Improving College Performance and Retention the Easy Way: Unpacking the ACT Exam

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*Improving college performance and retention can be difficult. We propose a simple and low-cost change in the way colleges use the ACT exam in their admission decisions that can greatly increase their ability to identify students at a high risk of under-performing and dropping out. Specifically, we show that only two of the four sub tests of the ACT, English and Mathematics, can effectively predict outcomes in college. This result is robust across various samples, specifications and outcome measures. We demonstrate that by eliminating the noise associated with the two non-predictive sub tests, student-college matches can be significantly improved.**

College performance and timely graduation are increasingly important policy issues. After six years, 35 percent of students who started a post-secondary program in Fall 2003 had not received a degree and were no longer enrolled in any institution of higher education (Radford et al., 2010). Additionally, many students who are capable and qualified to attend selective colleges "undermatch" and attend less-selective institutions where they are less likely to graduate (Bowen, Chingos, and McPherson 2009). This high dropout rate can be costly for

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the students who drop out, the students who could have been admitted in their stead, the colleges, which must devote significant resources to recruiting and orienting new students, and society which relies on college graduates to promote economic growth in an increasingly skill-based economy.

The education literature has discussed many possibilities for boosting college retention rates, such as removing financial obstacles (Dynarski, 2003, Singell, 2004), preparing high-school students better (DeBrock et al., 1996; DesJardins, Ahlburg, and McCall, 2002), improving the quality of the match between universities and students (Bowen, Chinos, and McPherson 2009), and improving the social and academic integration of students (Spady, 1970; Tinto, 1975; Bettinger and Baker, 2011). All of these likely reflect important factors in retention and performance. However, these solutions can also be costly and hard to implement. In this paper, we discuss an additional, simple, low-cost way to improve college performance and retention. Specifically, we propose that a simple fix in the use of ACT exam scores by college admissions officers can improve the likelihood that colleges admit students with the highest chance of succeeding.

The ACT, a term that originally stood for American College Testing, is a standardized U.S. college admissions exam. It has been growing in popularity, pulling even with its main competitor, the SAT (formerly, Scholastic Aptitude Test), in the total number of student test takers (Kaplan, 2009). The ACT covers four subjects: Mathematics, English, Reading and Science.[1] Scores from 1-36 on each of these components and an all-important composite score are provided to colleges for their use in admission decisions. The composite, a score from 1-36, is the rounded average of the scores on the four individual sections. Nearly all colleges indicate that they use solely the ACT composite score in their admissions

[1] Post-dating our data sample, an optional writing test was introduced in February 2005, mirroring changes to the SAT that took place in the same year.

process.[2] A common conversion chart developed by ACT Inc. and the College Board (publisher of the SAT) maps ACT composite scores against SAT scores for colleges that accept both ACT and SAT exams, as almost all four-year colleges do.

By using the ACT composite score, college admissions offices implicitly give equal weight to each of its four individual sub tests. In this paper, we explore the possibility that the individual sub scores differ in their ability to predict college outcomes. If this is the case, then colleges could improve their selection criteria by simply re-weighting the four ACT sub scores based on their individual predictive power.

We test for differences in predictive power among the four sub scores using Ohio Board of Regents data on all students that matriculated to a four-year public college in Ohio 1999. Along with demographic information about each student, the data contain important college performance measures such as Grade Point Average (GPA) and indicators for dropping out.

Not surprisingly and confirming a long line of literature, we find a strong correlation between higher ACT composite scores and positive college outcomes. However, this overall correlation masks an important pattern: Mathematics and English scores are much more tightly correlated with college success than are Reading and Science scores. In fact, after controlling for Mathematics and English scores, Reading and Science provide essentially no predictive power regarding college outcomes.

The difference in the predictive ability for Mathematics and English versus Reading and Science scores is consistent across different specifications and data sub samples. The finding is robust when controlling for indicators of the college that students attend, high school performance, student demographics, and

[2] We provide survey evidence from admissions offices to substantiate this claim.

college major. The results are also consistent across a wide variety of college outcomes including GPA for the first and second years and dropout rates for the first and third years. The results are very similar across different universities of varied quality. We also find that Mathematics and English scores are far better predictors than Reading and Science scores of *high school* GPA. This provides further evidence that the Reading and Science tests have very little predictive merit. Finally, we replicate our results using a smaller independent data source from a private university in the Western United States.

We provide a discussion of an alternative hypothesis for our results: sample selection bias. Since our models are calibrated using data for students who matriculated to college, it may be inappropriate to extrapolate these results to the entire applicant pool. However, we present several pieces of evidence that suggest that sample selection bias cannot explain our findings. Perhaps most compelling, we provide evidence from a dataset that contains high school GPA and ACT test scores for nearly one million students who took the ACT test in the early 2000s. We replicate the finding that the Math and English scores are better correlates with high school GPA than Reading and Science scores for this broader sample.

The observed differences in predictive validity between subject tests are associated with large, economically important difference in predictive ability. For example, our model predicts that a student who gets an ACT composite score of 24 by getting a 26 each on the Reading and Science tests and a 22 each on the Mathematics and English tests is 59 percent more likely to be a first-year dropout and 43 percent more likely to drop out by the third year of college, relative to a student who gets the same ACT composite score of 24, but with a 26 each on the Mathematics and English tests and a 22 each on the Reading and Science tests.[3]

[3] The 59% and 43% increase in the probability of dropping out comes from a 5.2 and 10.4 percentage point increase with a base dropout rate of 8.8% and 23.9% in the first and third year, respectively. It is also important to note that this example does not represent an out-of-sample

By introducing needless noise that obscures the predictive validity of the ACT exam, the Reading and Science tests may contribute to students being inefficiently matched to schools, admitted to schools that may be too demanding – or too easy – for their levels of ability. College admissions officers can solve this problem by creating their own composite score by unpacking the ACT and using only the Mathematics and English scores. Clearly a composite score that is based on the Mathematics and English sub tests will be highly correlated with the current ACT composite score. However, we show that these two measures of performance (ACT composite vs. Math-English composite) are different enough to be associated with large changes in admission outcomes.

For example, we conduct a simple calibration test that estimates the number of students that would be matched to a different Ohio college were the Math-English composite measure to be used (i.e. a composite score that gives equal weight to the Mathematics and English test scores and zero weight to the Reading and Science scores). Under strong assumptions, we estimate that as many as 55 percent of the students in Ohio would either move to a more or less selective school due to this more accurately predictive measure. We further calibrate how using an ACT measure based solely on the English and Mathematics subtests would impact the various colleges in our sample. We find that the top schools - who we assume get first choice when selecting students - would experience dropout rate reductions as large as 5-7%.

We also consider the likelihood that a college's selection goals extend beyond building a student body that gets good grades and graduates. For example, diversity of race, gender and major may all be important factors for universities to consider when admitting students. We find no evidence that using just the Mathematics and English sub scores would have an adverse impact on minority

result. More than 20% of the students in our data have an average Mathematics and English score that is either 2 points higher or 2 points lower than their overall ACT composite score.

admission rates and or admission rates by gender. We do, however, find evidence that students that are more likely to major in the sciences would slightly benefit from switching toward an admission score which only relies on the Mathematics and English sub scores.

We conclude with a discussion of why college admissions offices have not switched to using only the Mathematics and English scores. We suggest several possibilities, including the worry that it could hurt their standing in external rankings. Our results suggest that ACT, Inc. and colleges need to rethink the relative value of the additional parts of the exam in providing admissions officers with the information they need to admit students with the highest probability of success.

This paper contributes to the literature on the relationship between standardized test scores and college outcomes (Munday, 1967; Bowen and Bok, 1998; Burton and Ramist, 2001; Rothstein, 2004). Most recently, some have argued for eliminating the use of standardized tests in college admissions due to concerns that scores serve as proxies for other measures such as socioeconomic and minority status (e.g. Rothstein, forthcoming). Our paper does not take a side in this debate, but argues that if standardized test scores continue to be used in the admission process, they should at least be used efficiently (especially given that we show that this more efficient usage does not harm college acceptance for minority students).

The remainder of the paper proceeds as follows. Section I provides a more detailed description of the ACT test along with survey evidence of how the test is used by colleges in admissions. Section II describes the data used in our analyses and outlines the basic empirical framework. Section III presents our results, including a variety of robustness checks and additional analyses. Section IV concludes with a brief discussion of ways to improve the use of standardized test scores and the broader implications of this research.

I. The ACT Exam

The ACT is a national college admission examination, first administered in 1959 as a competitor to the College Board's SAT. Based in Iowa City, Iowa, the ACT has grown in popularity substantially since 1959. A recent article in *Fortune* magazine suggested that the SAT and ACT had equal market shares in recent years (Kaplan, 2009). Although the test is most popular in the South and Midwest, ACT results are accepted by all four-year colleges and universities in the United States.

The ACT consists of four multiple-choice sub-tests: Mathematics, English, Reading and Science. The Mathematics component is a 60-question, 60-minute test that covers basic math concepts that students typically learn by 11th grade. The English component is a 75-question, 45-minute test covering basic usage and mechanics of the English language, as well as rhetorical skills. The Reading component is a 40-question, 35-minute test that measures reading comprehension. The Science component is a 40-question, 35-minute test that measures a variety of science-related skills including data interpretation, analysis, evaluation and basic problem solving. A student receives a whole-number score from 1-36 on each of these tests. ACT Inc. markets the four-subject design as a superior test vehicle and promotes ACT as testing the actual high school curriculum, not serving as an aptitude or IQ test,[4] and at least five states (Illinois, Michigan, Kentucky, Colorado, and Wyoming) require high school graduates to take the ACT exam.

When students tell ACT Inc. where to send their test scores, the company provides each of the four sub test scores along with a composite score, the average of the four rounded to the nearest whole number. This composite is central to admissions. First, many schools (especially state schools) use an ACT

[4] Information for this paragraph was obtained from ACT Inc.'s website: http://www.act.org/.

composite score cutoff for guaranteed admission. For example, in California, applicants are guaranteed admission to the UC system if they reach certain SAT and high school GPA thresholds (see Rothstein (2004) for a more detailed discussion). In this automatic admission process, ACT composite (not the individual sub) scores are used to map ACT scores against SAT scores, which then are used as the cutoff. Even when schools do not set a specific ACT composite cutoff for admission, the score is generally described as the standardized test statistic used in the admission process. A review of college admissions office websites makes this clear. However, we also conducted a detailed survey of college admissions offices for the purposes of this study. Specifically, in October 2009, we interviewed admissions officers by phone, at all 13 of Ohio's four-year public colleges (the colleges in our data). Although respondents ranged from the dean of admissions to lower-ranked admissions officers, all respondents reported that they read applications and make admission decisions for their institutions. The interviews' primary purpose was to determine how each admissions office has used the ACT composite and individual test scores. The full interview protocol is provided as Appendix 1.

On the critical point of whether the composite or component scores are more often used, the result is clear: despite the availability of the subject-specific component scores, all of the institutions rely on the composite ACT score to make their admission decisions. Although the composite score is clearly the primary statistic used, a few nuances are worth mentioning. For example, one of the colleges interviewed indicated that it considers individual subject scores in rare situations. Specifically, for "strivers," students who perform better than expected given their poor-performing high school, the university at times considers individual sub scores as a way of understanding what makes the student special. Another institution noted that they might look at an individual sub score if a student's grades in a particular subject are very weak. For example, if a student is consistently getting Ds in the sciences but is otherwise a B student, the Science score may be used to provide further information. Finally, although admission decisions are made using the composite score, some colleges use individual test scores as a requirement to get into certain majors after the student enrolls. Despite these complicating factors, the fact remains that these schools by and large simply use the composite score in their admission decisions. No school indicated that they use only a subset of the test scores or that they re-weight individual test scores to create a new composite measure.

II. Data and Empirical Framework

We obtained our primary dataset from the Ohio Board of Regents. The data contain information on all students who matriculated to a public four-year public university in Ohio in 1999. Thirteen schools fit this description: The University of Akron, Bowling Green State University, Central State University, University of Cincinnati, Cleveland State University, Kent State University, Miami University, The Ohio State University, Ohio University, Shawnee State University, The University of Toledo, Wright State University and Youngstown State University.

The data provide information about the demographic characteristics of students (race, age and gender), their high school academic performance (ACT scores and student-reported high school GPA), and college information (campus attended, major chosen, first and second year GPA, and indicators for dropping out in the first, second and third years).

For several reasons, these data are ideal for studying the differential predictive power of individual ACT tests. First, the Ohio college system has more ACT than SAT students. According to McDaniel (2006), 66 percent of Ohio's 2005 high school graduates took the ACT whereas only 29 percent took the SAT. Second, the Ohio public-university system offers campuses that vary in student ability and academic standards. For example, the major universities are distinguished by their academic rigor (e.g. Ohio State University, Ohio University and Miami University)[5], while other, smaller campuses generally admit students with lower test scores (e.g. Cleveland State, Central State and Shawnee State). This diversity allows us to address the predictive power of the ACT more broadly than if our data were limited to just one or two institutions. Third, and finally, the data include very important college outcome variables (GPA and dropout rates) at an individual level linked to ACT scores.

Table 1 provides summary statistics for the 25,645 ACT-taking students in our sample. Of particular interest, our sample has a dropout rate of nine percent in the first year and 24 percent by the third year. The sample is slightly more female like most of higher education (54% female) and is predominantly white (85%). The average ACT composite score in our sample is approximately 22, which is at the 62nd percentile nationally. Table 1 also provides means and standard deviations for each individual ACT test.

To provide comparisons with national data, the last column in Table 1 contains summary statistics for the most comparable national data available. The data from Ohio seem reasonably representative of national numbers for students entering four-year public institutions. Their first-year GPA and dropout rates are similar although the Ohio students tend to dropout at a higher rate than the comparable national rate by the third-year. The Ohio sample is less racially diverse than the national average. The national ACT numbers are from all test takers, so it is no surprise that the enrolled students in Ohio have slightly higher scores.

Our empirical strategy is simple. We are interested in understanding the additional predictive power that each of the test scores provides conditional on the other scores. Our most basic empirical specification is:

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[5] These schools are ranked 56th, 124th and 79th respectively in the 2011 U.S. News & World Report college ranking (U.S. News & World Report, 2011).

(1) $\text{Outcome}_i = \alpha + \beta_1 \text{Mathematics}_i + \beta_2 \text{English}_i + \beta_3 \text{Reading}_i + \beta_4 \text{Science}_i + \varepsilon_i$.

wherein the outcome for each individual i will be either GPA or an indicator for dropping out, and the four main independent variables represent the test score (from 1-36) on the Mathematics, English, Reading, and Science ACT tests. For robustness, we will also present results from specifications that include controls such as demographic variables, high school GPA, major fixed effects, and campus fixed effects. Our baseline empirical specification assumes that each ACT sub test has a linear impact on the outcome variable. We have tested models with more flexible functional forms (quadratics, other higher-ordered polynomials, interactions, etc.). We find that the simple linear model where the sub tests are additively separable does a very good job fitting the data. While for some specifications a quadratic term may occasionally significantly improve the fit of the model, this is not common.

Assuming that the objective function of the university is the outcome variable of the regression, then college admissions offices ideally should use the weights associated with each test score ($\beta_1, \beta_2, \beta_3, \beta_4$) in the admission process. We are interested in testing the null hypothesis that $\beta_1 = \beta_2 = \beta_3 = \beta_4$, which we argued in the previous section is the manner in which these scores are currently being used in the admission process.

III. Results

A. Main results

Using our basic specification in Equation (1), Table 2 estimates the ability of the ACT to predict first-year college GPA. Column (1) provides the simple correlation between first-year GPA and the ACT composite score. Not surprisingly, the ACT composite score has a large and significant impact on first-year GPA: A one point increase in the ACT composite score is associated with a .072 increase in GPA.

Column (2) of Table 2 breaks down the ACT score into its four components. The results show a large and significant impact of both the Mathematics and English score on GPA. A one point increase in either of these test scores is associated with an approximately .035 increase in GPA. The ACT Reading test, on the other hand, shows a significant, but much smaller association with GPA (.005 increase in GPA per ACT test point). Finally, the point estimate on the ACT Science test score is small and actually negative.[6] The results from this specification indicate a clear difference in the predictive validity of the four sub scores for freshman GPA. After controlling for the other test scores, Mathematics and English scores have large effect sizes that are seven to nine times as large as the Reading and Science scores, which have small or even slightly negative effect sizes. The formal test of the hypothesis that all of the coefficients are equal is roundly rejected (F-statistic of 115 and p-value less than 0.000).

One question that arises in this type of analysis is whether omitted variable bias is an issue. We are not attempting to obtain exact causal estimates of the ACT subscores on outcomes, but rather, we are trying to understanding how predictive they are of future success. The correct number of control variables to use depends in part on how many other variables college admissions offices are using in their admission decisions. If the ACT score was the only thing they use for admissions, then we would actually prefer not to control for any other factors. However, to the extent that they also use high school GPA and other variables

[6] The consistently negative effects that we find on the Science test score (and Reading test score in the dropout regressions) may be driven, in part, by school mismatch. A high Science or Reading score may not be indicative of academic ability, but may be related to a student getting into a school for which they are not a good fit. This mismatch may help explain the small but negative estimates that we find.

when admitting, we would like to know the predictive power of the ACT subscores conditional on these variables. We may also want to control for college campus differences that could lead to biased results. For example, it is possible that students with high Reading scores purposely choose colleges that grade more strictly. Concerns of this type can be addressed by controlling for some basic student and school characteristics. In Columns (3)-(6) of Table 2, we once again regress first-year GPA on the four ACT sub scores, this time including increasingly detailed controls: campus, high school GPA, race and gender, and college major fixed effects. As expected, the effect size for the ACT scores shrink as other controls (e.g. high school GPA) are included due to ACT scores' high correlation with controls. However, the relative predictive power of the Mathematics and English scores compared with the Reading and Science scores remains.

As a further robustness check, we have also controlled for more detailed family and socioeconomic status variables. Specifically, we have run a model that includes mother's education and the family's Expected Family Contribution as determined by the federal government from information submitted on the financial aid application. We do not focus on this specification because these variables are only available for students who applied for financial aid. So, not only does it restrict the sample to a less generalizable population, but it also reduces the number of observations from 21, 757 (Column 6 of Table 2) to 14, 526. However, the results are nearly identical when we make this sample restriction and include the two additional family background controls. In fact, the coefficients remain identical to those in Column 6 of Table 2 for the English coefficient which changes from .016 to .015.

Although outcomes beyond first-year college GPA are unavailable for more recent cohorts, we do have first-year GPA outcomes for a similar cohort of entering four-year public college students from Ohio in 2006. Replicating Table 2 for this cohort yields very similar results. With the full set of controls, both the Mathematics and English scores have statistically significant coefficients of 0.026 and 0.020 respectively while the Reading and Science scores have point estimates of -0.001 and 0.004, neither of which is statistically significant. The findings based on this more recent data demonstrate that the observed relationships are stable over time and that the 1999 cohort is not an anomaly.

Table 3 presents an analysis like that in Table 2, using second-year GPA as the dependent measure. The effects are nearly identical to those of Table 2. Mathematics and English tests are highly predictive of second-year GPA, while Reading shows a small positive effect and Science shows a small negative effect. Once again, a formal test of the hypothesis that all of the coefficients are equal is rejected (F-statistic of 152 and p-value less than 0.000).

Table 4 uses first-year dropout rates as the dependent variable. For this analysis, we utilize logit regressions and present marginal effects. Once again, Column (1) shows a large association between the ACT composite score and dropout rates. Column (2) breaks down the results by individual test score. Mirroring the GPA tables, the estimates suggest that a student with a one point higher Mathematics or English score is .65 or .46 percentage points less likely to drop out, respectively. Conversely, the Reading and Science test scores both have insignificant coefficients with the opposite sign.

Columns (3)-(6) of Table 4 test the relationship between ACT sub scores and first-year dropout rates while including additional controls. The Mathematics and English test scores continue to have a strong and significant association with lower dropout rates, yet higher Reading and Science scores are actually associated with *higher* dropout rates (with the Reading coefficient being statistically significant).

Table 5 shows what happens when the dependent variable indicates whether students dropped out by their third year of college. Once again, higher

Mathematics and English scores predict lower dropout rates while Reading and Science scores predict small but higher dropout rates. We are able to strongly reject the hypothesis that all of the coefficients are equal (Chi-squared test statistic of 190 and p-value less than 0.000).

B. Heterogeneity Analysis

For our results to be useful, it is important to know if the difference in predictive power across ACT sub tests is driven by school type; in other words, if the effect is consistent across the range of schools. By looking at data from the different schools in our sample, we can consider the consistency of the effects that we find.

Table 6 estimates the impact of ACT test scores on first-year college GPA by university.[7] Our basic empirical finding is extremely robust across schools. For all schools in the sample, both the Mathematics and English scores strongly and significantly predict higher first-year GPAs. We also find an insignificant impact of Science and Reading scores on academic success for nearly all of the schools in the sample (the Reading test has a small but significant effect in two schools).

Table 7 shows a similar picture for third-year dropout rates. Although statistical power is limited when looking at dropout rates by university, we once again find that higher Mathematics and English scores are negatively correlated with dropping out (i.e., the higher the scores, the less dropping out) and that these effects are not being driven by just one or two schools in our sample. The effects are larger for Mathematics than English, but both are frequently statistically significant. Higher Reading and Science scores, on the other hand, are typically positively correlated with dropping out although rarely at a level of significance.

[7] The last column groups the 6 schools in the sample with the smallest number of observations. Due to privacy concerns by one university, we do not directly identify the campuses in these regressions.

C. Correlation between ACT test scores and high school GPA

Our main results suggest that after controlling for the Mathematics and English tests, the ACT Reading and Science tests do not predict college success. Given ACT Inc.'s assertion that its test follows the high school curriculum, it is possible that the Reading and Science tests are good at measuring skills that were useful in high school, but that are not useful for college performance. To test this possibility, we simply use high school GPA as our dependent variable.[8]

Table 8 provides the results from this regression. The first column shows that higher ACT composite scores are indeed positively correlated with higher high school GPAs.[9] However, Columns (2) and (3) show very clearly that Mathematics and English scores are much more correlated with high school GPA than Reading and Science scores. Whereas Reading and Science scores in this regression are positively correlated with high school GPA, the effect sizes are an order of magnitude smaller than the effect sizes for the Mathematics and English tests. These results suggest that the Reading and Science tests are not as good as the Mathematics and English tests at predicting success in either high school or college.

D. ACT scores and college performance in an independent sample

In addition to Ohio public school data, we also have a small dataset from Brigham Young University - a private university in the Western United States - that was obtained for a different research project. This dataset is limited in many ways: It is a small sample (1,712 students who were first-time freshmen in 1997 or 1998 and graduated by the summer of 2005), and the only available outcome variables are high school and college GPA. However, these data provide one more check of

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[8] Our data do not contain exact high school GPA scores, but a standardized scale from 1-7 for the high school GPA of each student recorded at the time they took the ACT.

[9] We report OLS coefficients in Table 8. Ordered Probit coefficients (unreported) provide qualitatively similar results.

robustness to see if our basic results hold in a completely different part of the country and with a private institution.[10]

Table 9 provides the estimates when college GPA and exact high school GPA are included as dependent variables. Once again, we find that the Mathematics and English ACT scores are significantly correlated with both high school and college GPA. Reading scores have a smaller but still significant correlation with college GPA and no correlation with high school GPA, once we control for the other test scores. The Science test score is not significantly correlated with either college or high school GPA.

E. Sample selection bias

We argue that the Reading and Science ACT test scores are less predictive of both past outcomes (high school GPA) and future outcomes (college GPA and dropout rates) than the Math and English test scores. We further argue in following sections that this finding can be used by admission offices to admit a set of students better prepared to succeed in college. One potential concern with our analysis (and one that often plagues predictive validity studies) is that we are using a model that is calibrated with data on students who were accepted and enrolled in college and extrapolating to the population of applicants. This sample selection or "restriction of range" bias can result in biased estimates of the predictive validity of exams. Thus, one might worry that it is sample selection that leads us to find differences in predictive validity across sub tests and that these differences do not exist in the overall applicant population, which would result in

[10] Not only is BYU a private institution in a different part of the country, but it is different on other dimensions as well. For example, the average college GPA in the BYU sample is 3.54 and the average ACT composite score is 27.94.

very different policy implications.[11] We provide several pieces of evidence that suggest that this is not a concern for our findings.

First, it is worth noting that a restriction in range has a fairly clean prediction on estimates for the predictive validity of a test in general: the estimates will have an upward bias. However, there is not necessarily any reason a priori to think that sample selection will disproportionately attenuate the coefficients on the Reading and Science sub tests. In fact, if there is a bias, it could be working against our findings as easily as it could be working in favor of the results that we find.

Second, many predictive validity studies rely on data from a single institution, which increases the risk that selection at admission biases the results. Because we use data for all four-year public schools across the state of Ohio, sample selection bias will be smaller than it may otherwise be.[12] In fact, the Ohio Board of Regents' High School Transition Report (2003) notes how the Ohio college system is fairly insular by indicating that 85.3% of Ohio high school students who attend college right after school do so in Ohio and 94.2% of Ohio high school students who attend college after a delay do so in Ohio. This suggests that the sample of matriculants in Ohio may be fairly similar to the application pool as a whole, thus limiting the potential bias due to restriction of range. Furthermore, as we report in section 4.2, our results are remarkably robust across the different schools in our sample - whether they be very selective schools or open-enrollment schools. If sample selection was creating a bias in our results, it is likely that it would be a much smaller concern for some of the schools in our sample relative to others. The similarity in our findings across these schools ameliorates the concern for sample selection.

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[11] See Rothstein (2004) for a detailed discussion of sample selection bias in a college admission setting.

[12] This is further supported by our inclusion of four open enrollment institutions included in our sample.

One way in which our sample of matriculants may not reflect the overall application pool is that some of the students who apply but are not accepted to a four-year school in our sample may attend a two-year college. If there is a sample selection bias that causes attenuation in the Reading and Science scores in our main sample, then we might expect very different effects when looking at college outcomes for two-year college students in Ohio. We obtained first-year college GPA data for all two-year public colleges in Ohio from the Ohio Board of Regents. Approximately 32 percent of two-year enrollees for the 1999 entering cohort in Ohio had taken the ACT exam. These students who took the ACT exam are the most likely to be students who applied to, but did not receive admittance to a public, four-year college. We replicate our analysis in Table 2 for this new sample of students and find very similar effects. Including all controls, we find statistically significant coefficients for Math and English of .021 and .012, and statistically insignificant coefficients for Reading and Science of .001 and .007.

While the evidence above suggests that our results are not driven by sample selection bias, it is necessary to observe the full set of applicants to college in order to completely rule it out. To get as close to this as possible, we obtained a dataset from the ACT company that provided composite and individual subject test scores for the more than one million students graduating from high school in 2005 who took the ACT. This data represents the entire pool of ACT test takers who applied to Ohio public colleges as well as any other college in the nation. The limitations of this dataset are that we have very few demographic characteristics about each test taker (e.g. race) and, more importantly, we do not observe college outcomes. We do, however, have self-reported high school GPA. As we demonstrated in section 4.3, the Math and English tests are also more correlated with high school GPA than the Reading and Science tests. Of course, these results are also subject to the concern of sample selection bias since we only see high school GPA for students who matriculated to Ohio public colleges. With the ACT data, however, we observe high school GPA for all students (whether they matriculated or not). If Math and English continue to be stronger correlates with high school GPA in this unrestricted sample, then this is strong evidence that sample selection concerns are not driving the effects that we find.

Table 10 reports the results using the ACT test taker sample.[13] Consistent with the earlier results on the correlation between ACT sub scores and high school GPA (Table 8), we find that Math and English are much stronger predictors of high school GPA than Reading or Science. While the coefficients are not directly comparable (the scaling of the dependent variable in Table 8 and Table 10 are different), the relative size of the Math and English vs. Reading and Science coefficients can be analyzed. Using the ACT sample, Table 10 shows that the Reading and Science coefficients are anywhere from about 1/4th to 1/10th the size of the Math and English coefficients. This corresponds reasonably well to the relative coefficient sizes in Table 8.

The data for all ACT test takers helps to allay concerns about sample selection bias that may have plagued our analysis. It also broadens the generalizability of our paper by showing that the differences in predictive power across the ACT sub tests are not limited to Ohio public colleges.

F. Using a reweighted ACT composite measure

The results that we have presented thus far suggest that admissions offices can use individual ACT sub scores to help predict college performance and retention. Specifically, students with the same composite score are more likely to have positive outcomes when they achieved that score by doing well on the Mathematics and English tests than on the Reading and Science tests.

[13] Observations were dropped if self-reported high school GPA was missing, less than 1.0, or greater than 4.0.

To illustrate this, we have created a simple ACT statistic as a potential alternative to the ACT composite score. The alternative measure that we use is the average of the Mathematics and English test scores (as opposed to the average of all four test scores). This new Mathematics-English composite score is clearly motivated by our finding that these two tests scores have unique predictive power whereas Reading and Science scores do not.

In Table 11, we illustrate the predictive power of the Mathematics-English composite score, while controlling for the traditional ACT composite score.[14] In this table, we provide results for all four of our college outcome variables. The first column for each outcome variable provides results with no controls other than the ACT composite score, while the second column for each outcome variable includes the full set of control variables. We find that the Mathematics-English composite score provides significant predictive power even after controlling for the ACT composite score. For example, while controlling for the ACT composite score, we find that a 1 point increase in the Mathematics-English composite score is associated with a .066 increase in first-year GPA and a .060 increase in second-year GPA (.040 and .036, respectively, with controls). This means that a student who obtained an ACT composite score of 24 by getting a 26 on both the Reading and Science tests and a 22 on both the Mathematics and English tests is predicted to have an approximately .24 lower GPA after the second year of college than a student who got the same ACT composite score of 24 by getting a 26 on both the Mathematics and English tests and a 22 on both the Reading and Science tests.

[14] In this regression, we actually control for the unrounded ACT composite score produced by the ACT company. We do this so that our results are solely driven by the differences in predictive power across the individual tests and not by the fact that the composite score that the ACT company provides is rounded. Our results are slightly larger if we control only for the rounded ACT composite.

We find similarly large effects for dropout rates. While controlling for the ACT composite score, we find that a 1 point increase in the Mathematics-English composite score results in a 1.3 percentage point reduction in the probability of dropping out in the first year and a 2.6 percentage point reduction in the probability of dropping out by the third year (.8 and 1.3 percentage points, respectively with controls). Given the base first and third-year dropout rates in our sample (8.8% and 23.9%), these represent large percentage changes.

For example, a student that obtained an ACT composite score of 24 by getting a 26 on both the Reading and Science sections and a 22 on both the Mathematics and English sections is predicted to be 59 percent more likely to drop out in the first year and 43 percent more likely to drop out by the third year (5.2 and 10.4 percentage points) than a student that obtained the same composite score of 24 by getting a 26 on both the Mathematics and English sections and a 22 on both the Reading and Science sections.

These effects can also be seen graphically. In Figure 1, we plot the first and second year college GPA against the difference between our Mathematics-English composite score and the ACT composite score. There is a clear upward-sloping pattern in which doing better on the Mathematics-English composite relative to the overall ACT composite score is associated with higher GPAs. Similarly, in Figure 2, we see a strong negative relationship between scoring well in Mathematics and English (relative to the ACT composite) and dropping out. This figure once again shows that the Mathematics-English composite score can predict large differences in academic success even when controlling for the ACT composite score.

G. The impact of using the reweighted composite measure on other outcomes

Academic performance (GPA) and retention are surely two of the most important aspects of a university's mission, but colleges are still likely to care about many other things related to students and their performance. For example, an admissions officer might be concerned that downplaying or dropping the Reading and Science tests for admissions might affect the types of students admitted, perhaps constraining diversity in demographics and interests. We are not able to test all possible issues that may concern admissions offices (e.g. we cannot test, for example, whether higher Reading and Science scores are associated with a student being more likely to join a club - which a university may value), however, we can look at three important issues: race, gender and choice of major.

One could try to understand the impact of disregarding Science and Reading tests in many ways. For example, we have regressed indicators for minority, gender and major on the ACT and Mathematics-English composite scores separately, comparing the coefficients to see if one is more highly correlated with these demographics than the other. When we do this, we find that the Mathematics-English composite score is less associated with minority status and gender than the ACT composite score and more strongly associated with Science major than the ACT composite score. However, none of these coefficients are significantly different.

Perhaps a more intuitive way of answering this question, however, is to do a simple calibration. We begin by ranking all students in our sample from 1 to 25,645 based on the ACT composite score wherein 1 represents the highest (best) ACT composite score and 25,645 represents the lowest (worst).[15] We then rank the students again from 1 to 25,645, this time using the Mathematics-English composite score. Once we have these two different rankings for each student, we can easily see the impact of the Mathematics-English composite ranking on the different subgroups relative to the ranking that uses the ACT composite only.

[15] Once again, we use the unrounded ACT composite score for this exercise. To break ties, we create a random number that is used across all calibration so that score ties are broken in the same way.

Switching from the ACT composite ranking to our proposed Mathematics-English composite ranking results in 1,654 minority students rising in rank and 1,498 dropping in rank (the average minority student rank improves from 17,378 to 17,260). The Mathematics-English composite ranking, therefore, has a positive effect on minority rank. Conversely, males are slightly hurt by the new Mathematics-English composite ranking; 5,781 rise in rank and 5,880 move down. Overall, the average male rank decreases from 12,145 to 12,186. Lastly, students who choose science majors are helped by the new ranking system; 2,579 increase in rank compared to 2,228 that decrease. Overall, the average rank of a student majoring in science rises from 9,366 to 9,149.

These results suggest that re-weighting the ACT test scores in admissions, to place either less or no emphasis on the Reading and Science tests, would not adversely affect minority students and have small positive effects for women and science-oriented students.[16]

H. Calibrating the overall impact of admission change

We have shown large differences in college outcomes among students who achieved the same ACT composite score with different combinations of sub scores. However, the number of students that might be affected by a change in admission policies (e.g. placing higher weight on the Mathematics and English scores) depends critically on the variability within ACT composite scores.

Mathematics-English composite scores vary substantially, even within a given ACT composite score. For instance, the example that we used earlier, comparing students who had a Mathematics-English composite score either 2 points higher or lower than the ACT composite score, is not unrealistic. Twenty-

[16] These effects are, of course, partial equilibrium effects. If a university admits more science-oriented students, some students that otherwise would have taken science courses may sort into a non-science major.

two percent of the students in the sample have Mathematics-English composite scores 2 or more points different from their ACT composite score. This suggests that using Mathematics-English instead of the ACT composite score in the admissions process could affect a large number of students. In other words, many students may be currently "over” or “under” placed, or not suitably matched with a given college, as the result of an admissions process that is overly reliant on apparently irrelevant Reading and Science tests.

To get a feel for the overall difference in matching that might take place if the Mathematics-English composite score were used, we do a simple calibration. We begin by assuming that Ohio is a closed college system and that students who matriculated to one of the Ohio schools in our sample would still do so even if all schools began to use the Mathematics-English composite score for admissions. We also assume that schools do not use any information other than ACT scores during the admissions process.[17] Finally, we will assume that the highest-ranked school in Ohio (based on U.S. News & World Report rankings) is allowed to fill its entering undergraduate cohort with its choice of all students in the sample, followed by the second-highest ranked school, etc. Under these assumptions, we can explore the impact of changing the admission criteria from using the ACT composite score to using our proposed Mathematics-English composite score. Under the first admissions rule, the top-ranked school in our sample would fill its freshman class with students starting with those who received an ACT composite score of 36 and then move progressively down to lower scores.[18] Under the second rule, the top-ranked school in our sample would fill its freshman class with students starting with those that received a 36 on the ACT Mathematics and

[17] We recognize that this is clearly an oversimplification. Our interview results suggest that admission offices place between 30 to 50 percent of their weight on ACT scores in the admission decision.

[18] Ties are broken using a random number that is generated for each student. This random number is chosen to be the same across both admission rules so that changes in student placement are not being affected by differences in tie breaks.

English tests and then move progressively down to lower Mathematics-English scores.

The results of this simple calibration indicate that the schools to which students are admitted vary greatly with the admission criteria used. Specifically, we find that 55 percent of students would be in a different school if the Mathematics-English composite score were used as the admission criterion instead of the ACT composite score. This scenario rests on some strong assumptions, such as colleges basing admissions decisions solely on ACT scores and students always choosing to enroll in the best ranked school. To the extent that colleges use other criteria in the admission process (e.g. high school GPA), the ACT score will have a smaller impact. It is possible, however, that even under these strong assumptions we could have found that very few students would be admitted to different schools. That would be the case were there not a lot of variation in the Mathematics-English composite score within a given ACT composite score. However, the calibration finding that up to 55 percent of students may be mismatched (under or over placed in the admission process) implies a great deal of variation, and that the ACT and Mathematics-English composite scores, although correlated, make many unique and independent predictions about which students will excel.

One further question that our calibration exercise can answer is the impact of moving from using the current ACT composite score to our proposed Mathematics-English composite score on individual universities in our dataset. We analyze this by simply comparing the 3rd-year dropout rate for the students that in our calibration are assigned to each school using the ACT composite measure and for the students assigned to each school using our proposed composite measure.

Table 12 provides the calibration results. The table lists the thirteen universities in our sample in order of their academic rating (Campus 1 being the highest rated and campus 13 being the lowest rated). The first column provides the realized 3rd-year dropout rates for the students that would be assigned to each of these universities if students are admitted based on their ACT composite score while the second column provides the results if students are admitted based on their Mathematics-English composite score.

The results show that if all schools began to use the Mathematics-English composite score as opposed to the ACT composite score, the highest-rated universities in our sample would experience a 5-7% decrease in their dropout rate while the lowest-rated universities would experience a 5-7% increase in their dropout rate. The intuition for this result is that the top schools would pass on students that had a high ACT composite score that was largely achieved by doing well on the non-predictive Reading and Science tests. Their new set of students would be of higher quality, thus reducing their dropout rate. The lowest-rated schools in our sample end up with students not selected by the higher-rated universities. These students scored poorly overall on the ACT, but especially scored poorly on the Math and English exams. This results in a lower-quality student population and, therefore, a higher dropout rate.

IV. Discussion and Conclusions

We have explored the predictive power that each of the four individual ACT tests have on college success. Despite the fact that colleges treat these test scores as if they have equal predictive value, we find that the Mathematics and English tests have significantly more predictive power than the Reading and Science tests. We argue that colleges could admit higher-quality students (who will earn higher GPAs and have lower dropout rates) simply by using a Mathematics-English composite score instead of the composite score provided by ACT, which averages all four tests. Importantly, we show that schools could obtain this increase in predictive power without adversely affecting minority students or greatly altering the gender mix of incoming classes.

Using the Mathematics-English composite score instead of the ACT composite score has the potential to generate significant welfare improvements through more efficient and effective college admissions. To some degree, making this change would simply encourage the most selective schools to reject certain applicants that are then passed down to less-selective schools. Thus, as in our calibration, the nationwide retention rate might only change a small amount. However, this change can still affect welfare in several ways. For example, using weights that are more predictive of success could reduce undermatching (Bowen, Chingos, and McPherson 2009). If undermatching places good students in support systems which will not help them continue in college, then the graduation rates for these students may decrease. Reducing undermatching could end up increasing graduation rates if it improves access to the support systems that students may not otherwise have access to. Moreover, to the extent that a degree from a more selective college is more valuable than a degree from a less selective college (Brewer, Eide, and Ehrenberg, 1996), placing students who are less likely to drop out at the more selective schools can be welfare enhancing.

In our analysis, we rely on college GPA and dropout rates as outcome variables. It can be argued, however, that the optimal dropout rate is not zero (for example, see Manski (1988)). It is certainly true that as college students learn more information about their own type, it may be optimal for some of them to drop out. Our results, however, suggest that students can be better informed about their own type before spending the time and money required to experiment on college. While some experimentation will surely still be needed, many students who are at the margin may be able to make more informed decisions about whether to attend college or not. Furthermore, from a college's perspective, lowering dropout rates is a very important metric and almost surely a good thing.

Thus, admission offices should be interested in our results regardless of the more general societal impact.

An obvious question is why, in the competitive college admissions market, admission officers have not already discovered the shortcomings of the ACT composite score and reduced the weight they put on the Reading and Science components. The answer is not clear. Personal conversations suggest that most admission officers are simply unaware of the difference in predictive validity across the tests. They have trusted ACT Inc. to design a valid exam and never took the time (or had the resources) to analyze the predictive power of its various components. An alternative explanation is that schools have a strong incentive - perhaps due to highly publicized external rankings such as those compiled by U.S. News & World Report, which incorporate students' entrance exam scores - to admit students with a high ACT composite score, even if this score turns out to be unhelpful.

There appear to be two potential solutions to this problem. First, admission offices can change their behavior to weight the Mathematics and English scores more heavily in their admission process. Although the college rankings methodology may not provide an incentive to change their behavior, it is possible that drawing their attention to the potential improvement in achievement and retention rates will be motivation enough. Second, ACT, Inc. can eliminate or significantly alter the Reading and Science exams. This solution would not only eliminate noise that interferes with the successful matching of students with schools, but it would also eliminate the welfare costs associated with more than 1.5 million students preparing for and taking these two additional exams (Reading and Science) every year. The time value alone associated with eliminating the need for students to prepare for and take these sub tests along with the resources consumed by ACT Inc. in creating and grading the exams can result in a significant welfare improvement.

In conclusion, there are many ways to improve the higher education system, but it often seems that complex problems (such as low college retention rates) require complex solutions. We argue in this case for a simple solution. Improving how the ACT exam is used for college admissions offers an easily implemented, low-cost solution that can yield potentially large benefits.

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Appendix 1: Admission Office Interview Protocol

Institution:

Date:

Interviewee:

Questions:

Why do you use ACT scores in the admission process?

Do you use it because it predicts first year grades, retention, or graduation?

In general, how do you use ACT scores in the admission process?

Does your institution focus on the composite score or the individual subject scores?

When you are evaluating an application, are all of the individual subject scores available for your review?

Can you explain how you might differently evaluate an applicant who intends to enter an engineering or science major?

When considering applicants for engineering or science majors, do you give more weight to the math and science scores on the ACT?

Have you conducted institutional research to examine how well ACT scores predict these outcomes at your campus?

If so, would you be willing to share those results?

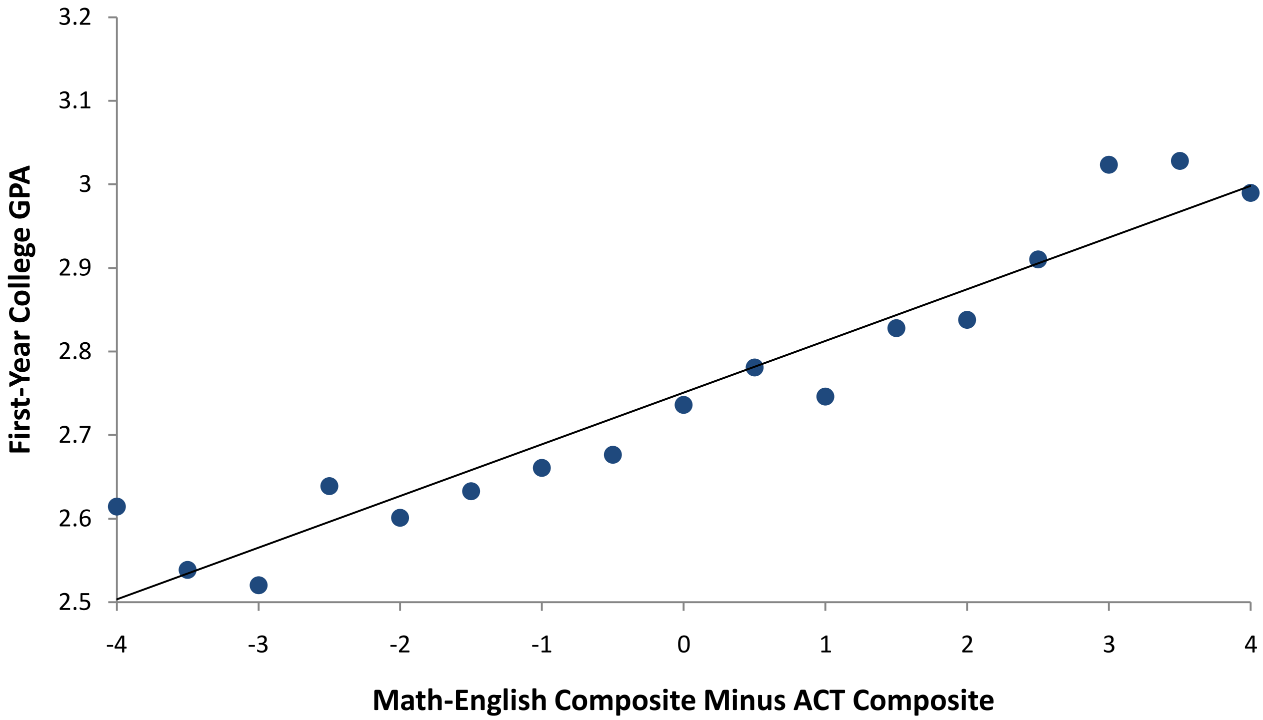
Do you adjust admission practices based on academic research?

Would you be willing to do so?

Is there any academic research that could be conducted that could help you to improve the admission process at your institution?

Figure 1 - College GPA. This figure plots first- and second-year college GPA against how well students did on a math-english composite score relative to their overall composite score. For example, panel A plots the average first-year gpa for students whose math-english composite ((math + english)/2) minus their ACT composite score ranged anywhere from -4 to 4. A linear trendline is also included.

A. First-Year College GPA



B. Second-Year College GPA

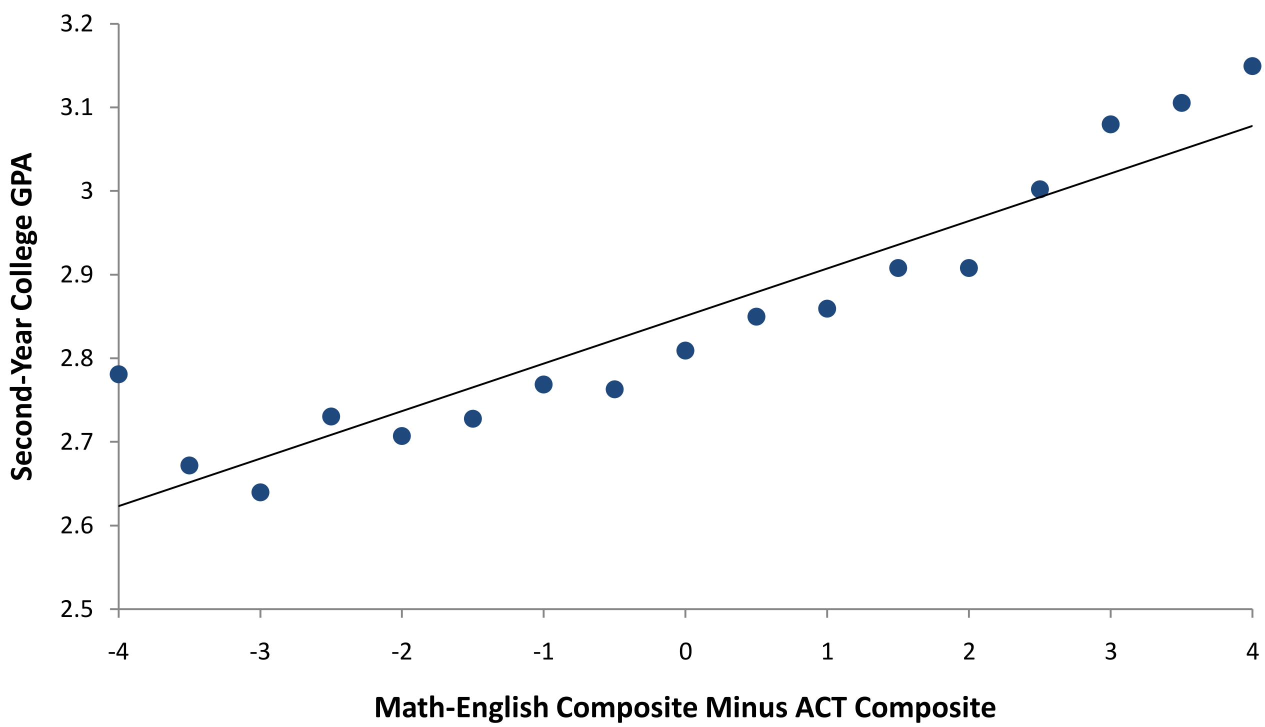
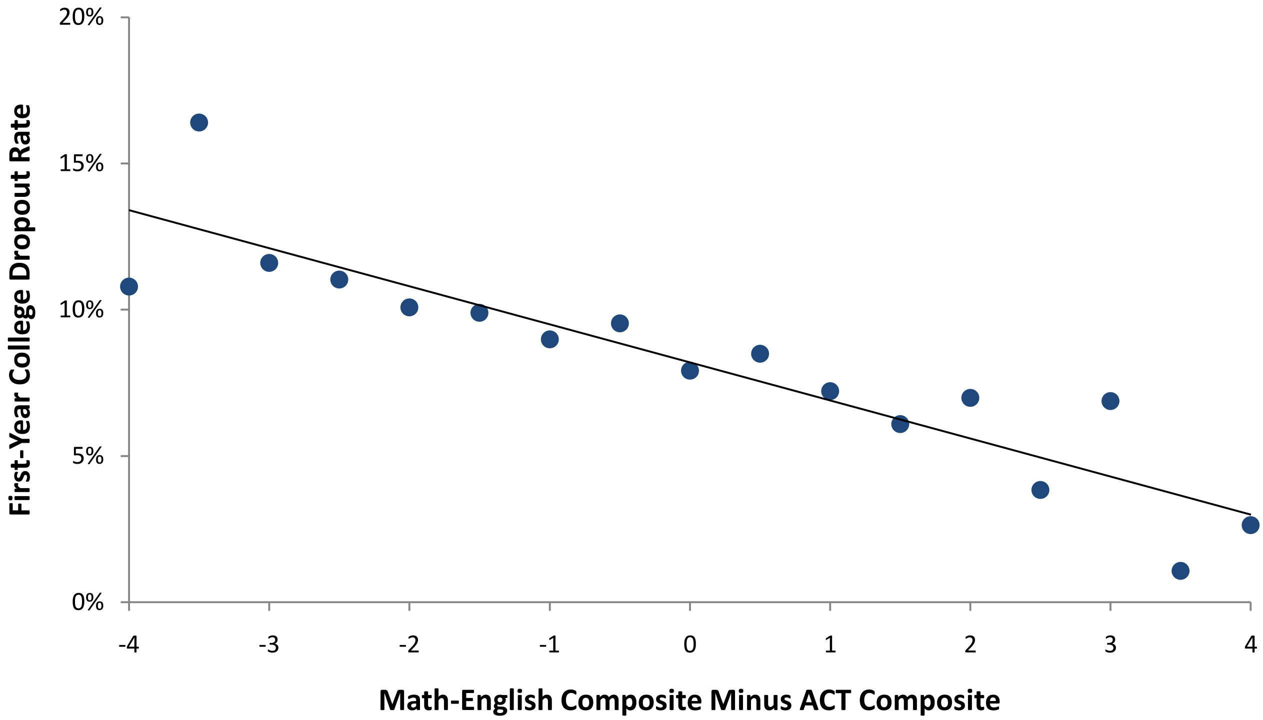


Figure 2 - Dropout Rates. This figure plots first- and third-year college dropout rates against how well students did on a math-english ACT composite score relative to their overall composite score. For example, panel A plots the first-year dropout rate for students whose math-english composite ((math + english)/2) minus their ACT composite score ranged anywhere from -4 to 4. A linear trendline is also included.

A. First-Year College Dropout Rates



B. Third-Year College Dropout Rates

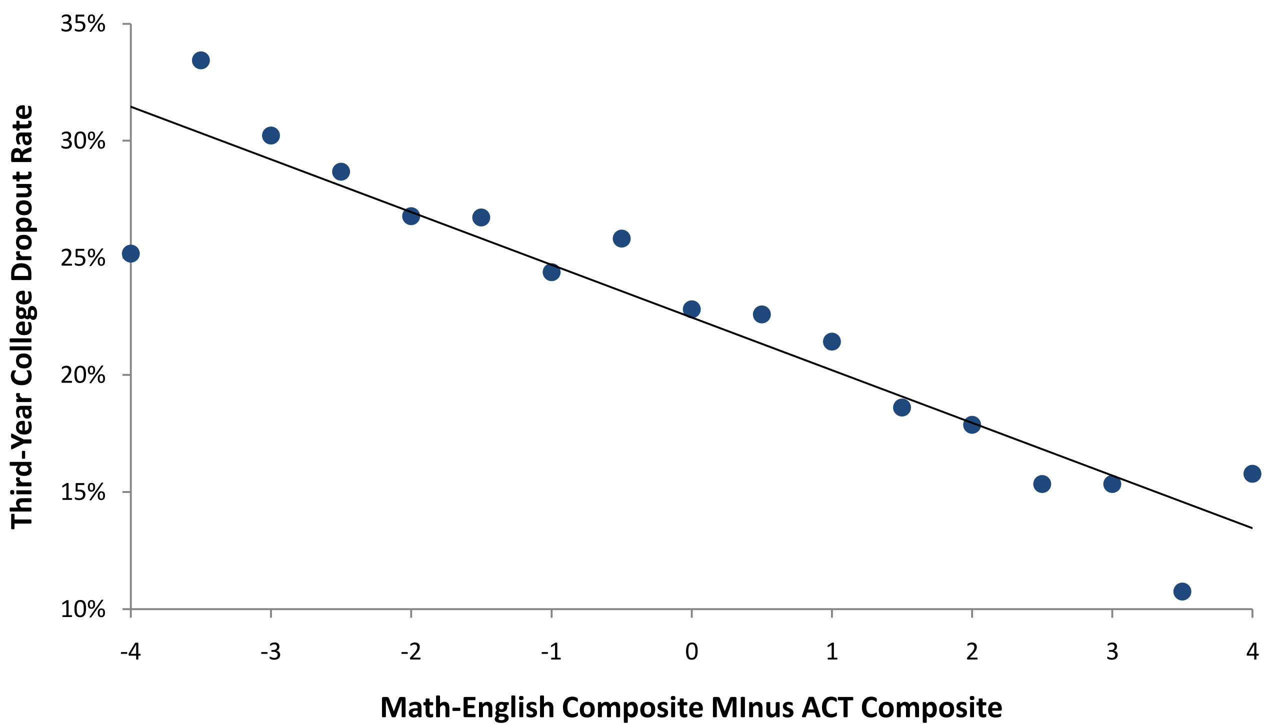


Table 1. Summary Statistics

	Ohio Sample		Nationally
	Mean	Standard Deviation	Standard Deviation
First-Year College GPA	2.71	0.85	2.68
Second-Year College GPA	2.80	0.68	-
First-Year Dropout Rate	0.09	0.28	0.11
Third-Year Dropout Rate	0.24	0.43	0.19
High School GPA (Scale 1-7)	5.95	1.06	-
ACT Composite Score	22.27	4.25	21.0
ACT Math Score	22.13	4.77	20.7
ACT English Score	21.67	4.97	20.5
ACT Reading Score	22.66	5.56	21.4
ACT Science Score	22.14	4.21	21.0
Fraction Male	0.46	0.50	0.44
Fraction White	0.85	0.36	0.75
Fraction Black	0.08	0.28	0.11
Fraction Hispanic	0.02	0.12	0.07
Fraction Asian	0.02	0.14	0.07
Fraction Other/Unknown Race	0.03	0.17	0.01
Observations	25,645	25,645	

Notes: Data for the Ohio sample were obtained from the Ohio Board of Regents. The Ohio data represent all ACT-taking students who matriculated to a four-year public university in Ohio in 1999. Data at the national level are also provided in Column 3 for comparison. First-year college GPA and first-year dropout rate were obtained from the Beginning Postsecondary Students Longitudinal Study 1996/1998 and represents the incoming cohort in 1995 attending 4-year public institutions. Third-year dropout rate and demographic variables were obtained from the Digest of Education Statistics (2001) for all 4-year public institution students. National ACT test scores were obtained from the 1999 ACT National Score Report Index and represent all student test takers.

Table 2. The Predictive Power of ACT Subscores on First-Year College GPA

	Dependent Variable: First-Year College GPA					
	(1)	(2)	(3)	(4)	(5)	(6)
ACT Composite Score	.072**					
	(0.001)					
ACT Math Score		0.034**	0.034**	0.016**	0.020**	0.026**
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ACT English Score		0.037**	0.036**	0.023**	0.018**	0.016**
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ACT Reading Score		0.005**	0.005**	0.004**	0.003*	0.003*
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ACT Science Score		-0.004*	-0.004*	-0.004*	-0.002	-0.001
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Campus Fixed Effects			X	X	X	X
High School GPA Fixed Effects				X	X	X
Race and Gender Fixed Effects					X	X
College Major Fixed Effects						X
R-Squared	0.128	0.141	0.165	0.225	0.231	0.251
Observations	25,243	25,243	25,243	24,168	24,168	21,757

Notes: Coefficient values and robust standard errors are presented from OLS regressions of first-year college gpa on the composite act score (Column (1)) and each of the ACT subscores (Columns (2)-(6)). Campus fixed effects are indicators for the campus to which the student matriculated. High school gpa fixed effects are indicators for each of the possible high school gpa levels (scale from 1 to 7). Race and gender fixed effects are indicators for gender and each of seven race categories. College major fixed effects are indicators for each of 293 potential college majors chosen by the student.

* significant at 5%; ** significant at 1%

Table 3. The Predictive Power of ACT Subscores on Second-Year College GPA

	Dependent Variable: Second-Year College GPA					
	(1)	(2)	(3)	(4)	(5)	(6)
ACT Composite Score	.072**					
	(0.001)					
ACT Math Score		0.031**	0.033**	0.016**	0.020**	0.026**
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ACT English Score		0.037**	0.036**	0.023**	0.018**	0.016**
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ACT Reading Score		0.006**	0.006**	0.005**	0.004**	0.004**
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ACT Science Score		-0.003*	-0.003*	-0.004*	-0.001	0.001
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Campus Fixed Effects			X	X	X	X
High School GPA Fixed Effects				X	X	X
Race and Gender Fixed Effects					X	X
College Major Fixed Effects						X
R-Squared	0.200	0.217	0.227	0.321	0.333	0.363
Observations	22,199	22,199	22,199	21,285	21,285	19,213

Notes: Coefficient values and robust standard errors are presented from OLS regressions of second-year college gpa on the composite act score (Column (1)) and each of the ACT subscores (Columns (2)-(6)). Campus fixed effects are indicators for the campus to which the student matriculated. High school gpa fixed effects are indicators for each of the possible high school gpa levels (scale from 1 to 7). Race and gender fixed effects are indicators for gender and each of seven race categories. College major fixed effects are indicators for each of 293 potential college majors chosen by the student.

* significant at 5%; ** significant at 1%

Table 4. The Predictive Power of ACT Subscores on First-Year Dropout Indicator

	Dependent Variable: First-Year Dropout Indicator					
	(1)	(2)	(3)	(4)	(5)	(6)
ACT Composite Score	-0.0088**					
	(0.0005)					
ACT Math Score		-0.0065**	-0.0053**	-0.0031**	-0.0030**	-0.0025**
		(0.0006)	(0.0006)	(0.0006)	(0.0007)	(0.0007)
ACT English Score		-0.0046**	-0.0035**	-0.0022**	-0.0021**	-0.0027**
		(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0007)
ACT Reading Score		0.0009	0.0011*	0.0014**	0.0014**	0.0014**
		(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
ACT Science Score		0.0010	0.0010	0.0013	0.0014	0.0012
		(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
Campus Fixed Effects			X	X	X	X
High School GPA Fixed Effects				X	X	X
Race and Gender Fixed Effects					X	X
College Major Fixed Effects						X
Pseudo R-Squared	0.029	0.036	0.054	0.063	0.064	0.083
Observations	25,645	25,645	25,645	24,551	24,551	22,111

Notes: Marginal effects and robust standard errors are presented from Logit regressions of a first-year dropout indicator on the composite act score (Column (1)) and each of the ACT subscores (Columns (2)-(6)). Campus fixed effects are indicators for the campus to which the student matriculated. High school gpa fixed effects are indicators for each of the possible high school gpa levels (scale from 1 to 7). Race and gender fixed effects are indicators for gender and each of seven race categories. College major fixed effects are indicators for each of 293 potential college majors chosen by the student.

* significant at 5%; ** significant at 1%

Table 5. The Predictive Power of ACT Subscores on Third-Year Dropout Indicator

	Dependent Variable: Third-Year Dropout Indicator					
	(1)	(2)	(3)	(4)	(5)	(6)
ACT Composite Score	-0.098**					
	(0.004)					
ACT Math Score		-0.013**	-0.011**	-0.006**	-0.007**	-0.006**
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ACT English Score		-0.008**	-0.005**	-0.003**	-0.002**	-0.002*
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ACT Reading Score		0.002*	0.002**	0.002**	0.002**	0.003**
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ACT Science Score		0.002	0.002	0.002*	0.002*	0.002*
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Campus Fixed Effects			X	X	X	X
High School GPA Fixed Effects				X	X	X
Race and Gender Fixed Effects					X	X
College Major Fixed Effects						X
Pseudo R-Squared	0.028	0.035	0.063	0.077	0.0775	0.098
Observations	25,645	25,645	25,645	24,551	24,551	22,111

Notes: Marginal effects and robust standard errors are presented from Logit regressions of a third-year dropout indicator on the composite act score (Column (1)) and each of the ACT subscores (Columns (2)-(6)). Campus fixed effects are indicators for the campus to which the student matriculated. High school gpa fixed effects are indicators for each of the possible high school gpa levels (scale from 1 to 7). Race and gender fixed effects are indicators for gender and each of seven race categories. College major fixed effects are indicators for each of 293 potential college majors chosen by the student.

* significant at 5%; ** significant at 1%

Table 6. The Predictive Power of ACT Subscores on First-Year College GPA - By University

	Campus 1	Campus 2	Campus 3	Campus 4	Campus 5	Campus 6	Campus 7	All Other Campuses
ACT Math Score	0.041**	0.040**	0.033**	0.034**	0.025**	0.036**	0.023**	0.033**
	(0.005)	(0.005)	(0.007)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)
ACT English Score	0.035**	0.020**	0.028**	0.033**	0.028**	0.043**	0.041**	0.042**
	(0.005)	(0.005)	(0.006)	(0.004)	(0.004)	(0.004)	(0.006)	(0.004)
ACT Reading Score	0.002	0.008	0.005	0.005	0.011**	0.008*	0.005	-0.001
	(0.004)	(0.004)	(0.005)	(0.004)	(0.003)	(0.003)	(0.005)	(.003)
ACT Science Score	-0.007	-0.004	-0.000	-0.008	-0.013*	-0.007	-0.003	0.002
	(0.006)	(0.006)	(0.007)	(0.005)	(0.005)	(0.004)	(0.007)	(.005)
R-Squared	0.103	0.132	0.081	0.124	0.09	0.154	0.13	0.123
Observations	2,798	2,345	2,404	2,334	2,499	4,676	2,087	6,100

Notes: Coefficient values and robust standard errors are presented from OLS regressions of first-year college gpa on each of the ACT subscores. Each column is restricted to data from an individual university. The last column includes data from the 6 smallest schools in our sample.

* significant at 5%; ** significant at 1%

Table 7. The Predictive Power of ACT Subscores on Third-Year Dropout Indicator - By University

	Campus 1	Campus 2	Campus 3	Campus 4	Campus 5	Campus 6	Campus 7	All Other Campuses
ACT Math Score	-0.004	-0.022**	-0.007*	-0.006**	-0.007**	-0.010**	-0.014**	-0.013**
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
ACT English Score	-0.004	-0.007*	-0.007*	-0.004	-0.002	-0.005*	-0.008*	-0.007**
	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
ACT Reading Score	0.003	0.002	-0.002	0.002	0.001	0.001	0.005	0.003
	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.001)	(0.003)	(0.002)
ACT Science Score	0.003	0.08*	-0.001	0.002	0.000	0.003	0.002	-0.000
	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)	(0.002)	(0.004)	(0.002)
Pseudo R-Squared	0.002	0.041	0.017	0.015	0.008	0.018	0.023	0.019
Observations	2,836	2,369	2,456	2,340	2,538	4,696	2,142	6,268

Notes: Marginal effects and robust standard errors are presented from Logit regressions of a third-year dropout indicator on each of the ACT subscores. Each column is restricted to data from an individual university. The last column includes data from the 6 smallest schools in our sample.

* significant at 5%; ** significant at 1%

Table 8. The Predictive Power of ACT Subscores on High School GPA

	Dependent Variable: High School GPA (Scale 1-7)		
	(1)	(2)	(3)
ACT Composite Score	0.136**		
	(0.001)		
ACT Math Score		0.073**	0.084**
		(0.002)	(0.002)
ACT English Score		0.055**	0.039**
		(0.002)	(0.002)
ACT Reading Score		0.004**	0.002
		(0.002)	(0.002)
ACT Science Score		0.007**	0.018**
		(0.002)	(0.002)
Race and Gender Fixed Effects			X
R-Squared	0.295	0.323	0.353
Observations	24,551	24,551	24,551

Notes: Coefficient values and robust standard errors are presented from OLS regressions of high school gpa (scale 1-7) on the composite act score (Column (1)) and each of the ACT subscores (Columns (2) and(3)). Race and gender fixed effects are indicators for gender and each of seven race categories.

* significant at 5%; ** significant at 1%

Table 9. The Predictive Power of ACT Subscores on College and High School GPA - BYU Sample

	College GPA		High School GPA
	(1)	(2)	(3)
ACT Math Score	0.015**	0.015**	0.016**
	(0.002)	(0.002)	(0.002)
ACT English Score	0.019**	0.019**	0.010**
	(0.003)	(0.003)	(0.002)
ACT Reading Score	0.006**	0.007**	0.002
	(0.002)	(0.002)	(0.002)
ACT Science Score	0.003	0.001	0.002
	(0.002)	(0.002)	(0.002)
Gender Fixed Effect	X	X	X
Major Fixed Effects		X	
R-Squared	0.192	0.443	0.132
Observations	1,712	1,712	1,706

Notes: Coefficient values and robust standard errors are presented from OLS regressions of graduating college gpa (Columns (1) and (2)) and high school gpa (Column (3)) on each of the ACT subscores. An indicator for gender is included and also indicators for each of 358 potential college majors (Column (2)).

* significant at 5%; ** significant at 1%

Table 10. The Predictive Power of ACT Subscores on High School GPA - Using Full ACT Test-Takers Database

	Dependent Variable: Self-Reported High School GPA		
	(1)	(2)	(3)
ACT Composite Score	0.0740**		
	(0.0001)		
ACT Math Score		0.0383**	0.0382**
		(0.0002)	(0.0002)
ACT English Score		0.0242**	0.0233**
		(0.0002)	(0.0002)
ACT Reading Score		0.0072**	0.0072**
		(0.0001)	(0.0001)
ACT Science Score		0.0049**	0.0052**
		(0.0002)	(0.0002)
Test Day Fixed Effects			X
R-Squared	0.349	0.365	0.380
Observations	936,666	936,666	936,666

Notes: Coefficient values and robust standard errors are presented from OLS regressions of self-reported high school gpa on the composite act score (Column (1)) and each of the ACT subscores (Columns (2) and(3)). Test day fixed effects are included in Column (3).
* significant at 5%; ** significant at 1%

Table 11. The Predictive Power of a Math-English Composite Score on Academic Success

	Dependent Variable							
	First-Year GPA		Second-Year GPA		First-Year Dropout Indicator		Third-Year Dropout Indicator	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Math-English Composite Score	0.066**	0.040**	0.060**	0.036**	-0.013**	-0.008**	-0.026**	-0.013**
	(0.004)	(0.004)	(0.003)	(0.003)	(0.001)	(0.001)	(0.002)	(0.002)
ACT Composite Score	X	X	X	X	X	X	X	X
Campus Fixed Effects		X		X		X		X
High School GPA Fixed Effects		X		X		X		X
Race and Gender Fixed Effects		X		X		X		X
College Major Fixed Effects		X		X		X		X
R-Squared/Pseudo R-Squared	0.140	0.251	0.216	0.362	0.036	0.083	0.034	0.097
Observations	25,243	21,757	22,199	19,213	25,645	21,410	25,645	21,967

Notes: Coefficients (Columns (1)-(4)) and marginal effects (Columns (5)-(8)) and robust standard errors are presented from OLS/Logit regressions where the dependent variable is first-year GPA (Columns (1) and (2)), second-year GPA (Columns (3) and (4)), first-year dropout indicator (Columns (5) and (6)), and second-year dropout indicator (Columns (7) and (8)). The key independent variable is the math-english composite score which we generate by taking the average of the math and english test scores. In Columns (1), (3), (5), and (7) we control for the actual ACT composite score (unrounded) and in Columns (2), (4), (6), and (8) we also control for our full set of control variables.

* significant at 5%; ** significant at 1%

Table 12. Calibration Results

	Callibration Results of 3rd-Year Dropout Rates by School Using Different Hypothetical Admission Rules		
	Using ACT Composite Score Rank	Using Math-English Score Rank	Percent Difference in Dropout Rates
Campus 1	0.156	0.144	-7.7%
Campus 2	0.147	0.140	-4.8%
Campus 3	0.188	0.182	-3.2%
Campus 4	0.209	0.205	-1.9%
Campus 5	0.220	0.222	0.9%
Campus 6	0.239	0.247	3.3%
Campus 7	0.261	0.278	6.5%
Campus 8	0.315	0.304	-3.5%
Campus 9	0.311	0.319	2.6%
Campus 10	0.345	0.363	5.2%
Campus 11	0.411	0.415	1.0%
Campus 12	0.458	0.486	6.1%
Campus 13	0.528	0.560	6.1%

Notes: This table provides the 3rd-year dropout rates for the students admitted to each college under two hypothetical admission plans. The first plan assigns the best students (as measured by their ACT composite scores) to the highest-rated Universities. The second plan assigns the best students (as measured by their Mathematics-English composite score) to the highest-rated Universities. The first two columns in the table indicate the 3rd-year dropout rates for the students assigned to each university based on the two different assignment plans. The 3rd column provides the percent difference in dropout rates between the two plans.