# Addressing the Needs of Under-Prepared Students in Higher Education: Does College Remediation Work?

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ABSTRACT

Each year, thousands of students graduate high school academically unprepared for college. As a result, approximately one-third of entering postsecondary students require remedial or developmental work before entering college-level courses. However, little is known about the causal impact of remediation on student outcomes. At an annual cost of over $1 billion at public colleges alone, there is a growing debate about its effectiveness. Who should be placed in remediation, and how does it affect their educational progress? This project addresses these critical questions by examining the effects of math and English remediation using a unique dataset of approximately 28,000 students. To account for selection biases, the paper uses variation in remedial placement policies across institutions and the importance of proximity in college choice. The results suggest that students in remediation are more likely to persist in college in comparison to students with similar test scores and backgrounds who were not required to take the courses. They are also more likely to transfer to a higher-level college and to complete a bachelor's degree.

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## I. Introduction

Although approximately two-thirds of recent high school graduates enter college each year, many of these students are unprepared academically for college-level material (Greene and Foster, 2003). In some cases, academic deficiencies are so severe that colleges choose to expel the students. For instance, during the fall of 2001, the California State University system "kicked out more than 2,200 students – nearly 7 percent of the freshman class – for failing to master basic English and math skills" (Trounson, 2002). However, the most common response has been to place ill-prepared students in remedial courses.[1] Because the average college student attends a nonselective institution to which he or she is almost assured admission, the remediation placement exam taken when first arriving on campus has become the key academic gate-keeper to postsecondary study.[2] In 2001, colleges required nearly one-third of first-year students to take remedial courses in reading, writing, or mathematics (NCES, 2003).

Remediation proponents suggest that the courses help under-prepared students gain the skills necessary to excel in college and may serve as a tool to integrate students into the school population (Soliday, 2002). In addition, by placing weaker students into separate courses, remediation allows colleges to protect institutional selectivity, regulate entry to upper level courses, and generate enrollment, particularly in English and math departments. However, by increasing the number of requirements and extending the time to degree, remediation may negatively impact student outcomes such as persistence, major choice, and eventual labor market returns.[3] Moreover, the cost of remediation is significant. In Ohio, public colleges spent approximately $15 million teaching 260,000 credit hours of high school-level courses to freshmen in 2000; another $8.4 million was spent on older students (OBR, 2001). In addition, the 20,000 freshmen in the courses paid $15

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[1] The literature defines "remediation" as coursework that is retaken while classes that focus on new material are termed "developmental." In this paper, we will refer to both types of below-college-level courses as remedial. This also includes "basic-skills training" and "nontraditional coursework" but not ESL courses.

[2] The bulk of remediation is provided by non-selective public institutions, the point of entry for 80 percent of four-year students and virtually all two-year students. Four-fifths of public four-year colleges and 98 percent of community colleges provide remedial courses.

[3] Nationally and in Ohio, most colleges offer general institutional credit for remedial courses but this credit often does not count towards a degree. Additionally, over four-fifths of campuses restrict enrollment in at least some college-level classes until remediation is complete (NCES, 2003; LOEO, 1995). These requirements may restrict students' course schedules and impede the ability to major in certain areas.

million in tuition for their remediation as well as used financial aid resources and sacrificed foregone wages. With an estimated annual cost of over $1 billion nationally at public colleges (Breneman and Haarlow 1997), many states question whether and, if so, how remediation should be offered. Remedial courses are "not allowed" at public institutions in two states, and at least eight states restrict remediation to two-year colleges. Other states have imposed or are considering limits on the government funding of remedial coursework (ESC, 2003).[4] Finally, critics question whether the courses remove the incentive for students to adequately prepare while in high school.

Despite the extensive use of remedial courses to address academic deficiencies, little is known about their effects on subsequent student performance in college. Who should be placed in remediation, and how does it affect their educational progress? Most states and colleges do not have exit standards for remedial courses and do not perform systematic evaluation of their programs (Crowe, 1998; Weissman, Bulakowski, and Jumisko, 1997). There are also no current benchmarks by which to judge the success of higher education's remediation efforts (Ohio Board of Regents, 2001). Moreover, two reviews of the literature on remedial and developmental education found the bulk of studies to be seriously flawed methodologically (O'Hear and MacDonald, 1995; Boylan and Saxon, 1999). A simple comparison of students placed in remediation to those who are not is inherently flawed due to differences between the students. For example, NCES (1996) suggests that freshmen enrolled in remedial classes are less likely to persist into their second year, but this evidence does not control for student ability or possible movement across colleges. The few papers that attempt to provide causal estimates of the impact of remediation tend to focus on a very small group of students at a single institution and do not examine outcomes beyond the first year (e.g. Aiken, West, *et. al.,* 1998). As noted by Phipps (1998), "conjecture and criticism have filled the void created by the lack of basic information."

This paper addresses this major hole in the literature. Using data from the Ohio Board of Regents (OBR), we track approximately 28,000 full-time, traditional-age freshmen at public colleges

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[4] For example, Florida and Illinois restrict remediation to two-year colleges, and the CUNY system came under fire in 1998 for implementing a similar restriction. The California State University system imposes a one-year limit on remedial work, while Texas, Tennessee, and Utah have or are considering similar restrictions.

over five years to investigate the impact of remediation on college performance and persistence. To avoid the inherent biases, we use an instrumental variables strategy that exploits the importance of proximity in the college choices of Ohio students and variation in remedial placement policies across institutions. Together, these two sources of variation provide an exogenous predictor of the likelihood of remediation. In essence, we compare observationally-alike students who attend different colleges, due to proximity, and therefore, have varying experiences with remediation. Because our estimation strategy relies upon students for whom placement in remediation varies depending on which college they attend, we focus only on these marginal students in our analysis. The results therefore reflect the effect of remedial courses on the marginal student. Our estimates suggest that remediation has a positive impact on the college outcomes of under-prepared students. Students placed in remediation are more likely to persist in college in comparison to students with similar test scores and backgrounds who were not required to take the courses. They are also more likely to transfer to a higher-level or more selective college and to complete a four-year degree.[5]

## II. The Supply and Demand of Remediation

### *Context of the Study: Ohio Students and Colleges*

This study focuses on traditional-age (18 to 20 years old) college undergraduates who entered public colleges in Ohio as first-time freshmen during the fall of 1998. With longitudinal information from college transcripts, applications, and standardized tests reports with the accompanying student surveys, the analysis tracks these students over five years. The sample is limited to full-time students who took the ACT (the primary admissions test in Ohio) and either attended a four-year college or signified the intent to complete a four-year degree on their community college application.[6] These restrictions are necessary because our estimation methodology requires preparation and achievement

[5] These results differ from earlier work that focused on math remediation at four-year colleges. The previous analysis tracked students for only four years and explored the possible signaling function of remediation in terms of re-sorting under-prepared students to less selective colleges. In contrast, this paper tracks students for five years, includes both four-year and two-year colleges, and focuses on students on the margin of needing the courses.

[6] Half of traditional-age students (35 percent of all students) denote on their community college application intent to get a four-year degree or transfer to a four-year institution. The ACT requirement further emphasizes that this sample had some four-year intent as it is not required for admission. Technical colleges are excluded.

information from the ACT survey. Furthermore, so that degree completion is a relevant indicator of success, students needed to signify in some way wanting a get a degree and being able to complete it in reasonable time (beginning college full-time). Students without valid zip code information were also dropped.

Although this paper focuses on students in Ohio, the results should have external validity due to patterns of enrollment and remediation similar to national averages (Mortenson, 2002; NCES, 1996). Moreover, Ohio plays a prominent role in higher education. The only states with greater numbers of students in public colleges are California, Texas, New York, and Illinois (NCES, 2000). Moreover, Ohio reflects the complete spectrum of communities, labor markets, and higher education options that exist across the nation. Ohio has a mixture of selective and nonselective four-year institutions as well as two-year community and technical colleges spread geographically across the state. Finally, because only 12 percent of students take remedial courses at private, four-year colleges (NCES, 2003), the focus on public colleges is likely to give an accurate picture of the general effects of remediation.

Table 1 provides summary statistics of the data.[7] As is typical in higher education, the sample is slightly more female, and the percentage of the sample that is African-American and Asian is similar to national college proportions (Hispanic students are underrepresented). Twenty-two and 14 percent took math and English remedial courses, respectively. Due the sample restrictions discussed above, these proportions are smaller than figures for the entire cohort of students who entered that fall.

In terms of student outcomes, 40 percent of students were no longer found in the Ohio public higher education system after five years and therefore are considered dropouts. This rate after five years is similar to the national average (Adelman 2006). Nearly 44 percent had completed a bachelor's degree after five years leaving 16 percent still pursuing their studies within the system. Given the system-wide nature of the data, we can accurately track students across schools and

[7] To be included in the sample, students must have had valid zip code information, and colleges needed to have clear records of which courses were considered remedial and which were not during the sample period. The sample excludes two schools due to the inability to identify which courses were remedial in 1998-99 (University of Cincinnati and Kent State University).

include individuals who may have continued their educations or completed their degrees at different schools from the ones they originally entered. However, the data do not include students who transfer to private colleges or out of the state. The potential measurement error is likely to be very small since the percentage of students thought to transfer to such schools is a small fraction of the total number of observed dropouts (Bettinger and Long, 2004).[8]

***Students in Remediation***[9]

In Ohio, all but one of the public colleges offer remedial courses to entering freshmen.[10] The first major group of students in remedial education is under-prepared recent high school graduates, many of whom exit secondary school without grade-level competency or the proper preparation for college-level material. In our sample, 37 percent of first-year students under the age of 19 fit into this category having graduated from high school without a college-prep curriculum (OBR, 2002). Studies have found that students who complete an academic core curriculum in high school are half as likely to need remediation in college in comparison to other students (OBR, 2002; Hoyt and Sorensen, 1999). However, 25 percent of those with a known core high school curriculum still required remediation (OBR, 2002). In addition to recent high school graduates, a substantial number of adult students enroll in developmental courses along with recent immigrants. Nationally, about 27 percent of remedial students are over the age of 30 (IHEP, 1998).

Table 1 summarizes the characteristics of students placed into remediation versus those who are not. As expected, students placed into remediation had lower ACT scores and high school GPAs. For example, students placed in math remediation scored a mean of 17.4 on the math section of the ACT while students who did not take the classes scored 23.3 (a similar gap, 15.8 versus 22.8, is found for English remediation). A simple comparison of the outcomes of students placed into

[8] Using data from the Integrated Postsecondary Education Data System on the number of transfers at each institution and assuming that transfer students are geographically representative of the incoming freshman class, then one would expect around 650 Ohio students to transfer to non-Ohio schools each year. If we further assume that *all* 650 transfer students just finished their first year of school, then about 4.3 percent of observed dropouts are actually transfer students.

[9] Bettinger and Long (forthcoming) provides a more general description of students in remediation in Ohio including their backgrounds, academic preparation, and other characteristics. The sample in that analysis is not limited to traditional-age students who intend to complete a degree.

[10] The exception is Central State University. Miami University also sends remedial students to satellite campuses.

remediation and those who are not suggests that remedial students had worse educational outcomes. After five years, a larger proportion of them dropped out of college without a degree (65.2 for those in math remediation versus 30.8 percent) and fewer of them completed a baccalaureate degree (18.1 for those in math remediation versus 53.3 percent). However, this comparison does not take into account differences in the sample of remediated and non-remediated students.

Remedial classes are designed to address academic deficiencies and prepare students for subsequent college success. By teaching students the material that they have not yet mastered, the courses may help under-prepared students gain skills necessary to excel in college. Students with similar academic deficiencies who are not in remediation may never gain a sufficient academic foundation. However, there are several reasons why remedial courses may in fact have the opposite effect. For instance, by increasing the number of requirements and extending the time to degree, remediation may lower the likelihood of degree completion. There may also be a stigma associated with remediation that may negatively impact student. Being placed into remediation may produce a "Scarlet Letter" effect as perceived by other students and faculty. If remedial students feel that their colleges are singling them out as poor performers, this may discourage additional effort. Previous research in education suggests that there is a stigma attached to under-prepared students, and thjs can be harmful to students (Basic Skills Agency 1997, MacDonald 1987). Additionally, most Ohio campuses restrict enrollment until remediation requirements are satisfied. Oftentimes, students cannot enroll in upper-division courses until remediation is successfully completed, and within some majors, students cannot start the core required classes until remedial courses are completed and passed. Such restrictions may also discourage students from completing remediation courses (Bettinger and Long, forthcoming).

Remedial courses may also be filled with negative peer effects. Recent work in economics (e.g. Sacerdote, 2000; Zimmerman, 2003; Hoxby, 2000) suggests that students who interact with peers who are higher achievers than themselves tend to improve. For example, Sacerdote (2000) found that having a roommate with higher standardized test scores appears to positively affect a student's college achievement. Similar to the dorm rooms, remediation generates the grouping of certain types of students together. By grouping lower-ability students in remedial courses, colleges may be producing negative peer effects amongst those students. In contrast, similar students not placed into remediation could benefit from positive peers effects by interacting with higher-ability students in non-remedial classes.

***Variation in Remediation Policies by Institution***

Within the state of Ohio, public colleges and universities are independent and autonomous. As shown by a 1995 study by the Ohio Legislative Office of Education Oversight (LOEO), each is free to set their admissions, placement, and remediation policies.[11] All schools require entering freshmen to take placement exams, but the placement instruments vary by institution and include different combinations of ACT and SAT scores, high school transcripts, assessment exams, and institutional-developed subject-area tests.[12] In addition, while there are statewide standards to distinguish between remedial and college-level work, given the autonomy of public colleges in Ohio, institutions differ in how they interpret these standards at the campus level (LOEO, 1995). For example, the cut-off scores used to determine placement differ among institutions, reflecting the varying interpretations of what comprises college-level coursework (LOEO, 1995). One survey found that cut-off scores for placement into writing remediation varied from 17 to 20 for the ACT writing score, 410 to 580 for the SAT verbal score, and 26 to 44 for the ASSET test (SHERAC, 1997).

Our data provide further evidence of how remedial placement policies differ across institutions. Unfortunately, we do not have remedial placement test scores for each student.[13]

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[11] However, Ohio public institutions are subject to the state's "open admissions" law that requires high school graduates to be admitted to the public school of their choice with certain exceptions. Students who have completed a college prep curriculum are generally accepted unconditionally.

[12] The assessment exams include the Computerized Adaptive Placement Assessment and Support Systems (COMPASS) and the Assessment of Skills for Successful Entry and Transfer (ASSET), both published by ACT, Inc. Each consists of a variety of tests to measure students' skill levels. For example, the ASSET exam is a written exam with as many as 12 subsections, including in depth assessment of students' writing, numerical, and reading skills.

[13] These would not be sufficient to predict placement anyway given that schools often use a combination of measures in determining whether remediation is needed. Extended conversations with college officials made clear that standardized formulae are not used; instead the different instruments are sometimes weighted different amounts when making decisions. Therefore, it would be impossible for us to replicate the remedial placement decision even if we did have placement test scores.

However, because we have data on all of the students in and out of remediation, we can use other academic proxies as predictors of placement. Figure 1 displays the degree of variation in placement policies using ACT score as a predictor of placement into remediation. Each row corresponds to a different group of colleges.[14] The left-hand graphs show the distribution of student body ACT scores at each set of institutions. To estimate the right-hand graphs, we use a two-step process to identify the most likely remediation placement cutoff for each campus. First, for each campus and for each possible ACT scores, we estimate Equation 1 using a Probit model:

(1) $\text{Remediation}_i = a + b * I(\text{ACT}>J)_i + e_i$

where "Remediation" is an indicator for whether the student enrolled in remedial math classes, I(ACT>J) is an indicator for whether the ACT math score of student *i* is greater than J, and J varies over the possible range of ACT math scores (1-36). This gives us the likelihood that a student with a particular ACT score would be placed in remediation at a particular campus. We save these maximum likelihood estimates, and in the second step, we rescale them relative to the maximum value of the likelihood function within that campus. To the extent that colleges use the ACT score to assign remediation, these likelihood plots show a spike at the most likely remediation placement cutoff value used by an individual school.[15]

While the distribution of student body ACT scores (left-hand graph) looks similar across for each type of school except the selective universities, the most likely remediation cutoffs in the right-hand column show much greater heterogeneity. For example, the student bodies look similar among nonselective, four-year public institutions (middle row), but the predicted ACT cutoffs vary across these institutions from a score of 14 to 23. Hence, while all the four-year and two-year nonselective colleges in the state serve similar-ability students (i.e. comparing the left-hand graphs of the first two rows), they use different thresholds to determine placement into remediation (the right-hand graph). As expected, the ACT scores of students at the selective, four-year universities are higher, but as explained below, only students at these schools who might plausibly be placed in remediation are

[14] Selective public institutions in Ohio require a certain academic standard but are not considered highly selective by national norms. Nonselective four-year colleges may require the ACT but are open admissions schools.
[15] A similar methodology is used in Kane (2003).

used in the main results. The scores of this subset of students are much more similar to those of students at nonselective colleges.

The results in Figure 1 are an oversimplification of individual colleges' remediation assignment rules. They focus on only one dimension (ACT scores) to illustrate the heterogeneity. As previously mentioned, remediation placement criteria can also include high school curricula, high school grades, and other indicators. As we explain below in our subsequent analysis, we use more flexible specifications that allow these other possible criteria to matter. In these augmented specifications, we can test whether the remediation placement rules are equivalent across campuses, and as we describe later, in these tests we soundly reject that the placement rules are equivalent.

In summary, a student who might place out of remediation at some Ohio colleges could be put into remedial courses at others. Institutional rules on placement into remediation might differ for several reasons. First, placement policies and rates vary due to differences in their student bodies. For example, the most selective colleges have different remediation policies than the community colleges perhaps due to differences in the preparation of their students and the demands of the curriculum at each school. However, even schools with similar student bodies vary in their remediation policies, and this is the variation of interest for our research strategy.

There are a number of reasons to believe remediation policies are exogenous to our outcomes of interest (student persistence and graduation). For instance, the cutoffs may be set according to the beliefs and opinions of the administration about remediation. One four-year university in Ohio decided to eliminate remediation after a change in college leadership. Students requiring remediation are now referred to a local community college (Sheehan, 2002). The preferences of the departments responsible for remedial courses are also likely to be important and could impact which exam is used or the relative weight given to high school preparation in determining placement. However, these opinions are not based on systematic research (OBR, 2001). In addition, colleges are largely unaware of whether their programs are working and what the long term outcomes of remedial students are. A 1991 internal report by the Ohio Board of Regents found that "very few institutions conduct consistent follow-up students of students completing developmental programs or track the students to completion of their educational goals" (LOEO, 1995).[16] Without clear best practices and little information on student outcomes, it is unlikely that placement policies are being shaped in systematic ways in reaction to student enrollments or program effectiveness.

One could imagine however that even if the administrators of remediation policies did not track long-run student outcomes, their remediation policies may still evolve in response to observing students' experiences in remedial classes. However, conversations with many college administrators suggest that remediation policies were set long ago and then have changed little with time. Many referred to past precedent as the reason for the current set of policies. Given these conversations, we are hopeful that placement policies are not being shaped in reaction to the outcomes of the programs themselves. Cost could also affect remediation policies. If the cost of remediation differs across schools, then they may cause policies to vary. Particularly over time, as college budgets become more or less constrained, institutions may be more or less willing to spend money on remediation.

Another theory is that the political economy and secondary schools of the surrounding area might also be important in determining the role of remediation at a college. For example, colleges may set their remediation policies in response to the skill level of local graduates or feeder schools. However, we find no support for this hypothesis. Table 2 displays estimates of the relationship between the estimated ACT cutoff for remedial placement and the characteristics of the college, its area high schools, and the local community. The high school variables include characteristics that predict college success (e.g. median income, socio-economic characteristics, test scores), and many of these characteristics are general indicators of the overall quality of education near the college campus. However, none of the variables are statistically significant. Two additional specifications focus only on the nearby, low-performing high schools. Graduates of these schools are very likely to need remediation, and so they may be more likely to influence college remediation policies.[17] However, again, none high school characteristics seem to explain the placement cutoffs. Therefore,

[16] Although the Ohio Board of Regents collects and assembles student unit record data, most schools do not have the information themselves nor the resources to analyze it to reflect on their own remediation policies.

[17] The main colleges in our analysis are non-selective, open admissions campuses. The charge of these colleges is to educate any student who graduates from high school, and they serve many of the students from these area low-performing high schools.

the remediation policies of colleges across the state appear to differ in nonsystematic ways, and this variation is central to our estimation strategy.

## III. Empirical Framework - Using Variation Across Colleges

### *Biases in the Study of Remediation*

To understand the impact of remedial education policies, we compare the outcomes of students placed in remediation to those who are not. However, selection issues preclude a straightforward analysis. The first major concern is ability bias. Lower-ability, less-prepared students are more likely to be placed in remediation. They are also, even in the absence of remediation, less likely to persist and complete a degree. Therefore, one does not know whether the more negative outcomes of remedial students are due to their lack of preparation or the remedial courses themselves.

A second concern is college choice. Enrollment in a particular college may be an endogenous choice reflecting both student ability and preferences about remediation. For example, a student wishing to avoid remediation might choose a college with a very low placement threshold. However, this second concern is not very likely as numerous studies suggest high school students understand little about the preparation necessary for college (Greene and Foster, 2003; SHERAC, 1997) and many papers decry the disconnect between what high schools tell students to do versus what college professors require (Kirst and Venezia, 2001; Venezia, Kirst, and Antonio, 2003). Other studies document the fact that most high school students are unaware of college admission procedures, costs, and aid (Kane and Avery, 2004). The literature also notes the surprise of many students when they are placed in remediation (Venezia, Kirst, and Antonio, 2003; Trouson, 2002).[18]

To address these issues, we construct a two-part instrumental variable (IV). The first part of the instrument deals with the possible endogeneity of college choice by using proximity as an exogenous predictor of the school attended. Previous research has shown that students are more

[18] Conversations with practitioners in Ohio have further convinced us that students overwhelmingly have very little understanding of remedial placement procedures or their need for the courses.

likely to attend one school over another based on how close the colleges are to their homes (Rouse, 1995; Card, 1995; Long, 2004a). In fact, in order to improve access, Ohio Governor James Rhodes who served as governor from 1963-1971 and from 1975-1983 attempted to influence the location of colleges so that every state resident was located within thirty miles of a college campus (OBR, 2001). As a result, the median distance from a student's home to their college is only 26 miles in our sample with nearly 60 percent of students attending a college within 50 miles of their homes.

The second part of the instrument deals with ability bias using variation in college remediation policies. As discussed in the previous section, colleges differ in their methods of assignment into remediation for reasons that we are assuming are exogenous to student outcomes. In our identification, we identify similar students attending different schools but facing dissimilar probabilities of remediation based on each college's placement policy.

In summary, we assume that proximity is related to the school chosen, and therefore the remediation policy the student faces, but it is not related to outcomes such as persistence in college. Our instrument thereby combines both the likelihood of a student choosing a given institution and the likelihood of being placed into remediation at that college. If distance exogenously predicts the college of attendance, and each college has a different remediation policy, then the interaction of these variables exogenously predicts remediation.[19]

***The Construction of the Instrumental Variable***

To approximate the likelihood that an individual will attend a specific college, we estimate the probability of attendance based on distance conditional on the individual choosing a public college. The predicted probabilities are determined using a conditional logistic regression model, a framework that has been used to study college choice as well as the selection between travel modes and occupations.[20] The conditional logit model is made up of $j$ equations for each individual $i$, with each equation describing one of the college alternatives. The dependent variable, signifying the choice of the individual, equals one for the alternative that was chosen,

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[19] The results are similar using an instrument based on the remediation probability at the nearest school.
[20] For an application of the conditional logit to college choice, see Long (2004).

and the model estimates the impact of distance on the probability of enrollment at each of the colleges relative to all the other alternatives.[21] Under the assumption that the $\varepsilon_{ij}$'s are independent and identically distributed with the extreme value distribution, we get the conditional logit functional form as shown in equations (2):

$$(2) \qquad \Pr(Y_i = j) = \frac{e^{B'X_{ij}}}{\sum_j e^{B'X_{ij}}}$$

$$B'X_{ij} = \alpha + \beta \mathrm{S_j} + \gamma_1 \mathrm{D_{ij}} + \gamma_2 \mathrm{D_{ij}^2} + \gamma_3 \mathrm{D_{ij}^3} + \gamma_4 \mathrm{D_{ij}} \mathrm{L_j} + \varepsilon_{ij}$$

where $S_j$ is a series of fixed effects for each college, $D_{ij}$ is the distance that student *i* lives from university *j* along with , $D^2_{ij}$ and $D^3_{ij}$, distance squared and cubed, and $D_{ij}L_j$, interactions between distance and the level of the college.[22] The conditional logit estimates suggest that our sample was much less likely to choose a college the farther away it was from their residence with a coefficient of -2.66 per 100 miles (the results are not marginal probabilities) and a Z-statistic of 51.91. This reflects that fact that 75 percent of the sample attended a college within 100 miles of their home, and nearly 60 percent attended a college within 50 miles. Using the estimated coefficients, we calculate the probability of enrollment at each college.

The second part of the IV predicts the likelihood of remediation. While using placement scores would be ideal, in their absence we use information on the characteristics of students placed in and out of remediation at each school. The likelihood of taking math remediation is modeled as a probit controlling for student characteristics such as math ACT score, the score squared, high school overall GPA, high school math GPA, the number of math classes taken in high school, race, gender, age, the type of high school attended, family financial background, postsecondary degree intent, and similar variables for those submitting the SAT. We also saturate the model with dummy variables for each college and separate interactions between the college dummy and the student's math ACT, math grades in high school, and years of math.[23] Using these coefficients, we then predict the

[21] Distance is calculated using the zip code on the college application and the zip code of the college.
[22] If the Independence of Irrelevant Alternatives (IIA) condition is met, the estimates will be consistent even if the decision to attend college at all is endogenous. See Long (2004) for discussion.
[23] By estimating this as one large model with dummy variables for each college, we hold constant across schools the role of student demographic characteristics (race, gender, and age), family income, type of high school, and type of

likelihood of math remediation for each student at each college in our sample. The same methodology was followed to predict the likelihood of English remediation (replacing math scores, grades, and semesters of courses with verbal scores and English grades and courses in high school). Likelihood ratio tests reject the hypothesis that the coefficients on the college dummy variables are the same. Therefore, institutional remediation rules do not appear to be equal and attending a different college could dramatically change the likelihood that an individual student would be placed into remediation.

We combine the probabilities of attendance and of remediation to build our instrument for remediation as shown in equation (3):[24]

$$
\begin{aligned}
(3)\quad Z &= \Pr[\text{Remed}_i \mid \text{Attends any university } j \text{ where } j \in J] \\
&= \sum_{j \in J} \Pr[\text{Remed}_i \mid \text{Attends university } j\,] \Pr[\text{Attends university } j \mid \text{Attends any university } j \in J]
\end{aligned}
$$

Table 3 provides an example of the instrument for an actual student. Column 1 shows the predicted probabilities of attendance at each of the campuses (calculated using the conditional logistic model). As shown for campus 28, the school the student actually chose, the probability of attendance based on distance was actually the second highest of the 45 possible institutions (17.1 percent). Column 2 uses the individual's test scores, high school preparation, and background characteristics to predict the probability of taking a remedial course at each campus. Finally, column 3 is the product of those two probabilities, the probability of attending each school weighted by the probability of remediation at that school. The instrument is constructed by summing all the values in column 3. The final instrument suggests that the student has a 12.4 percent chance of being in remediation. In our results of the first stage equation for math remediation, the coefficient of the instrument is 1.12 with a standard error of 0.0405, thereby making it significant at the 99 percent level. In a similar fashion, the coefficient on the IV for English remediation is 1.23 with a standard error of 0.0381.

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high school degree in determining the probability of remediation. The probability is only related to the math ACT score, years and grades in high school math, and the general placement threshold of the school.

[24] An alternative instrument would be to assign the probability of remediation for each student at only the nearest college. We get similar results when we use this "nearest college" instrument, which largely identifies the effects of remedial courses off of students who elect to not attend their closest institution. We prefer the instrument constructed in equation 3 because it identifies off variations across universities in policies as well as proximity.

The key variation in our instrument arises from differences across campuses in remediation placement rules. In our second stage, we control for the same individual characteristics included in estimating the remediation placement rules. Because of this, we control for the average likelihood of a given characteristic (e.g. ACT score) in predicting remediation in general. Variation in the weight and cutoffs that campuses place on a given characteristic (relative to the average weight across campuses) creates the variation in our instrument. Geographic proximity determines how much weight a particular campus placement rule receives in determining the likelihood of remediation for a student. Explained differently, the instrument is the change in an individual's probability of remediation based on a correction due to a student's proximity to each college campus, which each have varying remediation placement rules.

***Estimating the Effects of Remediation on the Marginal Student***

The effects of remediation are measured using the regression model shown in equation (4):

(4) $$\text{Outcome}_i = \alpha + \beta\, \text{Remed}_i + \gamma\, X_i + e$$

where *X* is a matrix of individual characteristics that may influence both assignment to remediation and students' outcomes. The model controls for race, gender, age, ACT composite score, ACT math (or English and Reading) score, high school GPA, high school rank, family income, high school types, semesters of high school math (or English), high school grades in math (or English), and type of high school degree (dummy variable for GED). Remediation enters as a dummy variable equal to one if the person enrolled in any remedial course. To test whether there are different effects for math versus English remediation, separate estimates by subject are provided. The outcomes are measured for five school years from Fall 1998 to Spring 2003. Students are considered "drop outs" if they are no longer at any public, Ohio college at the end of the time period and have not received a four-year degree. Students who have "transferred down" are at a less selective or lower-level college (university branch campuses are considered less selective than four-year colleges). Students who have "transferred up" went to a more selective or higher-level college. Unlike other studies, students who transferred to other colleges are not considered dropouts due to our ability to track students. It is important to note that this is the "intention to treat" effect as some students placed in remediation never complete the courses.

Our estimation strategy and results rely on students for whom the probability of remediation differs according to the college they attend. Therefore, the estimates are not reflective of students who would have either always or never been put in remediation, and keeping these students in the sample would skew the results.[25] The target sample is instead marginal students for whom it is questionable whether they do or do not need remediation. This margin may be especially important given the current debate as states and colleges try to determine ways to reduce and/or shift remedial services without terminating them completely.

To better focus on students on the margin of needing remediation, we imposed the following sample limitations. First, we dropped students who had less than a 25 percent chance of being placed in remediation at one of the most stringent schools (defined to have the 90$^{th}$ percentile placement threshold, one of the highest in the public college system).[26] In other words, students who had only a small probability of remediation under very rigorous standards are assumed to rarely be placed in remediation. Second, students who had at least a 25 percent chance of remediation at one of the most lenient schools (defined to have the 10$^{th}$ percentile placement threshold, one of the lowest) were also dropped. We assumed these students would almost always be placed into remediation regardless of the school policy. Finally, we dropped students who did not have much variation in the probability of remediation at each school. We defined this as having less than a 25 percentage-point difference between the 90$^{th}$ and 10$^{th}$ percentile remediation probabilities across the schools.[27] Because there are other possible ways to define the marginal group, the results below were also estimated using different cutoffs. For instance, rather than the 25 percent cutoffs used in the above definition, 33

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[25] When estimating the results using the full sample, students who would never or always be placed in remediation effectively drop out of the sample due to lack of variation in the treatment. Therefore, this restriction mainly affects students who would rarely be placed in remediation or rarely place out. However, because the aim of this paper is to understand the effects on students truly on the margin of needing remediation, we chose to exclude these outliers.
[26] So that the definition of the marginal sample is not driven by a single, outlier college, the 90$^{th}$ percentile is used rather than the college with the highest overall placement threshold. Similarly, the 10$^{th}$ percentile is used.
[27] Of the restrictions, the first (dropping students who would rarely be in remediation) and third (dropping students without much variation in their probability of remediation) are the most binding. These restrictions are also reinforcing: nearly all of the students dropped due to the first restriction also qualify to be dropped under to the third. Very few students would have been placed in remediation at the most lenient schools (the second restriction).

percent cutoffs were used. The results are robust to these different definitions. Additionally, results using the full sample of students may be thought of as a lower bound of the effect on the marginal student: the full sample is essentially equivalent to using the least restrictive possible definition of this group.

The last two columns of Table 1 provide summary statistics of the sample on the margin of needing remedial courses or not. Using the definition described above is very inclusive of many students, and the results apply to a large proportion of college students. The sample size drops only by a third for the Math Remediation group (slightly larger for the English remediation group) suggesting that variation in the remediation cutoff is important for the *majority* of students. In comparison to the full sample, fewer students are from the selective four-year colleges, but these students still make up the largest group. The marginal samples also have lower average ACT scores than the full sample again suggesting that students at the top of the distribution who would never be placed in remediation have been dropped; students who would have always been in remediation have also been dropped, but there are fewer of them. For instance, the sample of marginal students for the math analysis does not include any student with a math ACT score of eleven or below, and many students with math ACT scores of 12, 13, and 14 are also excluded due to having a high likelihood of being placed in remediation regardless of which college they attend.

## IV. The Effects of Math and English Remediation

### *The Overall Effects of Remediation*

This section discusses the impact of remediation on persistence, transfer behavior, and degree completion for similar students placed in and out of remediation. Tables 4 and 5 report the basic results of the impact of remediation on a variety of various outcomes using OLS and IV regression analysis.[28] The left panel displays results for the full sample while the right side focuses on the subset of students on the margin of needing remediation. Means of the outcome variable are shown

[28] Some of the estimates have fewer then the total number of observations due to the fact that students at selective four-year cannot transfer up and students at community colleges cannot transfer down.

to aid in interpretation. Each coefficient under the OLS and IV columns represents a separate regression with controls for race, gender, age, ACT composite score, ACT math (or English and Reading) score, high school GPA, high school rank, family income, high school type, semesters of high school math (or English), high school grades in math (or English), and type of high school degree (dummy variable for GED).

The first thing that is obvious from the results is the difference between the OLS and IV results. As discussed above, a simple comparison of students in and out of remediation is likely to suggest negative effects due to important academic differences in the underlying populations. For instance, as shown in Table 4, students in math remediation are found to be 13.7 percent more likely to drop out and 10.8 percent less likely to complete a degree by Spring 2003 (i.e. within five years) than students not in remediation. However, when using the IV strategy to deal with such biases, these negative estimates disappear.

A second major pattern in the results is the difference between those estimated for the entire sample versus the results on the marginal remedial students. As discussed above, the estimation strategy relies upon the sample of students for whom the likelihood of remediation varies across schools. As would be expected, many of the results become stronger once focusing more finely on this marginal group. As shown in the IV column of results for the margin sample, students in remedial math courses are nearly 10 percent less likely to drop out than similar students. As theory would predict, using more restrictive sample limitations to determine the subset of marginal students increases the positive estimated effects of remediation. For instance, when restricting the sample to students with at least a one-third chance (33 percent) of being placed into remediation at their most stringent school and less than one-third chance (33 percent) at their most lenient , math remediation is estimated to reduce the probability of dropping out by 13.5 percent (in comparison to a 9.6 percent reduction using the 25 percent cutoffs). Therefore, the subsample results displayed in the table may be thought of as conservative estimates of the impact of remediation on marginal students.

Table 5 shows that similar impacts are found for English remediation in terms of persistence and degree completion. Focusing on the IV results for marginal subsample, students in English remediation are 9.7 percent less likely to drop out and 9.3 percent more likely to graduate by Spring 2003 than similar students. In addition, students in English remediation are 18.7 percent less likely to transfer to a less-selective or lower-level college.

***The Effects of Remediation by Student Ability***

While the previous tables suggest that remediation has a positive effect overall on student outcomes, the next part of the analysis tests whether the effect differs by ability level as measured by ACT score. Table 6 displays the results from including an interaction between the student's ACT score and the remediation dummy variable; the top panel has the results for math while the bottom focuses on English. Although the coefficients for math remediation suggest it has a detrimental impact on student outcomes (e.g. increasing the likelihood of stopping out and reducing degree completion), once the results are evaluated at the mean ACT math score, the results are similar those found above. For example, evaluated at the mean ACT math score of students in math remediation (mean 17.68), students in remedial math courses are 14.0 percent less likely to drop out of college by Spring 2003. As shown by the sign of the interaction, the beneficial effects of remediation on stopping out increase with the ACT score. Students with higher math ACT scores who are placed into remediation are also more likely to transfer up, finish their degree, and complete more total credit hours.

The results in the bottom half of the table are also similar to the earlier results once evaluated at the mean. Using a mean English ACT score of 15.66 for the group in remediation, the results suggest that they are 11.7 percent less likely to stop out of college by Spring 2003. The impact of English remediation on reducing the probability of dropping out also appears to increase with ability as shown by the negative sign on the interaction between the remediation dummy variable and the ACT English score. However, unlike for math remediation, the reverse is true for the other outcomes. While students in English remediation *generally* tend to complete more credit hours, are more likely to transfer up, and graduate within five years, this positive effect declines the higher the

ACT score. Therefore, although math remediation appears to help higher ability students more overall, the impacts of English remediation by ability are more mixed.[29]

***The Effects of Remediation on Student Interest***

The final section of analysis examines whether the effects of remediation vary across students with different academic interests. For instance, the impact of remedial courses may differ depending on whether the student intended to major in a subject related to the field or not. On one hand, math remediation may send an especially influential signal to students intending to major in math-type courses that they will not succeed and should change to something different or dropout altogether. On the other hand, students intending to do math-type majors may view it as a necessary step and be especially motivated to succeed in the courses. Another question related to the issue is whether it makes sense to require math remediation for students not intending to major in math-related fields. Table 7 displays analyses of these questions by interacting the remediation variable with a dummy variable measuring students' pre-college interest in a related major. This information comes from the survey students fill out when taking the ACT, and so this variable is not influenced by their performance on the ACT or placement into or out of remediation. College majors have been categorized as a being generally math- or English-related for the analysis.[30]

As shown in the first row of each section of the table, remediation is estimated to have the same general effects. However, the second row of results displays that students needing math remediation who intended to major in a field related to math were more likely to complete their degrees within five years. However, these students did not necessarily major in a math-related subject. The last column examines the possible discouragement effect of remediation as the dependent variable measures whether students majored in a math-related subject. The coefficient on the dummy variable signifying pre-college interest in a math-related field suggests these students

[29] Additional analysis ran separate regression models for each ACT score and compared the coefficients on the remediation dummy variable. These results reinforce the conclusions drawn from Table 6.

[30] The following are considered math-related majors: Mathematics, Statistics, Sciences (biology, chemistry, physics, etc.), Business, Computer Science, Engineering, and Architecture. The following are considered English-related majors: Humanities, Foreign Languages, Social Sciences, Journalism, Communications, Education, and Social Work. Students who did not declare a major in college are excluded from the analysis.

were much more likely to major in such a subject as expected. However, students who had math remediation were less likely to major in a math-related subject than their peers with similar interests. Similar results are found for students in English remediation. They were less likely to major in an English-related field than other students with similar pre-college interests. Therefore, although there is generally no difference in the effect of remediation on students by subject of interest, remediation seems to have a discouragement effect on major choice.

## V. Conclusions

In summary, we estimate that students in remediation have better educational outcomes in comparison to students with similar backgrounds and preparation who were not required to take the courses. While OLS estimates suggest remediation has a negative effect, once controlling for selection issues, the results become positive thereby emphasizing how inappropriate it is to simply compare the outcomes of remediated and non-remediated students. Instead, by exploiting institutional variation in remedial placement policies and the importance of proximity in college choice, our analysis provides plausible estimates of the causal effects of remediation. Over five years, math and English remediation are estimated to reduce the likelihood of dropping out and increase the likelihood of completing a degree. Moreover, English remediation appears to reduce the likelihood of transferring to a less selective or lower level college. Lending further support to the results, as theory would predict, the estimates are more positive for the group of students on the margin of needing remediation than the general sample. Furthermore, as the definition of the marginal subsample becomes more restrictive, the estimates continue to increase in size. While the subsample of students is only on the margin of needing remediation (i.e. they would be assigned to the classes at some schools while not at others), the results clearly suggest that remedial classes still have beneficial effects for them.

While the sizes of the general results are similar for math and English remediation, once focusing on particular kinds of students, differences are found by remedial subject. The impact of math remediation appears to increase as the student's ACT increases across all of the outcomes. Meanwhile, the positive impact of English remediation increases with ACT score in terms of reducing the probability of stopping out, but it declines as ability increases for the other outcomes. In terms of student interests, math remediation increases the likelihood of degree completion among students intending to major in math-related fields though it slightly reduces the likelihood of majoring in such a field. English remediation is estimated to have a strong discouragement effect on students who intended to major in English-related fields.

In conclusion, remediation is an important part of higher education, and it plays a very significant role in attempting to address the needs of the thousands of under-prepared students who enter postsecondary institutions each year. While we find it to have a positive impact on educational outcomes, further research is needed to more completely understand its other effects. By focusing on the group of marginal students, we do not investigate the effects of remediation on students who are extremely under-prepared for college-level work (i.e. we do not have an appropriate control group for them because they are nearly always in remediation regardless of the college they attend). Future analysis needs to establish the impact of remediation on this group of students. Additionally, while our results give a general sense of the impact of remediation, it may be the case that certain types of instruction and supports are more beneficial than others, and this should be investigated.

Additional research on how to maximize the benefits of remediation is essential, as the cost of not offering the courses appears to be expensive. Our results suggest that under-prepared students without the courses are more likely to drop out of college and less likely to complete their degrees. Many sources document the higher incidence of unemployment, government dependency, and incarceration among individuals with less education, and the costs associated with these kinds of activities are large. Moreover, the increasing demands of the economy in terms of skill and international competition encourage the country to find an effective way to train its workers. As noted in a *Time* magazine article, eliminating remediation in higher education could “effectively end the American experiment with mass postsecondary education" (Cloud, 2002). With persistent concerns about the abilities of high school graduates, higher education must find ways to address the needs of under-prepared students.

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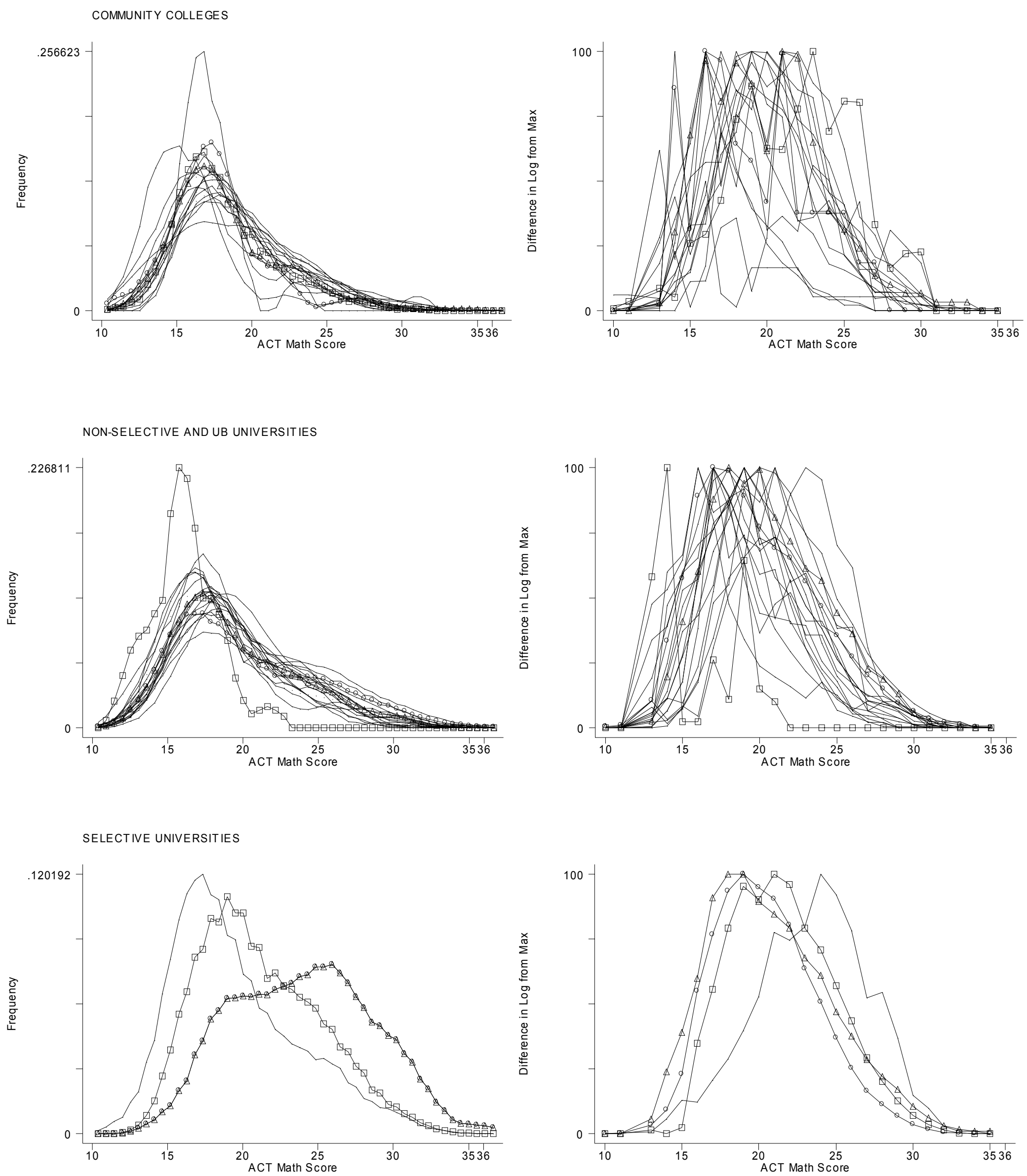
**Figure 1: The Distribution of ACT Scores and Likely Remediation Cutoff Score by Institution**




Notes: Each line represents a different institution. The graphs on the left are of the distribution of ACT scores. The graphs on the right show the likelihood of being placed in remediation for each ACT score. In the results, we focus on the students who might plausibly be placed in remediation. Therefore, while the overall ACT scores of students at selective, four-year universities are higher, the scores of the subset of students who could plausibly be placed in remediation are much more similar to those of students at nonselective colleges.

**Table 1: First-time, Full-time Students in Ohio Public Colleges, Fall 1998**

| | Full Sample | Remedial Placement | | | Marginal Students Affected by Differences in Remediation Policies | |
|---|---|---|---|---|---|---|
| | | No Remediation | In Math Remediation | In English Remediation | Math Sample | English Sample |
| *Demographics and Achievement* | | | | | | |
| Female | 0.5569 | 0.5560 | 0.5940 | 0.4729 | 0.5815 | 0.5207 |
| Black | 0.0719 | 0.0452 | 0.1422 | 0.1854 | 0.0846 | 0.1009 |
| Hispanic | 0.0164 | 0.0140 | 0.0258 | 0.0221 | 0.0179 | 0.0201 |
| Asian | 0.0184 | 0.0212 | 0.0095 | 0.0122 | 0.0131 | 0.0172 |
| ACT Overall Score (36 maximum) | 21.92 (4.30) | 23.37 (3.84) | 18.26 (3.03) | 17.21 (2.77) | 20.36 (3.23) | 19.77 (3.52) |
| *Math Preparation and Achievement* | | | | | | |
| ACT Math Score (36 maximum) | 21.74 (4.78) | 23.32 (4.43) | 17.38 (2.65) | --- | 19.67 (3.08) | --- |
| Grades in High School Math | 3.06 (0.75) | 3.26 (0.65) | 2.51 (0.74) | --- | 2.89 (0.69) | --- |
| *English Preparation and Achievement* | | | | | | |
| ACT English Score (36 maximum) | 21.25 (4.93) | 22.77 (4.43) | --- | 15.77 (3.38) | --- | 18.64 (3.98) |
| ACT Reading Score (36 maximum) | 22.28 (5.59) | 23.78 (5.22) | --- | 16.85 (4.06) | --- | 19.69 (4.74) |
| Grades in High School English | 3.23 (0.68) | 3.38 (0.57) | --- | 2.75 (0.63) | --- | 3.04 (0.64) |
| *College of Attendance and Outcomes* | | | | | | |
| Attend Selective 4yr | 0.5369 | 0.6438 | 0.2649 | 0.2099 | 0.4633 | 0.4431 |
| Attend Nonselective 4yr | 0.3581 | 0.3063 | 0.4634 | 0.5304 | 0.4079 | 0.4155 |
| Attend Comm. College | 0.1049 | 0.0500 | 0.2717 | 0.2598 | 0.1287 | 0.1413 |
| Math Remediation | 0.2237 | 0.00 | 1.00 | 0.5779 | 0.2925 | 0.3177 |
| English Remediation | 0.1405 | 0.00 | 0.3608 | 1.00 | 0.1741 | 0.2249 |
| Dropped Out before Spring 2003 | 0.4005 | 0.3082 | 0.6519 | 0.6680 | 0.4685 | 0.4773 |
| Total Credit Hours | 81.20 | 91.10 | 54.97 | 51.47 | 72.39 | 75.95 |
| Completed BA/BS degree within 5 yrs | 0.4361 | 0.5334 | 0.1810 | 0.1492 | 0.3525 | 0.3546 |
| Observations | 28,376 | 20,332 | 6349 | 4250 | 18,917 | 15,013 |

Notes: Standard deviations are shown in the parentheses. The number of observations for variables with less than the total observations is shown in brackets. Sample is restricted to traditional-aged (18-20), first-time students who entered full-time in Fall 1998 and had valid zip code information. Students are considered to have "Dropped Out" if they have not completed a bachelor's degree and are nowhere in the Ohio public higher education system in Spring 2003 (after five years). “Transfer Up” is defined transferring to a more nonselective or higher level college while "Transfer Down" is the reverse.

**Table 2: Local High School and Community Characteristics and Remediation Cutoffs**
Dependent Variable: Percentile of the Estimated ACT Cutoff for Remediation (OLS estimates)

| | All Nearby High Schools | | Nearby HS with fewer than 50% Pass 12th Grade Math Exam | |
|---|---|---|---|---|
| Radius of Sample | 10 Miles (1) | 30 Miles (2) | 10 Miles (3) | 30 Miles (4) |
| ***University Characteristics*** | | | | |
| University Branch | 3.01 (10.45) | -3.55 (9.91) | -6.86 (12.61) | -1.03 (9.19) |
| State Community College | 7.55 (10.47) | 8.28 (10.95) | 7.04 (12.86) | 12.37 (10.00) |
| Local Community College | 8.42 (11.66) | 6.52 (12.34) | 4.67 (14.98) | 6.65 (11.55) |
| Technical College | 2.67 (10.81) | -2.60 (12.40) | 1.94 (14.15) | 1.61 (11.45) |
| Selective Admissions | 13.89 (11.10) | 18.21* (10.24) | 21.36 (12.54) | 19.24* (9.69) |
| Degree of Urbanization | -0.88 (2.60) | -1.15 (2.50) | -0.30 (3.13) | -0.73 (2.52) |
| College Percent African-American | 0.65 (1.32) | 1.03 (0.90) | 1.47 (1.39) | 1.21 (0.85) |
| College Percent Hispanic | -7.25 (5.69) | -1.00 (3.68) | -3.51 (6.30) | -1.95 (3.62) |
| ***Local High School and District Characteristics*** | | | | |
| Pct. Free Lunch at the HS | -19.52 (90.69) | 29.50 (216.2) | -16.06 (87.43) | 225.11 (169.31) |
| 1995 Median District Income (000s) | 1.04 (2.32) | 0.20 (3.48) | 2.67 (2.84) | 4.04 (3.53) |
| HS Percent African-American | 20.85 (79.96) | -14.27 (138.9) | -7.77 (55.38) | -18.42 (77.66) |
| HS Percent Hispanic | 492.0 (338.3) | 154.8 (331.6) | 231.9 (334.7) | -117.5 (206.6) |
| Mean HS Math Pass percentage | 0.52 (0.93) | 0.52 (1.10) | -0.44 (1.28) | -0.31 (1.61) |
| HS Dropout Rate (3-year average) | -0.21 (0.84) | -0.91 (1.44) | -0.37 (0.73) | -1.99 (1.36) |
| HS 1997 Instructional Expend/Stud (000s) | -8.35 (9.64) | -3.41 (19.93) | 0.37 (10.80) | -14.32 (19.64) |
| Number of Local HS | 1.82 (1.97) | -0.87 (0.73) | 0.37 (2.93) | -2.31 (1.70) |
| Number of Local HS Students (000s) | -19.52 (90.69) | 29.50 (216.2) | -16.06 (87.43) | 225.11 (169.31) |
| Observations | 42 | 42 | 38 | 42 |
| R-squared | 0.4201 | 0.3221 | 0.3191 | 0.4025 |

** Significant at the 5% level * Significant at the 10% level
Sample: Public and private high schools and school districts within 10 or 30 miles of a public Ohio college.
Notes: Standard errors shown in parentheses. Variable means are weighted by the enrollment of the school or district. The percentile is the 1999 percentile among ACT test-takers nationally. The results do not change in statistical significance if the ACT cutoff score or the natural log of the score is used.

**Table 3: Example of the Construction of the Instrument using a Sample Student**

| College Campus | Predicted Probability of Enrollment given Distance | Predicted Probability of Math Remediation if Attend College | Column 1 * Column 2 |
|---|---|---|---|
| | (1) | (2) | (3) |
| 1 | .0000322 | .0214147 | .0000007 |
| 2 | .0041706 | .1407967 | .0005872 |
| 3 | .0702409 | .2123963 | .0149189 |
| 4 | .0000011 | .6154543 | .0000007 |
| 5 | .0000011 | .6019241 | .0000007 |
| 6 | .0000011 | .7366664 | .0000008 |
| 7 | .0021548 | .2368569 | .0005104 |
| 8 | .0033154 | .2448504 | .0008118 |
| 9 | .1448748 | .1591497 | .0230568 |
| 10 | .0002561 | .2801378 | .0000717 |
| 11 | .1737791 | .0303145 | .0052680 |
| 12 | .0032035 | .8401513 | .0026914 |
| 13 | .0000017 | .1572767 | .0000003 |
| 14 | .0000212 | .5702834 | .0000121 |
| 15 | .0035474 | .7567446 | .0026845 |
| 16 | .0000004 | .2208170 | .0000001 |
| 17 | .0024863 | .0000950 | .0000002 |
| 18 | .0015160 | .1478897 | .0002242 |
| 19 | .0000050 | .4503805 | .0000023 |
| 20 | .0032313 | .2508281 | .0008105 |
| 21 | .0000004 | .2624444 | .0000001 |
| 22 | .0032040 | .3407020 | .0010916 |
| 23 | .1196565 | .0433224 | .0051838 |
| 24 | .0091963 | .6631163 | .0060982 |
| 25 | .0002830 | .2911467 | .0000824 |
| 26 | .0000048 | .4136842 | .0000020 |
| 27 | .0007260 | .2317703 | .0001683 |
| **28 (attended)** | **.1714355** | **.1026604** | **.0175996** |
| 29 | .0693176 | .1118652 | .0077542 |
| 30 | .0001288 | .3324531 | .0000428 |
| 31 | .0000060 | .4262620 | .0000025 |
| 32 | .0000340 | .5179935 | .0000176 |
| 33 | .0136011 | .0167948 | .0002284 |
| 34 | .0207147 | .3456770 | .0071606 |
| 35 | .0008362 | .0000000 | .0000000 |
| 36 | .0008362 | .0009789 | .0000008 |
| 37 | .0008362 | .0000055 | .0000000 |
| 38 | .0000268 | .1431467 | .0000038 |
| 39 | .0070355 | .3050195 | .0021460 |
| 40 | .0000113 | .0719892 | .0000008 |
| 41 | .0000143 | .2834351 | .0000041 |
| 42 | .0000012 | .0955865 | .0000001 |
| 43 | .1255224 | .1086463 | .0136375 |
| 44 | .0435922 | .2501734 | .0109056 |
| 45 | .0001392 | .1497208 | .0000208 |
| **Instrument = Weighted Average of Remediation Probabilities = Sum of Column 3** | | | **0.1238** |

**Table 4: Effect of MATH Remediation - Full Sample versus the Effects on the Marginal Students**

| | Full Sample | | | | Marginal Students Affected by Differences in Remediation Policies | | | |
|---|---|---|---|---|---|---|---|---|
| | Depend. Variable Mean | Remediation Coeff. OLS | Remediation Coeff. IV | Obs. | Depend. Variable Mean | Remediation Coeff. OLS | Remediation Coeff. IV | Obs. |
| *Negative Educational Outcomes* | | | | | | | | |
| Dropped Out during First Year | .0825 | -0.0090** (0.0045) | 0.0033 (0.0157) | 28,376 | .1004 | -0.0095* (0.0054) | -0.0834** (0.0271) | 18,917 |
| Dropped Out by Spring 2003 | .4005 | 0.1368** (0.0075) | -0.0194 (0.0264) | 28,376 | .4685 | 0.1403** (0.0085) | -0.0959** (0.0436) | 18,917 |
| Transferred Down during First Year | .0614 | 0.0201** (0.0046) | -0.0255 (0.0164) | 24,543 | .0736 | 0.0242** (0.0053) | -0.0073 (0.0317) | 15,766 |
| Transferred Down as of Last record | .1498 | 0.0625** (0.0066) | -0.0324 (0.0227) | 25,398 | .1807 | 0.0641** (0.0078) | -0.0170 (0.0397) | 16,482 |
| *Positive Educational Outcomes* | | | | | | | | |
| Total Credit Hours completed | 81.20 | -11.0716** (0.6652) | -1.7931 (2.3197) | 28,376 | 72.39 | -10.902** (0.7453) | 1.3905 (3.7719) | 18,917 |
| Transferred Up as of Last record | .1610 | 0.0339** (0.0078) | -0.0439 (0.0289) | 12,965 | .1569 | 0.0345** (0.0082) | 0.0460 (0.0352) | 10,014 |
| Completed BA/BS Degree in 4 years | .2237 | -0.0662** (0.0067) | 0.1527** (0.0236) | 28,376 | .1831 | -0.0774** (0.0066) | 0.0998** (0.0337) | 18,917 |
| Completed BA/BS Degree in 5 years | .4361 | -0.1075** (0.0075) | 0.1138** (0.0263) | 28,376 | .3525 | -0.1126** (0.0080) | 0.0902** (0.0410) | 18,917 |

** Significant at the 5% level * Significant at the 10% level

Notes: Each coefficient under the OLS and IV columns represents a separate regression with controls for race, gender, age, ACT composite score, ACT math score, high school GPA, high school rank, family income, high school type, semesters of high school math, high school grades in math, and type of high school degree (dummy variable for GED). Standard errors are shown in the parentheses. Students are considered "dropouts" if they are no longer at any public, Ohio college at the end of the time period and have not received a Bachelor's degree. Students who "transferred down" were at a less selective or lower-level college as of their last enrollment record. Students who have "transferred up" went to a higher-level college or more selective college.

**Table 5: Effect of ENGLISH Remediation - Full Sample versus the Effects on the Marginal Students**

| | Full Sample | | | | Marginal Students Affected by Differences in Remediation Policies | | | |
|---|---|---|---|---|---|---|---|---|
| | Depend. Variable Mean | Remediation Coeff. OLS | Remediation Coeff. IV | Obs. | Depend. Variable Mean | Remediation Coeff. OLS | Remediation Coeff. IV | Obs. |
| *Negative Educational Outcomes* | | | | | | | | |
| Dropped Out during First Year | .0825 | 0.0126** (0.0053) | 0.0289* (0.0166) | 28,376 | .0954 | 0.0107* (0.0062) | -0.0051 (0.0244) | 15,013 |
| Dropped Out by Spring 2003 | .4005 | 0.0963** (0.0088) | -0.0216 (0.0277) | 28,376 | .4773 | 0.0825** (0.0101) | -0.0970** (0.0400) | 15,013 |
| Transferred Down during First Year | .0614 | 0.0053 (0.0054) | -0.0465** (0.0160) | 24,543 | .0664 | 0.0024 (0.0062) | -0.0604** (0.0231) | 12,399 |
| Transferred Down as of Last record | .1498 | 0.0116 (0.0078) | -0.1535** (0.0235) | 25,398 | .1624 | 0.0043 (0.0089) | -0.1868** (0.0338) | 12,891 |
| *Positive Educational Outcomes* | | | | | | | | |
| Total Credit Hours completed | 81.20 | -9.4803** (0.7752) | -11.1946** (2.4380) | 28,376 | 75.95 | -7.1873** (0.8331) | -2.6464 (3.2766) | 15,013 |
| Transferred Up as of Last record | .1610 | -0.0306** (0.0086) | -0.1308** (0.0361) | 12,965 | .1723 | -0.0194** (0.0096) | 0.0737 (0.0523) | 8242 |
| Completed BA/BS Degree in 4 years | .2433 | -0.0242** (0.0078) | 0.2056** (0.0248) | 28,376 | .1746 | -0.0252** (0.0077) | 0.1730** (0.0308) | 15,013 |
| Completed BA/BS Degree in 5 years | .4361 | -0.0768** (0.0087) | 0.0651** (0.0274) | 28,376 | .3546 | -0.0649** (0.0093) | 0.0927** (0.0370) | 15,013 |

** Significant at the 5% level * Significant at the 10% level

Notes: Each coefficient under the OLS and IV columns represents a separate regression with controls for race, gender, age, ACT composite score, ACT English score, ACT Reading score, high school GPA, high school rank, family income, high school type, semesters of high school English, high school grades in English, and type of high school degree (dummy variable for GED). Standard errors are shown in the parentheses. Students are considered "dropouts" if they are no longer at any public, Ohio college at the end of the time period and have not received a Bachelor's degree. Students who "transferred down" were at a less selective or lower-level college as of their last enrollment record. Students who have "transferred up" went to a higher-level college or more selective college.

**Table 6: IV Estimates - Interactions with ACT Score**

| | Dropped Out by Spring 2003 | Transferred Down as of Last record | Total Credit Hours | Transferred Up as of Last record | Completed BA/BS Degree in 5 years |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| A. MATH REMEDIATION | | | | | |
| Effect of Remediation | 0.2879** | 0.3999** | -64.3993** | -0.2533** | -0.4907** |
| | (0.1167) | (0.1089) | (10.2201) | (0.1073) | (0.1109) |
| Remediation * ACT Math Score | -0.0242** | -0.0263** | 4.1933** | 0.0184** | 0.0368** |
| | (0.0074) | (0.0071) | (0.6511) | (0.0060) | (0.0071) |
| ACT Math Score | -0.0172** | 0.0001 | 0.7901** | -0.0007 | 0.0131** |
| | (0.0025) | (0.0021) | (0.2217) | (0.0026) | (0.0024) |
| Observations | 18,917 | 16,482 | 18,917 | 10,014 | 18,917 |
| Dependent Var. Mean | .4685 | .1807 | 72.39 | .1569 | .3525 |
| | (6) | (7) | (8) | (9) | (10) |
| B. ENGLISH REMEDIATION | | | | | |
| Effect of Remediation | 0.2039** | -0.0468 | 39.8370** | 0.4095** | 0.1874** |
| | (0.0869) | (0.0826) | (7.1747) | (0.0869) | (0.0793) |
| Remediation * ACT English Score | -0.0205** | -0.0077 | -3.8338** | -0.0316** | -0.0114* |
| | (0.0064) | (0.0060) | (0.5306) | (0.0058) | (0.0059) |
| ACT English Score | -0.0171** | -0.0120** | 2.4964** | 0.0162** | 0.0232** |
| | (0.0017) | (0.0014) | (0.1432) | (0.0024) | (0.0016) |
| Observations | 15,013 | 12,891 | 15,013 | 8242 | 15,013 |
| Dependent Var. Mean | .4773 | .1624 | 75.95 | .1723 | .3546 |

** Significant at the 5% level    * Significant at the 10% level

Notes: Each specification represents a separate regression with controls for race, gender, age, ACT composite score, ACT math (or English and Reading) score, high school GPA, high school rank, family income, high school type, years of high school math (or English), high school grades in math (or English), and type of high school degree (dummy variable for GED). Standard errors are shown in the parentheses. Students are considered "dropouts" if they are no longer at any public, Ohio college at the end of the time period and have not received a Bachelor's degree. Students who "transferred down" were at a less selective or lower-level college as of their last enrollment record. Students who have "transferred up" went to a higher-level college or more selective college.

**Table 7: IV Estimates of the Impact of Remediation by Pre-College Plan of Study**

| | Dropped Out by Spring 2003 | Transferred Down as of Last record | Total Credit Hours | Transferred Up as of Last record | Completed Degree in 5 years | Choose Major in Field of Interest |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| A. MATH REMEDIATION | | | | | | |
| Remediation | -0.1025**<br>(0.0453) | -0.0102<br>(0.0412) | 1.1131<br>(3.9161) | 0.0519<br>(0.0366) | 0.0782*<br>(0.0426) | 0.0519<br>(0.0412) |
| Remediation * Pre-college interest in Math-Related Field | 0.0245<br>(0.0329) | -0.0274<br>(0.0307) | 1.6504<br>(2.8428) | -0.0195<br>(0.0327) | 0.0584*<br>(0.0309) | -0.0835**<br>(0.0303) |
| Pre-college interest in Math-Related Field | -0.0019<br>(0.0123) | 0.0046<br>(0.0100) | -1.6438<br>(1.0652) | -0.0035<br>(0.0147) | -0.0384**<br>(0.0116) | 0.3254**<br>(0.0112) |
| Observations | 18,917 | 16,482 | 18,917 | 10,014 | 18,917 | 17,643 |
| Dependent Var. Mean | .4685 | .1807 | 72.39 | .1569 | .3525 | .2792 |
| | (7) | (8) | (9) | (10) | (11) | (12) |
| B. ENGLISH REMEDIATION | | | | | | |
| Remediation | -0.1002**<br>(0.0408) | -0.1882**<br>(0.0346) | -1.9361<br>(3.3419) | 0.0873*<br>(0.0525) | 0.1042**<br>(0.0377) | 0.0907**<br>(0.0401) |
| Remediation * Pre-college interest in English-Related Field | 0.0134<br>(0.0429) | 0.0033<br>(0.0395) | -2.9881<br>(3.5128) | -0.0472<br>(0.0475) | -0.0485<br>(0.0397) | -0.2235**<br>(0.0416) |
| Pre-college interest in English-Related Field | -0.0195<br>(0.0129) | -0.0146<br>(0.0105) | 3.4901**<br>(1.0530) | 0.0408**<br>(0.0175) | 0.0485**<br>(0.0119) | 0.3337**<br>(0.0121) |
| Observations | 15,013 | 12,891 | 15,013 | 8242 | 15,013 | 14,066 |
| Dependent Var. Mean | .4773 | .1624 | 75.95 | .1723 | .3546 | .2866 |

** Significant at the 5% level * Significant at the 10% level

Notes: Each specification represents a separate regression with controls for race, gender, age, ACT composite score, ACT math (or English and Reading) score, high school GPA, high school rank, family income, high school type, years of high school math (or English), high school grades in math (or English), and type of high school degree (dummy variable for GED). Standard errors are shown in the parentheses. Students are considered "dropouts" if they are no longer at any public, Ohio college at the end of the time period and have not received a Bachelor's degree. Students who "transferred down" were at a less selective or lower-level college as of their last enrollment record. Students who have "transferred up" went to a higher-level college or more selective college. The following are considered math-related majors: Mathematics, Statistics, Sciences (biology, chemistry, physics, etc.), Business, Computer Science, Engineering, and Architecture. The following are considered English-related majors: Humanities, Foreign Languages, Social Sciences, Journalism, Communications, Education, and Social Work. Students who did not declare a major in college are excluded from the analysis.