REMEDIAL EDUCATION REFORM IN CALIFORNIA AND COMMUNITY COLLEGE STUDENT OUTCOMES

Alice Li *

This draft: April 20, 2023

DO NOT CITE OR DISSEMINATE WITHOUT AUTHOR PERMISSION.

Abstract

The efficacy of remedial education in helping students achieve academic success has long been debated. Between 2013 and 2017, California passed various remedial education reforms, first changing remedial education placement of students, and later removing remedial education mandates altogether. These reforms increased direct access to transfer-level courses for students without first requiring remedial education. I exploit the timing of these reforms to explore how students fare in community college without completing the remediation sequence. I find that these reforms induced students at all levels of academic preparation to take and pass transfer-level courses at similar or higher rates as students before the policy change, except for students at the lowest level of academic preparation, who passed at slightly lower rates. Furthermore, the removal of remediation requirements encouraged additional transfer-level course taking, but at a lower completion rate. Overall, removing remediation requirements had positive effects on student success for students at all levels of college readiness, particularly for those on the margin of requiring remediation.

*Alice Li, Email: alice.li@usdoj.gov; University of California Davis. The research reported here was supported through the generosity of funding from the College Futures Foundation and the Institute of Education Sciences, U.S. Department of Education, Grant R305E150006 to the Regents of the University of California. The research reported here was conducted under research partnership agreements between the University of California, Davis (Michal Kurlaender, PI) and the California Community Colleges Chancellor's Office and the California Department of Education, respectively. I would like to thank Michal Kurlaender, Scott Carrell, Paco Martorell for providing invaluable guidance and support. The findings and conclusions here are those of the author alone and do not necessarily reflect the positions or policies of the funders, including the Institute of Education Sciences or the U.S. Department of Education, or the data providers.

1 Introduction

Community college is a vital and substantial component of the higher education system in the United States today. In 2021, community colleges enrolled 41 percent of all undergraduates and 39 percent of all first-time college students.[1] In particular, the California Community College system is the largest system of higher education in the United States, enrolling 25 percent of all community college students in the nation.[2] Community colleges have been touted as a cheaper alternative and gateway to four-year colleges,[3] with the potential to help reduce inequities in income and wealth.[4] However, the reality has not been so rosy. Out of the California community college students who stated an intent to transfer or graduate with a degree, only 48 percent were able to do so in 6 years, despite these programs and degrees being meant to be accomplished in 2 years (PPIC, 2019).

Projections have suggested that the state of California will face a shortage of 1 million college-educated workers by 2030 (Johnson et al., 2015), stemming from low graduation rates. One reason cited for these low success rates is remedial education, which has been observed to function more as a roadblock for many students, rather than providing help and support as initially intended (MDRC, 2013). Remedial education, also referred to as developmental education, consists of courses that reteach and reinforce previously taught skills to help improve student outcomes in future college-level coursework.[5] Proponents of remedial education argue that remedial education can give struggling students individualized attention, and build confidence for later college-level courses.[6] Remedial education is extremely widespread, with 80 percent of students

[1]Fast Facts 2021. American Association of Community Colleges. https://www.aacc.nche.edu/wp-content/uploads/2021/03/AACC_2021_FastFacts.pdf. Accessed 12 Oct. 2021.

[2]Key Facts. California Community Colleges. https://www.cccco.edu/About-Us/Key-Facts. Accessed 12 Oct. 2021.

[3]Barrington, Kate. "Community Colleges are More Important than Ever." Community College Review. 07 July 2020. Accessed 12 Oct. 2021.

[4]Mintz, Steven. "Community Collges and the Future of Higher Education." 9 Mar. 2019. https://www.insidehighered.com/blogs/higher-ed-gamma/community-colleges-and-future-higher-education. Accessed 12 Oct. 2021.

[5]https://study.com/learn/lesson/what-is-remedial-education.html

[6]Barrington, Kate. "How Community College are Changing Remedial Education." Community College Review. 16 June 2021. https://www.communitycollegereview.com/blog/how-community-colleges-are-changing-remedial-education. Accessed 8 Nov. 2021.

enrolling at least once throughout their college journey, and disproportionately affects underrepresented minorities and socioeconomically disadvantaged students with less access to quality college preparation in high school (Cuellar Meija et al., 2016b).

However, despite intentions to support entering community college students considered underprepared, descriptive studies have shown that remedial education sequences have had unintended negative consequences, such as lengthening time to degree and encouraging overall attrition,[7] with many students never advancing to a transfer-level course. For example, in California specifically, English remediation sequences require an average of 1.9 terms for completion, and math remediation sequences require an average of 2.5 terms for completion. Attrition is extremely high, with only 44 percent of remedial math students and 60 percent of remedial English students completing the sequence (Bailey et al., 2010; Cuellar Meija et al., 2016b). This is particularly troublesome, as students will not be able to access certain college-level courses without finishing their remediation sequence, in particular introductory English and math courses that are required for graduation or transfer. Only 27 percent of students who take a remedial math course eventually complete a transfer-level math course with a C or better, while 44 percent of remedial English students go on to complete a transfer-level English course (Cuellar Meija et al., 2016b). These statistics also do not take into consideration any possible "discouragement effects," where students who are initially assigned to remedial education are discouraged from enrolling in community college at all (Scott-Clayton and Rodriguez, 2015).

These worrisome statistics have motivated the state of California to pass various reforms with the hopes of encouraging and bolstering student success. In 2013, California first passed remedial education placement reforms. Following concerns that these policies were not working as intensely as hoped, California then instituted one of the most sweeping changes to the remedial education system, effectively removing

[7] Bautsch, Brenda. "Hot Topics in Higher Education: Reforming Remedial Education." National Conference of State Legislatures. February 2013. https://www.ncsl.org/documents/educ/REMEDIALEDUCATION_2013.pdf. Accessed 28 July, 2021.

mandatory remedial education requirements altogether in 2017. I use the introduction of these policies as a source of quasi-exogenous variation, to study how remedial education reforms, as well as the complete removal of remedial education, affect community college student success outcomes, particularly with respect to course selection and overall units accumulated.

I take advantage of two rich and extensive administrative datasets which span from 2008-2020: 1) transcript data on all students enrolled in the now 116 community colleges in the California Community College (CCC) system from the California Community Colleges Chancellor's Office, and 2) data on the universe of public high school students in the state of California from the California Department of Education (CDE), which includes standardized test score data. I use high school demographic and academic ability variables to predict the likelihood that student would have been enrolled in remedial education before any reforms were made, which also acts as a proxy for perceived college readiness.

Although there are numerous descriptive studies regarding AB 705,[8] this is one of the only papers that can study the effect of the removal of remediation requirements on students along a continuous measure of college readiness. My paper has the advantage of being able to use rarely available student-level data on college course selection linked to student-level high school data including a rich set of controls, and information on parent education and English proficiency, along with more commonly observed controls such as gender, race, and socioeconomic status. Finally, it is one of few causal papers that can study the effect of increasing direct access to transfer-level courses, joining a collection of papers which study a similar policy change in Florida beginning in 2013 (Park-Gaghan et al., 2020, 2021), and the first to do so with respect to California.

I find that the effective removal of remedial education through Assembly Bill (AB) 705 had larger effects on course selection than the combination of policies implemented from 2013-2017. Earlier reforms to remedial education placement through multiple measures did not have large effects on the proportion of

[8] PPIC (2019); Cuellar Meija et al. (2018, 2021)

students enrolled in remedial English or math. In comparison, there were large reductions in the proportion of students enrolled in remedial courses after AB 705 was passed, particularly concentrated among students with the lowest levels of academic preparation.

In addition, AB 705 had comparatively larger effects on both math and English transfer-level course participation, with students after remedial reform implementation passing both subjects with a C or better at similar or even higher rates compared to students enrolled in community college before any remediation reform. This result holds for students across all levels of academic preparation, except for those deemed least prepared for college. These results are consistent with the motivation for AB 705 legislation, which was to completely eliminate the use of remediation unless deemed necessary.[9]

Both early reforms for course placement and the effective removal of remedial education affected students' overall course loads, with mixed results regarding course completion rates. During the time period of remedial education placement reforms, students attempted more transfer-level courses and completed them at higher rates than students before any policy reform. In contrast, after AB 705 was implemented, although students did attempt and earn more transfer-level units, they did so at a lower completion rate than did students before any policy change. These findings suggest that once given the option to take transfer-level courses, there is potential for students to take more transfer-level courses too quickly.

I find that the students who benefit the most from this increase in access to transfer-level courses are students on the margin of being placed into remedial education, and that these beneficial effects decrease but are still positive, as students are deemed to be less and less college ready. These results provide support for the previous literature, which has found that students who are most negatively affected by remedial education are those at the margin.[10]

This paper has many policy implications, particularly regarding the future of remedial education. Con-

[9] California State Assembly Bill. Assembly Bill 705: Seymour-Campbell Student Success Act of 2012. SEC 2.78213d(1)(A).

[10] There are some papers who find that remedial education actually has the largest negative effect for students at the lowest levels of academic preparation (Calcagno et al, 2007; Jepsen, 2006).

sidering that I find that many students, who would have been placed into remedial education before any reform was passed, were capable of passing transfer-level English or math, suggests that remedial education might not have imparted substantial benefits to those students. Since remedial education is a widespread, but costly intervention, it is important for colleges to understand what sort of benefits or costs are accruing as a result of this policy. As colleges nationwide move to restructure and reform remedial education, it is also necessary to understand how these policy changes affect all students across a range of academic needs, and not just at the margin.

2 Literature Review and Policy Background

Causal studies regarding the efficacy of remedial education have not come to a consensus, with studies finding a mix of negative or null effects of remedial education on a large range of student outcomes. Recent papers focusing on four-year college students similarly find mixed results on a myriad of outcomes, including credit accumulation, persistence, degree completion, and even labor market outcomes (Bettinger and Long, 2008; Calcagno and Long, 2008; Martorell and McFarlin, 2011; Boatman and Long, 2018). An earlier study by Bettinger and Long (2005) finds positive effects of math remediation on math credits completed and the probability of transfer for community college students, but no effect of English remediation on any measure of success, also suggesting the importance of studying effects separately by subject.

My paper relates specifically to a strand of literature focused on remedial courses and its effect on college outcomes, and more broadly on how college readiness affects college success. Many papers dedicated to understanding the effect of enrolling in remedial education utilize a regression discontinuity strategy (Calcagno and Long, 2008; Martorell and McFarlin, 2011; Duchini, 2017), which provides great internal validity, and focuses on students at the margin, who are potentially the students who would least benefit from remedial education.

A few papers regarding the efficacy of remedial education, such as Scott-Clayton and Rodriguez (2015).

Xu (2016), and Boatman and Long (2018), are able to study its effects on students over a range of academic needs. Boatman and Long (2018), like other papers, use a regression discontinuity design; however, they are able to analyze effects of remediation on students who are assigned to different quantities of remedial courses, considered as a proxy for college readiness. Their results suggest that the benefits of remedial courses on students' academic success are dependent on the level of student preparation. For example, students who only required one remedial course faced the largest negative effects, and were less likely to complete a college degree and accumulated fewer college credits over time. However, students required to take two remedial courses faced less negative effects, and in some cases, were even more likely to persist than similar students who were required to take only one remedial course.

In contrast, Xu (2016) finds that students who required the most remediation faced the largest negative effects. Following a similar strategy as Boatman and Long (2018), using regression discontinuity to study students on the margins of requiring different levels of remedial courses, Xu finds that students who required the lowest level of remedial education were more likely to drop out of college and, consequently, less likely to ever enroll in a transfer-level English course. Similarly, Clotfelter et al. (2015), using an instrumental variables strategy relying on variation of placement policies and geographic proximity of various community colleges, find that students at the bottom of the 8th-grade achievement distribution are the most adversely affected by remediation.

A potential reason for these mixed outcomes stems from how students are defined as underprepared and placed into remedial education. For many years, a large proportion of community colleges across the nation relied solely on placement exam score cutoffs to place students into remedial education,[11] and this was largely true in California community colleges (Cuellar Meija et al., 2016a). However, studies have shown that standardized testing routinely underplaces students into remedial education at an overwhelming

[11] Rutschow, Elizabeth Zachary, et al. "The Changing Landscape of Developmental Education Practices: Findings from a National Survey and Interviews with Postsecondary Institutions." Center for the Analysis of Posesecondary Readiness. Nov. 2019. https://postsecondaryreadiness.org/dev/wp-content/uploads/2019/11/changing-landscape-developmental-education-practices.pdf. Accessed 28 Apr. 2021.

rate (Belfield and Crosta, 2012), and can be a worse predictor of future academic success than overall high school performance (Scott-Clayton, 2012; Scott-Clayton et al., 2014; Allensworth and Clark, 2020).[12]

Before AB 705 was passed, placement of students into remedial education varied widely across the 114 community colleges in California. Although the vast majority of colleges relied mostly on assessment test scores taken by incoming first-time students, there was substantial variation in the cutoff score used to place students into remedial education, and even the exam administered was not consistent across colleges.[13]

These studies prompted the State legislature of California to pass a mandate in 2013 requiring community colleges to use multiple measures,[14] such as high school courses taken, or high school GPA, to place students into remedial education, instead of relying so heavily on entrance exam scores.[15] This mandate could affect students on the margin of requiring remedial education, diverting them from mandatory remedial education, and increasing their direct access to transfer-level courses. However, studies of these early efforts suggested that multiple measures were being inconsistently applied across colleges, and that this uneven implementation resulted in slow-moving changes in remedial education participation (Cuellar Meija et al., 2016a).

Colleges also offered students automatic exemptions from the remedial education assessment, through the submission of other test scores from college admission exams (SAT and ACT), college-level proficiency exams (Advanced Placement, International Baccalaureate), college-level course completion at another college (Cuellar Meija et al., 2016a), or scores on the high school 11th grade assessments through the Early Assessment Program.[16] Furthermore, students were allowed to retake the exam again, although retake policies varied across colleges as well. Nevertheless, even with potential test retakes and exemptions, a large

[12] However, there are some papers which suggest that standardized exams are just as good at predicting academic success as high school measures, or that standardized exams in conjunction with high school measures are better at predicting academic success.

[13] Meija, Marisol Cuellar, Olga Rodriguez, and Hans Johnson (2016). "Preparing Students for Success in California's Community Colleges." PPIC. https://www.ppic.org/content/pubs/report/R_1116MMR.pdf, accessed Mar. 31, 2021.

[14] 5 CA ADC § 55522

[15] Other measures include grade in the last math/English course, high school GPA, the Early Assessment Program (EAP) or counselor recommendation.

[16] Early Assessment Program. California Department of Education. *https://www.cde.ca.gov/ci/gs/hs/eapindex.asp*, Accessed 07 Jan. 2022.

proportion of students were still affected by and enrolled in remedial education. Roughly 31 percent of students took a remedial education course during their first semester of enrollment.[17] Thus, remedial education was widespread at California community colleges before 2017.

Concurrently, there was a related push in the California Community College system encouraging students to increase their transfer-level course participation, and thus encourage long-run student success.[18] Together, these changes indicate that transfer-level course participation should increase, and that remedial education enrollment should decrease during 2013-2017. However, descriptive studies indicated that these policies were not working quickly enough. To help further address these issues, California implemented one of the most sweeping changes to remedial education placement. In October 2017, Assembly Bill (AB) 705 was passed,[19] to address the well-documented problems regarding remedial education, and to change how colleges could place students into remedial education, with mandatory implementation by Fall 2019.[20]

AB 705 again reiterated that colleges more consistently use high school transcript data to place students, as research has shown standardized tests are poor indicators of future college success, and other measures, such as high school GPA, grades, and courses, can be better predictors of academic success (Scott-Clayton, 2012; Scott-Clayton et al., 2014; Allensworth and Clark, 2020). Furthermore, colleges had to "maximize the probability that a student will enter and complete transfer-level coursework in English and math within a one-year timeframe,"[21] suggesting that enrollment in remedial education would no longer be the default for entering students. Community colleges now have the burden of proof to show that a particular student would most likely not be able to pass a college-level course before placing them in remedial education. These factors together suggest that it will be difficult for colleges to deny most students entry to transfer-

[17] Statistics calculated internally.

[18] The California Community Colleges Chancellor's Office has made a concentrated push to improve student outcomes, specifically through closing achievement gaps, increasing degree attainment and transfers to four-year universities, and reducing unnecessary credit accumulation. *See,* Vision for Success. California Community Colleges. *https://www.cccco.edu/About-Us/Vision-for-Success*. Accessed 07 Jan. 2022.

[19] What is AB 705? California Community Colleges,https://assessment.cccco.edu/ab-705-implementation. Accessed 24 March 2021.

[20] AB 705 Resources. Academic Senate for California Community Colleges. https://asccc.org/ab-705-resources. Accessed 24 March 2021.

[21] California State Assembly Bill. Assembly Bill 705: Seymour-Campbell Student Success Act of 2012. SEC 2.78213d(1)(A).

level courses. AB 705 mandated that these changes be implemented systemwide by Fall 2019, although some colleges chose to pilot these changes earlier in 2018.[22]

A priori, it is not certain what effects these policy changes will have on student outcomes. Increasing direct access to transfer-level courses necessary for degree attainment or transferring to a 4-year college could decrease time to degree by allowing students to take the necessary classes more quickly. On the other hand, if some students are actually underprepared and require remedial education, then allowing direct access to transfer-level courses could result in more attrition and lower pass rates than before the policy change.

Few papers assess the impact of increasing open access to transfer-level courses, with the notable exception of recent studies focused on Florida. In 2014, Florida passed a similar bill to AB 705, drastically restructuring remedial education in the Florida College System, and no longer requiring students take the remedial education placement exam.[23] Park-Gaghan et al. (2020) find that the effective removal of remedial education helped narrow achievement gaps in gateway course passing for underrepresented minorities. In a closely related paper focused on Florida's policy change, Park-Gaghan et al. (2021) find positive effects on course pass rates for all students across different levels of college preparedness, as defined by general high school course taking, with the largest effects for students deemed the least prepared. However, they are unable to fully account for any linear pre-trends in their analysis, and cannot disentangle effects of policies that potentially affect students at all levels of academic preparation similarly.

I add to the literature on increased direct access to transfer-level courses by studying students along a continuous measure of college readiness, instead of focusing on students at the margin. Furthermore, I have a rich set of rarely available controls to account for student ability, through standardized tests in both English and math taken in high school.

---

[22] The RP Group (2019). "Access, Enrollment, and Success in Transfer-Level English and Math in the California Community College System." https://mk0edsource0y23p672y.kinstacdn.com/wp-content/uploads/2019/09/AccessEnrollmentSuccess_FINAL.pdf. Accessed May 5, 2021.

[23] SB 1720. https://www.flsenate.gov/Committees/billsummaries/2013/html/501.

I exploit the different timing of these policies, defining three separate time periods – before any of these remedial education reform policies have been implemented, an intermediate period that encompasses policies starting in 2013 that were considered to have somewhat less "bite," and after the passing of AB 705 as an additional policy heavily reforming remedial education.

3 Data

For this analysis, I use administrative data on the California Community College (CCC) system, which encompasses 116 colleges and represents the largest public higher-education system in the United States, serving over 2.1 million students.[24] This administrative data from the California Community Colleges Chancellor's Office (CCCCO) includes the population of students who enrolled in a community college from 2000-2020, although I focus only on college enrollment from 2011-2020 due to the timing of the policy change and other data restrictions.

The CCCCO data include information on the individual student's demographics, such as gender and race, as well as comprehensive transcript data. The transcript data are at the student-term level, and includes information on all courses taken by an individual student, including the grade earned in each course, the total number of units attempted, units earned, as well as longer-run outcomes, including certificates, awards earned, and transfer status. The CCCCO data also include granular data on each course, including remediation status, or basic skills status, and subject, as well as transfer status.

I complement the CCCCO data by matching at the student level to data on the entire universe of public high school students in California. This data from the California Department of Education (CDE) cover 5.7 million students from 2008 - 2020, with an average of 475,000 students per cohort. In addition, the CDE data include demographic information on the student's gender, race, socioeconomic status, birthday, and high school attended.

[24]Facts and Figures. Foundation for California Community Colleges. https://foundationccc.org/About-Us/About-the-Colleges/Facts-and-Figures. Accessed May 5, 2021.

4 Empirical Strategy

I use the introduction of various remedial education reforms in 2013, as well as the removal of mandatory remedial education in 2017, as sources of quasi-exogenous variation to study how changes in access to transfer-level courses affect students' academic success at California community colleges, measured by course selection, pass rates in transfer-level courses, and overall course load.

I compare college outcomes of students, before, during, and after the policy changes. I define the "before" period to be from Fall 2011 up to and including Spring 2013, the "intermediate" period to start from Fall 2014 up to and including Fall 2017, and the "after" period to be from Spring 2017 to Spring 2020.

Importantly, I do not observe whether students are recommended to enroll remedial education, only if they actually enroll in a remedial education course. Thus, I am not able to observe which students may have initially been recommended to take remedial courses, but did not actually take those courses due to exam retakes, or dropped out of school before taking remedial courses. Furthermore, as students no longer have to take the entrance exam that places students into remedial education after the implementation of AB 705, it's difficult to say which students might be affected by these remedial education reforms.

Instead, I use a rich variety of variables on demographics and ability chosen through a data-driven process to *predict* treatment intensity – a continuous variable representing the predicted probability a student takes remedial English (and separately for math) within the first semester of enrollment. Specifically, I focus on the first semester within the first year of enrollment conditional on the student being enrolled in credit-bearing courses. This restriction allows me to avoid any biases regarding students persisting into the spring semester, or students whose first semester is in the spring rather than the fall.[25]

I use the predicted probability of enrolling in a remediation course as a proxy for counterfactual treatment intensity had remedial education reforms not been passed to estimate the following equation:

[25] 23 percent of students first enroll in community college in the spring semester rather than the fall semester.

$$Y_{ihcts} = \alpha + \beta_1[\text{intermediate}_t] + \beta_2[\text{after}_t] + \beta_3[\hat{\text{T}}_{ihc(s=math)}] + \beta_4[\hat{\text{T}}_{ihc(s=Eng)}] \\ + X_{ihc} + \lambda_c + \lambda_h + \epsilon_{ichts} \tag{1}$$

where each observation is unique at the student i-semester t level, and Y_{ihcts} represents both continuous and binary outcomes, such as the total number of units taken in a semester or whether or not a student passed a transfer-level course for subject s (English or math). The variable $intermediate_t$ is an indicator variable which is 1 if the student is enrolled in community college during the initial reform period, when the course selection reforms focused on students with higher levels of academic preparation, during Fall 2014 to Fall 2016, inclusive. The variable $after_t$ is an indicator variable which is 1 if the student is enrolled in community college after the passing of AB 705, during Spring 2017-Spring 2020, inclusive. Finally, $\hat{\text{T}}_{ihcs}$ is the predicted treatment intensity, and is a continuous measure ranging from 0 to 1. The larger $\hat{\text{T}}_{ihcs}$, the more likely a student is predicted to have enrolled in a remedial education course in subject s within the first semester of enrollment. I control for both the predicted treatment intensity for English ($s = Eng.$) and math ($s = math$).

The coefficient of interests are β_1 and β_2, and fixed effects λ_c and λ_h are estimated at the college and high school level. X_{ict} is a vector of controls, including a linear time trend, and student controls for gender, race, age (in months), socioeconomic disadvantage status, and 6th grade standardized test scores in both ELA and math.

4.1 Model Selection and Predicted Treatment Intensity

To model predicted treatment intensity, I fit a lasso-logistic model to identify the best factors to predict the probability that a student would have enrolled in remedial education before the passing of remedial education reforms without overfitting the model. I use characteristics chosen from the CDE dataset to estimate a logit model calculating the probability a student would have been placed in remedial education, had these reforms not been passed.[26]

Important variables included in the lasso choice set are standardized test scores in both English and math; however, because California switched from the CST standardized test to the SBAC standardized test in 2014, and the two tests are not comparable over time, I use 6th grade test scores, which are the most recent test scores such that all students in the sample take the same version (CST).[27]

For this analysis, I focus specifically on students who decide to enroll in community college immediately after high school. This sample restriction is also partially due to data limitations after the implementation of AB 705 in 2017.[28] This constraint ensures that students in the later cohorts have an equal opportunity to enroll in community college as students who graduated high school earlier. Furthermore, depending on the timing of enrollment, these remedial education reforms might be more or less salient, depending on the student's goals. For example, "traditional" students' goals lean more towards 4-year transfer and degree receipt compared to students who might be enrolling in community college after spending time in the labor force thus making AB 705 more salient for their course selection. Findings from Calcagno et al (2007) and Jepsen (2006) support the idea that remediation might have positive effects for nontraditional students, in contrast to the somewhat negative effects of remediation on traditional students.

To find the predicted treatment intensity variables, I regress actual remedial education status on a host of characteristics chosen using the lasso logit methodology, a purely data-driven process that does not rely on a theoretical basis for choosing variables for prediction. This allows me to be agnostic as to why certain variables should or should not predict remedial education status.

The lasso logit methodology is a method of choosing variables to improve the prediction accuracy of a model, and in particular works to minimize the following equation:

[26]The complete list of the CDE variable choice set is in the Appendix.

[27]A potential robustness check could be to use only students with SBAC scores. However, this would exclude cohorts before 2013, who are the control group necessary for the analysis.

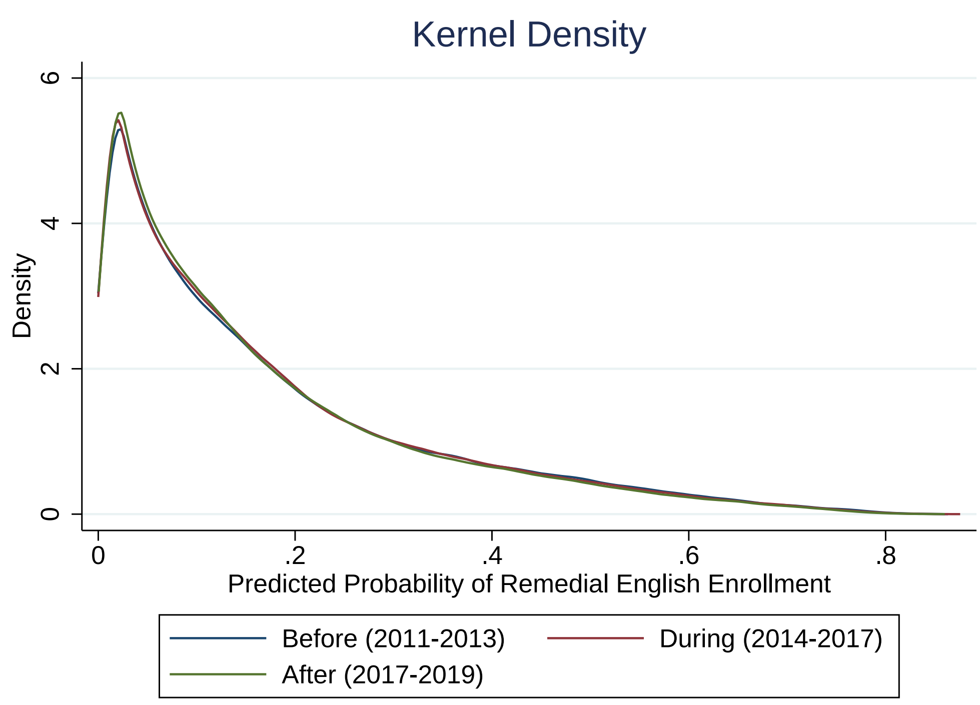
[28]This restriction is also due to being in between two different standardized test regimes.

$$L + \lambda(\sum |\beta_1| + |\beta_2|) + |\beta_3|) + ... \tag{2}$$

where L represents the log likelihood function, but the parameter of importance is λ, the penalization parameter. Various methods can be used to choose this parameter, but I use adaptive lasso, which is typically used when the goal is model selection. This particular method typically yields fewer variables than other methods.

I fit separate models for both predicted English and math remediation during the first semester of enrollment. I use only students who enroll in community college during 2011-2013, before any reforms to remedial education or course selection occurred, to create my prediction model. Furthermore, I focus on students who enroll in at least one credit-bearing course.[29]

Figure 1: Distribution of Predicted Probability of Remedial English Enrollment



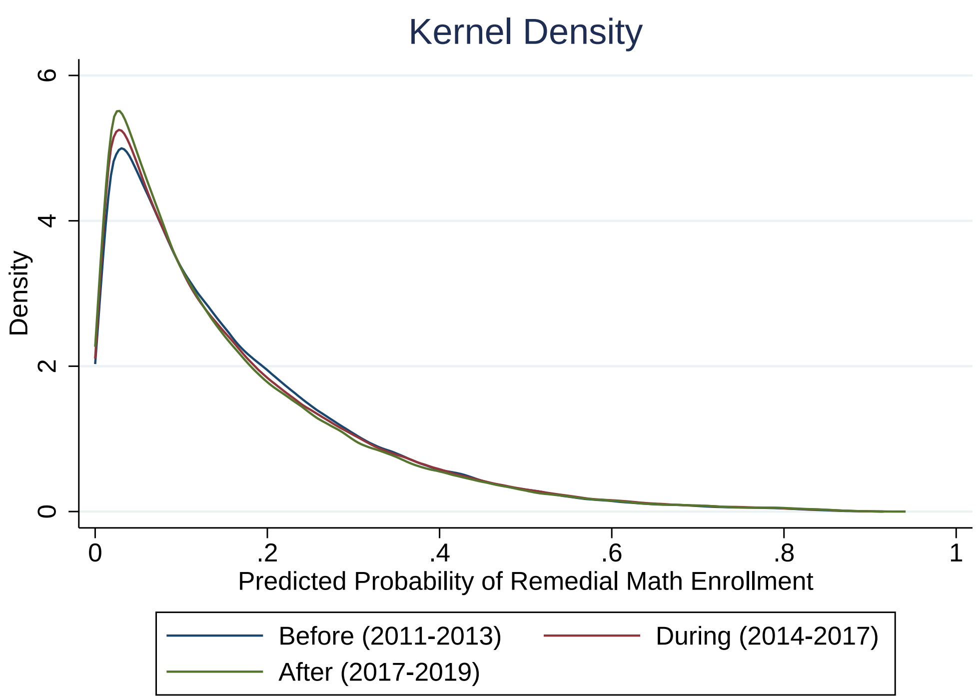
To predict whether a student would have enrolled in a remedial course within the first semester of

[29]Both transfer-level and remedial courses are credit-bearing, but remedial courses do not count towards a degree.

enrollment, I estimate separate binary logit models using the model chosen by the adaptive lasso method for each subject. These predictions are then included in Equation 1 as $\hat{\mathrm{T}}_{ihcs}$, as a continuous measure of treatment intensity, and represent the perceived college readiness of the student had the student been enrolled in community college during the period before any policy change.[30]

I plot the distributions of the predicted probability of being enrolled in remedial English in the first semester of enrollment for students before, during, and after remedial education reforms in Figure 1.

Figure 2: Distribution of Predicted Probability of Remedial Math Enrollment



Comparing the kernel densities of predicted probability of enrolling in remedial English for students in community college before, during, and after remedial education policy changes, there are fewer students with lower predicted probabilities of remedial English enrollment in community college during the "before" period (Fall 2011 - Spring 2013), compared to students in the "intermediate" (Fall 2014 - Fall 2017) and "after" (Spring 2017 - Spring 2020) period. Similarly, there are slightly fewer students with lower pre-

[30] Table 14 in the online appendix displays the selected model and associated coefficients for predicting English remedial participation and math remedial participation for students during the first semester a student is enrolled, respectively.

dicted probabilities of remedial English enrollment in the intermediate period compared to the after period. However, with respect to students with higher predicted probabilities of remedial English enrollment, the densities across time periods seem similar. The distribution of the predicted probability of remedial English enrollment is statistically significantly different across time periods.

Figure 2 shows that the distributions of the predicted probability of enrolling in a remedial math course, within the first semester of community college enrollment. There is a larger difference in the distribution of the predicted probabilities of math remedial enrollment compared to the distribution of the predicted probabilities of English remedial enrollment. Again, students in the period after the policy change are more likely to have a lower predicted probability of enrolling in remedial math than students in the period before and during remedial education policy changes.

5 Summary Statistics and Descriptive Trends

To understand how these policies may have affected community college students' course selection, I first graph course participation trends, separately by English and math course participation, and conditional on being in my sample of recent high school graduates.

Figure 3 graphs the proportion of students enrolling in each type of English course. I define "on-time" to be students who enrolled in community college during the first year after high school graduation. I focus on the student's first semester of attendance during this first year. Although the focus of this paper is on transfer-level and remedial course participation, I include participation in the non-transferable, degree-credit courses, such that the graph represents all English course takers.[31]

As seen in Figure 3, course participation rates in both transfer-level and remedial English are relatively flat from 2011-2013. After the implementation of the multiple measures mandate in 2013, represented by the red dashed line, there begins a steady increase in transfer-level course taking, as well as a slight decrease

[31] There are also non-degree credit, non-remedial courses, but the proportion of students enrolled in those courses are relatively stable and close to 0 across all years. Graphs including those trends are included in the Appendix.

Figure 3: English Course Taking

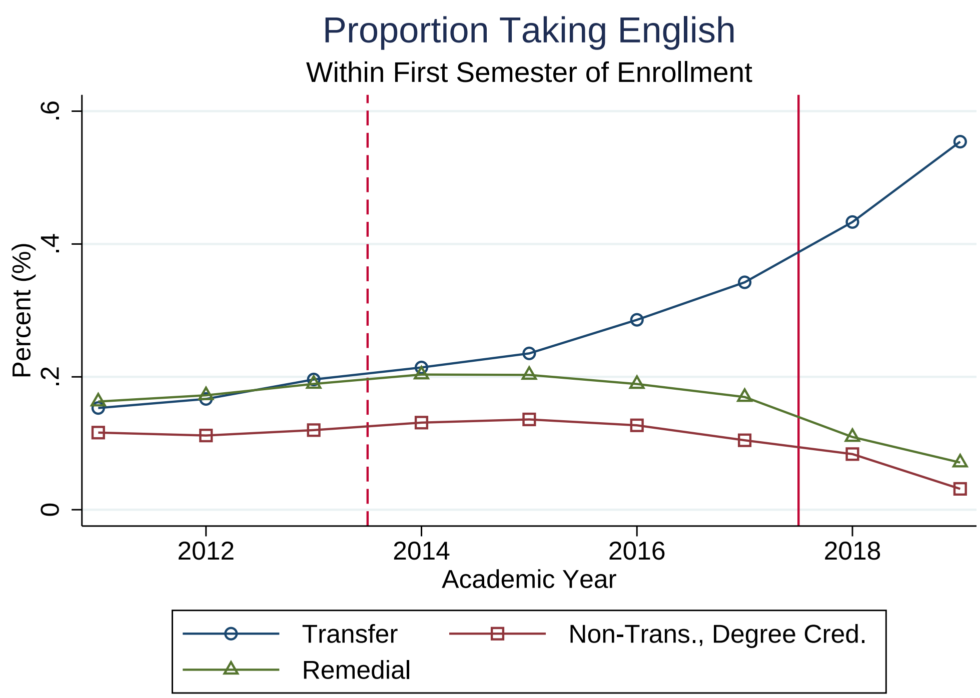
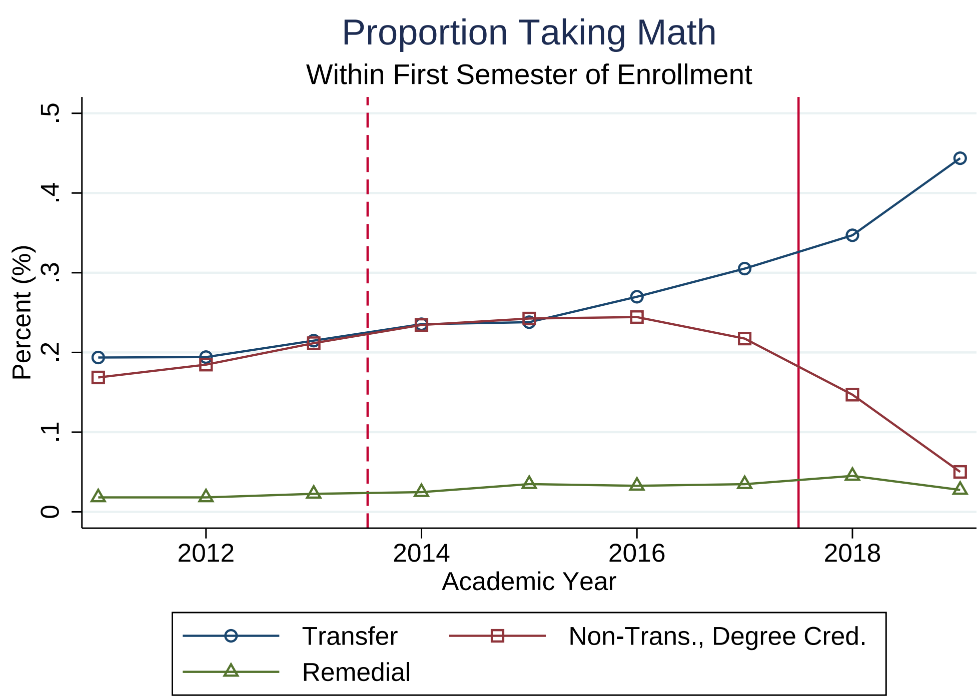


Figure 4: Math Course Taking



in remedial English course taking. By 2017, after AB 705, as represented by the solid red line, there are more precipitous increases in transfer-level English course participation, and decreases in remedial English course taking. There are similar, although somewhat muted, patterns regarding math course participation rates, as shown in Figure 4.

5.1 Composition Changes

It is possible that the changes in course participation rates as seen in Figure 3 and Figure 4 are not a result of policy changes, but rather changes in composition of the students enrolling in community college during each of the separate time periods. For example, if more students with higher abilities who could directly enroll in transfer-level courses regardless of any policy reforms decided to attend community college, then this could also explain the observed increases in the proportion of students taking transfer-level courses over time.

I first present summary statistics on the average demographic characteristics over the entire period of analysis, along with summary statistics within each time period, before, during, and after the policy changes of interest, in Table 1.

On average, there have been changes regarding the composition of students enrolling in community college over time. For example, the proportion of male, Asian, Black, and White students, along with average math standardized test score, have decreased over time, while the proportion of disabled, Hispanic, "Other Race," and socioeconomically disadvantaged students have increased. Furthermore, the predicted probability of remedial English for students enrolled in community college before any remedial education reform, is similar to the predicted probability of remedial English for students enrolled during remedial education placement reforms, but declines slightly by 0.005 percentage points on average for students enrolled after remedial education requirements were removed altogether. A similar pattern regarding the predicted probability of remedial math enrollment is seen across these three time periods as well, with students enrolled in

Table 1: Student-Level Summary Statistics - Demographics

	All (F2011-SP2020)	Before (F2011-SP2013)	Intermediate (F2014-F2017)	After (SP2017-SP2020)
Male	0.498	0.501	0.499	0.491
	(0.500)	(0.500)	(0.500)	(0.500)
Disabled	0.0701	0.0602	0.0664	0.0914
	(0.255)	(0.238)	(0.249)	(0.288)
Asian	0.123	0.129	0.120	0.121
	(0.329)	(0.335)	(0.325)	(0.326)
Hispanic	0.509	0.464	0.521	0.549
	(0.500)	(0.499)	(0.500)	(0.498)
Black	0.0592	0.0652	0.0585	0.0522
	(0.236)	(0.247)	(0.235)	(0.222)
Other Race	0.0317	0.0290	0.0308	0.0374
	(0.175)	(0.168)	(0.173)	(0.190)
White	0.285	0.325	0.277	0.248
	(0.451)	(0.468)	(0.448)	(0.432)
Age (in months)	142.5	142.5	142.6	142.5
	(4.913)	(4.928)	(4.954)	(4.810)
Economic Disadvantage	0.535	0.492	0.550	0.566
	(0.499)	(0.500)	(0.497)	(0.496)
CST ELA Z-Score	-0.0221	0.00381	-0.0380	-0.0274
	(0.851)	(0.837)	(0.853)	(0.865)
CST Math Z-Score	-0.0590	-0.0368	-0.0622	-0.0806
	(0.904)	(0.976)	(0.888)	(0.839)
Pr(Remed. Eng.)	0.174	0.176	0.175	0.170
	(0.163)	(0.166)	(0.163)	(0.160)
Pr(Remed. Math)	0.163	0.165	0.164	0.160
	(0.150)	(0.148)	(0.151)	(0.150)
Observations	1213138	387780	549131	275857

community college after AB 705 having, on average, 0.004 percentage points lower predicted probabilities of math remedial enrollment. This could be concerning if patterns regarding changes in ability as proxied by standardized test scores follow a similar pattern regarding the outcomes of interest.

Looking at average outcomes of interest across time for each time period, Table 2 shows that there is suggestive evidence that, while remedial education placement reforms might not have resulted in the course placement improvements intended, this was not the case with AB 705. Remedial course enrollment in both math and English actually increased slightly by 1.6 and 2.4 percentage points, respectively during the period of remedial education placement reform. However, after AB 705 was implemented, from 2017-2019, remedial English enrollment decreased by almost 10 percentage points, and remedial math enrollment decreased by 8.7 percentage points.

There are also large increases in transfer-level enrollment, for both English and math, and for both the intermediate period during remedial educational placement reforms, and after AB 705 was passed.

However, it is also arguable that there are larger increases in transfer-level participation after AB 705 was passed, relative to the increases during the intermediate period after remedial education placement reforms in 2013. For example, there was a 52.7 percent increase in transfer English participation, and a roughly 40 percent increase in transfer math participation, from before any remedial reforms were implemented to the intermediate period during remedial education placement reforms. However, there were much larger increases in transfer-level participation when comparing the "before" period to the "after" period. Both English and math transfer-level participation experienced an over 100 percent increase, when comparing before any remedial education reforms to after the institution of remedial education was discouraged altogether.

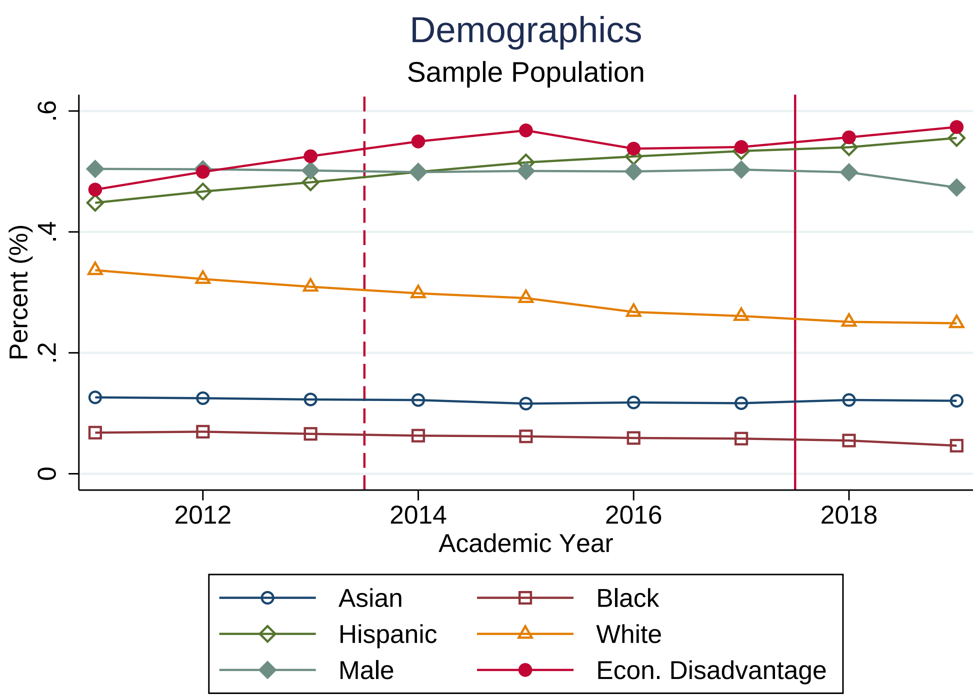
I also observe encouraging increases in transfer-level course pass rates, as well as increases in the number of units attempted and earned, both overall and specifically transfer-level units.

Next, I disaggregate these summary statistics to focus on how these demographic characteristics trend over time, and whether these trends move smoothly over time. Again it might be concerning if there are large

Table 2: Student-Level Summary Statistics - Outcomes

	All (F2011-SP2020)	Before (F2011-SP2013)	Intermediate (F2014-F2017)	After (SP2017-SP2020)
Remed. Eng. Enrollment	0.163	0.173	0.190	0.0955
	(0.369)	(0.378)	(0.392)	(0.294)
Remed. Math Enrollment	0.166	0.170	0.194	0.107
	(0.373)	(0.376)	(0.395)	(0.309)
Transfer Eng. Enrollment	0.293	0.180	0.275	0.488
	(0.455)	(0.384)	(0.447)	(0.500)
Transfer Math Enrollment	0.158	0.102	0.142	0.267
	(0.364)	(0.302)	(0.349)	(0.443)
Pass Transfer-Level English	0.236	0.139	0.223	0.399
	(0.425)	(0.346)	(0.416)	(0.490)
Pass Transfer-Level Math	0.112	0.0707	0.103	0.186
	(0.315)	(0.256)	(0.304)	(0.389)
Non-Transfer, Degree-Credit Eng.	0.105	0.119	0.124	0.0470
	(0.306)	(0.323)	(0.330)	(0.212)
Non-Transfer, Degree-Credit Math	0.185	0.181	0.215	0.130
	(0.388)	(0.385)	(0.411)	(0.337)
Total Units Attempted	10.94	10.37	11.04	11.53
	(4.128)	(4.287)	(4.002)	(4.046)
Total Units Earned	7.857	7.618	7.955	8.002
	(5.190)	(5.073)	(5.177)	(5.365)
Transfer Units Attempted	9.084	8.090	9.087	10.47
	(4.334)	(4.315)	(4.206)	(4.224)
Transfer Units Earned	6.825	6.077	6.918	7.690
	(4.816)	(4.591)	(4.737)	(5.112)
Observations	1213138	387780	549131	275857

Figure 5: Demographic Trends over Time

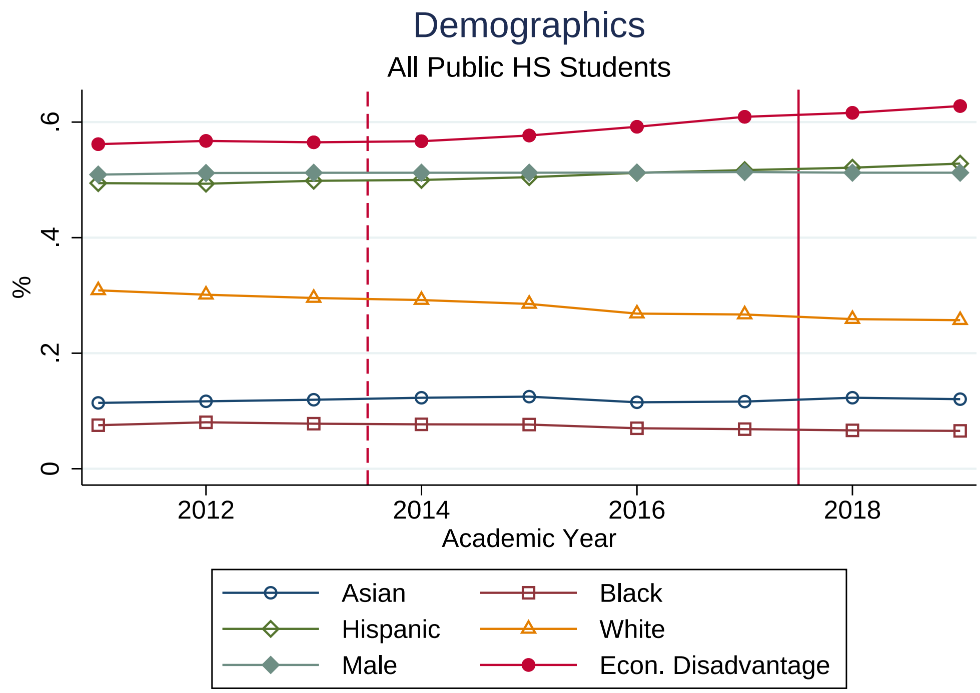


discrete changes in student composition at the same time as the policy changes, which could potentially be the true driver of effects observed, instead of the policy changes.

Figure 5 graphs these trends over time, plotting for each year the proportion of students enrolled for each demographic characteristic. The proportion of Asian, Black, and male students enrolled in community college are relatively stable over time, across all policy periods of interest. Although the proportion of Hispanic, white, and socioeconomically disadvantaged students are increasing over time, these changes are smooth across the vertical lines representing the year of policy reform, suggesting that these changes are not driving any changes in outcomes observed.

Furthermore, to show that these changes are merely reflective of overall demographic shifts in the state of California, I graph the demographic trends over time for all public high school students in California over this time, instead of only students who enroll in community college. Figure 6 displays very similar trends in demographic composition across time as students enrolled in community college, with slight decreases in

Figure 6: Demographic Trends over Time



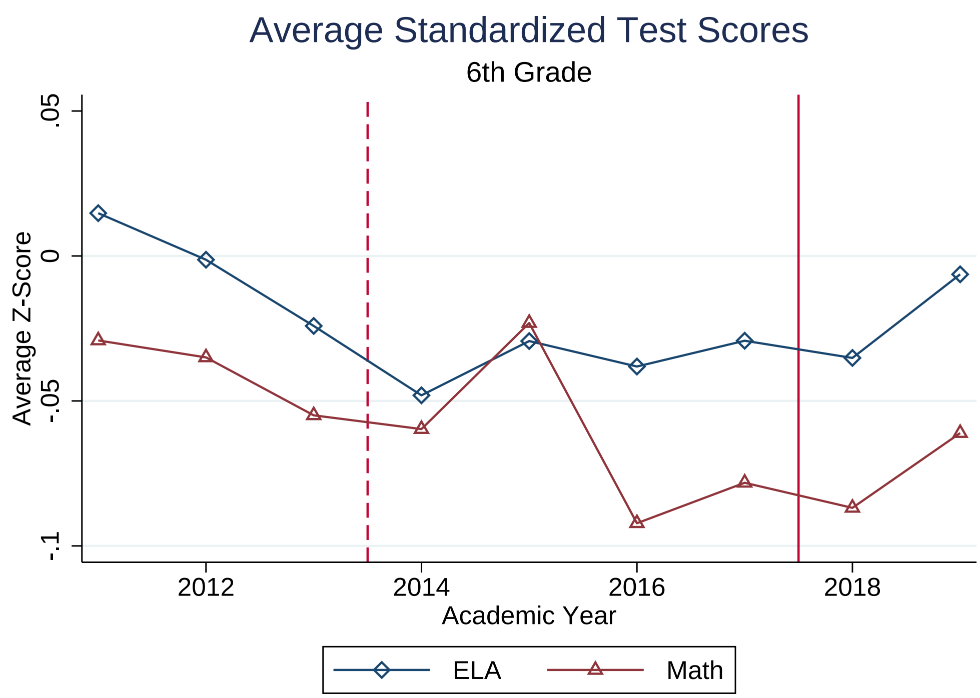
the proportion of white students, and slight increases in the proportion of Hispanic and socioeconomically disadvantaged students. This suggests that any shifts in demographic composition are not driven by changes in selection by students enrolling in community college.

I also graph the trends in average standardized test scores in both English (ELA) and math across time for each cohort in Figure 7. As previously mentioned, I have to use 6th grade exam scores as a result of data constraints. California switched from the California Standards Test (CST) exam to the Smarter Balance Academic Consortium (SBAC) exam in 2014. These tests are not comparable to each other. Consequently, to ensure that all students in my sample are taking the same exam during the same grade, I must use students' 6th grade exam scores. In addition, to compare these exam scores across cohorts, I standardize each cohort's test scores by finding their z-score.[32]

To further investigate whether the observed changes in course participation could stem from a change

[32] $z = \frac{x-\bar{x}}{\sigma_x}$.

Figure 7: Average Standardized Test Scores over Time



in the combination of demographic and ability variables, I predict the probability of enrolling in a transfer-level English or math course. I use various demographic variables, such as race, gender, socioeconomic status, and ELA and math standardized test scores to predict transfer-level course taking in either English and math for students enrolled in community college in the period before any policy change. I then use that prediction model to estimate the proportion of students likely to take transfer-level courses based on these variables alone. This exercise is to show that, if changes in these demographic and ability variables are actually the reason behind the observed course selection changes, then these predictions should be able to project a similar trend as the observed course selection changes.

I graph the average likelihood of taking a transfer-level course by year, along with the actual proportion of students taking a transfer-level course. As Figure 8 shows, the predicted proportion of students enrolled in transfer-level English based on demographic and ability characteristics alone is very stable and flat across all time periods, relative to the actual proportion of students enrolled in transfer-level English.

Figure 8: Predicted English Transfer-Level Course Taking

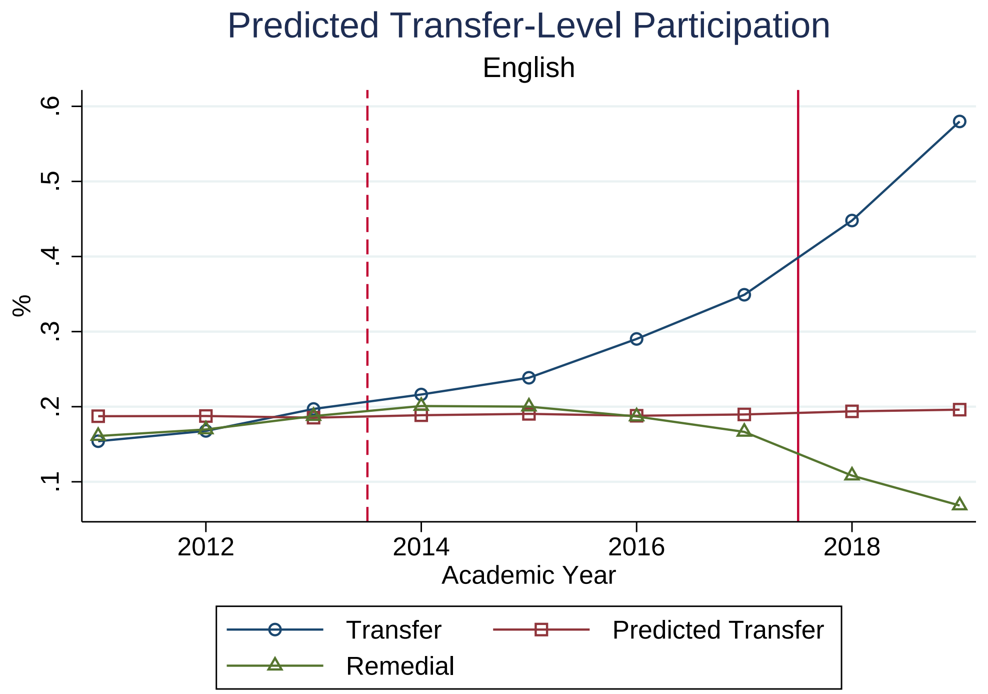
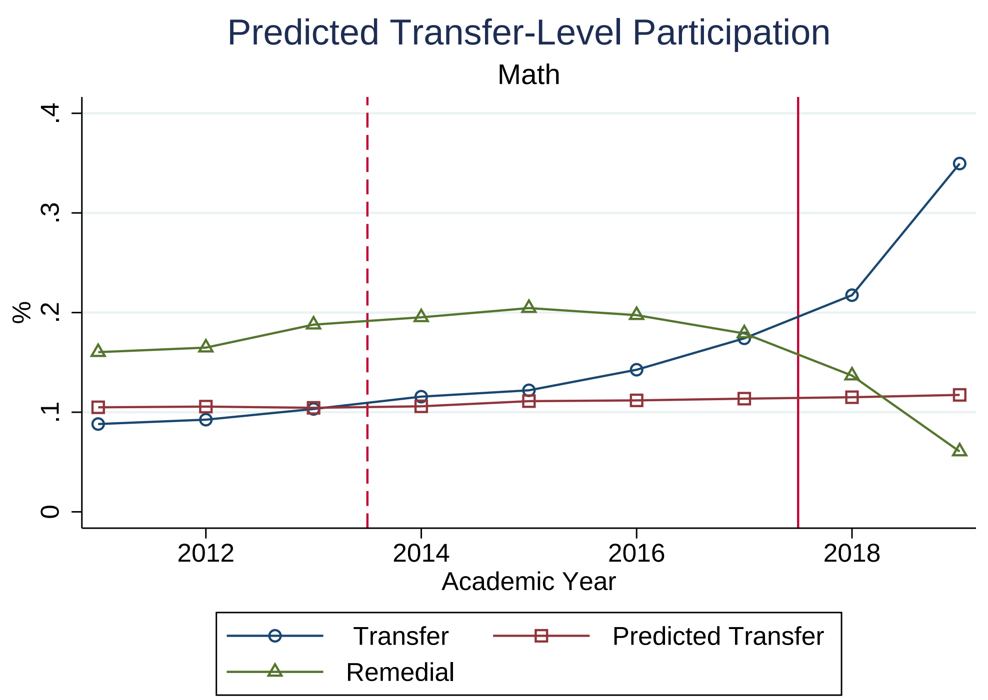


Figure 9: Predicted Math Transfer-Level Course Taking



Similarly, Figure 9 shows that the predicted proportion of students enrolled in transfer-level math based on demographic and ability characteristics is incredibly flat across all time periods, especially when compared to the actual transfer-level course participation observed over time. These graphs provide evidence that changes in transfer-level course participation in either English or math do not stem from composition changes in the students deciding to enroll in community college across time, and instead are likely driven by changes in policy.

6 Results

I investigate how students are affected by the two sets of policy changes. The first policy change consisted of the multiple measures mandate implemented in 2013. As hypothesized earlier, this measure is likely to affect students who had higher levels of academic preparation. In contrast, AB 705 with its effective removal of remedial education requirements, is likely to affect most the students with the lowest level of academic preparation.

6.1 Overall

I first examine how these two bundles of policies affected all students on average. Table 3 displays the average treatment effects of each policy period. The "Pass with a C" outcome is a binary measure, and equals 1 if a student received a C or better in a transfer-level course in English or math respectively, and 0 if otherwise. As many students might not elect to enroll in transfer-level courses, I assign those students a 0 as well for this variable, and thus capture the intent-to-treat (ITT) effect of the policies.

Table 3: Changes in Course-Taking

	Any	Remedial	Transfer-Level	Pass C
English Course Taking	(1)	(2)	(3)	(4)
Intermediate	0.127***	0.016**	0.110***	0.097***
	(0.010)	(0.007)	(0.007)	(0.006)
After	0.156***	-0.074***	0.310***	0.265***
	(0.014)	(0.012)	(0.014)	(0.010)
Average	0.472	0.173	0.180	0.139
Observations	951506	951506	951506	951506
Student Controls	X	X	X	X
High School FE	X	X	X	X
College FE	X	X	X	X
Predicted Treatment Intensity	X	X	X	X
Math Course Taking	(1)	(2)	(3)	(4)
Intermediate	0.100***	0.024***	0.044***	0.036***
	(0.009)	(0.005)	(0.004)	(0.003)
After	0.043***	-0.057***	0.161***	0.112***
	(0.012)	(0.010)	(0.010)	(0.007)
Average	0.455	0.170	0.102	0.071
Observations	951506	951506	951506	951506
Student Controls	X	X	X	X
High School FE	X	X	X	X
College FE	X	X	X	X
Predicted Treatment Intensity	X	X	X	X

Notes: For purposes of comparison, the average is calculated using only students enrolled in community college before any policy change (2011-2013). Student controls include indicators for gender, disability, race, and socioeconomic disadvantaged, with linear controls for age (in months), and standardized test scores. Standard errors are clustered at the community-college level.

"Intermediate" represents the initial period of policy reform from Fall 2014 - Fall 2017, covering the multiple measures mandate. Following the multiple measures mandate, remedial English enrollment increases 1.6 percentage points, while transfer-level English enrollment increases 11 percentage points, and the probability of passing transfer-level English with a C or better increases by 9.7 percentage points. The treatment-on-the-treated effect (TOT) is 88.2 percent (0.97/0.110), suggesting that, conditional on enrolling in an English transfer-level course, 88.2 percent of those students passed with a C or better. This is considerably higher than the transfer-level English pass rate during the period before any policy was implemented, at 77.22 percent (0.139/0.180).

Next studying students enrolled in the "after" period (i.e. after the implementation of AB 705 in Fall 2017), there are significantly larger effects on course selection. There is, a large decline in the proportion of students enrolling in remedial English after AB 705, of 7.4 percentage points, suggesting that the policy did have the intended effect. There is a comparatively larger effect on transfer-level English enrollment, at a 31 percentage points, with a corresponding increase in the probability of passing transfer-English of 26.5 percentage points. This translates to a TOT effect of 85.48 percent (0.265/0.310), which again is higher than the transfer-level English pass rate of 77.22 percent before any course selection policy was implemented. This suggests that, if we assume the influx of students enrolling in transfer-level English were indeed all students who would have been placed in remedial education in the regime before AB 705 was implemented, then 85 percent of them could have passed transfer-level English had they not been recommended to take remedial English.

Next, I conduct a similar analysis on math course enrollment. During the intermediate period during which the multiple measures mandate was passed, students were more likely to be enrolled in remedial math by 2.4 percentage points, more likely to be enrolled in transfer-level math by 4.4 percentage points, and also more likely to pass transfer-level math by 3.6 percentage points, than students who were enrolled in community college before any remedial education reform was passed. With respect to the effects observed during the same period for English course taking, the results for math course taking are comparatively smaller. The TOT effect for students passing transfer-level math is 81.81 percent (0.036/0.044), which is much higher compared to the pass rate of 69 percent (0.071/0.102) during the period before any remedial education reform.

There are also comparatively larger effects after AB 705 passed in 2017 relative to the intermediate period. There is a decrease in the probability of enrolling in a remedial math course of 5.7 percentage points, an increase in the proportion of the students taking a transfer-level math course of 16.1 percentage points, and a corresponding increase of passing transfer-level math with a C or better of 11.2 percentage points. The TOT effect is 69.5 percent (0.112/0.161), which is comparable to the pre-policy transfer-level math course pass rate of 69 percent.

Finally, I look at how these policies affected overall course load for students. I find that the number of both overall units, which include remedial courses in its count, and transfer-level units earned and attempted increased across both time periods. That the increase in overall units is smaller than the increase in transfer-level units, but still positive, suggests that although some students fully substituted remedial courses for transfer-level courses, some might have attempted other additional transfer-level courses, and thus attempting more units overall.

I find that that overall course completion rates were larger in the intermediate period (51 percent) than the “after” period (28.7 percent), but both overall course completion rates were lower than the before policy overall course completion rate of 73.5 percent. However, these overall course completion rate comparisons might be somewhat misleading, as students could be substituting remedial education courses for transfer-level courses in a multitude of ways. In contrast, the transfer-level course completion rate during the intermediate period of policy reform (Fall 2014 - Fall 2017) of 84.1 percent (0.872/1.037) is actually higher than the analogous completion rate of 75 percent before any policy change (Fall 2011 - Spring 2013), as well as the transfer-level completion rate of students after AB 705 passed at 66.5 percent. This result suggests that after AB 705 was passed, students might have been attempting more transfer-level units than they could handle.

Taking all of these results together, there are two noticeable patterns. First, that relative to English course-taking results, there are much smaller effects on math course-taking. Anecdotal evidence indicates that students are more hesitant to take transfer-level math courses[33] and that advisors are likely to suggest below transfer-level math placement for students with lower levels of college readiness (Cuellar Meija et al., 2021)

Second, another interesting pattern is that TOT effects on transfer-level pass rates, as well as transfer-level course completion rates, tend to be higher during the intermediate period of reform (Fall 2014 to Fall 2017) when the multiple measures mandate was implemented, compared to the TOT effects for students after AB 705 was passed. This points to suggestive evidence that each set of policies affect students at opposite ends of the college readiness scale. In other words, the remedial education placement reforms affects students on the margin of requiring remedial education, or with higher levels of academic preparation, while AB 705 affects students with lower levels of academic preparation. In order to test this hypothesis rigorously, I next conduct a heterogeneity analysis, grouping students by their predicted probability of enrolling in a remedial course, a proxy for perceived college readiness.

6.2 Heterogeneity Analysis

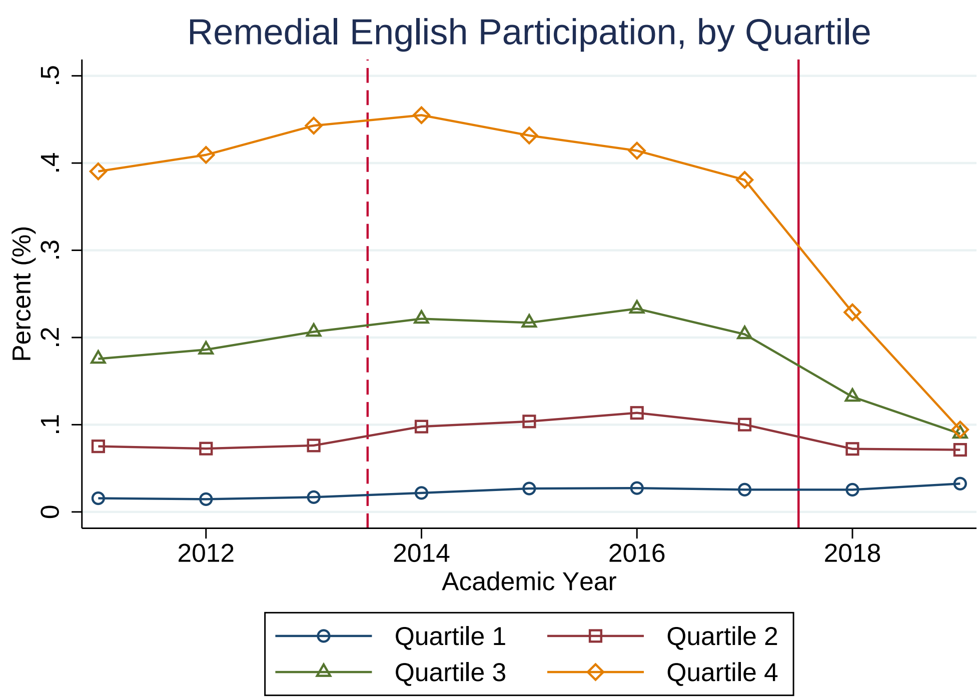
To conduct the heterogeneity analysis, I split the sample into four quartiles, based on students' predicted probability of enrolling in remedial education (predicted treatment intensity), separately for English and math. Students in the first quartile are those who are deemed the most academically prepared, and students in the fourth quartile are those who are deemed the least academically prepared, as under the old remedial education system before any policy change, which focused on standardized exams.

[33]"Overcoming Math Anxiety." Mission College Santa Clara. *https://missioncollege.edu/depts/math/math-anxiety.html*. Accessed 07 Jan 2022.

6.2.1 Course Taking

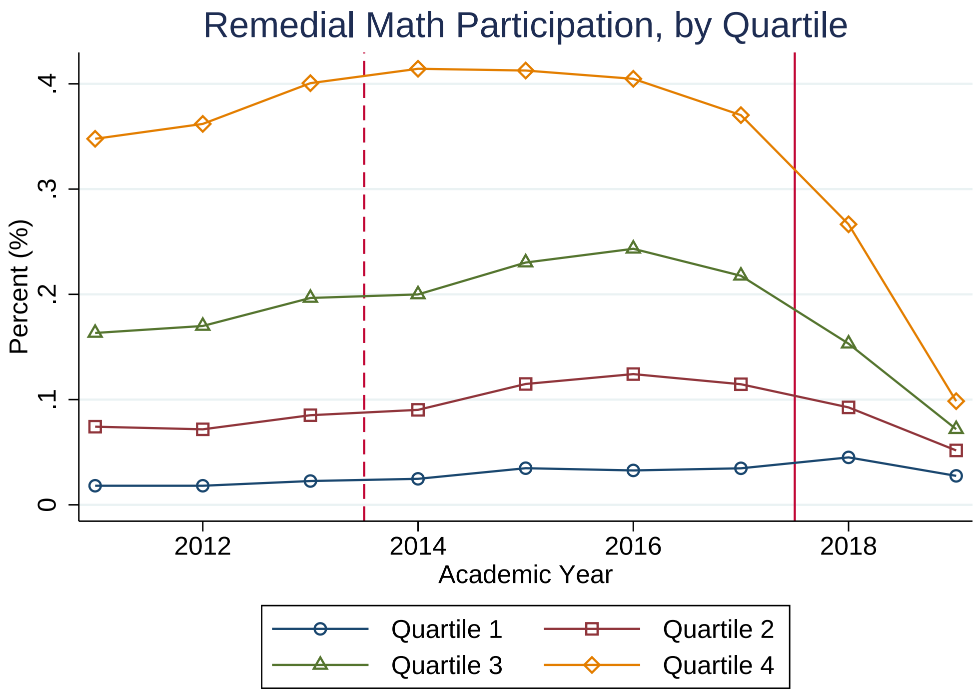
I first graph the proportion of students within each predicted probability quartile enrolled in remedial English and math, respectively, in Figure 10 and Figure 11. The red dashed line represents when the multiple measures mandate was implemented in 2013, and the red solid line represents when AB 705 was implemented in 2017.

Figure 10: Remedial English Course Taking, by Quartile



Although there are moderate increases in both the proportion of students taking remedial English and remedial math before any policy change for students in the 3rd and 4th quartile, the proportion of students enrolled in remedial English and math is relatively stable for students in the 1st and 2nd quartiles, or the students who are deemed most academically prepared. There is a slight decrease in the proportion of students in the 4th quartile taking remedial English and math in the intermediate period, and slight increases in the proportion of students in the 3rd and 2nd quartile taking remedial English and math, while the proportion of students in the 1st quartile stays relatively steady and close to zero.

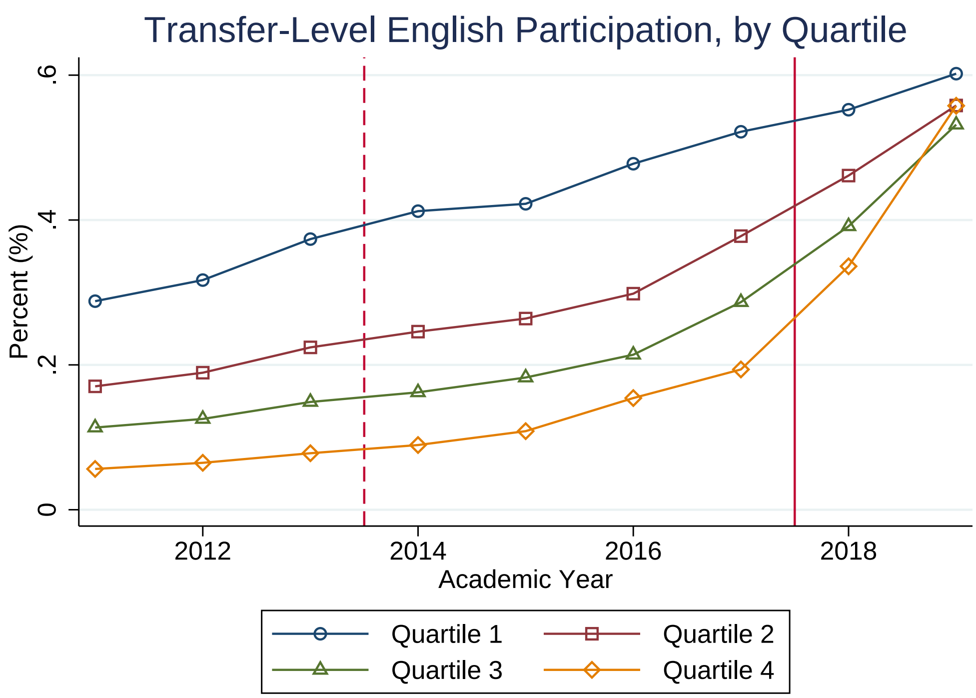
Figure 11: Remedial Math Course Taking, by Quartile



However, the most interesting trends are observed in the period after AB 705 was passed, with large declines in remedial participation concentrated among students in the 3rd and 4th quartiles, or the quartiles of students deemed the least college ready.

Similarly, Figure 12 and Figure 13 graph transfer-level course participation in both English and math by quartile, respectively. Again, there is a gradual positive trend in English transfer-level participation among students in the 1st quartile, although for the other quartiles, transfer-level English participation is relatively flat before any policy change, from 2011-2013. With respect to math transfer-level participation trends, the proportion of students enrolled remains relatively stable for all quartiles. However, for both English and math, there is a steady increase in transfer-level course participation during the intermediate period of policy change. In contrast, after AB 705 was passed, while there are increases in transfer-level participation at steeper rates for students in the 2nd and 3rd quartile than for students in the first quartile, the sharpest increase observed is for students in the 4th quartile, or students deemed least prepared for college.[34]

Figure 12: Transfer English Course Taking, by Quartile



There is not, however, a similar pattern observed for math transfer-level participation by quartile; although there are increases in transfer-level participation across all quartiles, the largest participation rate increase is not concentrated among students in the 4th quartile.[35]

[34] The observed increase in transfer-level English course participation rates after the implementation of AB 705 were 0.040, 0.098, 0.122, and 0.221, for quartiles 1, 2, 3, and 4, respectively.

[35] In contrast, the observed increase in transfer-level math course participation rates after the implementation of AB 705 were 0.07, 0.116, 0.125, and 0.08, for quartiles 1, 2, 3, and 4, respectively.

Figure 13: Transfer Math Course Taking, by Quartile

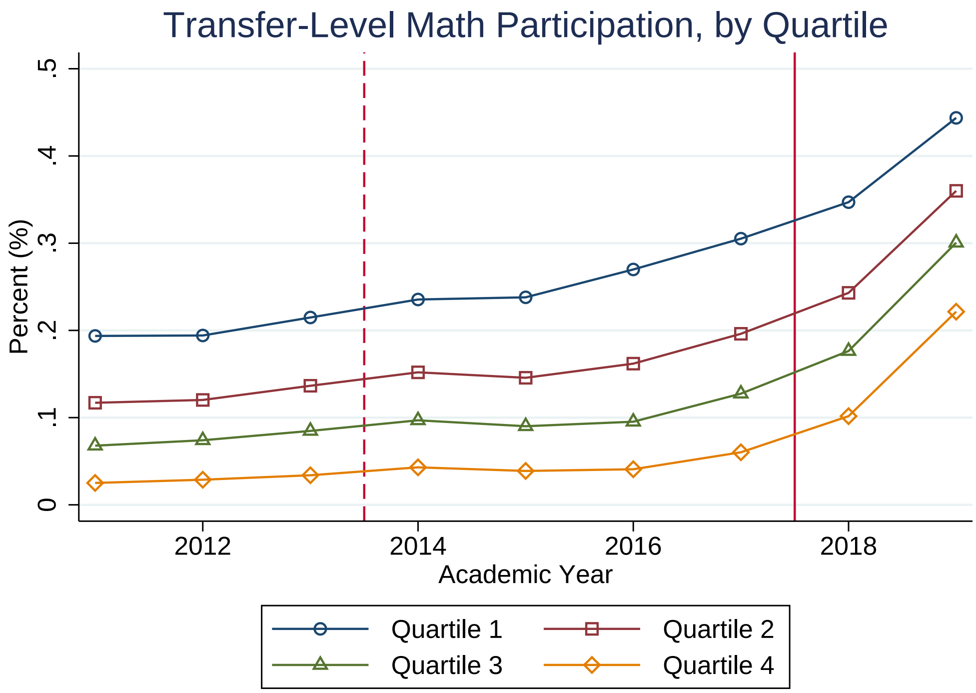


Table 4 shows how each quartile of students were affected by the policy changes. Again, as noted earlier, students in the 1st, 2nd, and 3rd quartiles experienced a slight increase in remedial English participation, from 0.9 - 2.8 percentage points, during the intermediate period of policy change from Fall 2014 - Fall 2017. However, after AB 705 was implemented, the overall decline in remedial English participation as observed in Table 3 is driven by large declines in English remedial participation by students in the top two quartiles, or the students who are deemed the least academically prepared. Furthermore, it is students in the 4th quartile, who are 23 percentage points less likely to be enrolled in English remediation.

Table 4: Remedial English Course Taking, By Quartile

Remedial English	Overall (1)	1st Qrt (2)	2nd Qrt (3)	3rd Qrt (4)	4th Qrt (5)
Intermediate	0.016**	0.009**	0.028***	0.028***	0.005
	(0.007)	(0.004)	(0.009)	(0.010)	(0.015)
After	-0.073***	0.012***	-0.004	-0.076***	-0.230***
	(0.012)	(0.004)	(0.009)	(0.012)	(0.021)
Average	0.173	0.016	0.076	0.194	0.420
Observations	951506	239698	238324	237718	234091
Student Controls	X	X	X	X	X
High School FE	X	X	X	X	X
College FE	X	X	X	X	X
Predicted Treatment Intensity	X	X	X	X	X

For purposes of comparison, the average is calculated using only students enrolled in community college before any policy change (2011-2013). Student controls include indicators for gender, disability, race, and socioeconomic disadvantaged, with linear controls for age (in months), and standardized test scores. Standard errors are clustered at the community-college level.

Looking at English transfer-level course participation in Table 5, there are large increases in transfer-level English course participation across all quartiles, for both time periods. Comparatively, the increases in participation are larger for students enrolled in the "after" period relative to students enrolled in the intermediate period. Furthermore, there are additional patterns that support the hypothesis that the multiple measures mandated implemented during the intermediate policy period affected more students who were more academically prepared, and AB 705 affected more strongly students who were deemed less academically prepared. The increase in transfer-level participation increases at a decreasing rate across quartiles, for students enrolled in the intermediate period, while the opposite pattern is observed for transfer-level participation during the period AB 705 was passed, with students in the 4th quartile experiencing the largest increase in transfer-level English participation.

Table 5: Transfer-Level English Course, By Quartile

Transfer-Level English	Overall (1)	1st Qrt (2)	2nd Qrt (3)	3rd Qrt (4)	4th Qrt (5)
Intermediate	0.110***	0.139***	0.108***	0.093***	0.080***
	(0.007)	(0.014)	(0.010)	(0.009)	(0.009)
After	0.310***	0.237***	0.293***	0.319***	0.370***
	(0.014)	(0.021)	(0.018)	(0.017)	(0.022)
Average	0.180	0.333	0.201	0.134	0.069
Observations	951506	239698	238324	237718	234091
Student Controls	X	X	X	X	X
High School FE	X	X	X	X	X
College FE	X	X	X	X	X
Predicted Treatment Intensity	X	X	X	X	X

Notes: For purposes of comparison, the average is calculated using only students enrolled in community college before any policy change (2011-2013). Student controls include indicators for gender, disability, race, and socioeconomic disadvantaged, with linear controls for age (in months), and standardized test scores. Standard errors are clustered at the community-college level.

Finally, Table 6 displays the effects of each policy period on whether or not students pass transfer-level English with a C or better. For the intermediate policy period, the increase in the probability of passing transfer-level English is positive across all four quartiles of students, but declines moving from students with the highest level of academic preparation in the 1st quartile to students with the lowest level of academic preparation in the 4th quartile. In contrast, after AB 705 was passed, the observed pattern is reversed, with students in the 4th quartile experiencing the largest increase in the probability of passing transfer-level English with a C or better, at 28.4 percentage points.

When looking across all four quartiles, the pass rate conditional on actually taking a transfer-level English course (TOT effect) is higher for students enrolled in the intermediate period than the "before" period. This pattern is similar for students enrolled in the period after AB 705 was passed, except for students in the fourth quartile, or students deemed the least college prepared, with respect to the old remedial education placement system. This finding suggests that some of the students in the fourth quartile who enrolled in transfer-level English might not yet have been prepared to take that course.

Table 6: English Pass Rates, By Quartile

Pass Rates	Overall (1)	1st Qrt (2)	2nd Qrt (3)	3rd Qrt (4)	4th Qrt (5)
Intermediate	0.097***	0.129***	0.095***	0.081***	0.068***
	(0.006)	(0.011)	(0.008)	(0.007)	(0.007)
After	0.265***	0.229***	0.258***	0.269***	0.284***
	(0.010)	(0.015)	(0.011)	(0.012)	(0.014)
Conditional Pass Rates					
Before	0.772	0.793	0.774	0.758	0.806
Intermediate	0.882	0.928	0.880	0.871	0.850
After	0.855	0.966	0.881	0.843	0.768
Average	0.139	0.265	0.154	0.100	0.054
Observations	951506	239698	238324	237718	234091
Student Controls	X	X	X	X	X
High School FE	X	X	X	X	X
College FE	X	X	X	X	X
Predicted Treatment Intensity	X	X	X	X	X

Notes: For purposes of comparison, the average is calculated using only students enrolled in community college before any policy change (2011-2013). Student controls include indicators for gender, disability, race, and socioeconomic disadvantaged, with linear controls for age (in months), and standardized test scores. Standard errors are clustered at the community-college level.

I repeat the same analysis for math course taking. Overall, there are similar, though more muted patterns observed for math course taking. For example, Table 7 shows that, similar to English remedial course taking, there are small increases in math remedial participation across all quartiles during the intermediate policy change. In addition, after AB 705, there is again, an overall decrease in remedial math participation, driven by decreases in participation by students in the 3rd and 4th quartile particularly. For example, students in the 4th quartile after AB 705 was passed were 17.8 percentage points less likely to enroll in remedial math compared to students in the 4th quartile enrolled before any remedial education reform.

With respect to math transfer-level course taking, I observe similar patterns in Table 8 to that of English transfer-level course taking in Table 5. For example, there are increases in transfer-level math participation across all quartiles, and for both time periods. Furthermore, participation increases at a decreasing rate from students in the first quartile, who are deemed most college ready, to students in the fourth quarter, who are deemed the least college ready, in the intermediate policy period. However, with respect to transfer-level participation after AB 705 was passed, the increase in participation rates is no longer increasing across

Table 7: Remedial Math Course Taking, By Quartile

Remedial Math	Overall (1)	1st Qrt (2)	2nd Qrt (3)	3rd Qrt (4)	4th Qrt (5)
Intermediate	0.024***	0.012***	0.033***	0.039***	0.017*
	(0.005)	(0.003)	(0.007)	(0.009)	(0.010)
After	-0.056***	0.020**	-0.001	-0.062***	-0.178***
	(0.010)	(0.009)	(0.008)	(0.009)	(0.018)
Average	0.170	0.020	0.080	0.182	0.379
Observations	951506	228026	241467	242209	238062
Student Controls	X	X	X	X	X
High School FE	X	X	X	X	X
College FE	X	X	X	X	X
Predicted Treatment Intensity	X	X	X	X	X

Notes: For purposes of comparison, the average is calculated using only students enrolled in community college before any policy change (2011-2013). Student controls include indicators for gender, disability, race, and socioeconomic disadvantaged, with linear controls for age (in months), and standardized test scores. Standard errors are clustered at the community-college level.

quartile. Although the changes in enrollment are positive across all quartiles, the changes are relatively similar across the 1st, 2nd, and 3rd quartiles, with a slightly smaller increase for students in the 4th quartile. In fact, the increase in transfer-level math enrollment for students in the 4th quartile does not offset the decrease in remedial math participation, suggesting that despite open access, students who are deemed least ready for college math are the most hesitant to enroll in transfer-level math.

Table 8: Transfer-Level Math Course Taking, By Quartile

Transfer-Level Math	Overall (1)	1st Qrt (2)	2nd Qrt (3)	3rd Qrt (4)	4th Qrt (5)
Intermediate	0.045***	0.058***	0.042***	0.033***	0.024***
	(0.004)	(0.009)	(0.006)	(0.005)	(0.003)
After	0.161***	0.158***	0.160***	0.157***	0.134***
	(0.010)	(0.016)	(0.011)	(0.011)	(0.012)
Average	0.102	0.205	0.129	0.077	0.030
Observations	951506	228026	241467	242209	238062
Student Controls	X	X	X	X	X
High School FE	X	X	X	X	X
College FE	X	X	X	X	X
Predicted Treatment Intensity	X	X	X	X	X

Notes: For purposes of comparison, the average is calculated using only students enrolled in community college before any policy change (2011-2013). Student controls include indicators for gender, disability, race, and socioeconomic disadvantaged, with linear controls for age (in months), and standardized test scores. Standard errors are clustered at the community-college level.

Next, Table 9 next shows how students fared in transfer-level math courses after the implementation of the varying course-selection policies. Again, there are increases in the proportion of students passing transfer-level math with a C better across all quartiles and in both time periods. Similar to changes in English transfer-level pass rates, during the period of intermediate policy change, there are increases in math transfer-level pass rates at a decreasing rate, as students are less and less academically prepared (moving from the 1st quartile to the 4th). Unlike English transfer-level pass rates in the period after AB 705 was passed, math transfer-level pass rates follow a similar pattern as math transfer-level pass rates for students enrolled in the intermediate period.

Table 9: Math Pass Rates, By Quartile

Pass Rates	Overall (1)	1st Qrt (2)	2nd Qrt (3)	3rd Qrt (4)	4th Qrt (5)
Intermediate	0.036***	0.049***	0.036***	0.024***	0.016***
	(0.003)	(0.007)	(0.005)	(0.003)	(0.002)
After	0.112***	0.126***	0.112***	0.100***	0.079***
	(0.007)	(0.012)	(0.009)	(0.007)	(0.007)
Conditional Pass Rates					
Before	0.696	0.741	0.672	0.636	0.667
Intermediate	0.800	0.845	0.857	0.727	0.667
After	0.696	0.797	0.700	0.637	0.590
Average	0.071	0.152	0.086	0.049	0.020
Observations	951506	228026	241467	242209	238062
Student Controls	X	X	X	X	X
High School FE	X	X	X	X	X
College FE	X	X	X	X	X
Predicted Treatment Intensity	X	X	X	X	X

Notes: For purposes of comparison, the average is calculated using only students enrolled in community college before any policy change (2011-2013). Student controls include indicators for gender, disability, race, and socioeconomic disadvantaged, with linear controls for age (in months), and standardized test scores. Standard errors are clustered at the community-college level.

6.2.2 Course Load

Another outcome of interest is overall course load. Although course selection policies directly affected remedial and transfer-level English and math courses, it is possible that students shifted their other course taking in addition. For example, students might opt to take fewer courses overall as a response to taking more time-intensive, difficult transfer-level courses. On the other hand, students who no longer have to enroll in remedial courses might substitute transfer-level courses for those remedial courses instead, and might even be inclined to take additional transfer-level courses.

Table 10: Transfer Units, By English Quartile

	Overall (1)	1st Qrt (2)	2nd Qrt (3)	3rd Qrt (4)	4th Qrt. (5)
Transfer Units Attempted					
Intermediate	1.037***	0.826***	0.925***	1.022***	1.218***
	(0.054)	(0.095)	(0.071)	(0.066)	(0.063)
After	2.361***	1.841***	2.191***	2.448***	2.749***
	(0.081)	(0.133)	(0.096)	(0.094)	(0.113)
Average	9.09	9.52	8.36	7.67	7.12
Transfer Units Earned					
Intermediate	0.872***	0.719***	0.787***	0.823***	1.013***
	(0.039)	(0.066)	(0.055)	(0.051)	(0.061)
After	1.571***	1.403***	1.473***	1.514***	1.665***
	(0.062)	(0.101)	(0.080)	(0.067)	(0.091)
Average	6.92	7.71	6.35	5.67	5.09
Observations	951506	239698	238324	237718	234091
Completion Rate					
Before	0.761	0.810	0.760	0.739	0.715
Intermediate	0.841	0.870	0.851	0.805	0.832
After	0.665	0.762	0.672	0.618	0.606
Student Controls	X	X	X	X	X
High School FE	X	X	X	X	X
College FE	X	X	X	X	X
Predicted Treatment Intensity	X	X	X	X	X

Notes: For purposes of comparison, the average is calculated using only students enrolled in community college before any policy change (2011-2013). Student controls include indicators for gender, disability, race, and socioeconomic disadvantaged, with linear controls for age (in months), and standardized test scores. Standard errors are clustered at the community-college level.

Focusing on changes in overall transfer-level units taken by English readiness quartiles,[36] I find that there are increases in both transfer-level units attempted and earned across both time periods, and across all quartiles, as seen in Table 10.

However, it is uncertain if these results are merely reflective of the increases in English transfer-level

[36] I conduct a similar analysis for math transfer-level units. However, results are largely similar, due to the fact that students in a particular quartile based on predicted English remedial enrollment is likely in the same quartile based on predicted math remedial enrollment. Tables are located in the Appendix.

course taking. Considering increases in transfer-level English and math and decreases in remedial English and math were observed, it should be expected to see increases in overall transfer-level course taking. If students in the 4th quartile experienced a 37 percentage point increase in the probability of enrolling in transfer-level English, then a 1.11 unit increase in overall attempted transfer-level course taking is expected for students in the 4th quartile.[37] In contrast, students are, on average, enrolling in an additional 2.75 transfer-level units, suggesting that, in addition to enrolling in transfer-level English, students in the 4th quartile are also attempting other transfer-level courses.

Potentially more informative are the transfer-level course completion rates, which I calculate by dividing the increase in transfer-level units earned by the increase in transfer-level units attempted. The transfer-level course completion rate by students enrolled during the intermediate policy period are, across all quartiles and overall, higher than that of students enrolled before the course-selection policies of interest. In contrast, there are much lower transfer-level course completion rates for all quartiles of students enrolled in community college after the implementation of AB 705, compared to students enrolled in community college during the intermediate period of policy reform, and students enrolled before any reform. These results again lend support that the policies implemented during the intermediate period of policy change affected students of the highest academic readiness the most, and AB 705 affected students deemed least college ready the most.

That the coefficients for overall units (not just transfer-level) in Table 11 are positive, but not as large as increases in transfer-level units taken suggest that while some students are merely substituting their remedial course for a transfer-level course, some students are also taking *additional* transfer-level courses. That is, if all students were only substituting remedial courses and transfer-level courses one to one, then the expectation would be that there are no changes in overall course load.

[37] On average, a course is 3 units. 0.37 * 3 = 1.11

Table 11: Overall Units, By English Quartile

	Overall (1)	1st Qrt (2)	2nd Qrt (3)	3rd Qrt (4)	4th Qrt. (5)
Total Units Attempted					
Intermediate	0.696***	0.641***	0.733***	0.684***	0.707***
	(0.069)	(0.096)	(0.086)	(0.073)	(0.097)
After	1.130***	1.069***	1.125***	1.157***	1.155***
	(0.091)	(0.115)	(0.104)	(0.098)	(0.145)
Average	11.04	10.93	10.52	10.24	10.16
Total Units Earned					
Intermediate	0.355***	0.470***	0.394***	0.253***	0.293***
	(0.044)	(0.072)	(0.060)	(0.052)	(0.059)
After	0.324***	0.680***	0.380***	0.173**	0.035
	(0.064)	(0.081)	(0.085)	(0.077)	(0.101)
Average	7.95	8.84	7.88	7.43	7.125
Observations	951506	239698	238324	237718	234091
Completion Rate					
Before	0.720	0.809	0.749	0.726	0.701
Intermediate	0.510	0.733	0.538	0.370	0.414
After	0.287	0.636	0.338	0.150	0.030
Student Controls	X	X	X	X	X
High School FE	X	X	X	X	X
College FE	X	X	X	X	X
Predicted Treatment Intensity	X	X	X	X	X

Notes: For purposes of comparison, the average is calculated using only students enrolled in community college before any policy change (2011-2013). Student controls include indicators for gender, disability, race, and socioeconomic disadvantaged, with linear controls for age (in months), and standardized test scores. Standard errors are clustered at the community-college level.

These results taken together provide suggestive evidence that the two policy periods affected students at different levels of college readiness. The multiple measures mandate affected students who were deemed more prepared for college work, while AB 705 most affected students at lower levels of college readiness.

I find that, overall, there were increases in the proportion of students across all levels of college readiness who enrolled and passed transfer-level English and math with a C or better, after the introduction of AB 705, despite mostly affecting students deemed less academically prepared for college. When examining the TOT effect, I find that almost all students across a range of college readiness were able to pass transfer-level English (and math) courses at similar, or higher, rates than students enrolled in community college before either set of policy changes. This does not hold, however, for students in the 4th quartile of both the predicted probability of enrolling in English and math, respectively. This result suggests that there are some students who are the least prepared that are enrolling in transfer-level English or math that may not be ready to do so.

6.3 By Treatment Intensity

Finally, I use the predicted probability of enrolling in remedial English (math) as a continuous treatment variable, and interact it with the "intermediate" and "after" policy variables, estimating the following equation:

$$\begin{aligned} Y_{ihcts} = \alpha &+ \beta_1[\text{intermediate}_t * \hat{\text{T}}_{ihcs}] + \beta_2[\text{after}_t * \hat{\text{T}}_{ihcs}] \\ &+ \beta_3[\text{intermediate}_t] + \beta_4[\text{after}_t] + \beta_5[\hat{\text{T}}_{ihcs}] \\ &+ \lambda_c + \lambda_h + X_{ihc} + \epsilon_{ichts} \end{aligned} \tag{3}$$

where each observation is unique at the student i-semester t level, and Y_{icts} represents both continuous and binary outcomes, such as the total number of units taken in a semester or whether or not a student passed a transfer-level course for subject s (English or math). The variable $intermediate_t$ is an indicator variable which is 1 if the student is enrolled in community college during the initial remedial education reform period, where reforms centered on the method of remedial education placement, during 2013-2017. The variable $after_t$ is an indicator variable which is 1 if the student is enrolled in community college after the passing of AB 705, during 2018-2019. Finally, $\hat{\text{T}}_{ics}$ is the predicted treatment intensity, and is a continuous measure ranging from 0 to 1. The larger $\hat{\text{T}}_{ics}$, the more likely a student is predicted to have enrolled in a remedial education course in subject s within the first year of enrollment.

The coefficients of interests are β_1 and β_2, and fixed effects λ_c and λ_h are estimated at the college and high school level. X_{ihc} is a vector of controls, including a linear time trend, and student controls for gender, race, age (in months), socioeconomic disadvantage status, and 6th grade standardized test scores in both ELA and math.

The purpose of this exercise is to try and isolate the effects of AB 705 as a policy on its own. Considering the suggestive evidence that AB 705 had disparate effects on students with the highest predicted probability of enrolling in remedial education, and should have not affected students with the highest academic preparation (or the lowest predicted probability of remedial education enrollment) as much. Thus, the expectation would be to see effects increase as the predicted probability of remedial enrollment increased.

Table 12 looks at these effects treating college readiness as a continuous variable. Looking at effects during the intermediate policy period, there is no longer a statistically significant change in the proportion of students taking remedial English as the predicted treatment intensity increases.[38] There are statistically significant decreases in both transfer-level English course taking and the corresponding pass rate, corresponding to that in Table 5, all quartiles of students experience large increases in English transfer-level participation, but at a decreasing rate. It is reassuring that the decrease in passing with a C or better is almost exactly the same as the decrease in transfer-level English participation, suggesting that the decrease in pass rate is a result of the decrease in course participation.

[38] In Table 4 the increases in remedial English participation are not increasing when moving from the 1st quartile to the 4th quartile.

Table 12: Course Taking, By Treatment Intensity

	Any	Remedial	Transfer-Level	Pass C
	(1)	(2)	(3)	(4)
English				
Intermediate × Pr(Remed. Eng.)	-0.108**	-0.029	-0.112***	-0.111***
	(0.044)	(0.040)	(0.033)	(0.027)
1 S.D. Effect	[-1.7%]	[-0.4%]	[-1.8%]	[-1.7%]
After × Pr(Remed. Eng.)	-0.143**	-0.624***	0.291***	0.123***
	(0.058)	(0.052)	(0.070)	(0.045)
1 S.D. Effect	[-2.3%]	[-9.9%]	[4.7%]	[2.0%]
Average	0.472	0.173	0.180	0.139
Observations	951506	951506	951506	951506
Student Controls	X	X	X	X
High School FE	X	X	X	X
College FE	X	X	X	X
Math				
Intermediate × Pr(Remed. Math)	-0.146***	-0.027	-0.055***	-0.055***
	(0.035)	(0.034)	(0.017)	(0.014)
1 S.D. Effect	[-2.3%]	[-0.4%]	[-0.3%]	[-0.8%]
After × Pr(Remed. Math)	-0.323***	-0.549***	-0.057	-0.100***
	(0.047)	(0.072)	(0.049)	(0.030)
1 S.D. Effect	[-5.2%]	[-8.8%]	[-.9%]	[-1.6%]
Average	0.455	0.170	0.102	0.071
Observations	951506	951506	951506	951506
Student Controls	X	X	X	X
High School FE	X	X	X	X
College FE	X	X	X	X

Notes: For purposes of comparison, the average is calculated using only students enrolled in community college before any policy change (2011-2013). Student controls include indicators for gender, disability, race, and socioeconomic disadvantaged, with linear controls for age (in months), and standardized test scores. Standard errors are clustered at the community-college level.

Focusing on students after AB 705 was passed, there are large reductions in enrolling in remedial English and math, that increase as the predicted probability of remedial enrollment increases. For example, a one standard deviation increase of 16 percent in the predicted probability of enrolling in remedial English leads to a 9.9 percent decrease in the probability of actually enrolling in remedial English, and a 4.7 percent increase in the probability of enrolling in transfer-level English. Furthermore, the one-standard-deviation ITT effect on the transfer-level English pass rate is 2 percent. That the increase in transfer-level English participation is smaller than the decrease in remedial English participation suggests that as the predicted probability of remedial English enrollment increases, students are somewhat more hesitant to take transfer-level English.

Again, there are similar patterns for math course taking, although all effects are smaller than that for English course taking. During the intermediate period of policy reform, there is no longer a statistically significant effect on remedial math enrollment. Although there are statistically significant reductions in both the transfer-level math enrollment and corresponding pass rate as the predicted probability of math remedial enrollment increases, the declines are exactly the same, suggesting that the decrease in pass rate is driven only by decreases in transfer-level math enrollment.

After AB 705, a one standard deviation increase in the predicted probability of enrolling in remedial math of 16 percent leads to a 8.8 percent decline in the probability of actually enrolling in remedial math. However, interesting to note is that there is no longer a statistically significant increase in the proportion of students enrolling in transfer-level math, *as the predicted probability of enrolling in remedial math increases.* Note in Table 8 that while there were positive effects of AB 705 on the proportion of students enrolling in transfer-level math for students in all quartiles, those increases slightly decreased moving from the 1st quartile to the 4th. Initially disappointing is seeing that the intent-to-treat effect of AB 705 is negative for passing transfer-level math with a C or better. However, in light of the quartile analysis in Table 9, this negative coefficient only indicates that there are still increases in the probability of passing transfer-level math, but that these increases are decreasing as the probability of remedial math (or predicted treatment intensity) increases.

These results make intuitive sense – students who are deemed less prepared are more hesitant to enroll in transfer-level courses despite open access to them. This can be seen from the fact that the decrease in remedial course enrollment was not completely offset by the increase in transfer-level enrollment. Furthermore, the declines in math transfer-level pass rates indicate that pass rates declined as students who were deemed less college prepared enrolled in transfer-level math.

It is important to note, however, that these results do not contradict the heterogeneity analysis by quartile. This treatment intensity analysis hypothesizes that effects from these policies change at an increasing rate along a continuous measure of college readiness. That is, it is not enough for there to be a level shift across all students, but that students with the highest predicted probability also experience the largest change.

Next, Table 13 shows how overall course load changed during the different policy periods, for students as they are deemed less and less prepared for college. Although overall units attempted did not increase during either policy, the number of units earned does decline after AB 705 was introduced, with the number of units earned declining as students are deemed less and less prepared for college. However, these seemingly negative effects hide changes in the *types* of courses being taken.

For example, after AB 705 was passed, a one standard deviation increase in the predicted probability of enrolling in remedial English of 16 percent leads to a 0.32 increase in the number of transfer-level credits attempted, and a 0.09 increase in the number of transfer-level credits earned.[39] These results together suggest that students who were most affected by AB 705, that is students who were deemed the least prepared for college, were likely substituting some of their remedial courses with transfer-level courses, but not all, leading to an overall decline in units taken, but an increase in transfer-level courses taken.

Studying effects of the policies by treatment intensity provide suggestive evidence that, as students' college readiness declines, the positive effects of the policies decline slightly as well. However, when taking

[39] Results are very similar using the likelihood of requiring remedial math.

Table 13: Overall Units, By Treatment Intensity

	Overall		Transfer-Level	
	Units Attempted	Units Earned	Units Attempted	Units Earned
	(1)	(2)	(3)	(4)
English				
Intermediate × Pr(Remed. Eng.)	0.081	-0.274	0.975***	0.853***
	(0.291)	(0.212)	(0.235)	(0.209)
1 S.D. Effect	[0.01]	[-0.44]	[0.16]	[0.14]
After × Pr(Remed. Eng.)	0.218	-1.394***	1.983***	0.573*
	(0.425)	(0.331)	(0.373)	(0.300)
1 S.D. Effect	[0.03]	[-0.22]	[0.32]	[0.09]
Average	10.37	7.62	8.09	6.08
Observations	951506	951506	951506	951506
Student Controls	X	X	X	X
High School FE	X	X	X	X
College FE	X	X	X	X
Math				
Intermediate × Pr(Remed. Math)	-0.279	-0.806***	1.230***	0.982***
	(0.237)	(0.208)	(0.276)	(0.262)
1 S.D. Effect	[-0.04]	[-0.13]	[0.20]	[0.16]
After × Pr(Remed. Math)	-0.300	-1.972***	2.277***	0.742**
	(0.366)	(0.324)	(0.469)	(0.371)
1 S.D. Effect	[0.05]	[-0.32]	[0.36]	[0.12]
Average	10.37	7.62	8.09	6.08
Observations	951506	951506	951506	951506
Student Controls	X	X	X	X
High School FE	X	X	X	X
College FE	X	X	X	X

Notes: For purposes of comparison, the average is calculated using only students enrolled in community college before any policy change (2011-2013). Student controls include indicators for gender, disability, race, and socioeconomic disadvantaged, with linear controls for age (in months), and standardized test scores. Standard errors are clustered at the community-college level.

these treatment intensity results in conjunction with the quartile results, it indicates that while students at all levels of college readiness experienced positive results as a result of the reforms, these benefits declined as students' academic preparation decreased.

7 Conclusion

Remedial education is a costly practice implemented across the United States to address the flagging academic success of students deemed underprepared for college work. However, despite the widespread use of remedial education, previous empirical studies have found mixed results regarding its effect on students' academic success, as measured by persistence, units earned, and a multitude of other benchmarks. Thus, it is uncertain how a policy in California increasing open access to transfer-level courses for all students might affect the academic success of students. For example, if remedial education has positive effects on students' academic achievements, then allowing open access to transfer-level courses could result in lower course pass rates, lower course grades, and longer time to degree for students who would have benefited from remedial education. On the other hand, if remedial education had a null or negative effect on students' academic success by underplacing students, then allowing these students to have direct access to college-level courses could increase long-run student success outcomes, such as transferring to a 4-year college or earning an associate's degree.

I add to this literature by being the first to study the effects of remedial education reform policies for students on a continuous measure of college readiness, and for the state of California. In particular, I find that the multiple measures mandate passed in 2013 had smaller effects on course selection than did AB 705 passed in 2017. However, while the multiple measures mandate targeted students with more academic preparation, AB 705 influenced more students at lower levels of college readiness.

I find that, after AB 705, there was a large reduction of students taking remedial English and math, driven by students with the lowest estimated levels of academic preparation. However, during both periods, there were large increases in transfer-level participation, and pass rates, in both English and math, suggesting that many students who would have been placed in remedial courses could have passed transfer-level courses at similar or higher rates than students before any policy was passed. This result is true for students across all quartiles in both subjects, except for students in the 4th quartile, or students with the lowest level of academic preparation. Although these students were still experiencing increases in the probability of passing transfer-level English and math, the conditional pass rate was lower than the pass rate before any course selection policies were passed. This suggests that some students with lower academic preparation were taking transfer-level courses before they were adequately prepared.

Furthermore, as college readiness declines, I find that students are more hesitant to take transfer-level courses, despite open access, particularly in math. Anecdotal evidence has suggested that could be driven in part by counselors' hesitance in encouraging students to take transfer-level math. This finding might be somewhat concerning, particularly in light of the importance of "gateway momentum," and evidence suggesting that students students who are able to take and complete transfer-level, or "gateway" math and English courses, within their first year of enrollment are more likely to graduate with college credential.[40] My results suggest that if a major goal of these remedial education reforms were to help encourage student success, there may be other barriers, besides remedial education, in place.

I also find that there were increases in transfer-level units attempted and earned, during both periods and across all quartiles. However, the course completion rate was higher for students enrolled during the intermediate period, and lower for students enrolled after AB 705 was implemented, compared to students enrolled in the period before any policy change. These results suggest that allowing open access for students to enroll directly into transfer-level courses encourages students to take more transfer-level courses, although the additional courses might be more than some students can handle.

Overall, I find that these policies had a positive effect on transfer-level course participation and pass

[40] Jenkins, Davis and Thomas Bailey. "Early Momentum Metrics: Why They Matter for College Improvement." CCRC. Feb. 2017. https://files.eric.ed.gov/fulltext/ED572783.pdf.

rates on students across all ranges of academic preparation, with the largest positive effects for students on the margin of requiring remedial education. A natural question to ask is, given these positive short-run effects, how might these policies affect long-run outcomes, such as transfer to a 4-year college, or receiving an associate degree, and the timeframe in which they complete these goals.

However, there are still some students who require support in college-level courses. Although remedial education seems to be inefficient in providing education support, important new work has been studying the effects of emerging alternatives, such as co-requisite courses (Ran and Lin, 2022).

References

ALLENSWORTH, E. M. AND K. CLARK (2020): "High School GPAs and ACT Scores as Predictors of College Completion: Examining Assumptions About Consistency Across High Schools," *Educational Researcher*, 49, 198–211.

BAILEY, T., D. W. JEONG, AND S.-W. CHO (2010): "Referral, Enrollment, and Completion in Developmental Education Sequences in Community Colleges," *Economics of Education Review*, 29, 255–270.

BELFIELD, C. R. AND P. M. CROSTA (2012): "Predicting Success in College: The Importance of Placement Tests and High School Transcripts," Tech. rep., Community College Research Center, working Paper No. 42.

BETTINGER, E. AND B. T. LONG (2005): "Remediation at the Community College: Student Participation and Outcomes," *New Directions for Community Colleges*, 129, 17–26.

——— (2008): "Addressing the Needs of Underprepared Students in Higher Education: Does College Remediation Work?" *Journal of Human Resources*, 44, 736–71.

BOATMAN, A. AND B. T. LONG (2018): "Does Remediation Work for All Students? How the Effects of Postsecondary Remediation and Developmental Courses Vary by Level of Preparation," *Educational Evaluation and Policy Analysis*, 40, 29–58.

CALCAGNO, J. C. AND B. T. LONG (2008): "The Impact of Postsecondary Remediation Using a Regression Discontinuity Approach: Addressing Endogenous Sorting and Noncompliance," Tech. rep., National Bureau of Economics Research, working Paper No. 14194.

CLOTFELTER, C. T., H. F. LADD, C. MUSCHKIN, AND J. L. VIGDOR (2015): "Developmental Education in North Carolina Community Colleges," *Educational Evaluation and Policy Analysis*, 37, 354–375.

CUELLAR MEIJA, M., O. RODRIGUEZ, AND H. JOHNSON (2016a): "Determining College Readiness in California's Community Colleges: A Survey of Assessment and Placement Policies," Tech. rep., Public Policy Institute of California, https://www.ppic.org/content/pubs/report/R_1116ORR.pdf, accessed Mar. 31, 2021.

——— (2016b): "Preparing Students for Success in California's Community Colleges," Tech. rep., Public Policy Institute of California, https://www.ppic.org/content/pubs/report/R_1116MMR.pdf, accessed Mar. 31, 2021.

——— (2018): "Remedial Education Reforms at California's Community College: Early Evidence on Placement and Curricular Reforms," Tech. rep., Public Policy Institute of California, https://www.ppic.org/wp-content/uploads/remedial-education-reforms-at-californias-community-colleges-august-2018.pdf, accessed Sept. 1, 2021.

CUELLAR MEIJA, M., O. RODRIGUEZ, H. JOHNSON, AND C. A. PEREZ (2021): "Community College Math in California's New Era of Student Success," Tech. rep., Public Policy Institute of California, https://www.ppic.org/publication/community-college-math-in-californias-new-era-of-student-access/, accessed Jan. 07, 2022.

DUCHINI, E. (2017): "Is College Remedial Education a Worthy Investment? New Evidence from a Sharp Regression Discontinuity Design," *Economics of Education Review*, 60, 36–53.

JOHNSON, H., M. C. MEIJA, AND S. BOHN (2015): "Will California Run Out of College Graduates?" Tech. rep., Public Policy Institute of California, https://www.ppic.org/wp-content/uploads/rs_archive/pubs/report/R_1015HJR.pdf, accessed Oct. 12, 2021.

MARTORELL, P. AND I. MCFARLIN (2011): "Help or Hindrance? The Effects of College Remediation on Academic and Labor Market Outcomes," *Review of Economics and Statistics*, 93, 436–54.

MDRC (2013): "Developmental Education: A Barrier to a Postsecondary Credential for Millions of Americans," https://www.mdrc.org/sites/default/files/Dev%20Ed$_0$20113$.pdf, accessedOct.$7, 2021.

PARK-GAGHAN, T. J., C. G. MOKHER, X. HU, H. SPENCER, AND S. HU (2020): "What Happened Following Comprehensive Developmental Education Reform in the Sunshine State? The Impact of Florida's Developmental Education Reform on Introductory College-Level Course Completion," *Educational Researcher*, 49, 656–66.

PARK-GAGHAN, T. J., C. G. MOKHER, H. SPENCER, AND S. HU (2021): "Do Rising Tides Lift All Boats? Exploring Heterogeneous Effects of Florida's Developmental Education Reform by High School Academic Preparation," *American Journal of Educaiton*, 127, 471–95.

PPIC (2019): "Improving College Completion," Tech. rep., Public Policy Institute of California Higher Education Center, https://www.ppic.org/wp-content/uploads/higher-education-in-california-improving-college-completion-october-2019.pdf, accessed Oct. 7, 2021.

RAN, F. X. T. AND Y. LIN (2022): "The Effects of Corequisite Remediation: Evidence From a Statewide Reform in Tennessee," *Educational Evaluation and Policy Analysis*, 44, 458–84.

SCOTT-CLAYTON, J. (2012): "Do High-Stakes Placement Exams Predict College Success," Tech. rep., Community College Research Center, working Paper No. 41.

SCOTT-CLAYTON, J., P. M. CROSTA, AND C. R. BEDFIELD (2014): "Improving the Targeting of Treatment: Evidence from College Retention," *Educational Evaluation and Policy Analysis*, 36, 371–93.

SCOTT-CLAYTON, J. AND O. RODRIGUEZ (2015): "Development, Discouragement, or Diversion? New Evidence on the Effects of College Remediation Policy," *Education and Finance Policy*, 10, 4–45.

XU, D. (2016): "Assistance or Obstacle? The Impact of Different Levels of English Developmental Education on Underprepared Students in Community Colleges," *Educational Researcher*, 45, 496–507.

Appendix

Table 14: Prediction Model Coefficients

	Remedial Eng. Status (1)	Remedial Math Status (2)
ELA Z-Score × ELA Perf. Level	-0.176***	-0.088***
	(0.017)	(0.010)
ELA Z-Score^2	-0.297***	-0.105***
	(0.021)	(0.013)
Math Perf. Level	-0.110***	-0.434***
	(0.011)	(0.022)
ELA Z-Score	-0.165**	-0.081**
	(0.065)	(0.037)
Hispanic	0.171***	0.099***
	(0.032)	(0.036)
White	-0.176***	-0.100**
	(0.032)	(0.042)
Male	-0.189***	-0.267***
	(0.018)	(0.020)
Math Z-Score × Math Perf. Level	-0.018**	-0.086***
	(0.009)	(0.015)
Math Z-Score	0.037	0.108***
	(0.030)	(0.041)
Asian	0.180***	-0.345***
	(0.043)	(0.050)
Disabled	0.204***	0.149***
	(0.042)	(0.040)
Parent Education Level	0.026***	0.021***
	(0.005)	(0.005)
Age (in months)	0.010***	0.008***
	(0.001)	(0.001)
Economic Disadvantage	0.137***	0.077***
	(0.017)	(0.020)
Limited English Proficiency	0.114***	0.063**
	(0.041)	(0.026)
ELA Perf. Level	-0.294***	
	(0.016)	
Black		-0.062
		(0.051)
Math Z-Score^2		0.004
		(0.007)
Other Race		-0.057
		(0.045)
Constant	-0.487**	-1.655***
	(0.222)	(0.187)
Observations	281816	287989
Y Mean	0.176	0.165

Figure 14: English Course Taking

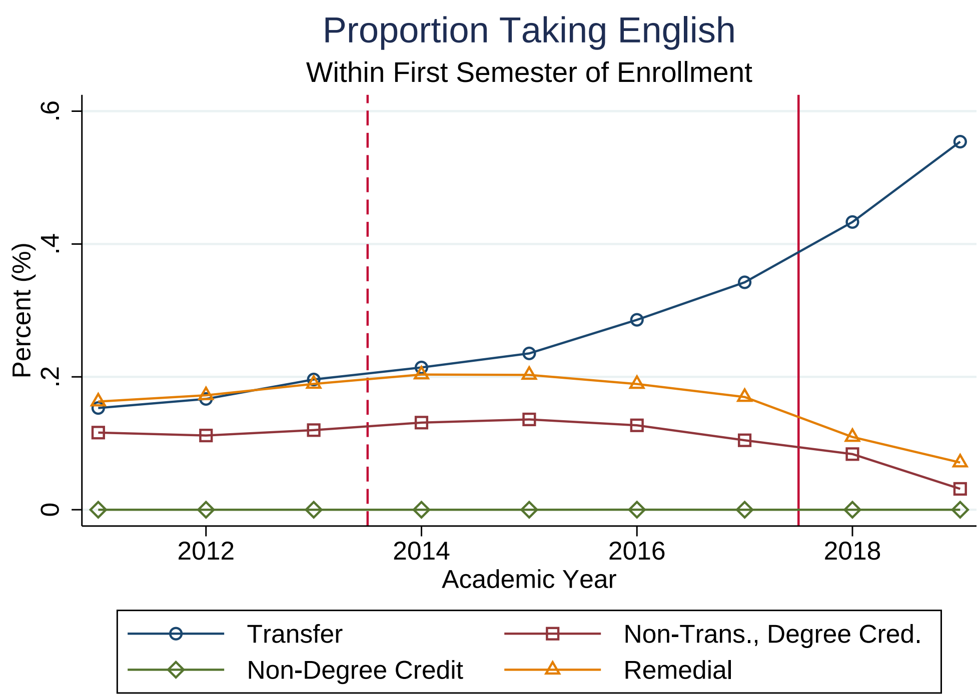
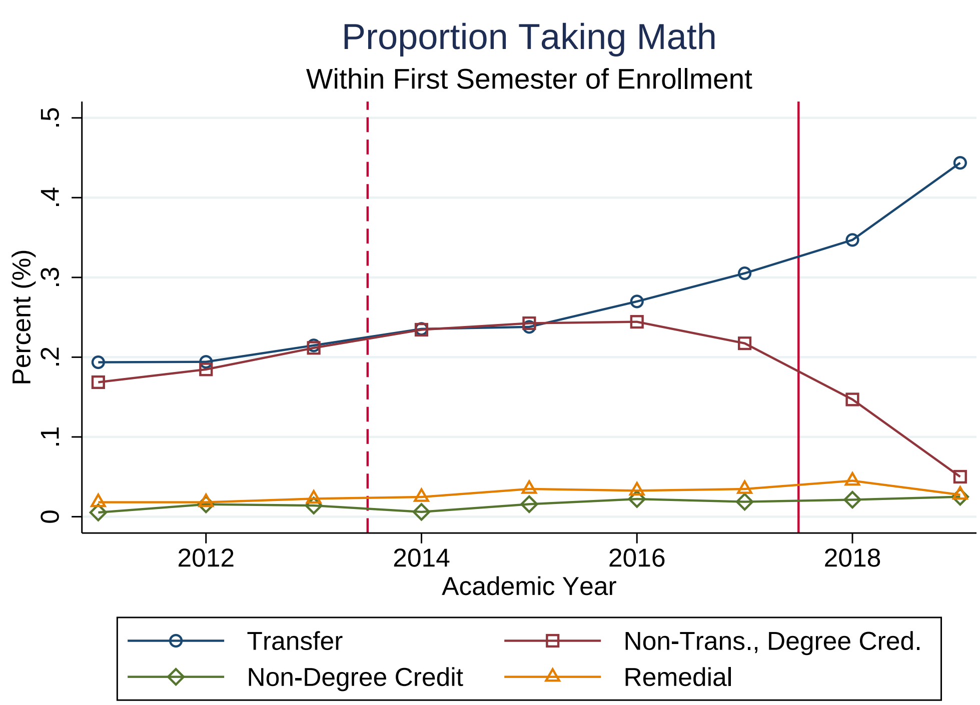


Figure 15: Math Course Taking



List of Covariates Included in Lasso Process:

- Age (in months)
- Age^2
- Age^3
- 6th Grade ELA Standardized Scale Score
- 6th Grade ELA Standardized Scale $Score^2$
- 6th Grade ELA Standardized Raw Score
- 6th Grade ELA Performance Level
- 6th Grade ELA Performance Level $\times$ 6th Grade ELA Standardized Scale Score
- 6th Grade Math Standardized Scale Score
- 6th Grade Math Standardized Scale $Score^2$
- 6th Grade Math Standardized Raw Score
- 6th Grade Math Performance Level
- 6th Grade Math Performance Level $\times$ 6th Grade Math Standardized Scale Score
- Parent's Education
- Socioeconomic Disadvantaged
- Asian
- Black
- Hispanic
- White
- "Other" Race
- Disability
- Limited English Proficiency
- Gender
- Language
- English Proficiency Level
- Migrant
- Reclassified English Proficiency
- Charter School
- Gifted and Talented
- 6th Grade Science Subject
- 6th Grade Science Raw Score
- 6th Grade History Subject
- 6th Grade History Raw Score
- CST Math Subject

Figure 16: Proportion of Students Enrolled in Remedial English,

by Predicted Remedial English Status

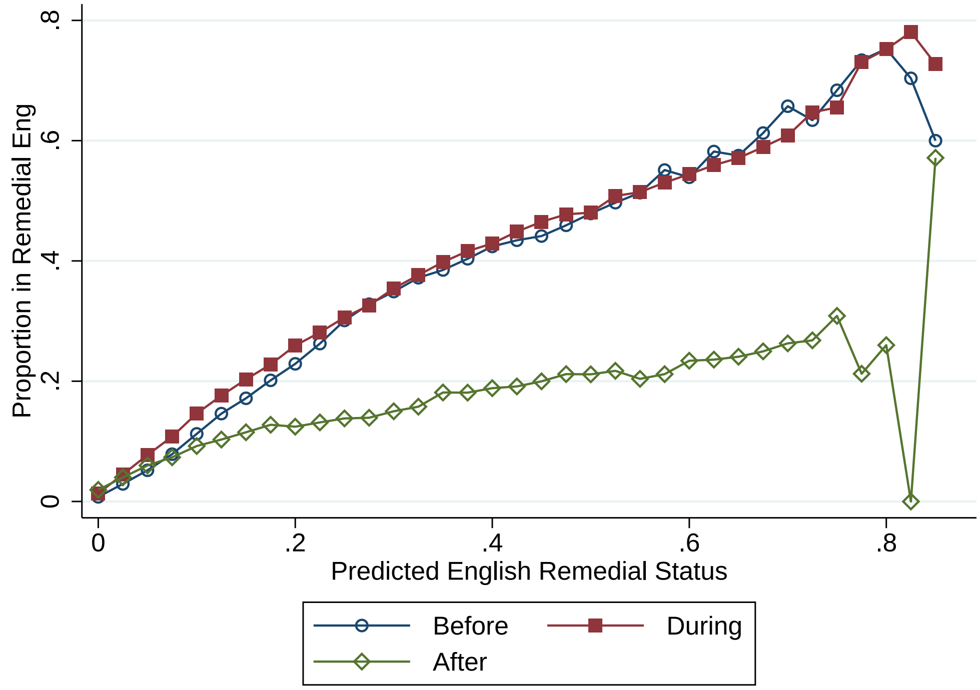


Figure 17: Proportion of Students Enrolled in Transfer English,

by Predicted Remedial English Status

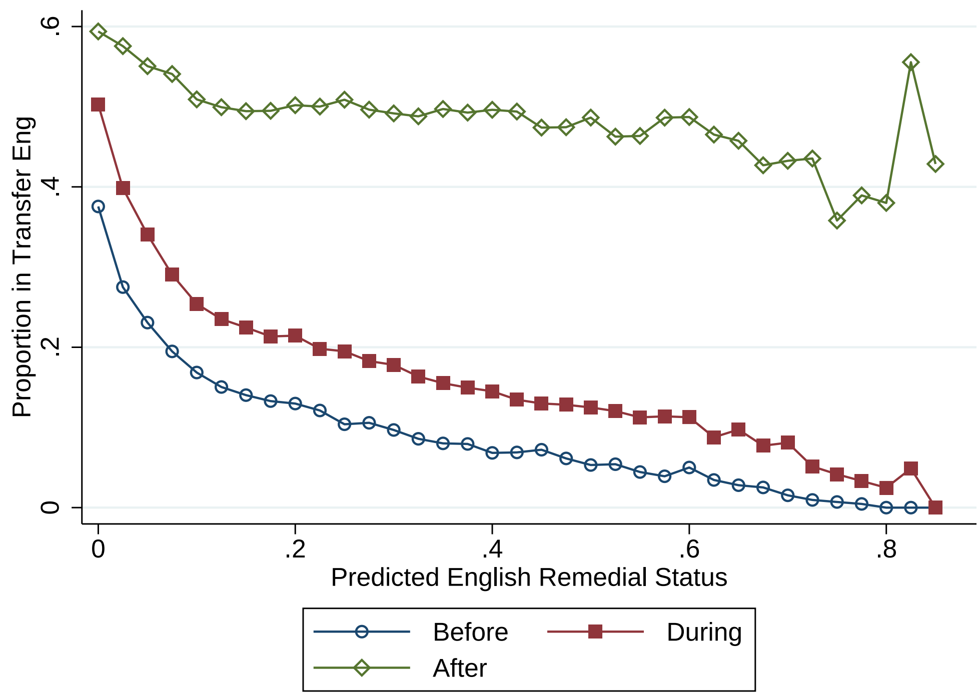


Figure 18: Proportion of Students Enrolled in Remedial Math,

by Predicted Remedial Math Status

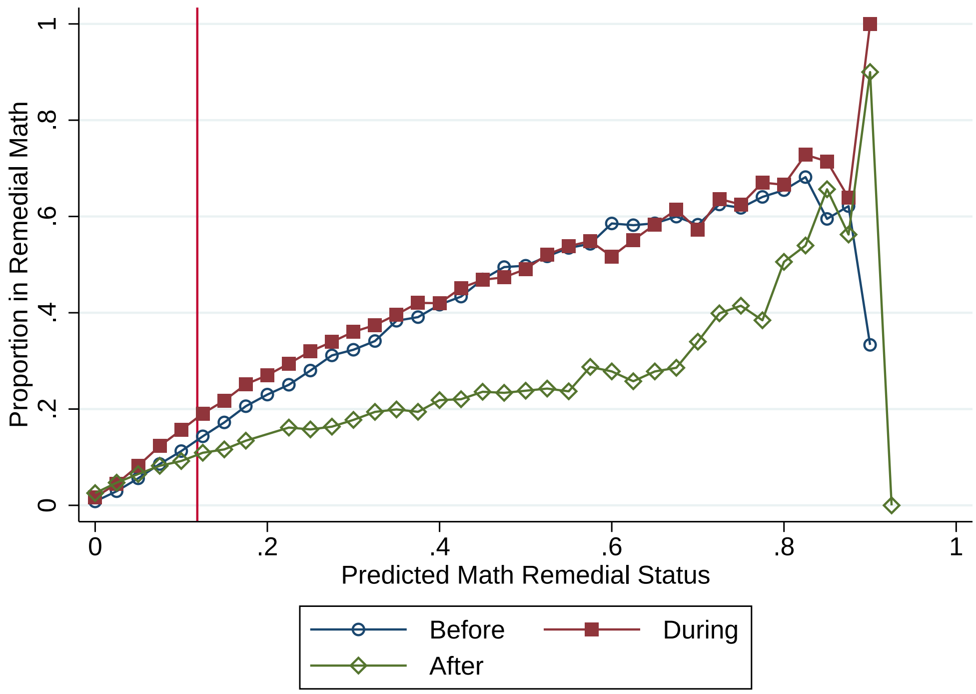


Figure 19: Proportion of Students Enrolled in Transfer Math,

by Predicted Remedial Math Status

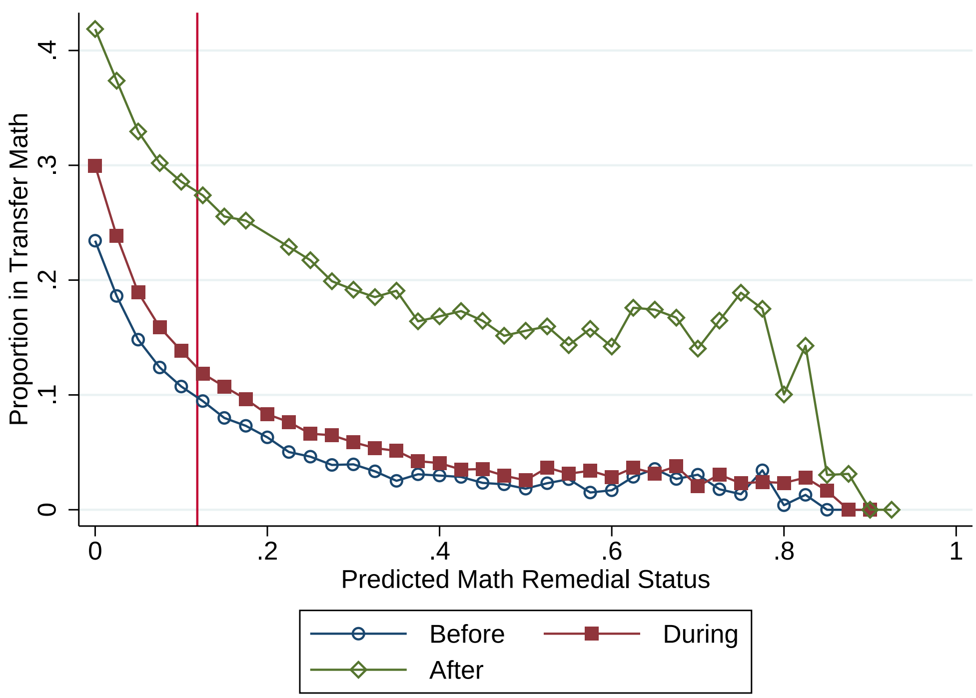


Figure 20: Average ELA Z-Score of Students

by Predicted Remedial English Status

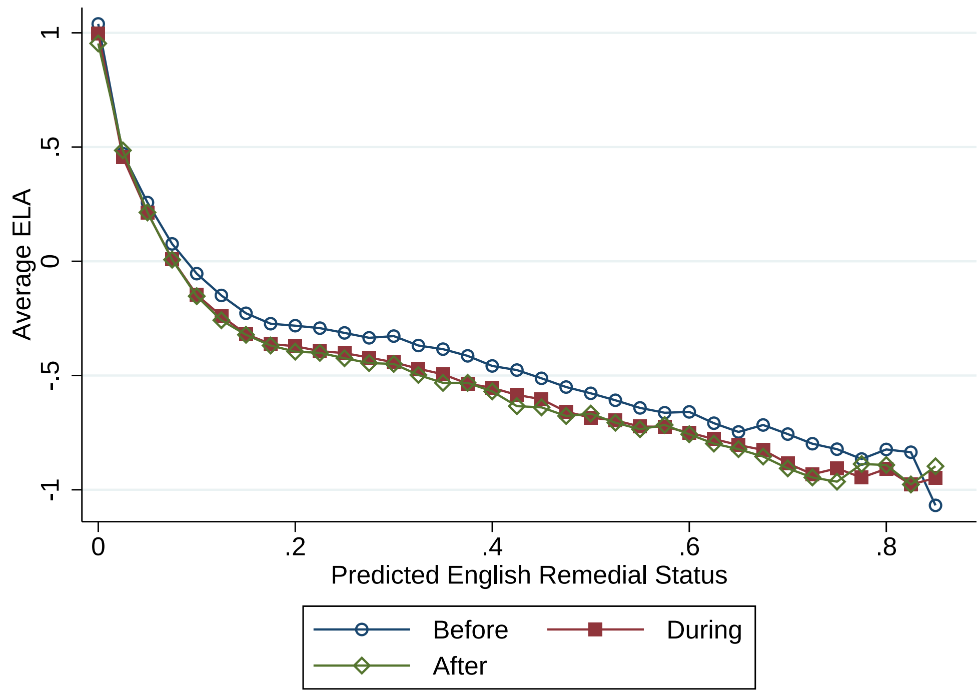


Figure 21: Average Math Z-Score of Students,

by Predicted Remedial English Status

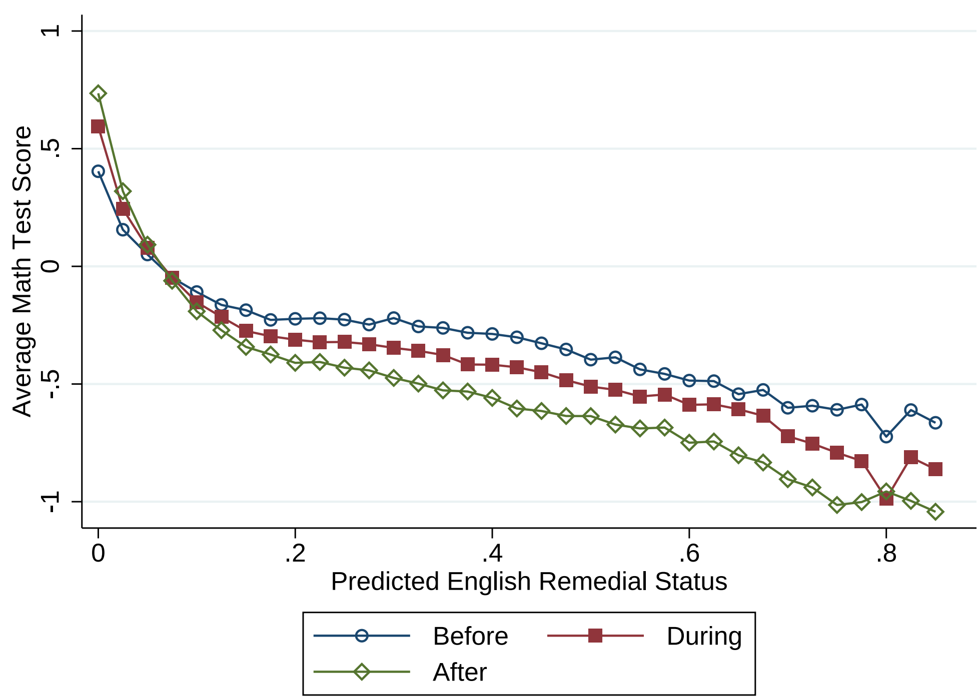


Figure 22: Average ELA Z-Score of Students,

by Predicted Remedial Math Status

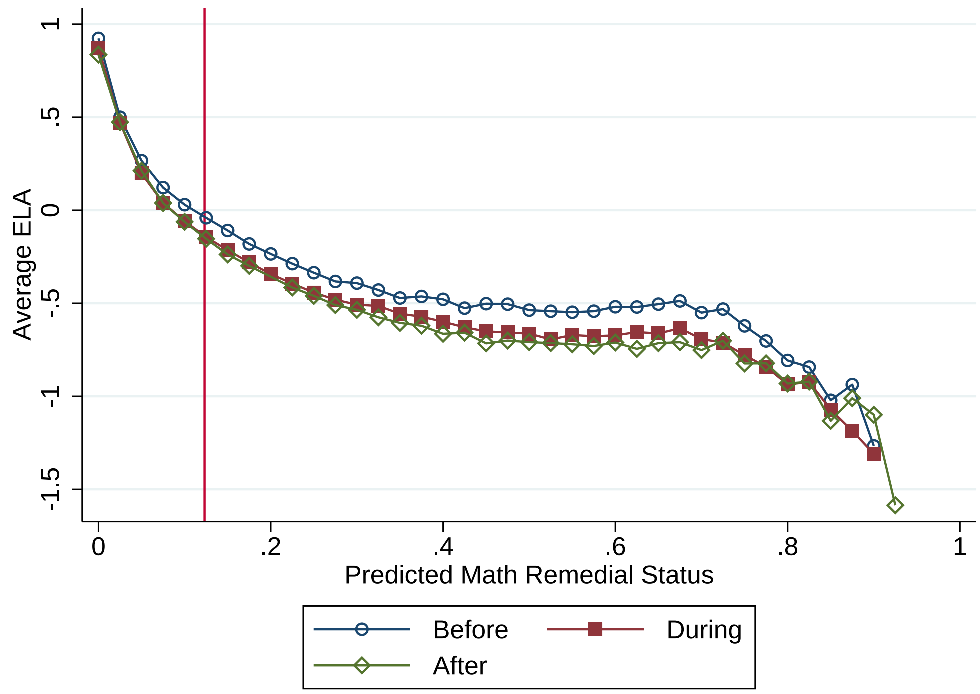


Figure 23: Average Math Z-Score of Students,

by Predicted Remedial Math Status

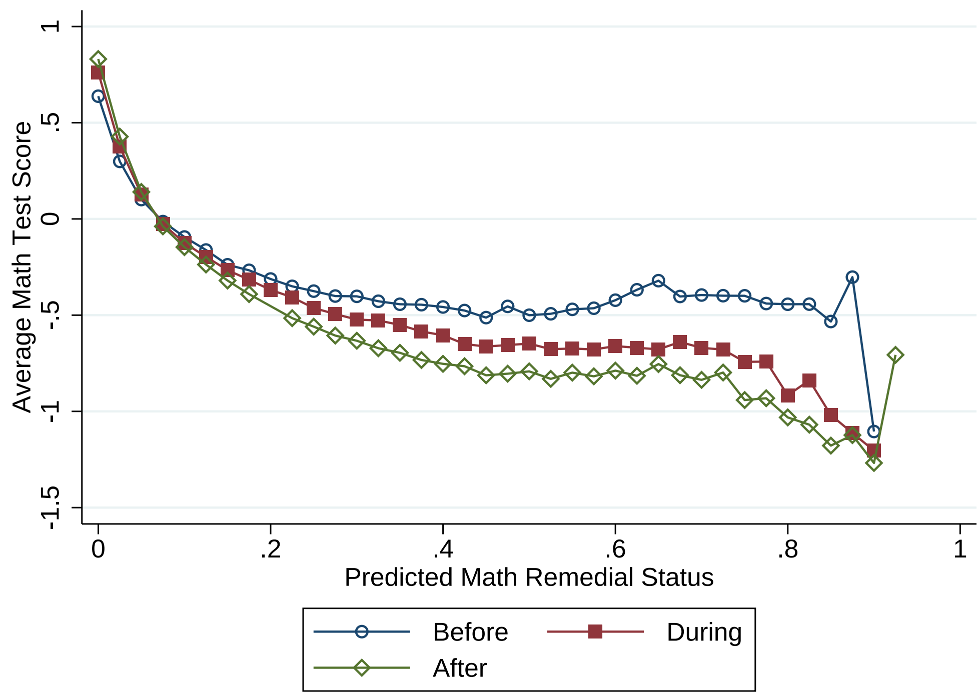


Table 15: Overall Units, By Math Quartile

	Overall (1)	1st Qrt (2)	2nd Qrt (3)	3rd Qrt (4)	4th Qrt. (5)
Total Units Attempted					
Intermediate	0.696***	0.721***	0.715***	0.697***	0.626***
	(0.069)	(0.099)	(0.079)	(0.082)	(0.076)
After	1.130***	1.132***	1.123***	1.143***	1.085***
	(0.091)	(0.121)	(0.095)	(0.108)	(0.124)
Average	10.37	10.83	10.64	10.38	10.16
Total Units Earned					
Intermediate	0.355***	0.537***	0.424***	0.274***	0.187***
	(0.044)	(0.071)	(0.056)	(0.053)	(0.051)
After	0.324***	0.758***	0.391***	0.165**	-0.047
	(0.064)	(0.083)	(0.077)	(0.083)	(0.089)
Average	7.62	8.63	8.54	7.56	7.11
Observations	951506	228026	241467	242209	238062
Completion Rate					
Before	0.735	0.797	0.803	0.728	0.700
Intermediate	0.510	0.745	0.593	0.393	0.299
After	0.287	0.670	0.356	0.144	0.043
Student Controls	X	X	X	X	X
High School FE	X	X	X	X	X
College FE	X	X	X	X	X
Predicted Treatment Intensity	X	X	X	X	X

Notes: For purposes of comparison, the average is calculated using only students enrolled in community college before any policy change (2011-2013). Student controls include indicators for gender, disability, race, and socioeconomic disadvantaged, with linear controls for age (in months), and standardized test scores. Standard errors are clustered at the community-college level.

Table 16: Transfer Units, By Math Quartile

	Overall (1)	1st Qrt (2)	2nd Qrt (3)	3rd Qrt (4)	4th Qrt. (5)
Transfer Units Attempted					
Intermediate	1.037***	0.845***	0.896***	0.988***	1.235***
	(0.054)	(0.104)	(0.065)	(0.063)	(0.064)
After	2.361***	1.847***	2.151***	2.464***	2.724***
	(0.081)	(0.146)	(0.091)	(0.091)	(0.112)
Average	8.09	9.52	8.54	7.85	7.02
Transfer Units Earned					
Intermediate	0.872***	0.717***	0.773***	0.831***	1.007***
	(0.039)	(0.079)	(0.051)	(0.043)	(0.062)
After	1.571***	1.418***	1.452***	1.531***	1.631***
	(0.062)	(0.110)	(0.072)	(0.068)	(0.092)
Average	6.08	7.69	6.55	5.81	5.02
Observations	951506	228026	241467	242209	238062
Completion Rate					
Before	0.752	0.808	0.767	0.740	0.715
Intermediate	0.841	0.849	0.863	0.841	0.815
After	0.665	0.7628	0.675	0.621	0.599
Student Controls	X	X	X	X	X
High School FE	X	X	X	X	X
College FE	X	X	X	X	X
Predicted Treatment Intensity	X	X	X	X	X

Notes: For purposes of comparison, the average is calculated using only students enrolled in community college before any policy change (2011-2013). Student controls include indicators for gender, disability, race, and socioeconomic disadvantaged, with linear controls for age (in months), and standardized test scores. Standard errors are clustered at the community-college level.