038	***
Teacher Characteristics						
Years of teaching experience	-0.005	0.001	***	-0.001	0.001	
Proportion						
doctoral degree	0.180	0.195		0.205	0.173	
master's degree + 30 credits	0.026	0.025		0.043	0.023	**
master's degree	-0.063	0.031	**	-0.003	0.027	
bachelor's degree + 30 credits	0.002	0.020		-0.002	0.018	
emergency credential or waiver	0.105	0.035	***	0.066	0.031	**
first- or second-year teachers	-0.061	0.039		0.011	0.035	
N	3489			3489		
Adjusted R-squared	0.617			0.704		

Note: The dependent variable in each regression is the proportion of students from each high school that need remedial math (English) upon entering a CSU campus. Year fixed are effects included in both regressions. ***, **, * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 5: Regression Results						
	Math Regressions			**English Regressions**		
	Estimate	Std. Error	Signif.	Estimate	Std. Error	Signif.
Student Characteristics						
Average SAT score	-0.001	0.000	***	-0.001	0.000	***
Proportion						
Asian students	-0.216	0.053	***	0.487	0.047	***
black students	0.267	0.080	***	0.386	0.071	***
Hispanic students	0.075	0.028	***	0.367	0.025	***
other race/ethnicity students	-0.038	0.109		0.242	0.096	**
Teacher Characteristics						
Years of teaching experience	-0.005	0.001	***	-0.001	0.001	
Proportion						
doctoral degree	0.204	0.194		0.234	0.172	
master's degree	0.005	0.038		0.150	0.033	***
emergency credential or waiver	0.108	0.033	***	0.067	0.029	**
first- or second-year teachers	-0.070	0.039	*	0.004	0.035	
Interactions (proportion)						
Master's * Asian	0.388	0.137	***	-0.109	0.121	
Master's * black	-0.036	0.219		-0.419	0.194	**
Master's * Hispanic	-0.108	0.073		-0.250	0.065	***
Master's * other race/ethnicity	-0.637	0.295	**	-0.329	0.262	
N	3489			3489		
Adjusted R-squared	0.617			0.705		

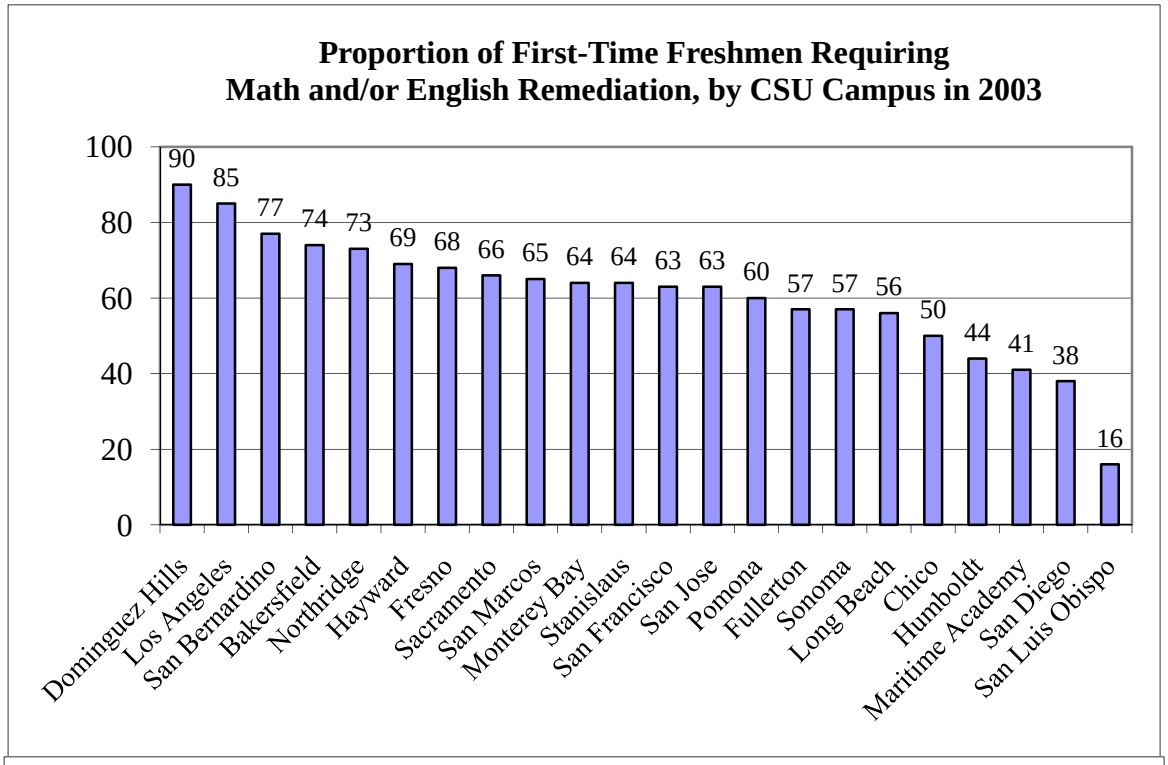
Note: The dependent variable in each regression is the proportion of students from each high school that need remedial math (English) upon entering a CSU campus. Year fixed effects are included in both regressions. ***, **, * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

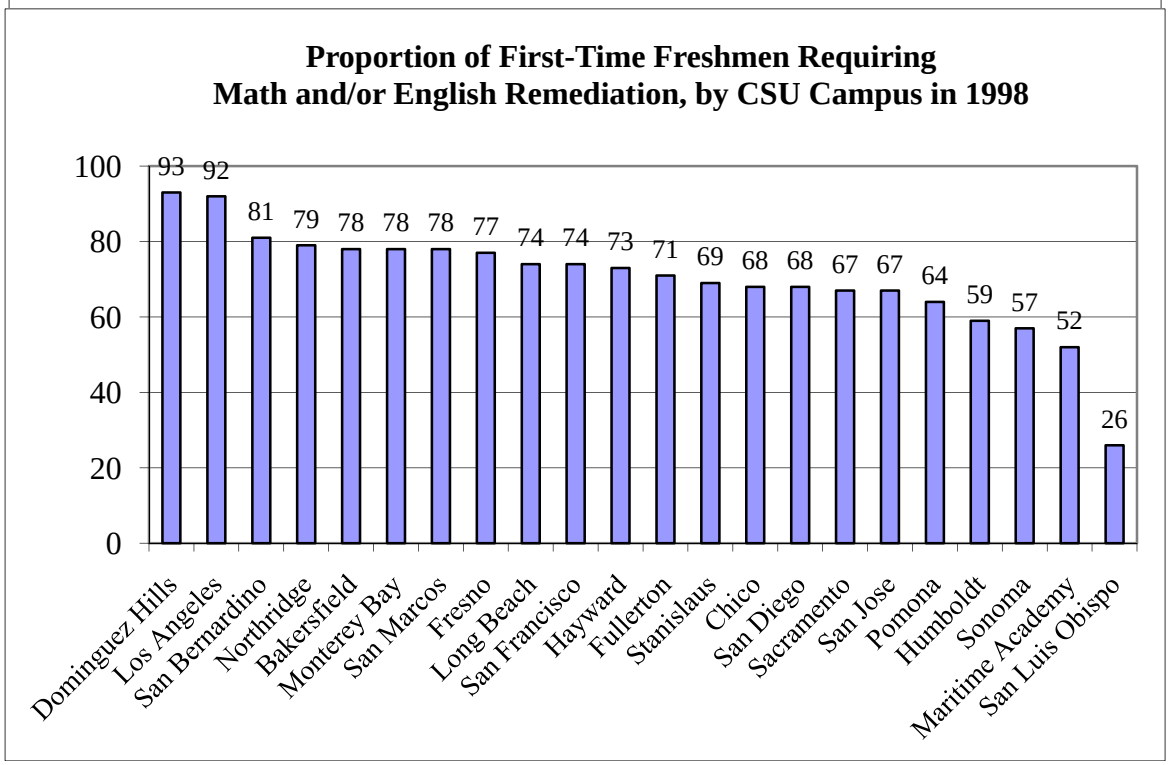
Figure 1



Source: Author's calculations based on data from the California State University Office of the Chancellor, Division of Analytic Studies.

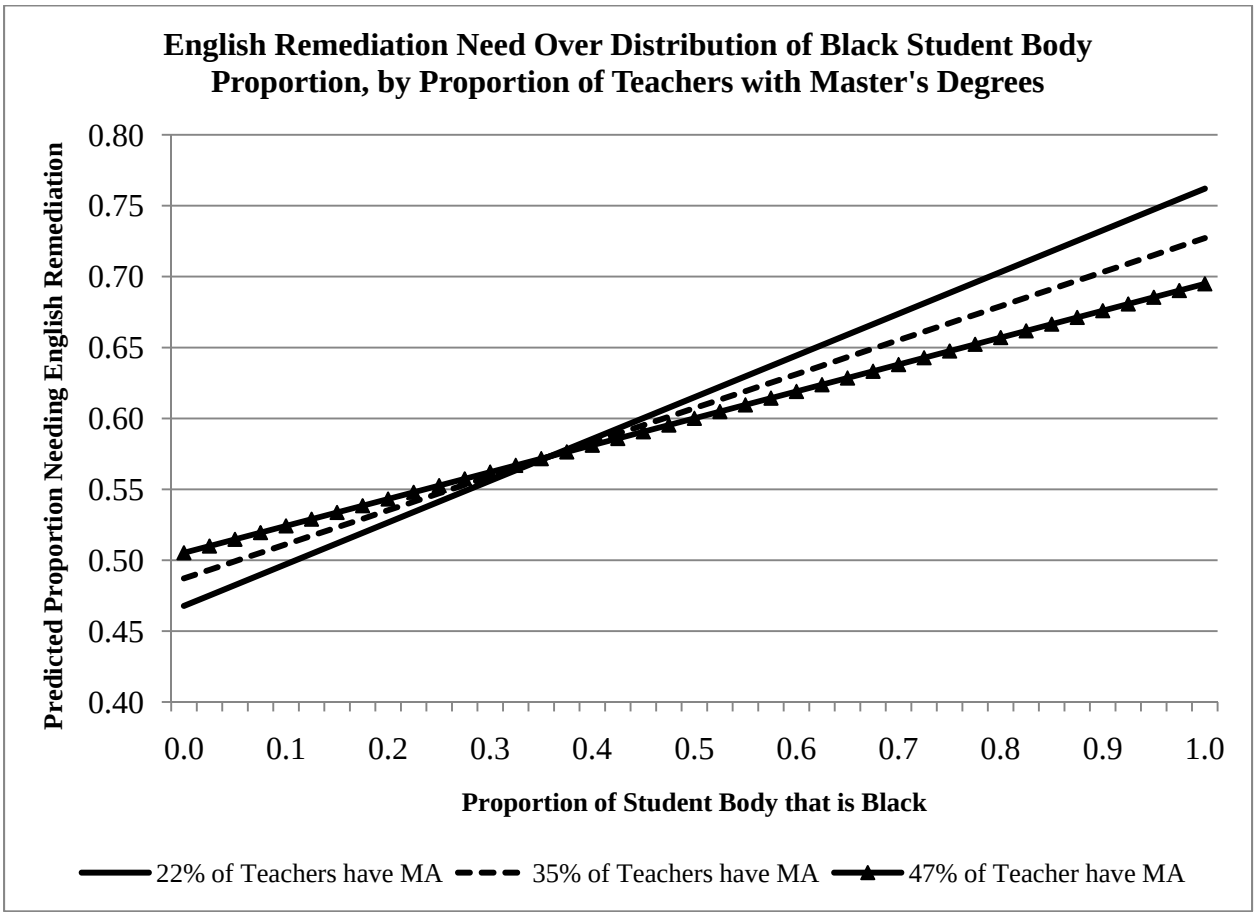
Figure 2





Source: California State University Office of the Chancellor, Division of Analytic Studies.

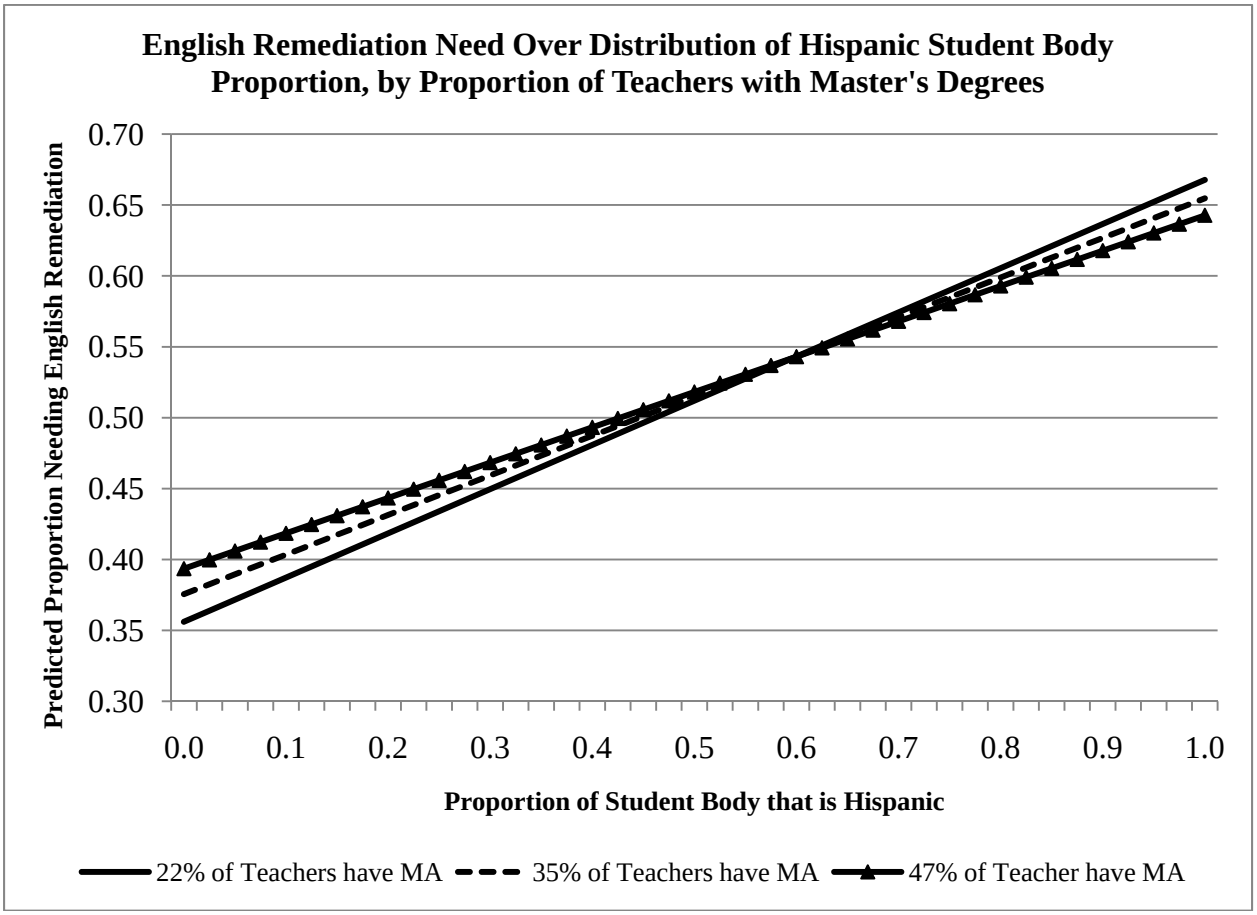
Figure 3



Source: Author's calculations based on data from the California State University Office of the Chancellor, Division of Analytic Studies and parameter estimates in Table 5.

Note: 35 percent is the average proportion of teachers with master's degrees across all schools in the sample. The standard deviation of 13 percentage points implies that one standard deviation below and above that mean value is consistent with 22 and 47 percent of teachers with master's degrees, respectively.

Figure 4



Source: Author's calculations based on data from the California State University Office of the Chancellor, Division of Analytic Studies and parameter estimates in Table 5.

Note: 35 percent is the average proportion of teachers with master's degrees across all schools in the sample. The standard deviation of 13 percentage points implies that one standard deviation below and above that mean value is consistent with 22 and 47 percent of teachers with master's degrees, respectively.