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Weighting recent performance to improve college and labor market outcomes☆

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ABSTRACT

There is a great deal of policy interest in reducing college dropout rates, increasing graduation rates, and improving labor market outcomes. To this end, individual colleges and state university systems use high school grade point averages and class rankings in an effort to offer admission and scholarships to students who are most likely to achieve long-run success. However, a significant fraction of students exhibit steep positive or negative performance trends during high school. This study shows that academic performance in later grades is given no greater weight in admissions but is the best predictor of college and labor market outcomes, greatly exceeding prior grades and entrance exam scores. Placing greater weight on later grades and extending application deadlines to allow the consideration of 12th grade performance is shown to significantly alter which students are admitted to college and to improve their expected long-run outcomes. Importantly, weighting recent performance does not appear to affect college diversity. Evidence is presented that the predictive power of later grades is driven primarily by students who experience large negative performance trajectories during high school.

1. Introduction

High school grade point average (GPA) is perhaps the single most important determinant of student access to post-secondary opportunities: several states employ policies that guarantee admission to a public university based on class ranking; admissions offices use GPAs to rank applicants; and many colleges and scholarship organizations have minimum GPA requirements.[1] Such policies give equal weight to performance at each high school grade level, implicitly assuming that each grade is equally important for predicting future success. In contrast to this assumption, this paper presents evidence that a student's performance in later grades has far more power for predicting college dropout, on-time graduation, and future earnings than does performance in prior years. Evidence is presented that the predictive power of later high school grades stems in part from persistent trends in student effort. These findings suggest that using grade level GPAs may result in the allocation of enrollment slots and financial resources to students who have higher probabilities of success. Likewise, extending application deadlines would allow the consideration of 12th grade performance, which is most predictive of long-run outcomes. The results have important policy implications in light of the labor market returns associated with college completion and the high cost of increasing enrollment and persistence through financial aid and grants.[2]

Data on high school course grades and state university applications for four Florida cohorts reveal that admissions during the period of study were based on grade point averages, with nearly identical weight given to performance in 9th, 10th, and 11th grades (and less to 12th grade performance, which is only partially revealed

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[1] State policies that guarantee admissions based on class rank include the Talented Twenty Program in Florida, the California Master Plan for Higher Education, and the Texas Top 10 Percent Plan. Many universities use a matrix of GPA and entrance exam score to allocate scholarships (e.g. Brigham Young University, the University of Nevada at Las Vegas, and Northern Illinois University). Likewise, the NCAA uses a sliding scale of GPA and SAT score to determine eligibility for athletic scholarships.

[2] For examples of the literature examining the returns to college attainment, quality, and completion, see Jaeger and Page (1996), Kane and Rouse (1995), Brewer et al. (1999), Black and Smith (2006), Card (2001), Long (2010), and Carneiro et al. (2011). Studies of the effect of financial resources on student persistence in college include DesJardins et al. (2002), Bettinger (2004), Cohodes and Goodman (2014), Deming and Dynarski (2010), Dynarski (2008), Glocker (2011), Scott-Clayton (2011), Singell (2004), Stinebrickner and Stinebrickner (2008), and Goldrick-Rab et al. (2016).

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at the time decisions are made). This balance across grade levels is consistent with the common practice among colleges, and large universities in particular, of constructing an admission index using cumulative high school GPA and entrance exam score.[3] However, giving equal weight to each grade level necessarily discards a large amount of information stemming from substantial variation in student performance over the four years of high school. For example, within-student changes in GPA between 9th and 12th grades have a standard deviation of 0.7 points. Among students in the middle quintile of performance in 9th grade, 11% are in the top quintile by 12th grade while 15% are in the bottom quintile.

University enrollment records reveal that performance in later grades of high school is far more predictive of dropout and on-time graduation than performance in earlier grades. For example, one additional GPA point in 11th grade is associated with an increase of 16 percentage points in the probability of graduating from a state university, compared to an increase of 5 percentage points for a GPA point in 9th grade. Similarly, the later GPA point is five times more predictive of dropping out of college within two years. Linked employment records further reveal that 11th grade performance is twice as predictive of labor market earnings as 9th grade performance. Extending the analysis to consider 12th grade performance, which is only partially observed during the admissions process, results in a similar pattern. Performance in the final year of high school is more predictive of graduation and earnings than is performance in prior years. Of particular policy relevance is that differences in performance across grade levels have very weak correlations with students' socioeconomic characteristics.

A concern raised in studies examining the predictive power of entrance exams is the issue of selection into college, as admission and thus attendance is a function of exam scores.[4] This analysis is able to abstract from this challenge in two ways. Because each grade level receives equal weight in admissions, there is essentially no evidence of differential admission and attendance at state universities across students with better or worse performance at different grade levels.[5] Interestingly, this balance does not appear to stem primarily from the policy of guaranteed admission for students in the top 20% of their graduating class. Students were only eligible for this program if they applied to three zuniversities and were rejected by each one, which is the case for a small percentage of applicants observed in the data. The issue of unobserved outcomes is also alleviated by the fact that 92% of applicants are observed attending either a community college or a state university. Specifications that include fixed effects for application portfolios or university attended generate estimates that are nearly identical to those that do not, indicating that the results do not stem from selection into colleges of differing quality.

A number of studies find that exam scores are given disproportionate weight relative to their predictive power and tend to disadvantage lower-income and minority students (e.g., Rothstein, 2004; Scott-Clayton, 2011 and Black et al., 2016). Bettinger et al. (2013) further note that two subsections (Math and English) of the ACT are more predictive than the others (Reading and Science) and thus efficiency is improved if the less relevant sections are ignored. This study finds that the SAT is given a great deal of weight in admissions, but, after conditioning on grade level GPAs, has modest predictive power for dropout, graduation, and future earnings. Thus, differentiating between grade levels contributes an order of magnitude more in terms of potential gains for long-run outcomes and has fewer implications for diversity.[6]

The use of GPA and class rank by colleges and states assumes that each grade level is an equally valuable measure of potential — an assumption that is inconsistent with the empirical evidence and with traditional models of human capital accumulation. Two classes of explanations emerge for why performance in later grades is more predictive of long-run outcomes: 1) student-based explanations in which trends in effort or investment during high school persist into college; and 2) course-based explanations in which the composition or content of classes taken later in high school better reveals college potential. To shed light on the role of persistent changes in effort, I classify students by their trends in performance and find that students on steep downward trajectories disproportionately drive the results. The importance of effort is supported by the finding that performance in non-academic electives taken in later grades, which are unlikely to reflect college-level academic material, is more predictive of college performance than academic and non-academic classes taken in earlier grades. There is less evidence that the power of later grades stems from changes in course composition or difficulty. Specifically, restricting attention to core subject areas that are balanced across grade levels does not significantly alter the results. Likewise, omitting Advanced Placement courses that are taken in later grades and cover college-level material does not reduce the explanatory power of later grades.

The results presented in this paper highlight two potential opportunities for the more efficient allocation of resources. First, conditional on the data available to admissions offices, states, and scholarship organizations, giving greater weight to more recent performance is likely to improve the expected outcomes of selected students. Second, delaying application deadlines to allow the consideration of additional 12th grade performance information would result in the selection of students who are more likely to succeed in college. It is important to note that a systematic change in the weight given to grade level GPAs by a large number of universities could cause students to exert more or less effort throughout high school, thus generating changes in learning and potentially altering the predictive power of performance trends. Abstracting from such general equilibrium issues to focus on the decisions of individual universities, a simple exercise reveals that decisions based on disaggregated grades rather than averages would change the set of admitted students by about 13% for a university with an acceptance rate of 50%, and that new admits would be 10 percentage points more likely to graduate than the students they replace. Importantly, because GPA performance across grade levels is not correlated with demographics, the pool of students admitted using disaggregated grades would be as

[3] A number of universities make the formula they use to compute their indices publicly available. See, for example, Iowa State, Utah State, Alabama State, the University of Memphis, Southern Utah, the University of Southern Florida, the University of Colorado System, the California State University System, and many others. In nearly every case, the index is based on a student's cumulative high school GPA (an exception is California, where 9th grade performance is excluded). While highly selective colleges may have the resources to use a more holistic approach, they too face incentives to use cumulative averages, as rankings such as the U.S. News & World Report consider high school class rank as a measure of selectivity.

[4] See, for example, Rothstein (2004) and Black et al. (2016). In an effort to overcome the issue of selection into college, these studies have exploited the fact some states guarantee admission to a state university if a student has a given class rank or GPA, thus abstracting from the extensive margin of being admitted to a state university due to exam score.

[5] The lack of selection on grade level performance is also apparent at each separate state university, so there is no evidence that students who perform better in later grades relative to earlier grades have access to better undergraduate programs.

[6] The finding that differentiating GPA by grade level does not penalize low-income and minority students is important in light of a large literature which reveals that minor obstacles can deter students from low-income households from attending and persisting in college (e.g. Bettinger et al., 2012, Bulman, 2015, Goodman, 2016, Hoxby and Turner, 2013, Hurwitz et al., 2015, Stinebrickner and Stinebrickner, 2003).

diverse as those they replace in terms of race, gender, and household income.[7]

This paper contributes to the literature in several ways. It highlights a fundamental inefficiency in using overall GPAs when optimizing important long-run outcomes of interest such as dropout, graduation, and earnings. The policy implications of the analysis appear to have little or no downside for diversity. The examination of student trajectories, balanced academic sequences, AP courses, and non-academic electives provides insight into the mechanisms driving the persistence of performance. While this study focuses on post-secondary admissions policies, the use of GPAs extends beyond high school to college. For example, minimum GPA thresholds are frequently used to determine eligibility for transferring from community colleges to four-year universities, and college GPAs are used to retain eligibility for federal, state, and institutional financial aid.[8]

The paper is organized as follows. Section 2 introduces the data and describes within-student variation in academic performance over time. Section 3 presents the dichotomy between admissions policies and long-run outcomes. Section 4 considers potential mechanisms. Section 5 discusses the policy implications of the findings and Section 6 concludes.

2. Data and grade point averages

2.1. High school, college, and labor market data

The analysis is based on de-identified records for the 1999 to 2002 high school cohorts maintained by Florida's K-20 Education Data Warehouse.[9] High school transcripts are linked to application and enrollment records for state universities and to unemployment insurance records. The data include high school grades, application and admissions decisions, university and college enrollment, degrees awarded, and annual earnings.[10] ACT scores are converted to their SAT equivalent scores using concordance tables developed by the College Board and ACT. High school transcripts are used to construct overall grade point averages and separate averages for each year of high school. Academic and non-academic courses are separated in order to compute the GPAs considered for admission. Letter grades are converted to a four point scale in which an "A" is worth 4 points and an "F" is worth 0 points. Advanced courses such as Advanced Placement and International Baccalaureate are graded on a 5 point scale.

The data indicate the applications students send to public universities and the admissions decisions. Enrollment data indicate whether or not students enroll, the semesters of enrollment, and whether they earn degrees. Students are defined as having dropped out if they are observed enrolling in at least one of the two semesters of the prior academic year and in neither of the semesters of the current year. Students are considered to have graduated within five years if they are awarded a BA from any state university within five years of their last year of high school. Annual income is measured in 2010, which is 8 to 12 years after high school graduation. Table 1 presents summary statistics. The average GPA for state university applicants is about 3.5 in each year of high school. The average applicant applies to 1.8 universities, is admitted to 1.3, and has a 67% chance of ultimately enrolling. About 92 % of applicants to a state university enroll at a state university or a community college, suggesting that the fraction of applicants leaving the state for college or attending a private college is modest. Approximately 25 % of those who attend a state university after high school drop out within two years and 53% earn a degree within five years. Average income among those employed in 2010 is 42,955 dollars.

Table 1
Summary statistics for college applicants.

	Mean (1)	Std. Dev. (2)
Demographics		
Male	0.41	0.49
Female	0.59	0.49
Asian	0.04	0.21
Black	0.18	0.38
Hispanic	0.14	0.35
White	0.62	0.49
Grade point average		
GPA Grade 9	3.47	0.77
GPA Grade 10	3.46	0.77
GPA Grade 11	3.42	0.73
GPA Grade 12	3.50	0.74
Changes in grade point average		
GPA Change 9 to 10	−0.01	0.49
GPA Change 10 to 11	−0.04	0.51
GPA Change 11 to 12	0.08	0.55
GPA Change by demographics		
GPA Change 9–12: Male	−0.02	0.68
GPA Change 9–12: Female	0.07	0.64
GPA Change 9–12: Asian	−0.08	0.64
GPA Change 9–12: Black	0.12	0.69
GPA Change 9–12: Hispanic	0.06	0.69
GPA Change 9–12: White	0.01	0.64
Long-run outcomes		
Applications	1.81	1.07
Admissions	1.34	0.96
Attend 4-Yr state college	0.67	0.47
Attend 2 or 4-Yr college	0.92	0.27
Drop out within 2 years	0.17	0.37
Graduate within 5 years	0.39	0.49
Employed in 2010	0.57	0.49
Income if employed	42,955	32,235

Note: This table presents summary statistics for applicants to public universities between 1999 and 2002. Students are those who attended four years of high school in the state. Grade point averages for each year of high school are weighted to account for advanced courses and thus may take on values between 0 and 5. Applications and admissions are those that occur within one year of high school graduation. A student is considered to have dropped out if the student is enrolled for at least one semester in the prior year and for no semesters in the current year. Income is conditional on employment.

2.2. GPA variation during high school

High school grade point averages play a key role in access to college because they are used to rank applicants and allocate financial resources. The use of overall averages rather than grade level averages is important if student performance varies significantly during high school and if performance trends persist into college. As shown in Table 1, average GPAs are similar in 9th through 12th grades. This stability in average grades is not, however, indicative of individual

[7] This is in contrast to reweighting across academic subjects which may be differentially correlated with socioeconomic factors. For example, performance in English classes in high school may be more strongly correlated with household income or being a native speaker than is performance in math classes. Thus, colleges that value having balance in demographics or fields of study may choose not to optimize admissions to maximize graduation rates if it requires reweighting in this dimension.

[8] Further, professional programs such as law and medical schools give weight to college GPAs for admission. While employer practices are not well documented, it is undoubtedly the case that college GPAs are used by some companies when screening potential employees. Thus, the finding that averages dispense with highly predictive information about long-run outcomes may have important implications that extend beyond the context of this study.

[9] The de-identified records were provided as part of the state research agenda to increase completion rates within the post-secondary sector (5.c.ii) and to increase enrollment in programs with strong workforce outcomes (5.a.v).

[10] The data set used for this study does not include university grades, so this outcome is not considered in the analysis.

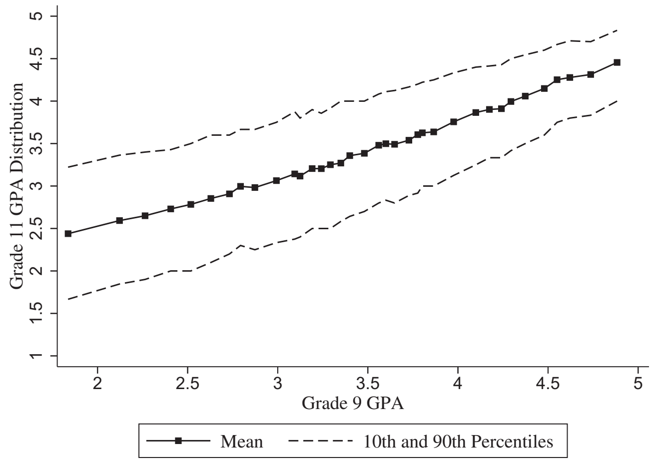

Fig. 1. Variation in grade point average between 9th and 11th grades. **Note:** This graph presents the relationship between students' grade point averages in 9th and 12th grades. The lines represent the mean, 10th percentile, and 90th percentile of the distribution of 12th grade GPAs. Grade point averages for each year are weighted to account for advanced courses.

students having stable performance over time. Many students experience significant variation in their GPAs as they progress through high school. The year-to-year difference in grades has a mean of approximately zero but a standard deviation of about 0.5. Fig. 1 presents graphical evidence of the large upward and downward trajectories in students' GPAs during high school. For example, among students with a 3.5 GPA in 9th grade, 10% earned below a 2.7 in 11th grade and 10% earned a 4.0 or higher. The graph also shows that variation in grade point averages during high school is not restricted to low- or high-performing students. Likewise, transition matrices show that among students in the middle quintile of performers in 9th grade, only 29% remained in this group in 12th grade.[11] About 11% of these students ascended to the top quintile of performers, while 15% fell to the bottom quintile. Thus, it appears that overall GPAs obscure large and potentially important trends in performance during high school.

The demographics of students whose grades trend upward and downward during high school are important for interpreting the results and for understanding the policy implications of this study. Specifically, if low-income and minority applicants are more likely to have negative grade trends, it may partially explain why later grades are more predictive of long-run outcomes and would imply that giving greater weight to 11th and 12th grade performance could alter the diversity of those admitted to college. Table 1 presents the difference in GPAs in 12th grade relative to 9th grade by race and gender. These differences reveal that, if anything, the GPAs of minority applicants rose slightly relative to those of non-minorities and had nearly identical variance.[12] Thus, changes in GPA during high school among state university applicants do not appear to be highly correlated with demographics.

3. Recent performance and long-run outcomes

This section examines the disconnect between the weight given to GPAs at each grade level during the admissions process and to their power for predicting dropout, on-time graduation, and earnings. The analysis is extended to consider the relative predictive power of entrance exams. The potential confounding issues of selection into college and into colleges of differing quality are examined explicitly.

3.1. Estimating the importance of GPAs

The primary specification includes covariates that closely mirror those available to universities at the time that they make admissions decisions:

$$Outcome_{isc} = \alpha_{sc} + X_i\gamma + \sum_{g=9}^{g=12} \beta_g GPA_g + \epsilon_{isc}. \tag{1}$$

Each student's outcome depends on a high school by cohort fixed effect, α_{sc}, SAT score, demographics, and a set of indicators for each state university application. Exploiting only variation within high school cohorts should abstract from issues such as unobserved school quality, which could be correlated with positive or negative grade trends during high school.

If students with stronger performances in earlier or later grades have more potential in a way that is observable to universities but not to the researcher, then this should be reflected in the weight given to different grade levels in admissions. Alternatively, if universities give equal weight to each grade, then it supports the hypothesis that they use the overall averages reported on transcripts and that students on upward and downward trajectories are treated as equally desirable from the perspective of the university. The same specification is used to estimate the predictive power of performance at each grade level for long-run college and labor market outcomes. The relative magnitudes of these coefficients across grade levels are compared to those for admissions, highlighting the fundamental disconnect. Heterogeneity analysis is presented in which the primary specification is replicated for each race and gender and for students attending high schools that serve low- and high-income households.

A challenge occurs if differential performance across grade levels is correlated with the likelihood with which outcomes are observed (extensive margin) or the quality of the state university attended (intensive margin). Specifically, if a student who performs well in 11th grade is systematically more or less likely to attend a state university conditional on applying than a student who performs well in 9th grade, then comparing admissions with college outcomes may be invalid due to compositional changes. This concern is largely alleviated by the fact that the vast majority of applicants remain in state — 92% attend a community college or state university. Furthermore, I explicitly estimate the relationship between performance at different grade levels and a student's likelihood of attending a state university. On the intensive margin, students who perform better in later grades could be more or less likely to attend universities that have higher or lower dropout and graduation rates. To address this, I estimate specifications with controls for application portfolios (which may help to control for selection on unobservables) in the style of Dale and Krueger (2002) and with controls for the university attended.

3.2. Admissions and attendance outcomes

An examination of the outcomes of all students who applied to a state university reveals that admissions decisions place nearly identical weight on GPA at each grade level available at the time of

[11] Transition matrices are presented in Online Appendix Table A1.

[12] The correlations between being Black, Hispanic, and White and change in GPA between 9th and 12th grades are 0.05, 0.02, and −0.04, respectively. Further, considering all high school students and not just college applicants reveals nearly identical correlations.

Table 2
Grade level importance: college and labor market outcomes.

	Admit rate	Attend 4-yr college	Drop out in 2 years	Graduate in 5 years	Employed	Ln Income (if employed)
Grades 9 to 12	(1)	(2)	(3)	(4)	(5)	(6)
GPA Grade 12	0.029***	0.028***	−0.116***	0.148***	−0.001	0.138***
	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)	(0.010)
GPA Grade 11	0.071***	0.031***	−0.062***	0.098***	−0.010*	0.072***
	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)	(0.012)
GPA Grade 10	0.065***	0.034***	−0.022***	0.049***	0.007	0.072***
	(0.003)	(0.004)	(0.005)	(0.005)	(0.006)	(0.013)
GPA Grade 9	0.066***	0.034***	−0.017***	0.035***	0.016***	0.028**
	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)	(0.012)
Grades 9 to 11	(7)	(8)	(9)	(10)	(11)	(12)
GPA Grade 11	0.083***	0.044***	−0.113***	0.164***	−0.010**	0.132***
	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)	(0.011)
GPA Grade 10	0.070***	0.038***	−0.041	0.072***	0.007	0.093***
	(0.003)	(0.004)	(0.005)	(0.005)	(0.006)	(0.013)
GPA Grade 9	0.069***	0.036***	−0.027***	0.048***	0.016***	0.041***
	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)	(0.012)
Observations	92,580	92,580	61,628	61,628	61,628	36,220
Mean Dep	.769	.666	.253	.531	.588	44,679

Note: This table presents the relationship between grade point average in each year of high school and college admissions, attendance, drop out within 2 years, graduation within 5 years, employment in 2010, and labor market income. College and labor market outcomes are estimated conditional on attendance. Grade point averages for each year are weighted to account for advanced courses. Each specification includes a high school by cohort fixed effect, SAT score, demographics, and an indicator for each university application. Standard errors are clustered at the high school by cohort level. The symbols *, **, and *** indicate significance at the 10, 5, and 1% levels.

application.[13] Table 2 shows that a one point higher GPA in 9th, 10th, and 11th grades increases the chances of admission by 6.6, 6.5, and 7.1 percentage points, respectively. Thus, universities appear to treat those with the same overall GPA as approximately equivalent. The balance across grade levels also suggests that students with higher grades later in high school do not systematically possess characteristics that make them more desirable to admissions committees but are unobserved in the data. Students have not completed 12th grade at the time that applications are due and admissions decisions are made. The partial availability of senior year grades is clearly reflected in the coefficient on grade 12 GPA, which is less than half as large as the coefficients on prior grade levels. The bottom panel of Table 2 presents the estimates under the assumption that universities only observe performance in grades 9 through 11, which generates similar weights across the three grade levels. Overall, the estimates reveal that a student with a high GPA as a junior and senior may not be admitted due to poor performance as a freshman.

Importantly, there is no systematic difference in state university attendance by differences in performance across grade levels. A one point higher GPA in 9th, 10th, or 11th grade increases the probability of attending a four-year state college by about 3 percentage points on an average rate of attendance of 67%. A potential concern is that differential selection into attendance is obscured by controlling for entrance exam performance (or other covariates), which may be more strongly correlated with performance in later grades. However, a specification with no controls reveals a similar lack of selection.[14] Thus, there is little evidence that the composition of students applying to and attending a state university is correlated with performance differences across grades. This suggests that any disconnect between admissions and long-run outcomes associated with GPA differences across grade levels is not driven by sorting in this dimension. Likewise, the difference in the probability of observing an individual in the labor market across grade level performance is modest and remains small when conditioning on college attendance. Thus, it seems unlikely that differences in earnings are due to selection.

3.3. Long-run college and labor market outcomes

In contrast to the equal weight given in admissions, academic performance in later grades is far more predictive of long-run outcomes than performance in earlier grades. When considering only performance in grades 9 through 11, a one point higher GPA in 11th grade corresponds to a reduction in dropout of 11 percentage points and an increase in the probability of graduating within five years of 16 percentage points.[15] By comparison, a one point increase in 9th grade performance is associated with a reduction of 3 percentage points in the probability of dropping out and a 5 percentage point increase in the probability of graduating. Further, a one point higher GPA in 11th grade is correlated with an increase in expected labor market

[13] As noted above, admissions and attendance results do not appear to stem from guaranteed admission for the top 20% of each graduating class. This policy requires that a student must be rejected from three universities prior to requesting a complimentary review by all universities. In practice, 78% of the students in the data apply to only one or two universities and, among those who apply to three universities, only 7% are rejected by all three (and less than 1% of students with above average GPAs are rejected by all three). As discussed in the Introduction 1, a more likely cause of balance across grade levels is the use of cumulative GPAs when computing admissions indices, which is a common practice at large universities.

[14] If entrance exam scores are more strongly correlated with GPA in later grades, then including these scores as a control could reduce the amount of selection that is observed in the estimates. As shown in Online Appendix Table A2, a regression of attendance on 9th, 10th, and 11th grade GPA with no control variables results in point estimates of 5.3, 5.1, and 5.3, respectively. This exercise is supported by evidence that entrance exam scores are slightly more strongly correlated with performance in earlier grades than with performance in later grades.

[15] While college grades are not observed, dropout is likely to stem in large part from academic performance in college. Several studies explicitly consider the process by which students update their beliefs in college and decide whether or not to drop out based on academic performance (e.g., Manski, 1989; Stinebrickner and Stinebrickner, 2012).

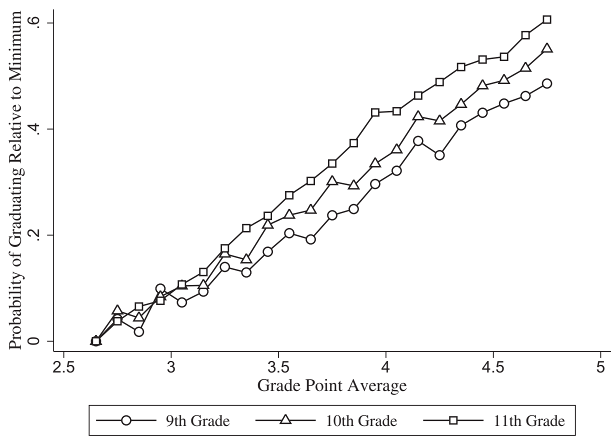

Fig. 2. Relationship between graduating from college and grade level GPAs. **Note:** This graph presents the relationship between students' grade point averages in 9th, 10th, and 11th grades and their probability of graduating from a four-year college within five years of high school graduation. The probabilities are normalized to zero for the lowest grade point average in the graph to facilitate comparison. Grade point averages for each year are weighted to account for advanced courses.

earnings of 13% compared to 4% for a grade point in 9th grade.[16] Performance in 12th grade is even more predictive of future success. For example, when predicting college dropout using all grade levels, GPA points in grades 11 and 12 are associated with reductions of 6 and 12 percentage points respectively, while 9th grade performance has little additional explanatory power. Fig. 2 presents graphical evidence of the value of later grades for predicting college success relative to earlier grades. Specifically, while the slope of the graduation rate is increasing in 9th, 10th, and 11th grade GPA, it is steeper in each subsequent year. This increasing slope reveals that the relationship between student performance and college outcomes becomes stronger in later grades. These results suggest that performance persists from high school into college and, in the absence of a strong behavioral response from students, states and universities could benefit from giving greater weight to more recent academic performance by weighting each grade separately and by considering 12th grade GPA.

Of interest is the extent to which the predictive power of later grades stems from a correlation with socioeconomic characteristics. The statistics presented in Section 2 indicate that trends in grades are not strongly associated with race and gender. I confirm this by sequentially adding controls for entrance exam scores, high school attended, and demographics to the baseline specification, which has little effect on the estimates.[17] That is, the finding that later grades are most important for predicting college and labor market outcomes does not appear to stem from a systematic correlation between performance in later grades and socioeconomic factors that also shape long-run outcomes. Heterogeneity analysis reveals that the pattern of results is nearly identical across race, gender, and students from high schools that serve higher- and lower-income households (as measured by the fraction of students eligible for a free lunch).[18] Thus, the predicted performance of each group could be improved if colleges placed greater weight on later-year GPAs when evaluating applicants.

The dropout and graduation results presented in Table 2 are conditional on attending a state university. The fact that differential performance across grades does not significantly affect admission or attendance probabilities on the extensive margin suggests that these estimates are not driven by compositional changes in the students whose outcomes are observed. However, a potential concern arises if students with better performance in later grades sort into higher quality universities. Thus, I examine the role of selection into universities on each long-run outcome with a specification that adds fixed effects for each student's application portfolio and university attended. The results exhibit nearly identical patterns, with later performance having the greatest predictive power for dropout decisions, graduation within five years, and income.[19] Thus, there is no evidence that the results are due to differential sorting into universities.

3.4. Entrance exams

College entrance exams, the SAT and ACT, play a key role in admissions decisions and have been given a great deal of attention in the literature. Entrance exams and GPAs are measured on different scales, so I normalize them to be in terms of standard deviations from the mean in order to aid in comparisons. The estimates in Table 3 indicate that entrance exam scores are given significant weight in admissions, approximately double the magnitude of each grade level GPA. In contrast, there is little evidence that (conditional on attendance) these scores add significant predictive power with respect to whether a student will drop out, graduate, or earn more in the labor market. For example, a one standard deviation higher test score is associated with the same increase in graduation rate as a one standard deviation increase in 9th grade GPA, and is less predictive than GPA in 10th, 11th, or 12th grade. These results are consistent with several studies which find that, after controlling for a rich set of demographic controls, the predictive power of entrance exams is significantly attenuated.[20] An important caveat is that, unlike grade level GPAs, there is evidence of selection into attending college and college quality based on entrance exam scores. That is, the results could be driven in part by differences in the composition of students who are admitted to and attend each college. The finding that GPAs have more explanatory power than entrance exams for predicting college persistence is not the focus of the analysis, but indicates that a more effective use of GPAs may have greater potential policy implications.

4. Potential mechanisms for persistence

The results in Section 3 reveal that applicants with higher GPAs in later grades are less likely to drop out, are more likely to graduate, and earn more in the labor market. This section considers two

[16] In prior research, Miller (1998) finds that employers appear to undervalue high school GPAs at the time of hiring. This is noted from the fact that grades are not predictive of wage differences in the first year of employment but are a significant predictor of wages nine years later.

[17] As shown in Online Appendix Table A2, the predictive power of a GPA point in 11th grade is 17.5 percentage points in a specification with no controls and 16.4 percentage points with a full set of entrance exam, high school, and demographic controls. Similar robustness is found for grades 9 through 12 in Online Appendix Table A3.

[18] Estimates are presented in Online Appendix Table A4.

[19] As shown in Online Appendix Table A5, the predictive power of one GPA point in 12th grade is 14.4 percentage points in specifications with and without fixed effects for application portfolios and colleges attended. Effects estimated for universities separately reveal that each allocates approximately equal weight to GPAs in grades 9 to 11 for admissions and that students who perform better in later grades have better outcomes regardless of where they attend college.

[20] Rothstein (2004) finds that accounting for demographics and selection reduces the estimated predictive power of the SAT by 60%. Black et al. (2016) note that adding the SAT to a rank-based admissions policy generates "only minimal gains in college GPA and four-year graduation rates." Geiser and Santelices (2007) and Bowen et al. (2009) also find that entrance exam scores have far less explanatory power for graduation rates than average high school GPA. It is important to note that much of the literature in this area has focused on the power of entrance exams for predicting college grades, which this study does not consider due to data limitations, rather than longer-run outcomes like on-time graduation and labor market earnings.

Table 3
Grade level importance relative to entrance exams.

	Admit rate	Attend 4-yr college	Drop out in 2 years	Graduate in 5 years	Employed	Ln Income (if employed)
Grades 9 to 12	(1)	(2)	(3)	(4)	(5)	(6)
GPA Grade 12 (std. dev.)	0.019***	0.020***	−0.084***	0.118***	−0.000	0.093***
	(0.002)	(0.003)	(0.004)	(0.004)	(0.003)	(0.008)
GPA Grade 11 (std. dev.)	0.042***	0.020***	−0.048***	0.082***	−0.009**	0.051***
	(0.002)	(0.003)	(0.004)	(0.004)	(0.004)	(0.009)
GPA Grade 10 (std. dev.)	0.042***	0.023***	−0.022***	0.044***	0.002	0.053***
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.010)
GPA Grade 9 (std. dev.)	0.044***	0.023***	−0.014***	0.035***	0.010***	0.020**
	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)	(0.009)
SAT Score (std. dev.)	0.110***	0.065***	0.021***	−0.003	−0.066***	−0.004
	(0.003)	(0.005)	(0.003)	(0.004)	(0.003)	(0.008)
Grades 9 to 11	(7)	(8)	(9)	(10)	(11)	(12)
GPA Grade 11 (std. dev.)	0.050***	0.029***	−0.087***	0.136***	−0.009**	0.093***
	(0.002)	(0.003)	(0.004)	(0.004)	(0.004)	(0.008)
GPA Grade 10 (std. dev.)	0.045***	0.027***	−0.036***	0.064***	0.002	0.069***
	(0.002)	(0.003)	(0.004)	(0.004)	(0.004)	(0.010)
GPA Grade 9 (std. dev.)	0.046***	0.026***	−0.023***	0.048***	0.010***	0.030***
	(0.002)	(0.003)	(0.004)	(0.004)	(0.004)	(0.009)
SAT Score (std. dev.)	0.112***	0.066***	0.016***	0.005	−0.066***	0.002
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.008)
Observations	92,580	92,580	61,628	61,628	61,628	36,220
Mean Dep	.769	.666	.253	.531	.588	44,679

Note: This table presents the relationship between test scores and grade point average in each year of high school and college admissions, attendance, drop out within 2 years, graduation within 5 years, employment in 2010, and labor market income. College and labor market outcomes are estimated conditional on attendance. Grade point averages for each year are weighted to account for advanced courses. Explanatory variables are normalized to be in terms of standard deviations in order to enable comparisons between GPAs and test scores. Each specification includes a high school by cohort fixed effect, demographics, and an indicator for each university application. Standard errors are clustered at the high school by cohort level. The symbols *, **, and *** indicate significance at the 10, 5, and 1% levels.

classes of explanations for why performance in the later years of high school persists into college: 1) student-based explanations in which effects stem from persistent changes in effort or investment; and 2) course-based explanations in which the subject composition or skills required for courses taken in later grades better reflect a student's likelihood of success. To shed light on these alternative mechanisms, I first consider the role of performance trajectories. I find that students with the most extreme negative performance trajectories are disproportionately more likely to drop out and to fail to graduate. I then consider the role of course composition by replicating the primary design using GPAs based on subsets of classes. First, I restrict attention to core academic sequences to ensure that the analysis is based on a balanced comparison of subject areas across years. Second, I exclude Advanced Placement classes to reveal the extent to which the baseline estimates are driven by college-level content in later grades. Finally, I consider the explanatory power of performance in non-academic electives, which is likely to abstract from grade level variation in academic rigor and may reflect something closer to changes in effort.

4.1. Persistence in the context of human capital

The use of overall GPAs in state policies and by universities assumes that each grade level provides an equally accurate measure of a student's potential for success. This would be the case if, for example, college potential were fixed and GPA in each year of high school were a measure of this potential plus a random error term. However, this is not consistent with the finding that later grades are better predictors of subsequent success, with the empirical fact that grades are correlated over time, or with human capital theory.

Models of human capital accumulation frequently assume that prior year human capital is a sufficient statistic for aptitude and investment in all prior years (e.g., Rivkin et al., 2005; Cunha and Heckman, 2007). In the literature, investment is defined variously as including parental inputs, school expenditure, teacher quality, peers, and other factors. Investment can include a student's allocation of time or effort to studying, which seems especially relevant for high school-aged students and may vary over time for a multitude of reasons.[21] In such models, recent performance may be the best predictor of subsequent success either through the accumulation of human capital (current year performance is a sufficient statistic for all prior years) or if changes in effort are persistent over time.[22] A student-based explanation is consistent with persistent trends in performance during high school and with the finding that later grades are the best predictors of college dropout, graduation, and labor market earnings.

Alternatively, in a course-based explanation of persistence, academic classes taken in later grades may be a better measure of the aptitude needed in college than courses taken in earlier grades. For example, if courses in 11th and 12th grades require more independent learning than courses taken in prior years, students who are good independent learners will see their GPAs increase between their freshman and senior years. If the skills needed for academic success are positively correlated over time, then later grades would be more predictive of college performance.

[21] Effort or investment could change for a wide range of reasons, such as the natural maturation process, shifts in interests, changes in peer groups, depression, drug use, changes in home life, or a new mentor or role model. A student who does poorly as a 9th grader may mature into a responsible senior. Alternatively, a student with good grades early in high school who falls in with the wrong crowd may suffer a decline in academic performance.

[22] This study does not attempt to differentiate between changes in conscientiousness or effort. Noftle and Robins (2007) find a strong relationship between a student's conscientiousness assessed prior to college and grades earned during college. Further, they find that the predictive power of conscientiousness is mediated when controlling for effort, and that students who experience upward trends in conscientiousness during college tend to have the best college outcomes.

4.2. Student trajectories

The importance of performance in later grades suggests that high school trends continue into college. Thus, I compare the outcomes of students who are "on the decline" and "on the rise" with the outcomes of students who have more stable performance during high school. To identify outcomes by trajectory, I estimate the following specification:

$$Outcome_{isc} = \alpha_{sc} + \gamma AvgGPA_i + \sum_{j=1}^{10} \beta_j I_j(Trend_i) + \epsilon_{isc} \quad (2)$$

where $AvgGPA_i$ is the overall grade point average for student i and $Trend_i$ is the change in GPA between grades 9 and 11 or grades 9 and 12. As these effects may not be linear, I model trends flexibly using ten trend bins. A middle group of students with changes in GPA within 0.05 points of the mean change is omitted and the point estimates are relative to this group. Thus, each coefficient β_j gives the performance difference for students who experienced positive or negative changes while conditioning on overall GPA (i.e. abstracting from differences in levels of performance).

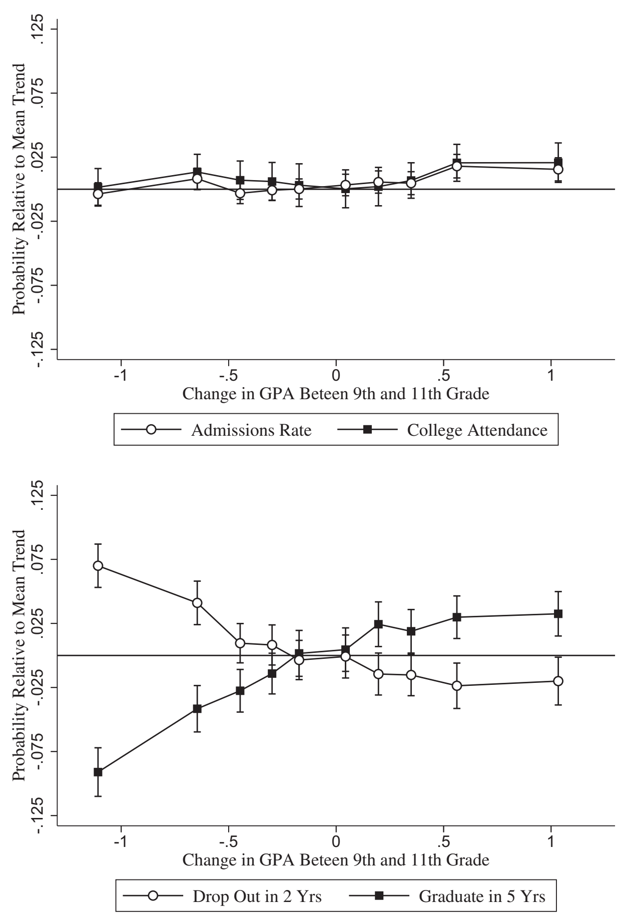

Fig. 3. Positive and negative GPA trajectories and college outcomes. **Note:** This figure presents estimates of the relationship between the change in students' GPAs and their likelihood of college admission, college attendance, dropping out within 2 years, and graduating within 5 years. The estimates are based on a specification that includes a high school by cohort fixed effect, SAT score, demographics, and an indicator for each university application. Standard errors are clustered at the high school by cohort level. The omitted comparison group are those with changes in GPA within 0.05 points of the mean change between 9th and 11th grades. The confidence intervals are at the 95% level.

The results presented in Fig. 3 show the relationship between performance trends between 9th and 11th grades — grades that are available to universities at the time admissions decisions are made. They reveal that students with negative performance trends were as likely to be admitted and to attend a four-year college as those with more stable grades. However, these students were more likely to drop out within two years of enrollment and less likely to graduate within five years. Students with the largest negative trajectories disproportionately drive the relationship between performance in later grades and long-run outcomes, as they are 7 percentage points more likely to drop out and 10 percentage points less likely to graduate. While students with positive trajectories have positive outcomes relative to the median, the differences are more muted. For example, those with the largest positive changes are only about 3 percentage points more likely to graduate within five years. Thus, it appears that the strong relationship between long-run outcomes and performance in later grades is determined in large part by students whose academic performances were eroding rapidly prior to enrollment at state universities. The use of averages in admissions does not penalize students on downward trajectories despite the fact that they under-perform dramatically in college and in the labor market.[23] The fact that the results are driven by steep negative performance trajectories suggests that a persistent shift in effort or investment could be an important determinant of the predictive power of later grades.[24]

4.3. Course composition and advanced placement

The predictive power of later courses could stem in part from changes in course composition. To examine this possibility, I restrict attention to subsets of courses that abstract from the influences of changes in subject composition and difficulty. To further separate the role of academic rigor from student effort, I consider the explanatory power of non-academic electives that are less likely to vary significantly in academic content across grades.

Certain subject areas may be more predictive of college performance, and these courses may be more commonly taken in later grades. For example, performance in English classes is correlated with socioeconomic characteristics that predict success in college. Likewise, students may select into elective academic courses, such as a foreign language, in a way that is correlated with college outcomes. Thus, if the distribution of subject areas is not balanced across grades, then it could cause performance in later grades to be more predictive. To generate estimates that abstract from course composition, I restrict attention to academic sequences in English, math, science, and history. Specifically, a student's grade level GPA is computed using only core academic courses taken by the student in all four years of high school. The resulting analysis is based on courses that are balanced across subjects and grade levels. The estimates presented in Table 4 reveal an identical pattern to the estimates based on all academic classes. Performance in grades 11 and 12 is most predictive of dropout and likelihood of graduating. Thus, the primary

[23] The point estimates for the trend between grades 9 and 11 are presented in Online Appendix Table A6. These results are supported when considering performance trends between 9th and 12th grades, which highlight the admissions advantage of students who have declining performance (see Online Appendix Table A7). This is due to the fact that 12th grade performance is largely unobserved and unused by universities when making admissions decisions.

[24] Alternatively, for this pattern to be consistent with a course-based explanation, changes in course content during high school would need to be highly effective at exposing students who appeared to be high performers in 9th grade but actually lack the skills necessary to succeed in college.

Table 4
Core sequences, advanced placement, and non-academic electives.

	Admit rate	Attend 4-yr college	Drop out in 2 years	Graduate in 5 years	Employed	Ln Income (if employed)
Core academic squences	(1)	(2)	(3)	(4)	(5)	(6)
Core academic GPA 12	0.022***	0.018***	−0.090***	0.113***	−0.001	0.113***
	(0.002)	(0.003)	(0.004)	(0.005)	(0.004)	(0.009)
Core academic GPA 11	0.052***	0.026***	−0.042***	0.069***	−0.007	0.045***
	(0.002)	(0.003)	(0.004)	(0.004)	(0.004)	(0.010)
Core academic GPA 10	0.057***	0.032***	−0.019***	0.040***	0.005	0.061***
	(0.002)	(0.003)	(0.004)	(0.004)	(0.004)	(0.010)
Core academic GPA 9	0.054***	0.024***	−0.015***	0.031***	0.008**	0.023**
	(0.002)	(0.003)	(0.004)	(0.004)	(0.004)	(0.010)
Non-AP classes	(7)	(8)	(9)	(10)	(11)	(12)
Academic non-AP GPA 12	0.030***	0.030***	−0.102***	0.127***	0.006	0.114***
	(0.003)	(0.004)	(0.004)	(0.005)	(0.004)	(0.010)
Academic non-AP GPA 11	0.069***	0.038***	−0.058***	0.089***	−0.006	0.073***
	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)	(0.011)
Academic non-AP GPA 10	0.067***	0.032***	−0.032***	0.064***	0.003	0.081***
	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)	(0.012)
Academic non-AP GPA 9	0.067***	0.032***	−0.021***	0.041***	0.014***	0.034***
	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)	(0.012)
Non-academic classes	(13)	(14)	(15)	(16)	(17)	(18)
Non-academic GPA 12	0.034***	0.031***	−0.090***	0.121***	0.019***	0.105***
	(0.003)	(0.004)	(0.006)	(0.006)	(0.005)	(0.012)
Non-academic GPA 11	0.047***	0.020***	−0.037***	0.075***	−0.001	0.051***
	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)	(0.012)
Non-academic GPA 10	0.059***	0.032***	−0.030***	0.062***	0.019***	0.058***
	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)	(0.013)
Non-academic GPA 9	0.088***	0.044***	−0.027***	0.074***	0.019***	0.076***
	(0.004)	(0.004)	(0.006)	(0.006)	(0.005)	(0.011)
Observations	92,580	92,580	61,628	61,628	61,628	36,220
Mean Dep	.769	.666	.253	.531	.588	44,679

Note: This table presents the relationship between grade point average in each year of high school and college and labor market outcomes for three subsets of classes. The top panel includes only core Math, English, Science, and History sequences taken by a student in all four years of high school. The middle panel includes only academic classes that are not Advanced Placement. The bottom panel includes only non-academic electives. Grade point averages for each year are weighted to account for advanced courses. Each specification includes a high school by cohort fixed effect, SAT score, demographics, and an indicator for each university application. Standard errors are clustered at the high school by cohort level. The symbols *, **, and *** indicate significance at the 10, 5, and 1% levels.

results of the analysis do not appear to stem from variation in the subject area of courses across grade levels.[25]

Alternatively, later grades may be better predictors of college performance if the courses better reflect aptitude for independent, college-level work. In the context of high school, AP courses are designed to include college-level material and are most often taken in grades 11 and 12. I examine whether the pattern of results is driven by AP courses by restricting the sample to academic courses that are not AP. The estimates in Table 4 are nearly identical in magnitude and pattern to those in the primary specification. Thus, abstracting entirely from the influence of AP courses indicates that these courses are not the primary determinant of the importance of later grades.[26] A related concern arises from the fact that all advanced classes (including AP) are graded on a five point scale rather than a four point scale. It is possible that this difference in scaling makes later GPAs more informative (e.g. by better separating students of different aptitudes). However, using a four point scale for all classes generates estimates that are nearly identical to those from the baseline specification.[27]

Thus, while course composition and material may partially explain the predictive power of later grades, there is little evidence that these factors are the primary determinant. Conversely, estimates of the importance of trajectories are suggestive that student-based explanations play a more dominant role. To explore this further, I note that the explanatory power of academic courses in later grades may reflect both changes in effort and changes in

[25] Likewise, considering each subject sequence separately exhibits the same pattern, with 9th grade being least predictive and each subsequent grade being more predictive. An alternative to restricting attention to balanced sequences is to control for subject-specific GPAs while including the full sample of academic courses, which is shown in Online Appendix Table A8. This reveals that performance in English classes is most strongly correlated with a student's likelihood of graduating, while performance in math classes is most strongly correlated with future income. Controlling for subject-specific GPAs results in differences in grade level effects that are nearly identical to those in the preferred specification. For example, one GPA point in 12th grade has an 11.8 percentage point larger effect on graduating than a GPA point in 9th grade, which is comparable to the gap of 11.3 percentage points between grade levels in the baseline specification.

[26] As an alternative to this approach, I replicate the primary specification while including detailed information about the pattern of AP courses taken by each student. Specifically, estimates shown in Online Appendix Table A9 include an indicator for whether the student took each possible AP course, the GPA earned in that course, and the score earned on the corresponding AP exam. The resulting estimates are very similar to those in the baseline specification. Dividing students into groups who have and have not taken an AP course indicates that later grades are predictive of long-run outcomes for both groups. As with subject-specific GPAs, performance on English and history AP exams is predictive of graduating on time, perhaps due the correlation with unobserved socioeconomic factors.

[27] The unscaled results are presented in Online Appendix Table A9.

Table 5
Admissions and graduation rates: average vs. disaggregated grades.

	Acceptance rate				
	10%	30%	50%	70%	90%
Fraction change in admits	.325	.188	.132	.086	.033
Grad rate: no longer admitted	.844	.738	.649	.550	.390
Grad rate: newly admitted	.908	.819	.741	.656	.516
Admitted only with overall GPA					
Grade 9 GPA	4.715	4.452	4.186	3.914	3.502
Grade 10 GPA	4.688	4.39	4.121	3.805	3.343
Grade 11 GPA	4.469	4.123	3.832	3.519	3.059
Grade 12 GPA	4.211	3.779	3.440	3.076	2.490
Asian	.096	.079	.069	.069	.068
Black	.030	.056	.081	.109	.166
Hispanic	.084	.108	.121	.121	.142
White	.771	.740	.712	.684	.601
Admitted only with disaggregated GPA					
Grade 9 GPA	4.341	3.926	3.591	3.246	2.762
Grade 10 GPA	4.465	4.051	3.704	3.353	2.857
Grade 11 GPA	4.479	4.138	3.883	3.577	3.106
Grade 12 GPA	4.738	4.46	4.223	3.980	3.618
Asian	.075	.054	.045	.042	.032
Black	.046	.075	.092	.122	.255
Hispanic	.090	.121	.117	.133	.139
White	.774	.735	.732	.686	.554

Note: This table presents the difference between admitted students based on overall GPAs versus disaggregated GPAs by grade level. The top panel presents the fraction change in admitted students based on these two methods and the expected graduation rate for those students admitted under one regime and not the other. The second panel presents the characteristics of students who are only admitted if overall GPAs are used for admissions, while the bottom panel presents the characteristics of students who are only admitted using separate GPAs for each grade level. The results are presented for five acceptance rates: 10, 30, 50, 70, and 90%.

the academic content of courses. To abstract from the role of academic content, I restrict attention to non-academic electives. These classes represent 36% of the grades received in high school and include subjects such as health, personal fitness, drama, photography, chorus, and keyboarding. Variation in performance in such courses across grade levels is perhaps less likely to be due to significant differences in academic rigor and thus may isolate effort. Replicating the primary design using only these classes reveals greater predictive power for later grades. As shown in Table 4, one GPA point in 12th grade is three times more predictive of dropout than a point in prior years and is twice as predictive of graduating and earnings. Further, when including academic and non-academic courses in the same specification, performance in non-academic electives in 12th grade is more predictive of college outcomes than is performance in academic courses in 9th and 10th grades.[28]

5. Policy implications for diversity and graduation rates

The analysis in Section 3 reveals that using disaggregated GPAs by grade level has the potential to improve the allocation of university enrollment slots and financial resources. Giving greater weight to more recent academic performance rather than using overall averages may change the composition of admitted students and increase expected graduation rates. The importance of this finding in practice depends on the fraction of applicants whose performance varies substantially during high school, as this will determine the extent to which resources would be allocated to different individuals and whether these individuals are likely to meaningfully outperform those whom they replace.

Several studies in the literature consider the policy implications of applying alternative weights to admissions factors for college outcomes and diversity (e.g. Bettinger et al., 2013; Belasco et al., 2014; Scott-Clayton et al., 2014; Black et al., 2016).[29] I consider the pool of applicants to the state's flagship university and consider who would be admitted under two admissions regimes. The first regime attempts to maximize the graduation rate using each student's overall GPA, SAT score, and other academic characteristics observable to an admissions committee. The second regime has the same goal but uses the disaggregated GPA for each grade level.[30] For the two regimes, I determine the fraction of admissions decisions that would differ and compare the demographics and expected graduation rates of students admitted in one regime and not the other. The magnitude of the difference in composition is likely to vary with the selectivity of the college or university, so the results are presented for hypothetical acceptance rates of 10, 30, 50, 70, and 90%.

The results of the alternative admissions regimes are presented in Table 5. For a college with a 50% acceptance rate, 13% of applicants admitted using overall GPAs would no longer be admitted using disaggregated GPAs. This large difference in acceptances is consistent with the substantial variation in students' grades between 9th and 12th grades. The fraction of changes to the admitted pool is significantly higher for more selective colleges (33% for a college with a 10% acceptance rate) and lower for less selective colleges (3% for a college that accepts 90% of applicants). The differences by selectivity are

[28] See Online Appendix Table A10 for estimates based on a specification that includes both academic and non-academic GPA at each grade level.

[29] For example, Black et al. (2016) find that incorporating entrance exam scores into an X percent plan reduces diversity with minimal gains. Bettinger et al. (2013) assume that only ACT scores are considered and, if colleges choose from all students in the state, that restricting admissions to the subsections that matter significantly alters who is admitted and the expected college dropout rate.

[30] Note that ignoring other academic observables, such as entrance exam scores, and expanding the pool of applicants to all students in the state is likely to inflate the policy implications. Likewise, reweighting across GPA and entrance exams or across subject areas may generate undesirable changes for state universities, such as reducing diversity in terms of demographics or intended area of study.

intuitive, as a college with a very high acceptance rate has no margin on which to accept a very different group of applicants, whereas a very selective college could admit an entirely new group.

Switching to a regime that weights grade levels separately may be undesirable if it reduces diversity. However, the results of the exercise suggest that the students admitted only under the disaggregated regime are nearly identical in composition to those they would replace. The minor demographic differences appear to increase the fraction of Black students and reduce the fraction of Asian students. By design, the applicants admitted under the two regimes differ significantly in their performance across grade levels. As a result, the expected graduation rate of those accepted only under the disaggregated regime is between 6 and 13 percentage points higher than the students they replace. Replicating this exercise to reduce dropout or to increase expected earnings generates similar findings, as each of these outcomes is best predicted by placing the greatest weight on GPAs in later grades.

It is important to consider that the analysis above is from the perspective of a single university and abstracts from the general equilibrium implications of the widespread adoption of such policies. Specifically, a policy environment in which many universities and scholarship organizations weight later grades more heavily could reduce student effort in earlier grades and increase effort in later grades. In the best-case scenario, students would respond primarily by exerting more effort in 12th grade, which previously received little weight in admissions, and thus would be better prepared for college. In the worst-case scenario, students would expend less effort in 9th grade (reducing overall learning), and the predictive power of later grades could be significantly attenuated by strategic gaming. Of course, it is not clear if and to what extent students are strategic in this dimension and if they are willing or able to significantly alter steep performance trajectories.

6. Conclusion

The use of overall grade point averages is ubiquitous for determining access to college. Guaranteed admission policies explicitly use class rankings and individual colleges and universities use GPAs at their own discretion. Further, many colleges, universities, and scholarship organizations have eligibility rules based on overall GPAs. However, the empirical evidence suggests that performance in later grades is more predictive of success in college and the labor market than performance in 9th and 10th grades. Students who exhibit their best performances as high school juniors and seniors are less likely to drop out and are more likely to graduate on time than students with identical GPAs but whose best performances occurred as freshmen or sophomores. Examining the predictive nature of trajectories and non-academic courses suggests that persistent changes in effort provide at least a partial explanation for this phenomenon.

The results have important implications for policy. Distributing admissions slots and financial support in a way that places greater weight on performance in later grades would result in the selection of students who are more likely to succeed. Further, abstracting from competition across colleges, changing deadlines to allow the consideration of more grades from students' senior years would result in the selection of stronger candidates. Of note is that for the population examined, disaggregated GPAs by grade level are the dominant predictor of college completion and labor market success, exceeding the contribution of entrance exam scores. Further, switching to a system that places greater weight on performance in later years does not appear to negatively affect diversity, as minority students do not exhibit disproportionately negative performance trends during high school.

Natural extensions of the study would examine if the results are similar in other states and for private colleges and universities. Further, college grade point averages are frequently used to determine community college transfer eligibility, financial aid retention, and admissions to graduate and professional schools; and they are used by employers to screen potential employees. In each context, additional research might reveal potential gains from weighting recent performance.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jpubeco.2016.12.002.

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