Aiming High and Falling Short:

California's 8th Grade Algebra-for-All Effort

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Abstract: The U.S. is in the midst of an effort to intensify middle school mathematics curricula by enrolling more 8th graders in Algebra. California leads this effort, and the state moved in 2008 to make Algebra the accountability benchmark test in 8th grade mathematics. This paper takes advantage of this unevenly-implemented policy to understand the effects of curricular intensification in middle school mathematics. Using district-level panel data from all California K-12 public school districts, we generate fixed effects and random growth model estimates of the effects of increasing 8th grade Algebra enrollment rates on 10th grade mathematics achievement. We find that enrolling more students in advanced courses has negative consequences for students' achievement.

U.S. students persistently trail their international peers in mathematics achievement, performing particularly poorly on the application of mathematical concepts (Organization for Economic Cooperation and Development, 2009; Gonzalez et al., 2008; Schmidt 2012). This skills gap impedes U.S. economic growth and competitiveness and contributes to economic inequality (Goldin & Katz, 2008). Over the last several decades, U.S. schools have dramatically intensified high school mathematics curricula in an attempt to improve U.S. mathematics achievement (Author 2012a). Central to this movement is the effort to enroll a greater proportion of students in Algebra while they are in middle school. Algebra serves a crucial gatekeeping function in U.S. schools. For students who fail to master Algebra in 8th or 9th grade, the path to advanced training in mathematics and, subsequently, many well-paid and high-status careers is blocked (Adelman, 1999; Author, 2008; Long, Conger, & Iatorola, 2012). Furthermore, it is a uniquely challenging course, drawing heavily upon the concrete procedural skills that students develop in elementary mathematics and requiring students to develop a new set of abstract reasoning skills (Carraher & Schliemann, 2007; Howe, 2005; Vogel 2008).

In this paper, we take advantage of an ambitious but unevenly implemented effort to enroll all California 8th graders in Algebra to understand the consequences of curricular intensification for student achievement. Using district-level panel data from all K-12 public school districts in California, we estimate the effects of increasing 8th grade Algebra enrollment rates on 10th grade mathematics achievement. The results of these analyses are counter-intuitive, suggesting that enrolling students in advanced math courses has negative consequences for students' mathematics achievement.

1. Context: 8th grade Algebra-for-all in California

Over the past three decades, California has led the national effort to universalize 8^{th} grade Algebra (Loveless 2008). In 1987, California's State Superintendent of Public Instruction argued that detracking middle schools was a central step toward raising academic standards in high schools. In 1992, the state department of education called for "heterogeneous grouping and detracking as a goal" and the 1997 revision of the state's content standards called on middle schools to enroll all 8^{th} graders in Algebra I. In 1999, the California State Senate passed the *Public School Accountability Act* (PSAA). By penalizing schools for enrolling 8^{th} graders in pre-algebra or other general math courses, the law created powerful incentives for schools to place more 8^{th} graders in Algebra (Author, 2012). The adoption of these standards spurred rapid intensification in middle school mathematics curricula in California. Between 1999 and 2008, the proportion of California 8^{th} graders enrolled in Algebra more than tripled, from 16 percent to 51 percent (Rosin, Barondess, & Leichty 2009).

In 2008, the state's Board of Education voted to make the Algebra California Standards Test (CST) the "sole test of record" for the state's 8^{th} graders. This vote required 8^{th} graders to demonstrate proficiency on the state's end-of-course Algebra standards exam in order to satisfy accountability expectations under the *No Child Left Behind Act* and California's *Public Schools Accountability Act* (Rosin, Barondess, & Leichty 2009). However, California's 8^{th} grade Algebra mandate was never fully implemented. Responding to a challenge from California school administrators and school boards, the courts postponed the policy's implementation in the spring of 2010. Later that year, under pressure from the Obama administration and the state's teachers' unions, the California Academic Content Standards Commission adopted the Common Core State Standards, which recommend pre-Algebra content for 8^{th} graders. While California's revised middle school math standards continue to encourage schools to enroll all 8^{th} graders in

Algebra, state accountability policy no longer mandates accelerated Algebra (Wurman & Evers 2011).

California's decades-long effort to universalize 8th grade Algebra created a fluid policy environment. Over the last several years, districts across the state have moved to enroll more students in early Algebra. Many districts began to track greater proportions of 8th graders into Algebra courses long before the state attempted to mandate the course. In informal conversations, district officials from across the state indicate they anticipated the 8th grade Algebra mandate. Many supported the mandate, viewing it as a tool to mitigate inequalities in the opportunity to learn. In these districts, officials acted to accelerate middle school mathematics curricula even before the mandate was put into place. Other district officials, however, remained committed to the idea of sorting students into middle school mathematics courses based on their prior achievement, and were reluctant increase 8th grade Algebra enrollments even after the state created incentives to do so. Furthermore, after the state stepped away from its 8th grade Algebra mandate, 8th grade Algebra enrollment rates began to decline in some – but not all – California districts. As a result, patterns of 8th grade Algebra enrollment rates vary considerably across districts. This variation creates a unique opportunity to estimate the effects of increasing 8th grade Algebra on student mathematics achievement.

2. Curricular intensification and its consequences

California's effort to enroll all 8th graders in Algebra is one of several educational policies designed to increase the rigor of American secondary education dating back at least to the Reagan administration's 1983 *A Nation at Risk* report (National Commission on Excellence in Education 1983). Warning of a "rising tide of mediocrity that threatens our very future," the commission argued that all American students should be exposed to a more rigorous "New

Basics" course curriculum. American educational policy-makers largely implemented the commission's vision of intensifying the curriculum in American schools in the decades that followed by articulating standards for student learning at each grade level, creating school accountability systems tied to these standards, raising high school graduation requirements, and implementing high school exit exams aiming to certify that graduates have mastered basic academic skills (Darling-Hammond & Berry 1988; Timar & Kirp 1989; Wilson & Rossman 1993; Center on Education Policy 2009).

The American curricular intensification movement is predicated on the intuitively appealing notion that students learn more in academically challenging educational environments; a theory that is often referred to as "opportunity to learn" (Porter 2002). Several studies, including research focusing on national curricula, state standards, student course trajectories, and teacher practices, indicates that students who are exposed to rigorous curriculum and instruction experience greater achievement gains on average than those who are not (e.g., Author 2008; Argys, Rees, & Brewer 1996; Gamoran et al., 1997; Gamoran & Hannigan 2000; Long, Conger, & Iatarola 2012; Schmidt et al., 2001, 2011). These studies employ a wide range of controls and a few use propensity matching or longitudinal analyses in an attempt to isolate the effect of rigorous course enrollment for students' later outcomes. Taken together, their results suggest that efforts to enroll more students in accelerated Algebra courses should boost student achievement.

However, this literature is limited in two important regards: First, efforts to estimate the effects of curricular intensification using observational data are subject to considerable selection bias, since students who enroll in advanced courses differ from students who do not on a wide range of characteristics. Relatively few studies have attempted to estimate the effects of advanced course-taking in experimental or rigorous quasi-experimental settings, and those that do have returned sharply mixed results. Heppen et al. (2012) report the results of an experiment in which high-achieving 8th graders in 68 randomly-selected small, rural middle schools were offered access to an online Algebra course. In this case, access to online Algebra had a moderate positive effect on these high-achieving students' Algebra achievement as measured at the end of 8th grade (effect size=0.39), as well as their subsequent high school math course-taking. However, instrumental variable analyses taking advantage of rapid curricular intensification in 10 North Carolina school districts indicate that accelerated Algebra has a negative effect on student achievement (Clotfelter, Ladd & Vigdor 2012a, 2012b).

Second, policy efforts like California's 8th grade Algebra push do more than change a handful of students' course-enrollment patterns. Rather, they aim to make broad systematic changes in school curricula and organization. By reducing low-level courses and integrating students who once would have taken these courses into more advanced classrooms, these policies likely have a wide range of intended and unintended consequences on the content, pedagogy, and social organization of secondary schools (Gamoran & Hannigan 2000). Policies that increase the number of students in advanced courses increase the demand for teachers in these courses, often leading schools to assign new teachers or teachers who had previously specialized in teaching lower-level courses to advanced courses. Further, large-scale curricular intensification likely changes the distribution of student skills within advanced courses. These changes in classroom composition may have independent consequences on student learning (Nomi 2012; Zimmer & Toma 2000), as well as effects on teacher instructional content and methods (McPartland & Schneider, 1996).

Perhaps due to these implementation challenges, evaluations of broad-based curricular intensification efforts return fewer positive results than analyses of the student-level effects of advanced course enrollment (Stein, Kaufman, Sherman, and Hillen 2011). Allensworth et al. (2009) find no evidence to suggest that a Chicago Public Schools effort to enroll all 9th graders in Algebra I and college prep English improved student achievement, graduation rates, or college-going. While difference-in-difference analyses suggest that the "double-dose" Algebra curriculum that Chicago implemented as a part of this effort was effective for low-achieving students (Nomi & Allensworth 2009), Nomi (2012) finds that curricular intensification in Chicago had unintended negative effects for high-achieving students. Furthermore, preliminary evidence from California is similarly discouraging. Descriptive analyses of state-wide data (Liang, Heckman, & Abedi, 2012) as well as district case-study data (Author, 2012b) indicate that California students placed in 8th grade Algebra learn no more than similarly-skilled students placed into pre-Algebra.

3. Evaluating California's 8th grade Algebra-for-all effort

In this paper, we use district-level panel data describing California public school districts between 2003-04 and 2009-10 to estimate the effects of increasing the percent of students enrolled in 8th grade Algebra on students' mathematics achievement. Like students in middle and junior high schools throughout the United States, 8th graders in most California middle schools have the option of enrolling in one of several tiered mathematics courses, including remedial and applied mathematics, general mathematics or pre-Algebra, Algebra, and, for a handful of particularly advanced students, Geometry or higher level mathematics. Since secondary math courses are nearly universally sequenced in American secondary schools, 8th grade course enrollments largely determine students' chances of enrolling in more advanced courses throughout high school. In particular, students must take Algebra in 8th grade in order to take Calculus before they graduate from high school.

Our analyses draw upon district-level data collected from the California Basic Educational Data System (CBEDS) and the California High School Exit Exam (CAHSEE), describing middle school math course enrollment patterns and subsequent mathematics achievement for students enrolled in all California public school districts that serve students from middle school to high school.[1] Table 1 reports descriptive data for 8th graders enrolled in California unified school districts in each cohort between 2003-04 and 2009-10. In each of these years, the 222 school districts that are at the focus of this study enrolled approximately 300,000 8th graders. In 2003-04, approximately 40 percent of these students enrolled in Algebra or a more advanced math course during their 8th grade year. By 2009-10, that percentage was more than 60 percent. By comparison, NAEP data indicate that 8th grade Algebra enrollment rates among public school students nationwide increased from 24 percent to 35 percent between 2000 and 2010.

The analyses that follow utilize a balanced panel that excludes approximately 100 districts that report data in one or more year, but not in each of the study years. Since these districts are relatively small, our balanced panel accounts for over 85 percent of California 8th graders in unified school districts in any given year. Furthermore, as the descriptive data for all California districts reported in Table 1 indicates, the differences between districts that provide balanced data and those that do not are not pronounced.

[Insert Table 1 about here]

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[1] Unlike much of the United States, several California localities maintain separate elementary and secondary school districts. Since these districts report data separately, we are unable to link 8th grade math course enrollments in these districts with measures of student 10th grade mathematics achievement. Therefore, our analyses include only “unified” public school districts in California, or those that administer both elementary and secondary schools. In addition, the analyses exclude data reported separately by state boards of education (which often administer relatively small vocational schools and other special programs for “at-risk” youth”) and charter schools. Approximately two-thirds of California 8th graders enroll the districts that are included in our analyses.

Predictors of 8th grade Algebra enrollment rates in California K-12 School districts

Prior to estimating the achievement effects of increasing 8th grade Algebra enrollment rates, we use these panel data to explore district-level middle school math course placement trends. We first do so descriptively, investigating trends in 8th grade Algebra enrollment rates across the state and within the state's 12 largest school districts. Consistent with Table 1, district analyses indicate that districts across the state expanded 8th grade Algebra enrollments throughout the 2003-04 to 2009-10 period. However, the rate and timing of this curricular change varies considerably across districts, with some districts rapidly accelerating 8th grade Algebra enrollment prior to the state's attempted Algebra-for-all mandate and other districts maintaining responding far more slowly.

We explore this district variation in 8th grade Algebra enrollment trends using a series of four panel data models:

(1) $\%Alg_{d,t} = \beta_0 + \beta_1(X)_{d,t} + \alpha_t + \varepsilon_{d,t}$

(2) $\%Alg_{d,t} = \beta_0 + \beta_1(X)_{d,t} + \beta_2(API)_{d,t-1} + \alpha_t + \varepsilon_{d,t}$

(3) $\%Alg_{d,t} = \beta_0 + \beta_1(X)_{d,t} + \beta_2(API)_{d,t-1} + \beta_3(\%\ Alg)_{d,t-1} + \alpha_t + \varepsilon_{d,t}$

(4) $\%Alg_{d,t} = \beta_0 + \beta_1(X)_{d,t} + \beta_2(API)_{d,t-1} + \alpha_t + \alpha_d + \varepsilon_{d,t}$

The dependent variable in these models,$(\%\ Alg)_{d,t}$, represents the proportion of 8th graders in a given district (d) who completed the end-of-course CST in Algebra I or higher (e.g. Geometry, or Algebra II) in each year (t) between 2004 and 2010. These tests provide information about students' 8th grade mathematics course completion. California students who take basic skills or pre-Algebra courses sit for the General Math CST in the spring of their 8th grade year; while students who take Algebra courses sit for the Algebra CST and students who take Geometry sit for the Geometry CST. While schools and districts have limited discretion to allow special education students and English-language learners to opt out of these tests, California and federal accountability policies penalize schools if more than 5 percent of students fail to complete the appropriate exam.[2]

Model 1 predicts 8th grade Algebra enrollment rates as a function of district demographics and time. This model includes variables representing the proportion of 8th graders who qualify for free or reduced lunch (FRPL),[3] the proportion of 8th graders who are classified as English language learners, and the natural log of district 8th grade enrollments. In addition, the model includes indicators for each school year. Model 2 adds districts' lagged Academic Performance Index (API) score. The API is a composite measure of student achievement that is central to California's school accountability system. The composite is a district's (and school's) weighted average of students' Math, English, Science, and History CST scores with Math and English accounting for 85 percent of the score. Model 3 captures growth in 8th grade Algebra enrollment by adding a lagged measure of district 8th grade Algebra enrollment rates. Finally, model 4 uses district fixed effects to assess the extent to which within-district changes drive 8th grade Algebra enrollment rate changes.

Panel analysis: California K-12 School Districts, 2004-2010 8th Graders

Following an examination of the patterns of Algebra enrollment across the timespan of our panel, we next estimate district fixed effects models to investigate the effects of changing 8th

[2] End-of-course tests present two advantages over course title as a measure of course completion: First, since California school accountability policy requires all districts report data on end-of-course test-taking for all students using a common form, comparable data are available on this measure across districts and over time. Second, course titles are often somewhat misleading. As an example, some schools refer to pre-Algebra courses as the first year in a two-year Algebra course sequence. As a result, the end-of-course tests provide a relatively reliable indicator of course content.

[3] We do not include a control for percent minority since this variable is highly correlated with the percent of FRPL students and the percent of ELL students (correlations between percent minority and both of these variables is roughly .7). It is also worth noting that ethnic composition of California school districts changes very little during the study period, so that these district fixed effects largely account for these demographic characteristics.

grade Algebra enrollment rates in California public school districts on student achievement. The most basic of these analyses takes the following form:

$$(5)\ Y_{d,t+2} = \beta_0 + \beta_1(\%\ Alg)_{d,t} + \beta_2(X)_{d,t} + \beta_3(API)_{d,t-1} + \alpha_d + \alpha_t + \varepsilon_{d,t}$$

In this model, the dependent variable, $Y_{d,t+2}$, is a district-level measure of student achievement on the spring 10th grade CAHSEE. This exam—which consists of roughly 90 multiple-choice questions covering Algebra, measurement and geometry, statistics, data analysis and probability, number sense, and mathematical reasoning—is designed under contract by ETS to align with California 7th and 8th grade instructional standards and is subject to annual independent validation. State law requires all students to pass this exam (as well as a parallel exam in English language arts) in order to earn a high school diploma. All California public school students take this exam for the first time in the spring of their 10th grade year.[4] Our analyses use CAHSEE data from two years after students in the panel completed 8th grade (March 2006-March 2012 CAHSEE administration). In addition to estimating the relationship between district-level 8th grade Algebra course-taking and mean CAHSEE math test scores, we analyze district mean scores on the CAHSEE sub-scales: probability and statistics, number sense, Algebra and functions, measurement and geometry, and Algebra I.

The model includes district fixed effects, α_d, to account for unobserved time-invariant differences between districts, and cohort fixed effects, α_t, to account for common trends across years. The fixed effects remove potential time-invariant between district differences as well as time-variant changes common to all districts that are related to both districts' Algebra enrollment rates and CAHSEE scores. We also include a vector of time-variant district characteristics to control for potential observable differences among districts, $X_{d,t}$. These include share of Free

[4] Although students may retake the CAHSEE multiple times after failing initially, we use only the first CAHSEE attempt in our analyses.

and Reduced Price Lunch, share of English Language Learner students, the natural log of district enrollment, and lagged Academic Performance Index (API) scores.

The key predictor variable in this analysis is the percent of district 8th graders who enroll in 8th grade Algebra or higher. To ease interpretation, we standardize this measure on the enrollment-weighted 2004-05 distribution, so that zero is equal to the 2004-05 mean and -1 and 1 are equivalent to one standard deviation above and below that mean. $\beta_1$in Equation 5 can be interpreted as an unbiased estimate of the change in district-level 8th grade Algebra enrollment rates on CAHSEE test scores, assuming district CAHSEE test score averages change over time at a common rate after controlling for observed time-varying district characteristics. If, however, test score averages follow district-specific trends – and particularly if these district-specific trends correlate with 8th grade Algebra course placement trends – Equation 5 may return biased estimates of the effects of increasing 8th grade Algebra enrollments. To address this potential threat to validity, we additionally estimate a random-growth model (Papke 1994; Wooldridge 2002; Zimmer & Buddin 2006).

This model estimates district-specific intercepts (α_d) and district-specific time trends ($\alpha_d * \tau$), and can be represented as:

(6) $Y_{d,t+2} = \beta_1(\%Alg)_{d,t} + \beta_2 X_{d,t} + \alpha_t + \alpha_d + \alpha_d * \tau + \varepsilon_{dt}$

This random growth model controls for both time-invariant between district differences, as well as differences in districts' average growth rate.[5] It should also be noted that the relationship between the independent variables and the dependent variable in a random growth model is only identified off non-linear changes over time. The time fixed effects in this model account for year-

[5] To estimate this, we start with the model: $Y_{dt+2} = \beta_1(\%Alg)_{dt} + \beta_2 X_{dt} + \alpha_t + \alpha_t * \tau + \varepsilon_{dt}$. We take the first-difference of this equation to remove district-specific intercept and are left with a constant trend for each district. We then estimate the first-difference of (6) using district and time fixed-effects to remove the district specific constant trends (see Papke 1994; Wooldridge 2002; Zimmer & Buddin 2006 for more detail about the RGM).

to-year secular changes in achievement that deviate from the common linear in achievement. Equation 6 yields unbiased estimates of the effect of 8th grade Algebra enrollment on student achievement if changes in algebra enrollment are exogenous to the independent variables as well as time-invariant and linearly time-varying district differences (e.g., district-wide teacher quality).

However, neither equations 5 or 6 address the potentially confounding consequences of short-term changes in district organization or management. If such changes systematically precede changes in middle school mathematics placement practices, estimates of the effects of 8th grade Algebra placement may be biased. One particularly troubling potential confounder is administrative turnover – the arrival of new administrative leadership might cause both 8th grade Algebra enrollment rates and later student achievement to shift. Since we do not have access to statewide panel data on district leadership, we are unable to evaluate this possibility. However, our discussions with district administrators provide anecdotal evidence to suggest that administrative turnover often occurs *after* districts attempt to intensify middle school mathematics curricula, rather than before.

All multivariate analyses are weighted by the mean of each district's 8th grade enrollment across the panel, in order to estimate the effects of 8th grade Algebra enrollment increases in the average students' setting. In addition, we estimate a series of supplementary models in which we investigate the extent to which the effects of curricular intensification vary with district size. We use district-level cluster-robust standard errors estimation throughout to address potential heteroskedasticity and serial correlation among district observations.

4. Changes in 8th grade Algebra enrollment rates

Over the course of the last decade, California districts dramatically intensified middle school mathematics curricula. This increase in 8th grade Algebra enrollment rates clearly predates the State Board of Education's attempt to make 8th grade Algebra the mathematics "course of record" for accountability purposes. However, 8th grade Algebra enrollment rates jumped in the year immediately after the state announced this policy shift, increasing from 53 percent in 2007-08 to 60 percent in 2008-09. 8th grade Algebra enrollment rates continued to rise across the state in the years immediately after this announcement, despite legal efforts to overturn the state's 8th grade Algebra mandate.

California's 8th grade student body has remained relatively demographically stable during this period of rapid curricular change. Free and reduced lunch enrollment rates vary between 51 and 56 percent during this time period, fluctuating gradually with broader shifts in economic conditions. The racial and ethnic composition of California 8th graders has remained constant during this time period, with slightly more than 60 percent of 8th graders identifying as black, Hispanic, Native American, or Pacific Islander.[6] The most striking demographic shift apparent in this table concerns the proportion of English-language learners in California schools. In 2003-04, 35 percent of California 8th graders were classified as English-language learners; by 2009-10, that number had dropped to 22 percent. More than three-fourths of these students are native Spanish speakers. State data indicate that the decline in ELL enrollment is largely a function of changing practices for reclassifying non-native speakers as English-language proficient.

[Insert Figure 1 about here]

While Table 1 suggests that accountability pressures from the State Board of Education led districts and schools across the state to enroll more students in 8th grade Algebra, Figure 1

[6] During this period, the Latino share of the California 8th grade population increased by approximately two percentage points, while the African-American share declined.

indicates that districts across the state took very different paths toward intensifying middle school mathematics curricula. This figure presents line graphs representing 8th grade Algebra enrollment rate trends between 2003-04 and 2009-10 for the twelve California unified school districts with the largest annual mean 8th grader enrollments over the panel period. Just one of these districts, Anaheim Union, seems to have responded directly to the state's Algebra accountability mandate, nearly universalizing 8th grade Algebra by doubling the proportion of 8th graders placed into Algebra or more advanced math courses in 2009-10. Other districts, including Corona-Norco, Garden Grove, and Los Angeles, seem to have responded to early signals from the state, increasing 8th grade Algebra enrollment rates by more than 20 percentage points in the years leading up to the passage of the 8th grade Algebra-for-all mandate. Several large California public school districts acted much more gradually to increase 8th grade Algebra enrollment rates. Capistrano is typical of this approach, gradually increasing 8th grade Algebra enrollment rates from approximately 20 percent to 40 percent over the study period. Middle school math enrollment trends follow a somewhat idiosyncratic pattern in the state's largest public school district, Los Angeles Unified, where 8th grade Algebra enrollment rates spiked at 67 percent in 2005 before decreasing to 49 percent in 2007 and increasing again to 60 percent by 2010. The degree of between-district heterogeneity is even more pronounced among smaller districts.

Table 2 takes a more systematic multivariate look at 8th grade Algebra enrollment rates in California school districts. The table's first model indicates that the state's secular increase in 8th grade Algebra enrollment rates was not driven by demographic change. Neither the size, nor the ethnic or language composition of California public school districts is associated with 8th grade Algebra enrollment. However, net of these controls, this model reveals substantial growth in 8th grade Algebra enrollments between 2004 and 2010. Consistent with Figure 1, this model suggests that this curricular intensification trend pre-dates the state's 2008 attempt to mandate 8th grade Algebra-for-all. Net of controls, Algebra enrollment rates increased during each year in this panel, with a particularly rapid uptick occurring between 2004 and 2005. However, the 5 percentage point jump in 8th grade Algebra enrollment rates that occurred between 2008 and 2009 is only slightly larger than the increases in the years immediately before and the same size as the increase that occurred one year later.

[Insert Table 2 about here]

The second model in Table 2 adds a control for lagged API scores. This model indicates that relatively high performing districts tend to have higher rates of 8th grade Algebra enrollment than lower-performing districts. After including this control for district academic performance, the percent minority coefficient becomes large and nearly statistically significant, providing a suggestion that high-minority districts enroll tend to enroll more 8th graders in Algebra than one might expect, given the average levels of academic readiness within district. The third model adds a control for lagged 8th grade Algebra rates. The coefficients for lagged API and percent minority are not significantly different from zero after the addition of lagged 8th grade Algebra or higher enrollment rates (designated by the "% 8th graders >= Algebra" coefficient) in the third model, suggesting that patterns in 8th grade Algebra enrollment are highly path dependent.

The fourth model in Table 2 considers changes in district-level 8th grade Algebra enrollment rates in a fixed effects framework. This model indicates that increases in ELL enrollments as well as API performance are associated with increases in 8th grade Algebra enrollments. The fixed effects models that follow estimate the relationship between 8th grade Algebra enrollment rates and mathematics achievement net of these potential confounders.

5. Effects of increasing 8th grade Algebra enrollment on student achievement

The analyses reported in Table 3 take advantage of these uneven patterns in district 8th grade Algebra enrollment rates to estimate the effects of changes in the proportion of students enrolled in 8th grade Algebra or higher on mathematics achievement. The first model in Table 3 does so using a district fixed-effects approach. This model considers the relationship between district 8th grade Algebra enrollment rates in a given year and mean CAHSEE math scores for 10th graders in the district two years later. The negative and statistically significant "% 8th graders >= Algebra" coefficient in this model indicates that efforts to enroll more middle school students in advanced mathematics courses have unintended negative consequences for student mathematics achievement. This model indicates that a 1 standard deviation increase from mean 2004-05 8th grade Algebra enrollment rates decreases mean student CAHSEE math scores by approximately 0.07 standard deviations. While small by conventional effect-size metrics, this effect is not trivial. By way of comparison, this estimated negative effect is approximately the same size as the average positive achievement effects associated with the federal *No Child Left Behind* Act (Dee & Jacob 2011) or about 15% of the Black-White achievement gap in Mathematics (Reardon 2008).

[Insert Table 3 about here]

The internal validity of the district fixed effects identification strategy hinges on the assumption that outside of the observable demographic controls and time fixed effects that account for state-wide year-to-year changes in Algebra policy included in our models, there are no time-varying within-district characteristics that systematically covary with both 8th grade Algebra placement patterns and CAHSEE math scores. This assumption is difficult to assess empirically. In order to relax this assumption, we estimate the random growth model that, in addition to the district fixed-effects, accounts for district-specific time-trends. This model accounts for district fixed effects, district-specific time-trends, and time fixed effects to account for possible time-variant within-district changes over time. This model also allows district CAHSEE scores to have different trends, relaxing the fixed effects model's assumption that conditional on time-varying controls, district CAHSEE scores follow similar secular trends. This random growth model returns coefficients similar magnitude and direction as the main district fixed effects model. However, since these models only use the non-linear variation in the independent variables to identify causal effects, they are somewhat less precise.

The analyses reported in Table 4 test the appropriateness of these fixed effects and random growth models through a series of placebo tests. Panel A of this table reports the results of analyses using the district fixed effects estimation strategy; Panel B reports the results of analyses using the random growth modeling strategy. The first model in both panels treats district minority enrollments as a dependent variable, with the intuition that 8^{th} grade Algebra enrollment rates do not plausibly influence student demographics. Both models pass this specification test, showing no significant effect of 8^{th} grade Algebra enrollment rates on student demographic change. Similarly the second model considers the unlikely effect of 8^{th} grade Algebra enrollment rates on total 8^{th} grade enrollments. Again, both models pass the specification test, returning non-significant 8^{th} grade Algebra effects on total 8^{th} grade enrollment. Finally, the third model in each panel investigates the connection between 8^{th} grade Algebra enrollment rates and 10^{th} grade test scores measured in the same year (rather than measured two years later as in Table 3, when on-track 8^{th} graders have progressed to 10^{th} grade). The fixed effects modeling strategy in Panel A returns a somewhat troubling result in this model, indicating that increases in 8^{th} grade Algebra enrollment rates correspond with contemporaneous decreases in 10^{th} grade test scores. This implausible relationship casts some doubt on the veracity of fixed-effects estimates of the effects of 8^{th} grade Algebra enrollment rates on student achievement reported in Table 3. However, the random growth model again passes this specification test, indicating that these results in Panel A are at least partially driven by district specific linear trends in contemporaneous CAHSEE scores. This analysis highlights the random growth model's importance for generating unbiased estimates of the achievement effects of 8^{th} grade Algebra enrollment rates.

[Insert Table 4 about here]

Although administered to students in the spring of their 10^{th} grade year, the CAHSEE is a criterion-referenced test designed to measure students' mastery of basic pre-Algebra mathematics content taken several years earlier. Since this test is not designed to capture student proficiency with more advanced mathematics concepts, it is possible that the analyses reported in the first model of Table 3 may provide negatively biased estimates of the relationship between 8^{th} grade Algebra enrollment rates and mathematics student learning. The models reported in Table 5 use detailed CAHSEE subscale score results to consider the extent of this potential bias. These subscales measure the percent of CAHSEE test score items students answered correctly in several distinct mathematics domains ranging from the relatively simple (Number Sense) to the more advanced (Measurement and Geometry; Algebra I). These analyses indicate that the effects of increasing 8^{th} grade Algebra enrollment rates are fairly consistently negative across the five domains. For example, a one-standard deviation increase in district 8^{th} grade Algebra enrollment rates is associated with a 5 point decline in the percentage of Number Sense questions students answer correctly. This result is not significantly different from the significant 4 point decline in Algebra I achievement. Similarly, a one standard-deviation increase in 8^{th} grade Algebra enrollment rates is associated with a 4 point decline in Measurement and Geometry achievement. These results are quite similar across the fixed effects and random growth model specification. The results reported in Table 5 thus provide some reassurance that the CAHSEE test adequately captures student mathematics achievement at least through basic Algebra and geometry, but also suggest that the declines in CAHSEE scores resulting from an increase in 8th grade Algebra enrollment are present and similar in magnitude in all major content areas assessed by the CAHSEE.

[Insert Table 5 about here]

The district fixed effects analyses reported in Tables 3 through 5 identify the effects of curricular intensification off of within-district changes in the percent of 8th graders enrolled in Algebra or higher over time. In Table 6 we build on these results by examining: 1) whether the effects that we observe are driven by large year-to-year shifts in Algebra enrollment (such as the sharp increase that Figure 1 shows between 2008 and 2009 in Anaheim); 2) whether enrollment changes that occurred before and after the 2008 policy had similar effects; and 3) whether the effects that we see are short term implementation costs associated with curricular intensitification. We examine each of these points in turn, first using the district fixed effects approach (Panel A) and second using the random growth modeling approach (Panel B).

[Insert Table 6 about here]

The first set of models we estimate in Table 6 investigate whether large year-to-year changes in 8th grade Algebra enrollment rates have disproportionately large achievement consequences. These models add dummy variables that equal one for districts in the years in which 8th grade Algebra enrollment rates increased or decreased by more than a standard deviation (>1 SD incr. and >1 SD dcr.) and more than two standard deviation (>2 SD incr. and

>2 SD dcr.) (as defined in the 2004 district 8th grade Algebra enrollment rate distribution). Using both the fixed effects and the random growth approach, these models return coefficients that are consistent with the finding that 8th grade Algebra enrollment rates and CAHSEE mathematics achievement are negatively related. The linear 8th grade Algebra enrollment rate term is negative in both models, although this coefficient is not statistically significant in the less efficient random growth model. However, none of coefficients associated with districts that experienced relatively large year-to-year changes in 8th grade Algebra enrollment rates are statistically significant, indicating that the results are not being driven by a small number of districts that undertook large year-to-year changes in middle school math placement.

The second set of models in Table 6 test whether changes in 8th grade Algebra enrollment rates that occur prior to the California Department of Education's attempt to mandate Algebra for all 8th graders have different achievement effects that changes that occur after the mandate. (The "post policy" indicator in this model takes a value of 1 for observations in the 2009 and 2010 school year and a value of 0 for all other years.) The main effect of 8th grade Algebra enrollment rate is significant and negative, indicating that increasing 8th grade Algebra enrollments by a standard deviation in the pre-policy period decreased CAHSEE scores. These effects are consistent across the two modeling strategies, with the fixed effects model returning a -0.07 effect and the random growth model returning a -0.04 effect. In both models, the 8th grade Algebra*post-policy interaction returns a positive coefficient. Although not statistically significant, its sign indicates that post-policy increases in 8th grade Algebra enrollment rates may have had less pronounced negative effects on math achievement.

Models 3 and 4 add lagged 8th grade Algebra enrollment rate control variables to the basic fixed effects model to investigate the extent to which year-to-year changes in 8th grade

Algebra enrollment rates have lasting negative consequences for CAHSEE math scores. If these lagged scores were significant and positive, they would suggest that observed negative effects of increases in 8th grade Algebra enrollment are short-lived and that average test scores tend to bounce back as districts design strategies to effectively educate a larger proportion of students in advanced middle school math courses. However, the coefficients for lagged 8th grade Algebra enrollment rates (in model 3) and twice-lagged 8th grade Algebra enrollment rates (in model 4) are both small and not statistically significant, indicating that 8th grade Algebra enrollment rate changes have lasting consequences for district CAHSEE math test score trajectories. While controlling for the lagged score does not reduce the magnitude of the main effect for 8th grade Algebra enrollment rate, it does reduce the precision of this estimate in the random growth model. As a result, the random growth model estimate of the effect of 8th grade Algebra enrollment is not significant net of lags.

The findings reported thus far are somewhat discouraging, suggesting that efforts to intensify middle school mathematics curricula have unintended negative consequences for student mathematics achievement across a broad range of domains. However, the analyses reported in Table 7 provide a glimmer of hope, indicating that curricular intensification efforts do not *always* have negative effects on student achievement. To estimate these models, we split California unified public school districts into tertiles based on their 2004 8th grade enrollments and then estimates district fixed effects analysis of the effects of curricular intensification on CAHSEE math scores on these subgroups. The resulting analysis suggests that the negative effects of increasing 8th grade Algebra occur exclusively in relatively large school districts (in this analysis, districts enrolling 850 or more 8th graders annually).[7] These findings are nearly

[7] Districts in the lowest-enrollment tertile enroll fewer than 300 8th graders annually; districts in the middle tertile enroll between 300 and 850 8th graders annually; 8th grade enrollments in the top tertile range from 850 to more

identical whether estimated using a fixed effects or random growth modeling strategy. In small and middle-sized districts, middle school mathematics curricular intensification has no effect on student achievement. In large districts, however, a 1 standard deviation increase in 8th grade Algebra enrollment decreases mean CAHSEE scores by 0.05-0.07 standard deviations, net of time-invariant district characteristics and controls. This result does not seem to be driven by any one large district. For example, the model returns nearly identical results if Los Angeles Unified or any other large district is excluded from the analysis. While we are unable to investigate the reasons underlying these differential effects, but we suspect that curricular change entails particularly pronounced logistical challenges in large schools and districts. We note that more than 80 percent of the 8th graders enrolled in the analysis districts during the study period attended high-enrollment districts.

[Insert Table 7 about here]

In sum, the results of our district fixed effects analyses paint a very discouraging picture of the effects of intensifying middle school mathematics curricula by enrolling more students in 8th grade Algebra. Contrary to the common-sense predictions of "opportunity to learn" theory and the findings of generations of observational studies, these analyses suggest that broad-based efforts to enroll more students in 8th grade Algebra have negative effects on student achievement in large school districts, and no benefits in small or medium districts.

6. Discussion

California is at the forefront of a national movement to enroll more students in more rigorous mathematics courses throughout secondary school. The proponents of this movement

than 50,000. The districts in the lower two tertiles are nearly all located in rural areas, and enroll somewhat fewer students of color and English language learners than the large districts. However, these demographic differences are not as pronounced as one might expect. 43 percent of students low-enrollment districts are black or Hispanic, compared to 47 percent of students in the middle enrollment districts and 59 percent of students in high enrollment districts.

argue that curricular intensification will better prepare students for productive careers in the global economy. The push to increase Algebra taking rates among 8th graders is a prime example of this curricular intensification effort. While this push has increased Algebra enrollments for traditionally underserved students in California and nationally, it is less clear if it has improved student achievement.

In this paper, we use a panel of district-level data from California's school districts to evaluate the relationship between changes in within-district Algebra enrollment rates and students' 10th grade math achievement. The results of our analysis highlight a potentially serious unintended consequence of the efforts to place more middle school students in Algebra. Increasing Algebra enrollment rates reduced districts' average CAHSEE scores, as well as scores on subscales covering basic math topics. These effects are concentrated in large districts, and we find little evidence of effects in small and medium districts.

How should we understand these disappointing results, particularly in light of previous research suggesting that heterogeneous ability grouping and the exposure to more advanced material increase student achievement? We suggest this is an important example of the difference general and partial equilibria. Much of the work demonstrating the benefits of advanced course taking and curricular intensification does so in a context where the only change is whether a given individual is placed into a higher level course. This framework approaches the question of course placement from a partial equilibrium perspective, so that everything else about the environment is assumed to remain constant. That is, the peers in the course, the teacher and their level of preparation to teach the course, the social meaning of the course, and other factors that could affect achievement do not change, allowing researchers to understand what would happen if a counterfactual person in an identical world was (or was not) exposed to the advanced course. However, policies rarely operate in this partial equilibrium. Rather, when a district or school moves to enroll more students in 8th grade Algebra, it changes not just whether a given individual receives access to Algebra instruction, but also affects the teachers and peers that an individual is likely to encounter in Algebra. Put differently, we suspect that Algebra means something different in schools that enroll 80 percent of 8th graders in Algebra than in schools that enroll 40 percent of 8th graders in Algebra. Likewise, we suspect that intensifying the curriculum to put more students into 8th grade Algebra is a much more challenging task in larger districts where course placement changes affect a larger number of students and teachers. As such, from a policy perspective we believe it is important to understand not just the effects of placing any given individual into Algebra ceteris paribus, but also the effects of implementing a broad-based Algebra-for-all policy. This general equilibrium approach allows for the fact that curricular intensification policies change the broader dynamics of peer and teacher interactions. In particular, our results suggests that future work should carefully attend to the challenges associated with implementing curricular intensification policies in large districts, as these districts appear particularly vulnerable to iatrogenic effects.

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Table 1: Descriptive statistics, 8th graders enrolled in California unified public school districts, 2003-04 – 2009-10

	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
Balanced Panel							
% in Algebra or higher	0.41	0.49	0.50	0.52	0.54	0.59	0.63
% minority	0.62	0.63	0.63	0.64	0.65	0.65	0.65
% ELL	0.36	0.35	0.26	0.26	0.26	0.24	0.23
District API	685.5	694.2	710.6	720.8	726.9	741.4	754.6
N(districts)	222	222	222	222	222	222	222
Weighted N	301,892	300,552	292,629	292,185	291,754	286,736	279,175
All districts							
% in Algebra or higher	0.41	0.49	0.51	0.53	0.55	0.60	0.63
% minority	0.61	0.63	0.62	0.63	0.63	0.64	0.64
% ELL	0.35	0.35	0.26	0.26	0.25	0.24	0.23
District API	687.8	694.7	710.9	722.6	729.9	742.1	756.7
N(districts)	282	285	293	288	296	309	300
Weighted N	336,084	336,010	341,332	336,131	333,089	337,277	317,902

Figure 1: Percent of 8th graders completed Algebra, Geometry, or Algebra II CST in the twelve largest California unified public school districts, 2004-2010

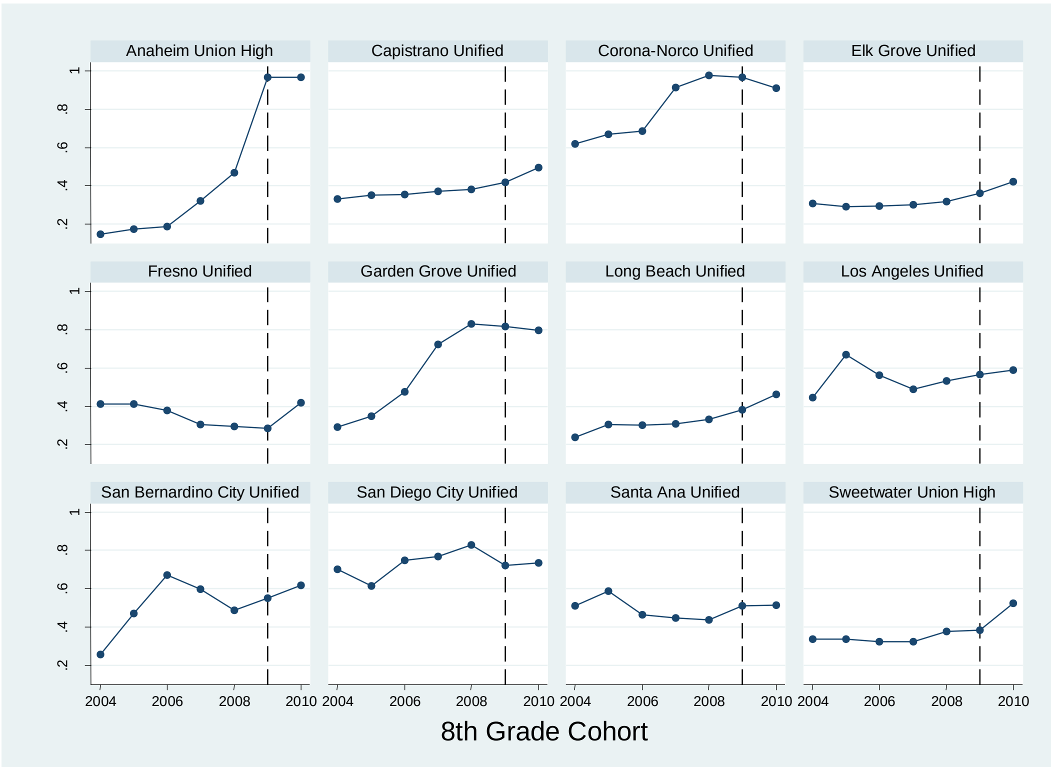

Table 2: OLS regression coefficients, predictors of 8th grade Algebra enrollment rate, California public school districts 2003-04 – 2009-10 (cluster robust standard errors at the district level)

	(1)	(2)	(3)	(4)
2004 (8th)	-0.20***	-0.12**	--	-0.13*
	(0.03)	(0.04)		(0.06)
2005 (8th)	-0.11**	-0.05	0.01	-0.06
	(0.03)	(0.04)	(0.03)	(0.05)
2006 (8th)	-0.09***	-0.04	-0.04	-0.03
	(0.02)	(0.03)	(0.02)	(0.03)
2007 (8th)	-0.07***	-0.04*	-0.03	-0.03
	(0.02)	(0.02)	(0.02)	(0.02)
2008 (8th)	-0.05***	-0.03+	-0.03+	-0.02
	(0.01)	(0.01)	(0.01)	(0.01)
2009 (8th)	--	--	--	--
2010 (8th)	0.05***	0.03*	0.01	0.02
	(0.01)	(0.01)	(0.01)	(0.02)
% Minority in district	-0.03	0.28+	0.04	0.19
	(0.10)	(0.15)	(0.05)	(0.62)
% ELL	0.12	0.17	0.10	0.63***
	(0.16)	(0.15)	(0.10)	(0.16)
Ln(8th Grade Enrollment)	0.00	0.00	-0.00+	-0.23+
	(0.01)	(0.01)	-	(0.14)
Lagged District API	--	0.09**	0.02+	0.14*
		(0.03)	(0.01)	(0.06)
% 8th graders >=Algebra, Y(t-1)	--	--	0.18***	--
			(0.01)	
Constant	0.55***	0.33***	0.43***	2.19*
	(0.05)	(0.09)	(0.03)	(0.99)
Adj. R-squared	0.11	0.14	0.67	0.29
# of districts	222	222	222	222
Rho				0.90

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Note: 2008-09, the first post-Algebra for all policy year, is the reference category.

Table 3: Fixed effects and random growth model coefficients, predictors of district mean CAHSEE math test scores, California public school districts 2003-04 – 2009-10 (balanced panel)

	Fixed effects	Random Growth
% 8th graders >=Algebra (std)	-0.07**	-0.05*
	(0.02)	(0.02)
2004 (8th)	-0.28**	--
	(0.10)	
2005 (8th)	-0.14+	0.06
	(0.08)	(0.04)
2006 (8th)	-0.10+	0.08
	(0.06)	(0.05)
2007 (8th)	-0.13**	-0.01
	(0.04)	(0.04)
2008 (8th)	-0.02	0.01
	(0.03)	(0.02)
2009 (8th)	--	--
2010 (8th)	0.00	-0.05+
	(0.03)	(0.03)
% black/Hispanic	-1.42	-0.54
	(1.04)	(1.00)
% ELL	0.18	0.2
	(0.36)	(0.51)
Ln(8th Grade Enrollment)	0.05	-0.13
	(0.28)	(0.22)
Lagged District API	0.47***	0.03
	(0.11)	(0.10)
Constant	0.82	0.12***
	(2.28)	(0.02)
Adj. R-squared	0.40	0.04
# of districts	220	213
Rho	0.84	0.33

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Table 4: Specification checks. Fixed effects and random growth model coefficients, predictors of 8th grade % minority, logged enrollment, and contemporaneous mean CAHSEE scores, California public school districts 2003-04 – 2009-10 (balanced panel).

	Panel A: Fixed effects models			**Panel B: Random Growth Models**		
	Grade 8 % minority	Grade 8 enrollment (ln)	CAHSEE math (Yt)	Grade 8 % minority	Grade 8 enrollment (ln)	CAHSEE math (Yt)
% 8th graders >=Algebra (std)	0.06	-0.01+	-0.05+	-0.07	-0.00	0.02
	(0.18)	(0.00)	(0.03)	(0.08)	(0.00)	(0.03)
2004 (8th)	-5.14***	0.08*	--	--	--	--
	(0.68)	(0.02)				
2005 (8th)	-4.07***	0.07*	--	0.23***	0.00	--
	(0.55)	(0.02)		(0.04)	(0.00)	
2006 (8th)	-2.45***	0.05**	-0.06	0.09	0.00	--
	(0.37)	(0.01)	(0.08)	(0.10)	(0.00)	
2007 (8th)	-1.27***	0.03**	0.02	0.48**	0.01	0.05
	(0.31)	(0.01)	(0.06)	(0.15)	(0.00)	(0.04)
2008 (8th)	-0.72***	0.03**	0.10**	0.25**	0.01+	0.09***
	(0.18)	(0.01)	(0.04)	(0.09)	(0.00)	(0.02)
2009 (8th)	--	--	--	--	--	--
2010 (8th)	0.69*	-0.03***	0.02	-0.31	-0.02**	0.03
	(0.32)	(0.01)	(0.04)	(0.29)	(0.01)	(0.04)
% black/Hispanic	--	0.62	0.52	--	0.09	1.07
		(0.23)	(1.20)		(0.01)	(1.32)
% ELL	15.27***	0.18***	-0.71	6.02***	0.18	0.44
	(1.64)	(0.08)	(0.71)	(1.56)	(0.13)	(1.13)
Ln(8th Grade Enrollment)	4.91*	--	-0.29	0.49	--	-0.28
	(2.00)		(0.28)	(0.85)		(0.34)
Lagged District API	-0.7	0.05+	0.55***	-0.38	0.00	0.16
	(0.76)	(0.03)	(0.16)	(0.48)	(0.02)	(0.14)
Constant	21.31	7.70***	2.25	0.73***	-0.01	0.07**
	(16.10)	(0.14)	(2.39)	(0.09)	(0.00)	(0.03)
Adj. R-squared	0.49	0.28	0.3	0.14	0.08	0.04
# of districts	222	222	219	222	222	210
Rho	1	1	0.89	0.39	0.43	0.34

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Table 5: Fixed effects and random growth model coefficients, predictors of district mean % correct CAHSEE math test subscales, California public school districts 2003-04 – 2009-10 (balanced panel)

	Panel A: Fixed effects models					Panel B: Random Growth Models				
	(1) Prob & Stats % correct (std)	(2) Number Sense % correct (std)	(3) Algebra & Functions % correct (std)	(4) Geo % correct (std)	(5) Algebra I % correct (std)	(1) Prob & Stats % correct (std)	(2) Number Sense % correct (std)	(3) Algebra & Functions % correct (std)	(4) Geo % correct (std)	(5) Algebra I % correct (std)
% 8th graders >=Algebra (std)	-0.05***	-0.05***	-0.04**	-0.04**	-0.04*	-0.05**	-0.05**	-0.04*	-0.05**	-0.04*
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
2004 (8th)	0	-0.28***	-0.1	-0.11	-0.20**	--	--	--	--	--
	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)					
2005 (8th)	0	-0.18**	-0.08	0.02	-0.05	0	0.03	0	0.10***	0.10***
	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)
2006 (8th)	-0.10**	-0.02	-0.07+	0.06	-0.12**	-0.08**	0.17***	0	0.15***	0
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)
2007 (8th)	-0.09**	-0.04	-0.01	0.04	-0.10**	-0.07**	0.09***	0.04+	0.10***	-0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
2008 (8th)	0.02	-0.15***	0.04+	-0.01	-0.12***	0.01	-0.10***	0.05*	0	-0.10***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
2009 (8th)	--	--	--	--	--	--	--	--	--	--
2010 (8th)	-0.05*	-0.16***	0.03	0.10***	0.07**	-0.06*	-0.22***	0.01	0.07**	0.04
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
% black/Hispanic	0.4	0.39	0.47	0.28	-0.16	-0.29	-0.03	-0.09	-0.55	-0.48
	(1.19)	(1.16)	(1.17)	(1.14)	(1.11)	(1.09)	(1.12)	(1.15)	(1.12)	(1.00)
% ELL	0.02	0.03	0.19	0.05	0.52*	0.39	0.39	0.14	0.38	0.37
	(0.23)	(0.27)	(0.23)	(0.29)	(0.21)	(0.36)	(0.33)	(0.33)	(0.37)	(0.38)
Ln(8th Grade Enrollment)	0.13	0.08	0.05	0	0.14	-0.25	-0.31	-0.27	-0.36+	-0.23
	(0.19)	(0.19)	(0.19)	(0.19)	(0.20)	(0.20)	(0.20)	(0.21)	(0.21)	(0.21)
Lagged District API	0.16*	0.17*	0.19*	0.20*	0.22**	-0.11	-0.13	-0.17	-0.14	-0.14
	(0.07)	(0.07)	(0.07)	(0.08)	(0.08)	(0.11)	(0.11)	(0.12)	(0.12)	(0.12)
Constant	-0.89	-0.41	-0.31	0.19	-0.66	0.05*	0.11***	0.08**	0.08***	0.09***
	(1.91)	(1.91)	(1.89)	(1.86)	(1.87)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
Adj. R-squared	0.06	0.19	0.12	0.14	0.17	0.04	0.15	0.02	0.04	0.07
# of districts	222	222	222	222	222	222	222	222	222	222
Rho	0.85	0.85	0.85	0.85	0.85	0.18	0.17	0.17	0.17	0.17

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Table 6: Fixed effects and random growth model coefficients, predictors of district mean CAHSEE math test scores, California public school districts 2003-04 – 2009-10 (balanced panel)

	Panel A: Fixed effects models				**Panel B: Random Growth Models**			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
% 8th graders >=Algebra (std)	-0.07*	-0.07**	-0.05**	-0.05*	-0.03	-0.04*	-0.04	-0.04
	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)
>2 SD incr.	0.06	--	--	--	-0.00	--	--	--
	(0.05)				(0.04)			
>1 SD incr.	-0.01	--	--	--	-0.01	--	--	--
	(0.04)				(0.03)			
>2 SD dcr.	-0.02	--	--	--	0.02	--	--	--
	(0.05)				(0.04)			
>1 SD dcr.	0.05	--	--	--	0.10	--	--	--
	(0.08)				(0.09)			
Post-policy period	--	-0.02	--	--	--	-0.03	--	--
		(0.03)				(0.03)		
% Alg * Post-policy	--	0.03	--	--	--	0.04+	--	--
		(0.03)				(0.02)		
% 8th graders >=Algebra (lag, std)	--	--	-0.01	--	--	--	0.01	--
			(0.02)				(0.01)	
% 8th graders >=Algebra (2nd lag, std)	--	--	--	-0.02	--	--	--	0
				(0.02)				(0.02)
yr8th== 2005	-0.15	--	-0.16+	--	--	--	0.04	--
	(0.09)		(0.09)				(0.05)	
yr8th== 2006	-0.14*	--	-0.14*	-0.15*	0.04	--	--	--
	(0.06)		(0.06)	(0.07)	(0.05)			
yr8th== 2007	-0.15**	--	-0.15***	-0.16**	-0.04	--	-0.04	-0.06**
	(0.05)		(0.04)	(0.05)	(0.04)		(0.04)	(0.02)
yr8th== 2008	-0.04	--	-0.04	-0.04	-0.01	--	0	-0.01
	(0.03)		(0.03)	(0.03)	(0.02)		(0.02)	(0.02)
yr8th== 2009	--	--	--	--	--	--	--	--
yr8th== 2010	0.01	--	0.01	0.01	-0.03	--	-0.04	-0.03
	(0.03)		(0.03)	(0.03)	(0.03)		(0.03)	(0.03)
Controls	+	+	+	+	+	+	+	+
Constant	-0.54	0.51	0.19	0.47	0.10***	0.12***	0.10***	0.08***
	(2.55)	(2.29)	(2.43)	(2.44)	(0.02)	(0.02)	(0.02)	(0.02)
Adj. R-squared	0.34	0.38	0.34	0.29	0.04	0.01	0.03	0.03
# of districts	219	220	219	216	211	213	211	209
Rho	0.89	0.81	0.89	0.9	0.37	0.32	0.36	0.38

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Table 7: Fixed effects and random growth model coefficients, predictors of district mean CAHSEE math test scores by 2003-04 district enrollment tertile, California public school districts 2003-04 – 2009-10 (balanced panel)

	Panel A: Fixed effects models			**Panel B: Random Growth Models**		
	Low enrollment	Mid-enrollment	High-enrollment	Low enrollment	Mid enrollment	High enrollment
% 8th graders >=Algebra (std)	0.01	0.01	-0.07*	0.03	0.00	-0.05*
	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
2004 (8th)	-0.05	-0.17	-0.38*	0.00	0.00	0.00
	(0.13)	(0.11)	(0.15)	(0.00)	(0.00)	(0.00)
2005 (8th)	-0.03	-0.02	-0.19	0.03	0.07+	0.10*
	(0.11)	(0.09)	(0.13)	(0.06)	(0.04)	(0.04)
2006 (8th)	0.09	-0.05	-0.12	0.14*	0.08	0.14**
	(0.10)	(0.08)	(0.09)	(0.06)	(0.05)	(0.05)
2007 (8th)	-0.02	-0.10+	-0.16*	0.04	-0.02	0.01
	(0.08)	(0.06)	(0.07)	(0.05)	(0.04)	(0.05)
2008 (8th)	-0.05	-0.05	-0.01	0	-0.04	0.06*
	(0.06)	(0.05)	(0.04)	(0.05)	(0.04)	(0.03)
2009 (8th)	--	--	--	--	--	--
2010 (8th)	-0.01	0.02	-0.05	-0.01	0.00	-0.13**
	(0.06)	(0.06)	(0.04)	(0.07)	(0.06)	(0.04)
% black/Hispanic	1.58	-0.64	-2.6	1.93	-0.24	-2.50*
	(1.05)	(0.94)	(1.62)	(1.76)	(1.65)	(1.08)
% ELL	0.67	-0.4	0.96+	0.9	0.52	1.27
	(0.56)	(0.71)	(0.53)	(0.64)	(0.76)	(0.79)
Ln(8th Grade Enrollment)	0.2	0.1	0.07	0.04	-0.08	-0.32
	(0.18)	(0.22)	(0.54)	(0.19)	(0.27)	(0.51)
Lagged District API	0.16	0.40**	0.53*	0.18	-0.12	0.13
	(0.10)	(0.13)	(0.20)	(0.13)	(0.14)	(0.15)
Constant	-1.54+	-0.02	1.11	-0.02	0.11***	0.14***
	(0.90)	(1.34)	(4.17)	(0.03)	(0.03)	(0.03)
Adj. R-squared	0.07	0.25	0.35	0.02	0	0.05
# of districts	61	79	80	56	77	80

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001