

# Updating Human Capital Decisions: Evidence from SAT Score Shocks and College Applications\*

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## Abstract

We estimate whether students update the colleges to which they consider applying in response to large, unanticipated information shocks generated by the release of SAT scores— a primary factor in admission decisions. Exploiting population data on the timing of college selection and a policy that induces students to choose colleges prior to taking the exam, we find that students update their portfolios in terms of selectivity, tuition, and sector. However, the magnitude of updating is too modest to significantly reduce unexplained variation across students, suggesting that non-academic factors are the dominant determinants of college match.

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# 1 Introduction

A large literature considers the role of non-academic determinants of college choice, such as tuition rates and parental resources. Updating decisions to reflect new information about academic ability provides an important alternative to such explanations. Thus recent studies have examined how the revelation of college grades affect students' dropout decisions and choice of major (Zafar, 2011; Arcidiacono, Hotz, and Kang, 2012; Stange, 2012; Stinebrickner and Stinebrickner, 2012 and 2013; Wiswall and Zafar, 2015; and Arcidiacono et al. 2016). This study provides a direct analogue at another crucial time for human capital investment: when high school students select colleges to which they may apply. Specifically, we examine whether students update the colleges to which they send their SAT scores in response to large, unanticipated positive and negative information shocks generated by the release of scores. Entrance exam scores are perhaps the most important new information students receive during the college selection process. Thus if students do not update their portfolios in response to their scores, it indicates that college selection is largely predetermined by non-academic factors and preexisting beliefs. The estimates provide new causal evidence about how human capital preferences are formed and why college mismatch occurs.<sup>1</sup>

The primary challenge in estimating whether students update is the need to observe their college choices before and after new academic information is revealed. Unfortunately, a student has only one realized application portfolio and, in many cases, receives only one entrance exam score. To overcome this, we exploit a College Board policy that induces students to select a limited number of colleges to receive their SAT scores at the time that they register for the exam.<sup>2</sup> Subsequently, students receive their scores and decide whether and where to send additional reports. Using new population data that include the exact date when each college was selected by the student, we are able to estimate the effect of SAT information shocks on the composition of the colleges selected. That is, we exploit a design that contrasts the colleges chosen before the SAT with those chosen after scores are released.

Several factors make this environment a nearly ideal context for identifying the extent to which students update the colleges they select. First, many students experience large SAT score shocks that are difficult to anticipate – the standard deviation of within-student differences between first and second SAT scores is 70.3 points, or 0.35 standard deviations. Second, we measure updating using the high-stakes selection of colleges to receive scores rather than with subjective survey responses that are common in the updating literature. Third, the data used for analysis include students' PSAT scores and, in many cases, two or more SAT attempts. Multiple exams allow us to measure what information is new to the student and to test whether or not students anticipate their scores. Finally, the analysis is based on national administrative data that produce precise estimates and allow us to consider heterogeneous effects across student ability and socio-

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<sup>1</sup>The college selection process is important in part because of the potentially high returns to attending a more selective college. For estimates of these returns, see Behrman, Rosenzweig, and Taubman (1996), Black and Smith (2006), Hoekstra (2009), and Cohodes and Goodman (2014).

<sup>2</sup>See Pallais (2015) for analysis showing that students tend to use the free score reports that are available prior to taking the exam. Three-quarters of SAT takers in our data use at least one of their free reports.

economic characteristics.

There are a number of reasons to believe that students should alter their college choices in response to SAT score shocks. Most notably, entrance exam scores and high school grades are typically the most important factors used by colleges when making admission decisions. This is evident from the widespread and often mechanical use of admission indices that are a function of GPA and exam score by public universities.<sup>3</sup> In addition, students may update their beliefs about their likelihood of being successful at more selective colleges given new objective information about their ability relative to a national pool of college-bound students. Identification of updating is based on a difference-in-differences style design that estimates the extent to which colleges selected before and after students learn their scores reflect this new information. We present an empirical model analogous to those used in the employer learning literature that reveals several important considerations for the interpretation of the reduced-form results.<sup>4</sup> The model confirms that students should place greater importance on SAT scores as they are released and reduce their reliance on measures of ability that were previously used to anticipate scores. We show that estimates of updating will be biased to the extent that students anticipate their scores or employ time-varying strategies that are correlated with ability, and we show how to correct for these issues.

The estimates reveal that an unanticipated positive (negative) shock causes a student to select a portfolio that has higher (lower) selectivity, tuition, graduation rates, fraction of private colleges, and geographic dispersion. However, the estimated effects are quite modest: after scoring 100 points higher on the SAT than anticipated, a student will select colleges whose matriculating students scored about 5 points higher on the exam. The magnitude of updating is even smaller when the cumulative portfolio is considered, because students select about half the colleges before taking the exam. Thus a one standard deviation SAT score shock results in an approximately 0.10 standard deviation shift in the selectivity of newly added colleges and a 0.05 standard deviation shift in the selectivity of the cumulative portfolio. The magnitude of these effects is one-tenth of the size observed in the cross-section, where a one standard deviation difference in SAT scores is associated with a 0.4 standard deviation difference in portfolio selectivity after controlling for a rich set of covariates. The disparity between our causal estimates and the cross-sectional correlation implies that much of the apparent match between student ability and college quality is due to unobserved, non-academic factors rather than sorting on academic qualifications. Inertia due to factors such as parental knowledge, financial resources, and geographic preferences results in new information closing a small fraction of the portfolio gap evident across students.

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<sup>3</sup>For example, admission indices are used by Alabama State, Iowa State, Utah State, the University of Memphis, the University of Southern Florida, the University of Colorado System, and the California State University System. Similarly, minimum SAT score admission requirements are used by the University of Mississippi, the University of Florida, Kansas State University, and the University System of Georgia. Authors' estimates for eight state universities indicate that the SAT and high school GPA are the dominant determinants of college admission.

<sup>4</sup>The model is closely related to those presented in Farber and Gibbons (1996), Altonji and Pierret (2001), and Lange (2007). The updating that occurs when students' scores are released shares similarities with the updating by employers when they observe the performance of employees (Arcidiacono, Bayer, and Hizmo, 2010; Rockoff et al., 2012; Kahn and Lange 2014). Student updating plays a significant role in theoretical models of college choice (Manski, 1989; Altonji, 1993; Altonji, Blom, and Meghir, 2012).

Students who take the SAT two or more times experience multiple information shocks. We find that the composition of colleges selected after the first exam more closely reflects the first score and likewise for colleges selected after the release of the second score. Importantly, the results indicate that students do not incorporate information from the second score into their choices when only the first score is known, supporting the validity of the empirical design. The fact that many students do not send reports to additional colleges after taking the SAT generates even more inertia in portfolio choice, so we present a lower bound response in which non-senders are assumed to not update their portfolios.

Two interesting forms of heterogeneity are evident in the analysis. First, higher-ability students update their portfolios significantly more than lower-ability students. This is consistent with students who conduct national searches more fully incorporating changes in admissions probabilities into their decisions than students who may restrict attention to local universities. Second, students who receive positive shocks update the selectivity of their portfolios significantly more than those who receive negative shocks. These results are supported by evidence that changes in portfolios are driven by students sending their scores more aggressively to selective “reach” colleges with little change in the less selective “safety” colleges.

A number of studies in the literature have found that human capital decisions are sensitive to perceived returns and expectations (Attanasio and Kaufmann, 2009; Jensen, 2010; Jacob and Linkow, 2011; Abramitzky and Lavy, 2014), performance labels (Papay, Murnane, and Willett, 2016), and parental perceptions of children’s ability (Dizon-Ross, 2014). Nonetheless, significant mismatch between student ability and college quality has been well documented (Arcidiacono, 2005; Arcidiacono, Khan, and Vigdor, 2011; Hoxby and Avery, 2013; Smith, Pender, and Howell, 2013; Arcidiacono and Lovenheim, 2016; Dillon and Smith, 2017). The modest effect of academic qualifications in this study is consistent with evidence that college choices are shaped by non-academic factors such as counseling services (Avery and Kane 2004; Carrell and Sacerdote, 2016; Oreopoulos and Ford, 2016), information about the cost of college (Bettinger et al., 2012; Hoxby and Turner, 2014), and ease of access to entrance exams (Klasik, 2013; Hurwitz et al., 2014; Bulman, 2015; Goodman, 2016). The estimates reveal the role of entrance exams in shaping college choices, shed light on how students update their human capital decisions, and add causal evidence to our understanding of college mismatch.

The paper is organized as follows. Section 2 describes the policy and administrative data used to conduct the analysis. Section 3 introduces an empirical framework of student updating and identifies several testable implications. Section 4 presents the primary specifications and results. Section 5 discusses the implications of the findings.

## 2 SAT Scores and College Score Reports

This paper uses administrative records from the College Board that include each SAT score and the exact timing of when students send score reports to colleges. Therefore our data takes the

form of a panel with colleges selected during multiple information periods: before the exam; after scores are released; and, for two-time takers, after scores for the second exam are released. Panel data provide an opportunity to factor out unobserved, time-invariant individual and household characteristics and beliefs that influence college choices. This section details the content of the individual-level administrative records, the construction of the sample for analysis, and the magnitude and predictability of within-student variation in exam performance.

## 2.1 Administrative Data

The SAT is a college entrance exam administered by the College Board that is taken by high school students across the United States, typically in their junior or senior year. The exam consists of math and critical reading sections scored between 200 and 800, so students can receive a combined score between 400 and 1600.<sup>5</sup> Each section was normalized in 1995 to have a mean score of 500 and a standard deviation of 110. The distribution of combined scores is presented in Figure 1. Along with scores for each SAT attempt, the data contain scores for the Preliminary SAT / National Merit Scholarship Qualifying Test (PSAT), which is a lower-stakes version of the SAT taken in a student’s sophomore or junior year of high school. PSAT scores range from 40 to 160, so they are multiplied by 10 to have the same scale as SAT scores. The College Board also administers a questionnaire upon exam registration that asks students to provide their high school GPA, race, parental income, high school attended, and home zip code.

The analysis in this paper examines the colleges to which students send their SAT scores via the College Board. When registering for the SAT, students have the option to send their scores to four colleges at no additional cost. They must select the colleges within nine days of taking the exam, so a high fraction of takers elect to send reports before the exam. After this period, scores may be sent for a fee of approximately 11 dollars each. Students from lower-income households are eligible to send additional reports for free. The analysis focuses on years prior to 2009 during which all of a student’s scores are reported to a college. In later years, Score Choice policies allowed students to choose which scores are sent, which significantly complicates the empirical design necessary to measure updating. Colleges do not automatically receive a new report if a student retakes the exam. Thus a student may send a report more than one time to the same college, which is particularly common among those who improve their scores.

Starting in 2007, the data include the exact date that students request each report, making it possible to separate the reports into information periods. For students who took the SAT once, we divide score reports into those requested before taking the exam and those requested after the scores are released.<sup>6</sup> For students who take the SAT twice, we consider reports requested before the first exam, after the first exam score is released but before the second exam is taken (including reports that are free with the second registration), and after the second exam score is released. Each

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<sup>5</sup>A writing section was introduced in 2005 but is not taken by all students or used by all colleges for admissions.

<sup>6</sup>Score Sends requests are delayed until new scores are available, so the analysis is based on the request date rather than the fulfillment date. About 3 percent of students make requests immediately after the exam is taken but before the scores are released. These requests are excluded because they may reflect partial treatment.

report sent to a four-year college is merged with college characteristics from the National Center for Education Statistics Integrated Postsecondary Education Data System. We then calculate the average characteristics of the colleges in each period, including the SAT scores of matriculating students, in-state tuition, graduation rate, fraction private, and distance from the student’s home. The distribution of portfolio quality in the pre-exam period is presented in Figure 1.

Because there is no national administrative database of college applications, studies have used score reports as a proxy for applications when studying the effects of affirmative action (Long, 2004; Card and Krueger, 2005), tuition levels (McDuff, 2007), guaranteed admission programs (Andrews, Ranchhod, and Sathy, 2010), score report fees (Pallais, 2015), and application patterns (Bound, Hershbein, and Long, 2009). In many contexts, the fact that students can send score reports to colleges to which they do not apply creates a wedge between the desired outcome (applications) and the observed outcome (score reports). However, score reports are advantageous for examining how students update their beliefs over time. While most applications are completed after students take the SAT, score reports reveal students’ choices before and after the exam. Further, completed applications are endogenous to the updating we wish to estimate. For example, a student may send a score report to a selective college prior to taking the SAT and not apply after receiving a lower-than-expected score.

Nonetheless, the evidence suggests that there is a strong (though not one-to-one) relationship between score reports and applications. Because more than 80 percent of traditional four-year colleges recommend or require entrance exam scores to be considered for admission, score reports largely define the set of four-year colleges to which a student could apply. Consistent with this, Card and Krueger (2005) find a “very high” correlation between application and score report totals for universities, and Smith (2016) finds that high-ability, low-income students report applying to more than 60 percent of the colleges to which they send score reports. Pallais (2015) finds a somewhat weaker relationship when estimating the responsiveness of students to additional free reports.

## 2.2 Population for Analysis

The analysis is based on the population of students who took the PSAT and SAT between 2007 and 2009 and who sent at least one score report before taking the SAT. The PSAT is taken by more than 75 percent of SAT takers and provides students with a measure of how they might perform on the SAT. Approximately 75 percent of SAT takers send at least one free score report to a college prior to taking the exam, and nearly two-thirds of these students use all four of their free reports. Table 1 presents summary statistics for the population of PSAT takers who took the SAT one or two times and for the subset of these students who sent score reports before and after the exam. Among one-time takers who send reports after the exam, 49 percent are male, 14 percent are black, and 13 percent are Hispanic. Mean PSAT and SAT scores are 1085 and 1136, respectively. Two-time takers who send reports are quite similar, with 46 percent male, 11 percent black, and 12 percent Hispanic, and average scores of 1086 on the PSAT and 1114 on the first SAT. Relative to the population of takers, these students have similar demographic characteristics but have higher

average performance on the PSAT and SAT.<sup>7</sup>

Table 2 presents the correlates of retaking the SAT. Larger score shocks, approximated by the difference between the SAT and PSAT scores, are only weakly correlated with taking the exam twice. For example, having an SAT score that is 100 points lower than one's PSAT is associated with an increase in the retake rate of 2 percentage points. By comparison, students from the highest income category are 9 percentage points more likely to take the exam than those in the lowest income category, and one GPA point is associated with an 11 percentage point higher rate of retaking. Thus higher-income and higher-performing students are over-represented in the sample of two-time takers. To ensure that splitting the sample does not bias the estimates, we replicate the design for a merged sample of one- and two-time takers.

The analysis is necessarily restricted to students who send score reports before and after taking the SAT. Columns (3) and (4) of Table 2 reveal that students from higher-income households and who have higher high school GPAs are more likely to send additional score reports after receiving their scores. In contrast, the estimates do not reveal that students who receive the largest information shocks are more likely to send additional reports. For example, a 100 point shock is associated with a less than 1 percentage point increase in the probability of sending additional reports. Nonetheless, students who send more reports may be those who are more sensitive to new information. Thus we implement a bounding exercise in Section 4.5 in which students who do not send additional reports after receiving their scores are included in the sample under the assumption that they did not update.

### 2.3 Within-Student Variation in Scores

There is significant within-student variation in scores earned on college entrance exams. This variation generates the information shocks necessary to identify updating and determines the importance of updating in practice. The top graph in Figure 2 presents the distribution of the differences between students' first SAT scores and their PSAT scores. The mean is close to 0 and the standard deviation of the difference is 85.6 points. Thus within-student variation is nearly one-half of the 190 point standard deviation across students. To examine the extent to which other factors may explain this variation, we generate a predicted SAT score using a rich set of observables in addition to the PSAT, including fixed effects for pre-exam portfolio selectivity, high school GPA, household income, gender, and race. The standard deviation of the difference between each student's actual and predicted SAT score is 80.5 points.<sup>8</sup> Thus the PSAT score appears to be the most important predictor of a student's SAT score for the researcher and perhaps for the student as well.

Within-student variation in scores is also evident when students take the SAT multiple times. The bottom graph in Figure 2 presents the distribution of the differences between students' first and second scores. The standard deviation of the difference is 70.3 points. This variation is especially

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<sup>7</sup>SAT takers who did not take the PSAT have similar demographic characteristics (51 percent are male, 11 percent are black, and 13 percent are Hispanic) but have lower performance on the SAT, with an average score of 958 points.

<sup>8</sup>While the PSAT has an R-squared of 0.86 for predicting SAT scores, the R-squared for all other covariates (including GPA and demographics) is 0.43.

interesting considering that the exams are, by design, equally difficult and cover the same body of knowledge. Note that while students perform slightly better on average the second time they take the exam, the mean improvement of 30 points is modest relative to the magnitude of the variation. As a result, nearly 40 percent of students earn a lower score when they take the exam a second time. This is notable because repeat takers have additional time for test preparation and experience taking the exam, and they may have chosen to retake in part because they had an unexpectedly poor performance the first time. We predict each student’s second score using all the observables listed above in addition to the first SAT score. The resulting standard deviation of the difference is 63.6 points.<sup>9</sup> That is, even with two measures of exam performance in hand, the PSAT and the first SAT, realized performance varies considerably and is difficult to predict. In Section 4, we supplement this descriptive evidence with an empirical test of whether students can anticipate their scores, exploiting the fact that anticipation will reveal itself as the incorporation of future scores into current portfolio choice.

### 3 Empirical Framework

We develop an empirical model that highlights several important considerations for interpreting the reduced form estimates. Intuitively, updating should result in positive coefficients on scores as they are released (i.e., students give weight to information as it becomes available) and negative coefficients on factors such as PSAT scores (i.e., students rely less on other measures of ability). The model also reveals methods for detecting and correcting two sources of bias in the estimates. First, if students partially anticipate their scores using factors that are unobserved by the researcher, then the estimates of updating will be attenuated. Intuitively, the magnitude of the information shock for the student is smaller than what is observable in the data. Second, students may employ strategies such as sending scores to “safety” colleges before the exam and “reach” colleges after (or vice versa). If these strategies are correlated with ability, then the estimates will be biased. We present a method to account for time-varying strategies, and show that the effect of the second score after only the first score is released can be used to recover causal effects.

#### 3.1 Student Updating

The empirical model is analogous to those in the employer learning literature (Farber and Gibbons, 1996; Altonji and Pierret, 2001; Lange, 2007), but with students updating their portfolios in response to receiving new information from the SAT. We present the model for students who take the exam twice, which accounts for one-time takers as a special case. Students form beliefs about optimal portfolios which can be summarized by a single continuous measure of quality  $y$ .<sup>10</sup> The

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<sup>9</sup>The addition of GPA and demographic covariates only increases the R-squared of the model from 0.88 to 0.89. Without the PSAT and first SAT, other covariates explain 38 percent of the variation in the second SAT score.

<sup>10</sup>We abstract from the method by which a student determines the optimal portfolio and only assume that there is a monotonic relationship between portfolio quality and student characteristics. For theoretical treatments of the portfolio choice problem see Epple, Romano, and Sieg (2006), Chade, Lewis, and Smith (2011), and Fu (2014).



portfolio is a function of three components:  $s$  are characteristics observable to the student and the researcher (e.g. PSAT scores);  $q$  are characteristics observable only to the student (e.g., personal essays); and  $z$  is the true SAT score that a student would receive in the absence of measurement error.<sup>11</sup> We assume the distribution of  $(s, q, z)$  is jointly normal with non-negative correlations across vectors. This assumption has been made previously in the literature (e.g., Lange, 2007), makes the model tractable, and there are several opportunities in the empirical analysis to examine if it is reasonable.<sup>12</sup> The optimal portfolio for a student  $i$  is assumed to be linear in these elements:

$$y_i = \delta q_i + r s_i + z_i \quad (1)$$

Since  $y_i$  has no natural scale, we normalize it so that the marginal effect of the true SAT score is equal to 1. Students select colleges to receive reports in  $t = 0$  without knowing either SAT score; receive their first score ( $z_1$ ) in  $t = 1$  and choose additional colleges; and receive their second score ( $z_2$ ) in  $t = 2$  and choose colleges with knowledge of both scores. These scores are imperfect signals of  $z$ :  $z_t = z + \epsilon_t$ , where  $\epsilon_t$  is a normally distributed measurement error term with mean zero and variance  $\sigma_\epsilon^2$ , and  $E[\epsilon_j \epsilon_k] = 0, \forall j \neq k$ .

It follows from joint normality that students' expectations of their scores prior to knowing the results of either exam can be written as  $z = E[z|s, q] + \nu = \gamma_1 q + \gamma_2 s + \nu$ , where  $\nu$  is a mean zero random variable with variance  $\sigma_\nu^2$ . In this expression,  $\gamma_1$  and  $\gamma_2$  reflect the extent to which students predict their SAT scores using unobservable and observable characteristics, respectively. At no point does a student observe the true score  $z$ , only the imperfect signals  $z_1$  and  $z_2$ . After each score is announced, students update their beliefs and rely less on  $q$  and  $s$  to predict their true scores:

$$\begin{aligned} E[z|s, q, z_1] &= (1 - \pi_1)(\gamma_1 q + \gamma_2 s) + \pi_1 z_1 \\ E[z|s, q, z_1, z_2] &= (1 - 2\pi_2)(\gamma_1 q + \gamma_2 s) + \pi_2 z_1 + \pi_2 z_2 \end{aligned} \quad (2)$$

The extent to which students update their beliefs depends on how accurate they believe their priors to be relative to actual exam scores. Specifically, the exams will receive weight  $\pi_t = \sigma_\nu^2 / (\sigma_\epsilon^2 + t\sigma_\nu^2)$ , which follows from Bayesian updating with a normally distributed prior and  $t$  normally distributed signals. Note that if students believe revealed scores to be very informative of  $z$  or only care about the admissions implications of realized scores, then  $\pi_1$  is close to 1, and if the test score is relatively uninformative,  $\pi_1$  is close to 0. Similar intuition applies for  $\pi_2$ . Substituting the expressions from

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<sup>11</sup>A fourth factor that can affect the portfolio are time-invariant characteristics unobservable to the student and the researcher (e.g., confidential letters of recommendation), often designated as  $\eta$  in the employer learning literature. In practice, these factors do not add intuition or alter the results of the model and thus are omitted for brevity.

The model differentiates between a *true* SAT score and the score a student earns, which allows the full set of scores to matter when individuals take the exam multiple times. As our analysis focuses on years prior to Score Choice, colleges observe and may use the full set of scores for admissions decisions. For students who take the exam only once, imposing that the true score is equal to the earned score has no consequences for the results.

<sup>12</sup>If the normality assumption is violated, then the expectations become linear projections and the signs of the predictions still hold.

(2) into (1), we can write the portfolios a student selects in each period as follows.

$$\begin{aligned}
y_0 &= [\delta + \gamma_1] q + [r + \gamma_2] s \\
y_1 &= [\delta + \gamma_1(1 - \pi_1)] q + [r + \gamma_2(1 - \pi_1)] s + \pi_1 z_1 \\
y_2 &= [\delta + \gamma_1(1 - 2\pi_2)] q + [r + \gamma_2(1 - 2\pi_2)] s + \pi_2 z_1 + \pi_2 z_2
\end{aligned} \tag{3}$$

The weight students place on unobservable characteristics  $q$  and observable characteristics  $s$  prior to learning exam scores is the sum of their direct effects on portfolio choice ( $\delta$  and  $r$ ) and their role in predicting unobserved SAT scores ( $\gamma_1$  and  $\gamma_2$ ). Students rely less on these characteristics after the release of the first score  $z_1$  (evident from the  $1 - \pi_1$  term), and further reduce this reliance after the release of the second score (evident from the  $1 - 2\pi_2$  term). The importance of each realized score is a function of the perceived accuracy of the exam.

### 3.2 Coefficient Estimates and Bias

This section presents the composition of the reduced form coefficients, potential sources of bias, and methods for correcting bias. In practice, we observe  $s$  and the two test scores,  $z_1$  and  $z_2$ , but not unobservables  $q$ . Because  $(s, q, z)$  are jointly normal, the conditional expectation of  $q$  given  $s$  and  $z$  and the linear projection are equivalent:

$$q = E[q|s, z] + u = \gamma_3 s + \gamma_4 z + u \tag{4}$$

In this expression,  $\gamma_3$  and  $\gamma_4$  reflect the extent to which students observable characteristics and true SAT score are predictive of their unobservable characteristics. As we do not observe  $z$ , but instead  $z_1$  and  $z_2$ , the researcher's expectation is

$$E[q|s, z_1, z_2] = [\gamma_3 + \gamma_4(1 - 2\phi_2)] s + \gamma_4\phi_2 z_1 + \gamma_4\phi_2 z_2 \tag{5}$$

where  $\phi_2$  is the standard coefficient from Bayesian updating with two i.i.d. normal signals, and reflects that more weight is placed on  $s$  due to the noisiness of  $z_1$  and  $z_2$  as predictors of  $z$ .

A difference-in-differences design that interacts all observables with an indicator for each time period will reveal how the coefficients on the test scores change as the scores are revealed to the student. We can define the following regressions of  $y$  on  $s$ ,  $z_1$ , and  $z_2$  in each period:

$$\begin{aligned}
E^*[E[y|s, q]|s, z_1, z_2] &\equiv a_0 s + b_0 z_1 + c_0 z_2 \\
E^*[E[y|s, q, z_1]|s, z_1, z_2] &\equiv a_1 s + b_1 z_1 + c_1 z_2 \\
E^*[E[y|s, q, z_1, z_2]|s, z_1, z_2] &\equiv a_2 s + b_2 z_1 + c_2 z_2
\end{aligned} \tag{6}$$

We can determine the coefficients by substituting (5) into (3):

$$\begin{aligned}
a_0 &= r + \delta[\gamma_3 + \gamma_4(1 - 2\phi_2)] + [\gamma_2 + \gamma_1\gamma_3 + \gamma_1\gamma_4(1 - 2\phi_2)] \\
b_0 &= \gamma_4\phi_2(\delta + \gamma_1) \\
c_0 &= \gamma_4\phi_2(\delta + \gamma_1)
\end{aligned} \tag{7}$$

Though the student does not observe  $z_1$  and  $z_2$  prior to taking the exam, the scores will have positive coefficients because they are correlated with the omitted variables  $q$ . These coefficients have two components. The first,  $\delta$ , is time invariant and reflects that  $q$  has a causal effect on  $y$ . The second is a time-varying “anticipation” effect  $\gamma_1$  which captures that students use unobservables  $q$  to predict  $z$  before the test scores arrive. The magnitudes are scaled up or down by the correlation between the unobservables and the true scores  $z$  ( $\gamma_4$ ) and the accuracy of realized scores as predictors of  $z$  ( $\phi_2$ ). Note that if realized scores are i.i.d. draws from the distribution of the true latent score, then  $b_0 = c_0$ , which provides a natural test of the validity of this assumption (i.e., the first and second SAT scores should have the same coefficients prior to either score being released).

After the first score is revealed, substituting (5) into (3) reveals that the coefficients change as follows:

$$\begin{aligned}
a_1 - a_0 &= -\pi_1 [\gamma_2 + \gamma_1\gamma_3 + \gamma_1\gamma_4(1 - 2\phi_2)] \\
b_1 - b_0 &= \pi_1(1 - \gamma_1\gamma_4\phi_2) \\
c_1 - c_0 &= -\pi_1\gamma_1\gamma_4\phi_2
\end{aligned} \tag{8}$$

As expected, students increase their reliance on the revealed scores and reduce their reliance on other measures of ability. However, the difference-in-differences coefficient  $b_1 - b_0$  on  $z_1$  is biased downward. It reflects both the causal estimate of updating,  $\pi_1$ , and a decrease in the reliance by the student on  $q$  to predict  $z$  ( $\gamma_1\gamma_4\phi_2$  is the anticipation term). The more accurately students can predict their scores using factors that we cannot observe, the more we will underestimate their response to new information. Fortunately, the magnitude of the bias is captured by the coefficient on the not yet revealed second score  $z_2$ . Thus the difference  $(b_1 - b_0) - (c_1 - c_0)$  yields  $\pi_1$ , the causal effect of updating.

Substituting (5) into (3) also reveals the estimates after both exam scores are released and can be expressed as follows:

$$\begin{aligned}
a_2 - a_0 &= -2\pi_2 [\gamma_2 + \gamma_1\gamma_3 + \gamma_1\gamma_4(1 - 2\phi_2)] \\
b_2 - b_0 &= \pi_2(1 - 2\gamma_1\gamma_4\phi_2) \\
c_2 - c_0 &= \pi_2(1 - 2\gamma_1\gamma_4\phi_2)
\end{aligned} \tag{9}$$

With all scores available to students, they further reduce their reliance on observable characteristics and now place positive weight on the second exam score. As in the pre-exam period, the coefficients

on the first and second SAT scores are equal if realized test scores are i.i.d. There is, however, no longer a natural correction for bias during this period.

We note that it is likely that students employ portfolio selection strategies that vary over time for reasons other than updating. For example, students may send scores to low-risk “safety” colleges before taking the exam and defer decisions about “reach” colleges until after learning their scores. These strategies will be innocuous if the changes over time are uncorrelated with the determinants of the optimal portfolio, as level changes are captured by time period fixed effects. However, higher-ability students might have larger or smaller average gaps between their “safety” and “reach” colleges than lower-ability students for reasons unrelated to updating. Time-varying strategies can be incorporated into the model by allowing the scale of  $y$  to differ across periods. Specifically, we allow students to select portfolios of quality  $y$  after the exam and portfolios of quality  $\Omega_0 y$  before the exam. A value of  $\Omega_0$  that is less than one indicates that higher-ability students choose more selective colleges after the exam relative to the pre-exam period than do lower-ability students (and vice versa for  $\Omega_0$  greater than one). Failure to adjust for this scaling will generate a mechanical bias in the estimates. For instance, if  $\Omega_0 < 1$ , the coefficient on the SAT in the post-exam period will reflect both updating and bias caused by higher-ability students applying more aggressively after the exam for reasons unrelated to score shocks.<sup>13</sup>

To correct for bias caused by time-varying strategies, we estimate the scaling factors explicitly and use them to adjust the portfolio scales in each period. Consider a regression of  $y_t$  on observable information about ability  $s$ . As originally shown by Farber and Gibbons (1996), this estimate will simply be  $E^*[\Omega_t E[y|s]|s] = \Omega_t E^*[y|s]$  where the equality follows from the law of iterated projections. We estimate this using a series of regressions,

$$y_t = d_t s + \epsilon_t \tag{10}$$

If the coefficient vector on  $s$  changes across time periods, it can only be attributed to changes in strategy. The estimate of  $\Omega_t$  is then  $\hat{\Omega}_t = \frac{d_t}{d_1}$ , where we normalize to period 1 scale for one-time takers and period 2 scale for two-time takers.

## 4 Estimates of Student Updating

College entrance exams are required by the vast majority of four-year colleges and are a primary factor in admission decisions. Thus the revelation of scores may be the single largest academic information shock that students experience with respect to shaping college choice. We employ a difference-in-differences style design to estimate if, and to what extent, students update the portfolio of colleges to which they send score reports in response to the revelation of their performance. The primary outcome of interest is college selectivity as measured by the average SAT scores of matriculating students. In addition, we examine alternative measures of college quality, including tuition levels, graduation rates, sector, and geographic proximity, and consider heterogeneity by

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<sup>13</sup>For example, for one-time takers, the estimate of updating will be  $b_1 - \Omega_0 b_0$ , which is larger than  $b_1 - b_0$ .

student ability and whether the score shock was positive or negative.<sup>14</sup> The results are presented for newly selected colleges in each period and for the resulting change in the cumulative portfolio. Cross-sectional estimates are presented in Appendix A for comparison.

## 4.1 Primary Specifications

In the case of students who take the exam one time, we estimate the following specification,

$$y_{it} = \beta_0 + \beta_1 s_i + \beta_2 z_{1i} + \beta_3 \mathbb{1}_{t=1} + \beta_4 s_i \mathbb{1}_{t=1} + \beta_5 z_{1i} \mathbb{1}_{t=1} + \epsilon_{it} \quad (11)$$

where, for simplicity, we can think of  $s_i$  as students' PSAT scores (though we also include high school GPA, household income, gender, race, and geographic location),  $z_1$  are SAT scores, and  $\mathbb{1}_{t=1}$  is an indicator for the score report being sent after the scores are released. The outcomes  $y_{it}$  are the average characteristics of the colleges selected before or after the scores are released, with one observation per student per period. The coefficient  $\beta_4$  represents the change in the coefficient on the PSAT after the SAT score is released, and  $\beta_5$  represents the change in the coefficient on the SAT. The specification allows the PSAT and SAT to differ in their relative importance. An alternative specification measures the score shock as the difference between the SAT and PSAT, which generates a coefficient that is the average of the increased weight students place on newly revealed SAT scores and the decreased weight placed on PSAT scores.

For students who take the SAT twice, the specification is,

$$\begin{aligned} y_{it} = & \beta_0 + \beta_1 s_i + \beta_2 z_{1i} + \beta_3 z_{2i} + \beta_4 \mathbb{1}_{t=1} + \beta_5 \mathbb{1}_{t=2} \\ & + \beta_6 s_i \mathbb{1}_{t=1} + \beta_7 z_{1i} \mathbb{1}_{t=1} + \beta_8 z_{2i} \mathbb{1}_{t=1} + \beta_9 s_i \mathbb{1}_{t=2} + \beta_{10} z_{1i} \mathbb{1}_{t=2} + \beta_{11} z_{2i} \mathbb{1}_{t=2} + \epsilon_{it} \end{aligned} \quad (12)$$

where  $z_{1i}$  and  $z_{2i}$  are the first and second SAT scores. The coefficients  $\beta_7$  and  $\beta_{11}$  represent the changes in the coefficients on the first and second SAT scores after each is released, and the coefficients  $\beta_6$  and  $\beta_9$  represent the corresponding changes for the PSAT. Two-time takers allow us to formally test whether the estimates of updating are biased upward or downward by score anticipation and time-varying strategies. Specifically, the coefficient  $\beta_8$  on the second SAT score when only the first score is known is a measure of net bias. As shown in Section 3, the difference  $\beta_7 - \beta_8$  is  $\pi_1$ , the unbiased estimate of updating in response to the SAT. We present specifications with and without adjusting  $y_{it}$  for time-varying strategies. As shown in Appendix B, higher ability students tend to exhibit larger differences in portfolio quality across information periods, which will generate upward bias in the estimates of updating.<sup>15</sup>

<sup>14</sup>Black and Smith (2006) detail the potential pitfalls of using a single measure of college quality, so we present a range of outcomes. Likewise, the use of ordinal variables such as test scores as an outcome has shortcomings (Bond and Lang, 2013 and 2014), so we verify that our results are robust to multiple polynomial transformations of our quality measure, including both highly left-skewed and highly-right skewed transformations.

<sup>15</sup>Note that the design is not sensitive to time-varying factors such as performance in high school, participation in test preparation classes, or changes in motivation. This is because students choose their pre-exam college portfolios shortly before taking the SAT, whereas the post-exam portfolios are selected after scores are released.

## 4.2 One-Time Takers: Updating

The estimates in Table 3 reveal that students update their college portfolios in response to new information. In the pre-exam period, the coefficient on the PSAT reveals that a 100 point score difference is correlated with an 11 point difference in the selectivity of the colleges to which students send their scores. A similar positive correlation exists for the SAT. Students update their college selections to reflect their SAT scores after they are released and concurrently reduce their reliance on PSAT scores.<sup>16</sup> In column (1), which includes a rich set of student characteristics, the estimates indicate that a 100 point increase in SAT score causes a 7 point increase in the selectivity of colleges relative to the pre-exam period. This estimate is essentially unchanged when we include high school and zip code fixed effects in columns (2) and (3); in both cases interacting the fixed effects with a period indicator to account for changes in portfolio composition that are common to a school or community. Column (4) presents the preferred, strategy-adjusted specification. The resulting estimates are slightly smaller than those from the unadjusted specification, with a 5.3 point change in portfolio selectivity per 100 point SAT score shock. This implies that the unadjusted estimates are biased slightly upwards, which is consistent with higher-ability students employing larger time-varying strategies. The adjusted estimates imply that a one standard deviation increase in SAT score leads to a 0.10 standard deviation increase in selectivity for newly added colleges.

The selectivity of the cumulative portfolio is important for understanding the extent to which score shocks are reflected in a student’s choice set. The estimates in columns (5) and (6) indicate that students update in response to new information, but the overall changes are smaller because the colleges selected before the exam do not change. A 100 point SAT score shocks changes the selectivity of colleges by about 3 points. That is, a one standard deviation shift in score changes the selectivity of the cumulative portfolio by 0.05 standard deviations. This high level of inertia over time challenges the assumption that academic qualifications are the primary determinants of college choice. The fact that students select a large fraction of colleges before taking the SAT further reduces the alignment between portfolios and academic ability.

These causal estimates of updating are one-tenth of the magnitude found in a cross-sectional analysis. Specifically, after controlling for a rich set of covariates, a 100 point difference in SAT scores is correlated with a 22 point difference in portfolio selectivity, or 0.4 standard deviations. Thus the degree of mismatch between student ability and college quality observed in cross-sectional data, which is high already, may understate the disconnect between academic qualifications and college preferences. This is surprising in light of the fact that, even if students know that scores are an imprecise measure of ability, the SAT plays a primary role in admission decisions and thus provides a strategic incentive for students to respond.

An alternative specification regresses portfolio quality before and after the scores are released on the gap between a student’s SAT and PSAT scores. The results presented in Appendix C reveal that a 100 point shock alters portfolio quality by 5 points, which is nearly identical to the primary

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<sup>16</sup>Appendix C presents a specification that includes a continuous measure of GPA rather than GPA fixed effects. The resulting estimates reveal that students also rely less on their GPA after the SAT score is known.

specification. It is worth noting that attending the most selective college may be less desirable than attending one at the appropriate level.<sup>17</sup> Thus we estimate if students who experience larger score shocks, measured in terms of the absolute value of the gap, are more likely to send reports to appropriate “target” schools. As shown in Appendix C, there is little evidence that this occurs to a significant degree.

### 4.3 Two-Time Takers: Updating

The results for two-time takers presented in Table 4 reveal that newly selected colleges in the period after each score is released reflect that score. The unadjusted estimate of the response to the first SAT is about 5 points per 100, while the magnitude of response to the second SAT is about 8 points per 100. The small positive coefficient on the not yet released second score in columns (1)-(3) is the net bias generated by time-varying strategies and score anticipation. After adjusting for strategies in column (4), the estimates of updating are 4 and 6 points for the first and second exams, respectively. The remaining bias is close to 0, indicating that students do not accurately anticipate their scores and that the coefficient on the first score can be interpreted causally. As predicted by the model, students rely less on the PSAT after the first score is known, and further reduce their reliance after the second score is known. Note that the effect of the first SAT score on colleges selected after the second score is revealed (measured relative to the baseline period) is small in magnitude. That is, students rely most heavily on new information when adjusting their portfolios.

The estimated effects of updating for the cumulative portfolio in columns (5) and (6) reveal that the first SAT, and not the second, affects the portfolio when only the first score has been released. A 100 point shock from the first SAT score causes students to adjust their portfolio by about 2 points. Note that the estimated bias is only 0.1 points, as indicated by the coefficient on the second score. After both exams are known to the student, the first and second scores have identical effects on the cumulative portfolio. Two results from this specification provide additional validation of the empirical design. First, if SAT scores are essentially random draws relative to a student’s expectations, then they should be given equal weight before either score is known. The estimated coefficients are 0.111 and 0.119 in period 0 and a formal test fails to reject that they are equal. Second, after both scores are known, each exam should be given equal additional weight for the cumulative portfolio. The coefficients for this period are very similar, with values of 0.015 and 0.014, and are not statistically different.

The estimates for two-time takers are similar to those for one-time takers in sign and magnitude. Nonetheless, to abstract from selection into retaking the exam, we merge one- and two-time

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<sup>17</sup>For example, Loury and Gorman (1995) find that students with low SAT scores have lower probabilities of graduating when attending colleges with relatively higher SAT scores. Arcidiacono et al. (2014) find that minority college completion rates actually increased after an affirmative action ban that caused a shifting of minorities into less selective schools. Arcidiacono, Aucejo, and Hotz (2016) find that students with weaker academic preparation have higher returns to pursuing STEM fields at less selective schools than at more selective schools. For a comprehensive review, see Arcidiacono and Lovenheim (2016).

takers and replicate the primary design. The results indicate that a 100 point test score shock causes a 5.5 point change in the average score of matriculating students at the colleges in the portfolio. This is consistent with the estimates generated separately for each group. A specification that regresses portfolio quality before and after each score is released on the gap between the score and a student’s PSAT reveals similar estimates. Specifically, as shown in Appendix C, the first and second scores generate increases in the selectivity of newly selected colleges of 3 and 6 points, respectively, and increases in the selectivity of the cumulative portfolio of 3 and 2 points.

Taken as a whole, the estimates reveal that students modestly update their college selections in response to large information shocks about the strength of their applications. The causal estimates of updating are a small fraction of the relationship observed in the cross-section. For example, among two-time takers, each 100 points on the second SAT is correlated with an 18 point difference in portfolio selectivity, which is five times the causal estimate for newly selected colleges and ten times the estimate for the change in the cumulative portfolio. Thus cross-sectional measures of student-college match may significantly overstate causal sorting on ability.

#### 4.4 Alternative Measures of Portfolio Quality

Table 5 presents estimates of updating for alternative college characteristics. The results follow a similar pattern to those for selectivity and reveal several interesting insights about how students update. The least selective college chosen after a score is released does not appear to be very sensitive to the score shock, while the most selective college is. Specifically, a 100 point score shock changes the selectivity of the best college chosen by 12 points for one-time takers and 13 points for two-time takers, while the corresponding changes for the least selective college chosen are less than 2 points. These results suggest that students may send their scores to a set of “safety” schools regardless of their SAT performance and choose “reach” schools on the basis of their probability of admission. Score shocks generate modest changes in the fraction of private colleges to which students send their scores. A 100 point positive shock increases the fraction of private schools selected by about 1 percentage point for both one- and two-time takers. Likewise, the expected graduation rate of colleges selected is about 1 percentage point higher. These results imply that a one standard deviation shock in performance on the SAT results in a shift in the fraction of private colleges of 0.05 standard deviations and in the graduation rate of 0.10 standard deviations.

Students who receive positive shocks may be more likely to consider colleges that require greater investment because of higher tuition levels or greater distance from home. This could occur if, for example, students realize that their higher scores are more likely to result in admission to selective colleges or if they (and their parents) are more willing to invest in human capital when the probability of success seems greater. The results reveal that a 100 point positive score shock increases the mean tuition of colleges selected by 400 dollars, or 0.10 standard deviations per one standard deviation score shock. The average distance of selected colleges increases by 10 miles, or 0.04 standard deviations.

The estimates for each college characteristic reflect decreased importance placed on the PSAT



after each SAT score is released. Of particular note for two-time takers is that, relative to the baseline period, the coefficients on the not yet released second SAT scores are generally not large or statistically significant, even without adjusting for strategies. Thus the estimates are not significantly biased by score anticipation and time-varying strategies that are correlated with ability. Time-varying strategy-adjusted estimates for each outcome closely mirror the unadjusted estimates in both sign and magnitude (see Appendix B). As with the selectivity estimates, colleges chosen after the second score is revealed primarily incorporate this new information and not the first score, even though both scores are known and the estimates are relative to the pre-exam period.

Overall, updating as measured by a range of college characteristics provides clear causal evidence that students incorporate new information about their probability of admission and likelihood of success into their portfolio choices. Students incorporate information shocks into college choices in a way that affects the selectivity of “reach” colleges, public versus private composition, graduation rates, tuition, and proximity to home. However, the updating is an order of magnitude smaller than the size of the score shock and what is observed in the cross-section, suggesting high levels of inertia in college choice.

#### 4.5 Extensive Margin Selection

Because reports must be sent after the exam in order to measure updating, the results are local to students who send more than the four free reports. While this is not a threat to the internal validity of the design, it does affect the interpretation of the estimates. As discussed in Section 2, sending additional score reports appears to be primarily a function of household income and performance in high school, and is only marginally sensitive to the magnitude of the score shock. Nonetheless, it is important to consider the implications for the estimates if those who send additional reports are more sensitive to new information than the population of SAT takers. Thus we estimate the lower bound of student response by assuming that all students who do not send additional reports did not update their preferences. In practice, this is done by replacing missing post-exam portfolios with pre-exam portfolios. The resulting estimates are presented in column (7) of Table 5. The estimates are mechanically smaller than the primary estimates but exhibit the same pattern of updating.

A specific subpopulation that may be especially prone to selecting out of sending additional reports are students who also take the ACT. These students may be less likely to use their SAT scores for admission and thus to reveal their entire portfolios. Thus we replicate the design while restricting attention to states where the SAT is the most commonly taken entrance exam. The results for this sample are nearly identical to those for the full sample, with a 100 point score shock altering the selectivity of colleges selected by 6 points for one- and two-time takers (see Appendix C). Thus it does not appear that the estimates are significantly biased by selection among ACT takers.

## 4.6 Heterogeneity in Updating

We examine if responsiveness to scores varies with student ability or with the direction of the shock. To examine whether students with higher or lower baseline ability update more, we consider students who score below 1000 on the PSAT (the median score) and students who score above 1200 and thus are likely to be competitive for admission to more selective colleges and universities. To examine if students respond differently to positive or negative shocks, we separately consider students whose SAT scores exceed or fall short of their PSAT scores.

The results in Table 6 reveal that students with high baseline PSAT scores update more than students with low baseline scores. For one-time SAT takers, updating among high ability students is 7.3 points per 100 points of score shock relative to 5.8 points for lower-ability students. However, among two-time takers, the differences are much more pronounced, with the higher-ability students exhibiting nearly double the level of updating. After the first and second SAT scores are released, students with high PSAT scores update their portfolios by 7.3 and 10.6 points, respectively, compared to only 3.5 and 6.5 points for students with low PSAT scores. A fully interacted model reveals that these differences are statistically significant.

This heterogeneity in baseline ability is consistent with high ability students considering a wider array of college choices and perhaps being more strategic in terms of selecting colleges based on admissions probabilities. For example, lower scoring students may only consider a fixed set of local public colleges and universities while high-performing students may conduct regional or national searches. Students conducting broader searches are likely to have greater flexibility to alter which colleges they consider and thus exhibit greater levels of updating in response to score shocks. In addition to greater updating, students with higher baseline scores have larger coefficients on their PSAT and SAT scores in the pre-exam period, suggesting that they sort more strongly on ability even prior to the SAT. Results by gender and income do not reveal large differences across students from high and low income families (see Appendix C). Thus the differences by student ability do not appear to be generated by differences in household resources.

Separating the results by whether students experience a positive or negative SAT score shock relative to their PSAT scores indicates that more updating occurs after a positive shock. For example, among one-time takers, a positive 100 point shock alters portfolio selectivity 8.3 points, which is statistically significantly different from, and more than twice as large as, the effect of a negative shock. This suggests that students may deviate from a set of “safety” colleges only when they receive positive news, and is consistent with our previous findings that information shocks primarily affect the quality of the most selective schools added to the portfolio.

## 5 Conclusion

The estimates in this paper reveal the role of entrance exams in shaping college portfolios, shed light on how students update their human capital choices, and provide causal evidence for the inertia underlying student-college mismatch. We find consistent evidence that students adjust the

colleges to which they send their SAT score reports in response to new information about the strength of their applications. Positive information shocks generated by SAT scores cause students to choose more selective colleges that charge higher tuition, have higher graduation rates, and are located farther from home. However, the magnitude of the responses is much too small to close the unexplained gaps between students who appear to have similar academic qualifications. These results suggest that it is difficult to change students' college choices even after providing them with new, highly relevant information about their probability of admission and likelihood of success. The results contribute revealed preference based evidence to a growing literature that attempts to understand how students update their human capital choices and why college mismatch occurs.

A point of significant policy interest is identifying ways to close the gap in outcomes between students from higher and lower-income households. College entrance exams are taken by nearly all students considering a four-year college. This study suggests that the SAT can play a role in bringing college portfolios into alignment with academic performance. However, there is a significant amount of inertia in portfolio choice that must be overcome. The predetermined nature of college choice for many students could be due to non-academic factors such as poor counseling, geographic preferences, price sensitivity, and loyalty to colleges attended by relatives and friends. Alternatively, students may not be skilled at translating SAT performance into college admission predictions. The magnitude of student updating is likely to vary with both the timeliness and the salience of new information about college choice. These findings may help to improve the way in which students, parents, and school counselors receive and respond to critical information in the application process.

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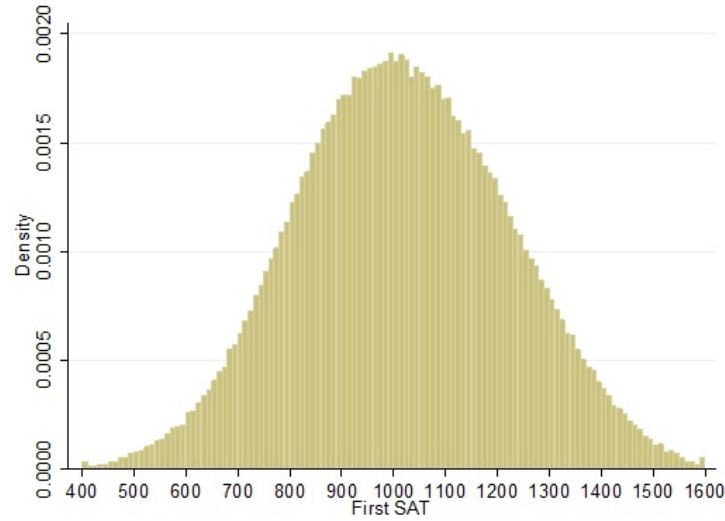
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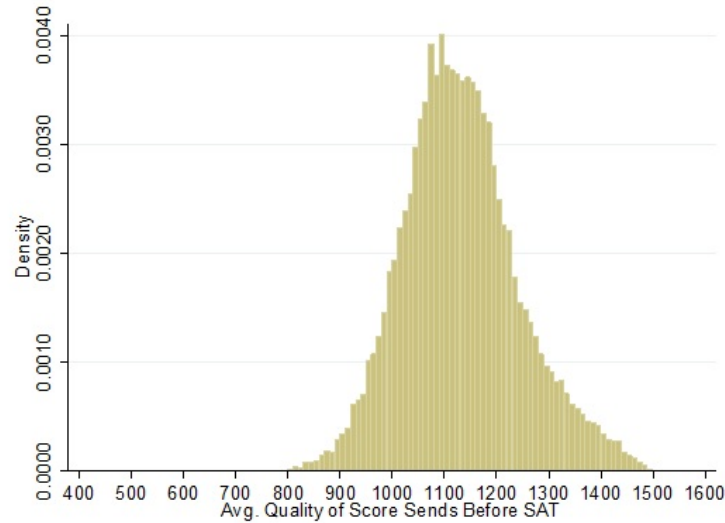
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Figure 1: Distribution of SAT Scores and Portfolio Quality

A. Distribution of First SAT Scores



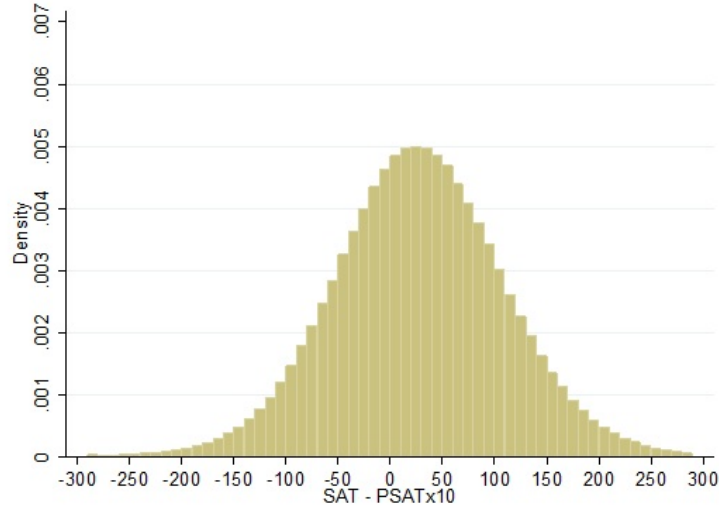
B. Distribution of Pre-Exam College Portfolios



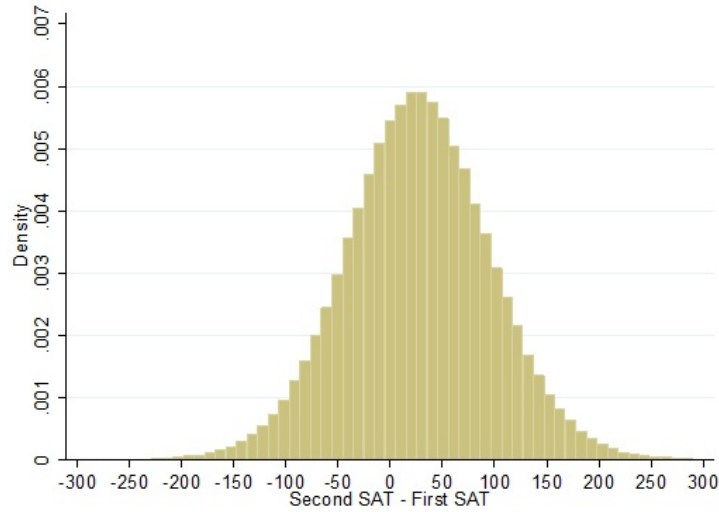
**Note:** The top figure presents the score distribution of students' first SAT scores. The score is measured in multiples of 10 points. The standard deviation of the distribution is 200 points. The bottom figure presents the distribution of the average SAT scores of matriculates of colleges in each students' score report portfolio (one measure of portfolio quality) in the pre-exam period. The standard deviation of the distribution is 110 points.

Figure 2: Within-Student Variation in Scores: PSAT, First SAT, and Second SAT

A. First SAT - PSAT



B. Second SAT - First SAT



**Note:** The top figure presents the difference between a student's SAT and PSAT scores. The PSAT score has been multiplied by 10 to be on the same scale as the SAT. The standard deviation of the difference is 85.6 points. The bottom figure presents the difference between a student's second SAT and first SAT scores. The standard deviation of the difference is 70.3 points.



Table 1: Summary Statistics

	Observations (1)	Mean (2)	Std. Dev. (3)
<i>Sample of One-Time Takers</i>			
Male	129,039	0.490	0.500
White	129,039	0.608	0.488
Black	129,039	0.136	0.343
Hispanic	129,039	0.133	0.340
Other Race	129,039	0.123	0.328
PSAT Score	129,039	1084.8	218.7
SAT Score	129,039	1135.5	220.0
<i>Sample of Two-Time Takers</i>			
Male	111,520	0.463	0.499
White	111,520	0.605	0.489
Black	111,520	0.113	0.317
Hispanic	111,520	0.116	0.320
Other Race	111,520	0.166	0.372
PSAT Score	111,520	1085.6	190.9
First SAT Score	111,520	1113.7	185.5
Second SAT Score	111,520	1146.4	190.9
<i>Population of One-Time Takers</i>			
Male	627,190	0.470	0.499
White	627,190	0.588	0.492
Black	627,190	0.161	0.368
Hispanic	627,190	0.158	0.365
Other Race	627,190	0.093	0.290
PSAT score	627,190	972.0	208.6
SAT Score	627,190	1009.3	213.5
<i>Population of Two-Time Takers</i>			
Male	534,399	0.452	0.498
White	534,399	0.604	0.489
Black	534,399	0.138	0.345
Hispanic	534,399	0.128	0.334
Other Race	534,399	0.131	0.337
PSAT Score	534,399	1010.8	192.1
First SAT Score	534,399	1038.0	190.6
Second SAT Score	534,399	1064.4	196.6

**Note:** This table presents summary statistics for the population of students who took the PSAT and took the SAT one or two times, and separately for students who sent score reports to colleges before and after receiving their exam scores. All students included in this table took the PSAT as either a sophomore or a junior in high school. The cohorts included in the analysis graduated from high school between 2007 and 2009. The PSAT score has been multiplied by 10 to be on a comparable scale to the SAT score.

Table 2: Retaking the SAT and Sending Score Reports

	Retook SAT		Sent Post-Exam Reports	
	(1)	(2)	(3)	(4)
SAT - PSAT	-0.0004*** (0.0000)	0.0002*** (0.0000)	0.0000 (0.0000)	-0.0002*** (0.0000)
SAT - PSAT   *Positive		-0.0007*** (0.0000)		0.0003*** (0.0000)
PSAT Score	-0.0001*** (0.0000)	-0.0002*** (0.0000)	0.0003*** (0.0000)	0.0003*** (0.0000)
High School GPA	0.1058*** (0.0009)	0.1144*** (0.0009)	0.0788*** (0.0009)	0.0764*** (0.0009)
Male	-0.0215*** (0.0009)	-0.0164*** (0.0009)	-0.0165*** (0.0009)	-0.0179*** (0.0009)
Asian	0.0881*** (0.0019)	0.0852*** (0.0019)	0.0341*** (0.0020)	0.0349*** (0.0020)
Black	-0.0031* (0.0017)	-0.0114*** (0.0017)	0.0597*** (0.0017)	0.0620*** (0.0017)
Hispanic	-0.0163*** (0.0017)	-0.0214*** (0.0017)	-0.0012 (0.0017)	0.0003 (0.0017)
Parental Income 50-100k	0.0570*** (0.0013)	0.0585*** (0.0013)	0.0331*** (0.0013)	0.0327*** (0.0013)
Parental Income 100k+	0.0904*** (0.0015)	0.0923*** (0.0015)	0.0499*** (0.0015)	0.0494*** (0.0015)
Observations	1,157,855	1,157,855	1,157,855	1,157,855
R-squared	0.066	0.070	0.073	0.073

**Note:** This table examines the determinants of whether students retake the SAT and whether they send additional score reports. Columns (1) and (2) examine the extent to which student characteristics, household characteristics, and the magnitude of the score shock are correlated with retaking the exam. Columns (3) and (4) examine the extent to which these factors are correlated with sending additional score reports after taking the exam. The specifications includes the number and quality of reports sent before taking the SAT as additional control variables. The symbols \*, \*\*, and \*\*\* represent statistical significance at 10, 5, and 1 percent respectively.

Table 3: One-Time Takers: Portfolio Updating in Response to an SAT Score Shock

<i>Average SAT of Matriculates</i>						
	New Colleges Added to Portfolio				Cumulative Portfolio	
	(1)	(2)	(3)	Adjusted (4)	(5)	Adjusted (6)
PSAT Score	0.113*** (0.003)	0.111*** (0.003)	0.116*** (0.004)	0.132*** (0.004)	0.116*** (0.004)	0.123*** (0.003)
SAT Score	0.141*** (0.004)	0.136*** (0.004)	0.141*** (0.004)	0.160*** (0.005)	0.141*** (0.004)	0.149*** (0.004)
After SAT * PSAT Score	-0.022*** (0.004)	-0.031*** (0.005)	-0.029*** (0.005)	-0.045*** 0.005	-0.012*** (0.005)	-0.018*** (0.004)
After SAT * SAT Score	0.072*** (0.004)	0.070*** (0.005)	0.071*** (0.005)	0.053*** 0.006	0.029*** (0.005)	0.021*** (0.005)
Student Controls (x Post)	X	X	X	X	X	X
High School FEs (x Post)		X				
Zip Code FEs (x Post)			X	X	X	X
Observations	258,036	258,036	258,036	258,036	258,036	258,036
R-squared	0.360	0.339	0.359	0.358	0.397	0.394

**Note:** This table presents the estimated effect of newly released SAT scores on a student's choice of college portfolio for alternative specifications. Columns (1)-(4) present the change in the average SAT of matriculating students at colleges selected before and after a student's score is released. Columns (5) and (6) present the change in the cumulative portfolio as a result. The estimates in columns (4) and (6) have been adjusted to account for strategies that are correlated with student aptitude. Student controls include fixed effects for high school grade point average, race, gender, and household income. Each specification includes the interaction of the controls with an indicator for the post exam period. Note that only students who send score reports both before and after taking the SAT are included in the analysis. Standard errors are clustered at the zip code level. Bootstrapped errors are used in columns (4) and (6) to account for the fact that the adjusted outcomes incorporate the estimates of  $\Omega_t$ . The symbols \*, \*\*, and \*\*\* represent statistical significance at 10, 5, and 1 percent respectively.

Table 4: Two-Time Takers: Portfolio Updating in Response to SAT Score Shocks

<i>Average SAT of Matriculates</i>						
	New Colleges Added to Portfolio				Cumulative Portfolio	
	(1)	(2)	(3)	Adjusted (4)	(5)	Adjusted (6)
PSAT Score	0.075*** (0.004)	0.072*** (0.004)	0.077*** (0.004)	0.090*** (0.004)	0.077*** (0.004)	0.084*** (0.004)
SAT 1 Score	0.103*** (0.005)	0.099*** (0.005)	0.102*** (0.005)	0.119*** (0.006)	0.102*** (0.005)	0.111*** (0.006)
SAT 2 Score	0.110*** (0.004)	0.109*** (0.004)	0.127*** (0.004)	0.104*** (0.006)	0.109*** (0.004)	0.119*** (0.005)
After SAT 1 * PSAT Score	-0.016*** (0.003)	-0.018*** (0.005)	-0.019*** (0.006)	-0.030*** (0.006)	-0.010* (0.005)	-0.016*** (0.005)
After SAT 1 * SAT 1 Score	0.048*** (0.004)	0.055*** (0.006)	0.053*** (0.006)	0.041*** (0.007)	0.026*** (0.006)	0.021*** (0.007)
After SAT 1 * SAT 2 Score	0.011*** (0.004)	0.011* (0.006)	0.011* (0.006)	-0.004 (0.007)	0.007 (0.006)	-0.001 (0.007)
After SAT 2 * PSAT Score	-0.035*** (0.005)	-0.035*** (0.006)	-0.038*** (0.006)	-0.051*** (0.006)	-0.017*** (0.005)	-0.023*** (0.005)
After SAT 2 * SAT 1 Score	0.019*** (0.006)	0.016** (0.007)	0.017** (0.007)	0.000 (0.008)	0.024*** (0.006)	0.015** (0.007)
After SAT 2 * SAT 2 Score	0.079*** (0.005)	0.078*** (0.007)	0.079*** (0.007)	0.062*** (0.007)	0.024*** (0.006)	0.014** (0.006)
Student Controls (x Post)	X	X	X	X	X	X
High School FEs (x Post)		X				
Zip Code FEs (x Post)			X	X	X	X
Observations	334,506	334,506	334,506	334,506	334,506	334,506
R-squared	0.388	0.377	0.389	0.387	0.442	0.437

**Note:** This table presents the estimated effect of newly released SAT scores on a student's choice of college portfolio for alternative specifications. Columns (1)-(4) present the change in the average SAT of matriculating students at colleges selected before and after students' first and second SAT scores are released. Columns (5) and (6) present the change in the cumulative portfolio as a result. The estimates in columns (4) and (6) have been adjusted to account for strategies that are correlated with student aptitude. Student controls include fixed effects for high school grade point average, race, gender, and household income. Each specification includes the interaction of the controls with indicators for each post exam period. Note that only students who send score reports both before and after taking the SAT are included in the analysis. Standard errors are clustered at the zip code level. The symbols \*, \*\*, and \*\*\* represent statistical significance at 10, 5, and 1 percent respectively.

Table 5: Alternate Measures of Portfolio Quality

	Min SAT (1)	Max SAT (2)	Percent Private (3)	In-State Tuition (4)	4-Year Grad Rate (5)	Average Distance (6)	Lower Bound (7)
<i>One-Time Takers</i>							
PSAT Score	0.097*** (0.004)	0.126*** (0.004)	0.021*** (0.001)	7.471*** (0.298)	0.015*** (0.001)	0.244*** (0.016)	0.086*** (0.001)
SAT Score	0.127*** (0.004)	0.147*** (0.004)	0.020*** (0.001)	7.475*** (0.304)	0.020*** (0.001)	0.200*** (0.016)	0.086*** (0.001)
After SAT * PSAT Score	-0.044*** (0.006)	-0.017*** (0.006)	-0.012*** (0.002)	-2.993*** (0.444)	-0.005*** (0.001)	-0.087*** (0.023)	-0.002 (0.002)
After SAT * SAT Score	0.011* (0.006)	0.118*** (0.007)	0.011*** (0.002)	4.093*** (0.459)	0.010*** (0.001)	0.115*** (0.023)	0.014*** (0.002)
R-squared	0.212	0.322	0.081	0.171	0.291	0.045	0.223
<i>Two-Time Takers</i>							
PSAT Score	0.070*** (0.005)	0.082*** (0.005)	0.017*** (0.001)	5.483*** (0.362)	0.010*** (0.001)	0.147*** (0.018)	0.067*** (0.002)
SAT 1 Score	0.089*** (0.006)	0.102*** (0.006)	0.020*** (0.002)	6.735*** (0.425)	0.015*** (0.001)	0.159*** (0.021)	0.084*** (0.002)
SAT 2 Score	0.109*** (0.005)	0.100*** (0.005)	0.010*** (0.002)	4.819*** (0.411)	0.015*** (0.001)	0.146*** (0.020)	0.087*** (0.002)
After SAT 1 * PSAT Score	-0.017** (0.007)	-0.021*** (0.007)	-0.004* (0.002)	-1.164** (0.506)	-0.003*** (0.001)	-0.032 (0.025)	-0.008*** (0.002)
After SAT 1 * SAT 1 Score	0.042*** (0.008)	0.057*** (0.008)	0.007*** (0.002)	2.937*** (0.600)	0.007*** (0.001)	0.102*** (0.029)	0.025*** (0.003)
After SAT 1 * SAT 2 Score	0.011 (0.008)	0.010 (0.007)	0.003 (0.002)	0.977* (0.576)	0.001 (0.001)	0.020 (0.027)	0.007** (0.003)
After SAT 2 * PSAT Score	-0.059*** (0.007)	-0.022*** (0.007)	-0.009*** (0.002)	-2.858*** (0.553)	-0.006*** (0.001)	-0.057** (0.026)	-0.013*** (0.002)
After SAT 2 * SAT 1 Score	0.024*** (0.008)	0.017* (0.009)	-0.001 (0.003)	0.449 (0.645)	0.003** (0.001)	0.082*** (0.030)	0.019*** (0.003)
After SAT 2 * SAT 2 Score	0.015** (0.008)	0.131*** (0.008)	0.010*** (0.003)	4.036*** (0.622)	0.011*** (0.001)	0.066** (0.030)	0.028*** (0.003)
R-squared	0.241	0.336	0.095	0.182	0.315	0.045	0.389

**Note:** This table presents the estimated effect of newly released SAT scores on a student's choice of college portfolio for alternative measures of quality. The top and bottom panels present the effects for one- and two-time takers, respectively. The outcome in columns (1) and (2) correspond to the lowest and highest average SAT score of matriculating students among colleges in the portfolio. Column (3) is the fraction of colleges in the portfolio that are private not-for-profit. Columns (4) and (5) consider the average in-state tuition and graduation rates for colleges in the portfolio. Column (6) presents that average distance from each student's home zip code to the colleges to which they send reports. Column (7) assumes that students who do not send score reports after the exam do not update. Student controls include fixed effects for high school grade point average, race, gender, and household income. Each control is interacted with indicators for the post exam periods. Standard errors are clustered at the zip code level. The symbols \*, \*\*, and \*\*\* represent statistical significance at 10, 5, and 1 percent respectively.

Table 6: Updating by Ability and the Type of Shock

	Baseline Ability		Type of Shock	
	PSAT < 1000 (1)	PSAT > 1200 (2)	Positive (3)	Negative (4)
<i>One-Time Takers</i>				
PSAT Score	0.069*** (0.007)	0.170*** (0.008)	0.109*** (0.006)	0.126*** (0.010)
SAT Score	0.078*** (0.006)	0.228*** (0.008)	0.166*** (0.006)	0.100*** (0.010)
After SAT * PSAT Score	-0.018* (0.010)	-0.042*** (0.012)	-0.032*** (0.009)	-0.012 (0.014)
After SAT * SAT Score	0.058*** (0.009)	0.073*** (0.011)	0.083*** (0.009)	0.037** (0.015)
R-squared	0.119	0.275	0.385	0.289
<i>Two-Time Takers</i>				
PSAT Score	0.036*** (0.008)	0.104*** (0.009)	0.062*** (0.010)	0.124*** (0.012)
First SAT Score	0.058*** (0.008)	0.157*** (0.010)	0.117*** (0.010)	0.063*** (0.012)
Second SAT Score	0.086*** (0.008)	0.134*** (0.009)	0.126*** (0.009)	0.077*** (0.012)
After SAT 1 * PSAT Score	-0.017 (0.011)	-0.014 (0.013)	-0.027** (0.013)	-0.022 (0.017)
After SAT 1 * SAT 1 Score	0.035*** (0.011)	0.073*** (0.013)	0.078*** (0.014)	0.045*** (0.016)
After SAT 1 * SAT 2 Score	0.004 (0.011)	0.016 (0.013)	-0.003 (0.013)	0.018 (0.017)
After SAT 2 * PSAT Score	-0.034*** (0.012)	-0.041*** (0.014)	-0.048*** (0.014)	-0.044** (0.018)
After SAT 2 * SAT 1 Score	0.019 (0.012)	0.008 (0.015)	0.023 (0.016)	0.038** (0.017)
After SAT 2 * SAT 2 Score	0.065*** (0.012)	0.106*** (0.014)	0.083*** (0.014)	0.065*** (0.018)
R-squared	0.158	0.256	0.402	0.348

**Note:** This table presents the estimated effect of newly released SAT scores on choice of college portfolio for students with low and high PSAT scores and for students who experience positive and negative SAT score shocks. The top and bottom panels present the effects for one- and two-time takers, respectively. Each column presents the change in the average SAT of matriculating students at colleges selected before and after a student's score is released. Each specification includes zip code fixed effects interacted with an indicator for the post exam periods. Note that only students who send score reports both before and after taking the SAT are included in the analysis. Standard errors are clustered at the zip code level. The symbols \*, \*\*, and \*\*\* represent statistical significance at 10, 5, and 1 percent respectively.

# Appendix

## A Cross-Sectional Estimates

Table A1 presents the cross-sectional relationship of portfolio selectivity with academic and non-academic factors. The resulting coefficients provide baseline context for the causal estimates discussed in Section 4. We regress college portfolio selectivity (as measured by the average SAT score of matriculating students) on a student's PSAT score, SAT score, high school GPA, high school attended, and demographic characteristics including gender, race, and household income. For one-time takers, a 100 point difference in SAT score is correlated with a 20 point difference in selectivity. Thus a one standard deviation higher exam score is correlated with an approximately 0.4 standard deviation increase in portfolio selectivity. Among two-time takers, each 100 points on the second SAT is correlated with an 18 point difference in portfolio selectivity.

High school GPA and socio-economic factors are also strongly correlated with the college portfolios students select. A one point change in GPA is correlated with a difference of 30 to 50 points in portfolio selectivity and the difference in portfolio selectivity for students from households with income between 50,000 and 100,000 dollars relative to those with more than 100,000 dollars is about 7 points. The fact that demographic characteristics are strongly correlated with college choices suggests that non-academic factors play an important role in creating mismatch between student ability and college selectivity.



Table A1: Cross-Sectional Correlates of Portfolio Quality

	One-Time Taker	Two-Time Taker	
	Colleges Chosen After SAT (1)	Colleges Chosen After First SAT (2)	Colleges Chosen After Second SAT (3)
SAT 1 Score	0.217*** (0.004)	0.194*** (0.002)	0.119*** (0.004)
SAT 2 Score			0.184*** (0.004)
PSAT Score	0.090*** (0.004)	0.095*** (0.002)	0.043*** (0.003)
High School GPA	50.052*** (0.623)	40.738*** (0.302)	50.400*** (0.558)
Male	3.949*** (0.598)	8.293*** (0.280)	0.410 (0.492)
Asian	32.117*** (1.174)	30.919*** (0.554)	26.533*** (0.844)
Black	10.700*** (1.131)	12.917*** (0.527)	18.361*** (0.990)
Hispanic	21.029*** (1.079)	24.790*** (0.539)	24.104*** (0.931)
Parental Income 50-100k	-3.467*** (0.877)	-4.315*** (0.407)	-5.989*** (0.772)
Parental Income 100k+	4.205*** (0.880)	4.368*** (0.434)	1.525** (0.746)
Observations	128,680	372,232	172,720
R-squared	0.370	0.372	0.387

**Note:** This table presents the cross-sectional estimates of PSAT and SAT scores on the quality of the colleges to which students send score reports. Column (1) examines colleges selected after the SAT for one-time takers. Column (2) examines colleges selected after the first SAT for students who take the exam twice. Column (3) examines colleges selected after the second SAT for students who take the exam twice. Note that only students who send score reports both before and after taking the SAT are included in the analysis. The symbols \*, \*\*, and \*\*\* represent statistical significance at 10, 5, and 1 percent respectively.

## B Strategy-Adjusted Estimates

This appendix presents revised estimates after accounting for time-varying strategies that are correlated with student ability. These adjustments are important if higher-ability students systematically send score reports to more selective colleges after receiving their scores.

### B.1 Estimating Strategy

As introduced in Section 3, we can estimate time-varying strategies that are correlated with ability by estimating  $y_t = d_t s + \epsilon_t$  for the outcome of interest  $y_t$  on a measure of ability  $s$  that is known to the student in every period. The estimate of time-varying strategy relative to the last period  $T$  is  $\hat{\Omega}_t = \frac{d_t}{d_T}$ . This captures how portfolio characteristics vary across periods as a function of a measure of student ability.

Table B2 presents estimates of  $\Omega_t$  using the PSAT as the measure of ability known to the student in every period. Values less than 1 indicate that the outcome is systematically larger in the post exam period for students with higher measures of ability (i.e. the  $d_0 < d_1$  for one-time takers and  $d_0 < d_2$  or  $d_1 < d_2$  for two-time takers). This appears to be the case for 7 of the 9 outcomes, suggesting that higher-ability students are generally more aggressive with their post-exam portfolio than are lower-ability students.

### B.2 Adjusted Estimates for Alternative Outcomes

The resulting strategy adjusted estimates are included for the primary measure of college quality, SAT of matriculating students, in Tables 3 and 4 of the text. We present the equivalent estimates for alternative outcomes in Table B3. These estimates indicate clear evidence of updating in response to new information. For one-time takers, post-exam portfolios significantly discount the information in the PSAT while placing greater weight on the newly released SAT scores. Likewise, for two-time takers, students only place additional weight on the first and second scores after they are released. Importantly, there is no evidence that the second score is incorporated significantly when only the first score is known. Thus there is strong evidence that students do not anticipate future scores and the estimates are not biased after adjustment. This evidence is strengthened by the timing of students' portfolio selection. Specifically, colleges selected after the first exam are frequently chosen shortly before taking the SAT for a second time as one of the student's four free reports. Thus, if time-varying covariates are generating bias, reports sent after the first exam should be more correlated with the second score than with the first score.

Table B2: Estimates of Strategy Adjustment: Omega

	New SAT (1)	Cum SAT (2)	Min SAT (3)	Max SAT (4)	Perc Priv (5)	In-State Tuition (6)	Grad Rate (7)	Avg Dist (8)	Lower Bound (9)
<i>One-Time Takers</i>									
Omega (t=0)	0.883 (0.010)	0.949 (0.010)	1.206 (0.020)	0.751 (0.009)	1.063 (0.031)	0.967 (0.018)	0.898 (0.012)	0.971 (0.028)	0.941 (0.007)
<i>Two-Time Takers</i>									
Omega (t=0)	0.861 (0.010)	0.919 (0.009)	1.135 (0.019)	0.712 (0.009)	1.061 (0.026)	0.948 (0.016)	0.866 (0.011)	0.853 (0.025)	0.891 (0.005)
Omega (t=1)	0.972 (0.010)	0.980 (0.009)	1.258 (0.019)	0.810 (0.010)	1.180 (0.029)	1.073 (0.018)	0.978 (0.011)	1.000 (0.027)	0.966 (0.005)

**Note:** This table presents the estimates of time-varying strategy  $\Omega_t$ . The top and bottom panels present the adjustments used for one- and two-time takers, respectively. Estimates are based on changes in the outcome variable between periods as a function of performance on the PSAT.

Table B3: Alternate Measures of Portfolio Quality: Strategy Adjusted

	Min SAT (1)	Max SAT (2)	Percent Private (3)	In-State Tuition (4)	4-Year Grad Rate (5)	Avg Dist (6)	Lower Bound (7)
<i>One-Time Takers</i>							
PSAT Score	0.081*** (0.003)	0.169*** (0.005)	0.020*** (0.001)	7.733*** (0.280)	0.017*** (0.001)	0.257*** (0.017)	0.086*** (0.001)
SAT Score	0.106*** (0.004)	0.195*** (0.006)	0.019*** (0.001)	7.726*** (0.343)	0.023*** (0.001)	0.205*** (0.017)	0.086*** (0.001)
After SAT * PSAT Score	-0.027*** (0.005)	-0.061*** (0.006)	-0.011*** (0.002)	-3.346*** (0.405)	-0.007*** (0.001)	-0.101*** (0.022)	-0.002 (0.002)
After SAT * SAT Score	0.032*** (0.006)	0.071*** (0.007)	0.012*** (0.002)	3.924*** (0.475)	0.008*** (0.001)	0.118*** (0.026)	0.0143*** (0.002)
Observations	258,036	258,036	258,036	257,919	256,947	257,026	257,026
<i>Two-Time Takers</i>							
PSAT Score	0.061*** (0.004)	0.115*** (0.006)	0.016*** (0.001)	5.779*** (0.350)	0.012*** (0.001)	0.175*** (0.021)	0.076*** (0.015)
SAT 1 Score	0.078*** (0.005)	0.145*** (0.008)	0.019*** (0.002)	7.166*** (0.433)	0.017*** (0.001)	0.183*** (0.026)	0.094*** (0.002)
SAT 2 Score	0.096*** (0.005)	0.139*** (0.008)	0.010*** (0.001)	5.035*** (0.411)	0.017*** (0.001)	0.170*** (0.024)	0.098*** (0.002)
After SAT 1 * PSAT Score	-0.019*** (0.005)	-0.039*** (0.009)	-0.005 (0.002)	-1.736 (0.446)	-0.004 (0.001)	-0.061** (0.029)	-0.015*** (0.002)
After SAT 1 * SAT 1 Score	0.026*** (0.007)	0.052*** (0.011)	0.004** (0.002)	1.755*** (0.569)	0.006*** (0.001)	0.076*** (0.031)	0.020*** (0.003)
After SAT 1 * SAT 2 Score	-0.002 (0.007)	-0.003 (0.010)	0.002 (0.002)	0.392 (0.536)	-0.001 (0.001)	-0.000 (0.031)	-0.002 (0.003)
After SAT 2 * PSAT Score	-0.051*** (0.006)	-0.055*** (0.008)	-0.009*** (0.002)	-3.169*** (0.518)	-0.007*** (0.001)	-0.082*** (0.028)	-0.021*** (0.002)
After SAT 2 * SAT 1 Score	0.034*** (0.007)	-0.026** (0.011)	0.000 (0.003)	0.010 (0.691)	0.000 (0.001)	0.055 (0.035)	0.008*** (0.003)
After SAT 2 * SAT 2 Score	0.029*** (0.008)	0.092*** (0.010)	0.010*** (0.002)	3.848*** (0.644)	0.009*** (0.001)	0.045 (0.035)	0.017*** (0.003)
Observations	334,506	334,506	334,506	334,378	333,687	332,883	332,883

**Note:** This table presents the estimated effects of newly released SAT scores on a student's choice of college portfolio after adjusting for score report strategies. The outcomes are adjusted as detailed in Section 3 prior to estimation. The top and bottom panels present the effects for one- and two-time takers, respectively. The outcome in columns (1) and (2) correspond to the lowest and highest average SAT score of matriculating students among colleges in the portfolio. Column (3) is the fraction of colleges in the portfolio that are private not-for-profit. Columns (4) and (5) consider the average in-state tuition and graduation rates for colleges in the portfolio. Column (6) presents that average distance from each student's home zip code to the colleges to which they send reports. Column (7) assumes that students who do not send score reports after the exam do not update. Student controls include fixed effects for high school grade point average, race, gender, and household income. Each control is interacted with indicators for the post exam periods. Bootstrapped standard errors are used to account for the fact that the outcomes incorporate the estimates of  $\Omega_t$ .

## C Alternative Specifications and Samples

### C.1 A Specification Based on the Gap Between SAT and PSAT Scores

An alternative specification to the one presented in Section 4 interacts the difference between a student’s SAT and PSAT scores, (SAT-PSAT), with an indicator for each information period. This specification will produce identical estimates to the primary specification under two conditions. First, the extent to which students discount the PSAT after the SAT is revealed would need to match the extent to which they increase the importance of the SAT. That is, this design treats one point lower on the PSAT as equivalent to one point higher on the SAT, so the resulting estimate is the average of the weight students place on each of these exams. In practice, the amount that students discount the PSAT tends to be somewhat smaller in magnitude than the weight given to the newly revealed SAT score. Second, the estimates will not be equal if students employ time-varying strategies. Specifically, this specification does not suffer from a scaling effect because ability is differenced out by subtracting the PSAT score from the SAT score.

The estimates for this specification are presented in Table C4. They reveal that a 100 point score shock causes students to update the selectivity of the colleges they select by about 5 points for one-time takers and 3 points and 6 points after the first and second scores are released for two-time takers. These magnitudes are nearly identical to those in the preferred, adjusted specifications presented in Tables 3 and 4 of the paper.

### C.2 SAT Dominant States

Students who take the ACT in addition to the SAT may choose not to send their SAT scores to colleges if they perform better on the ACT. This issue adds a dimension of complexity in terms of selection that is not easy to model or desirable for estimation. To determine whether it affects the estimates presented in Section 4, we replicate the design while restricting attention to states in which the SAT is the most commonly taken exam. This approach is likely to significantly reduce the fraction of students who have taken the ACT in the sample.

The estimates for SAT dominant states are presented in Table C5 and are nearly identical to those for the sample of all states. Specifically, the preferred, adjusted estimate of updating for one-time takers is a 5.8 point increase in selectivity for a 100 point score shock, relative to 5.3 points for the full sample. For two-time takers, the estimates of updating are 4.1 points after the first exam and 6.5 points after the second exam, which is comparable to 4.1 and 6.2 points for the full sample. Thus the fact that some students take both the ACT and the SAT does not appear to significantly confound the empirical design.

### C.3 Target Colleges

When selecting a college, sometimes going to the best school can be less important than going to the “right” school. In our main analysis, we show that students’ college portfolios, as measured by

the schools they designate to receive their SAT scores, become more closely correlated with their SAT scores once the scores are known. However this may not necessarily mean that students are making “better” choices. Perhaps students systematically overshoot relative to their ideal college choice once this information is revealed.<sup>18</sup>

This appendix estimates the quality of the matching between students and their portfolio choices in response to new information. Intuitively, once students learn their SAT scores, they may be more likely to send reports to colleges with which they are better matched, and the biggest change may be for those who receive the largest SAT score “shock”. This will occur if a student’s beliefs about which schools are a good match become both more correct and more precise.<sup>19</sup> Table C6 examines the fraction of colleges in a student’s portfolio for which the median incoming student has an SAT score within 5 percent of the student’s score (i.e., a target college). About 25 percent of colleges fall into this range. However, there is no evidence that students who experience the largest shocks ultimately send reports to a higher fraction of target colleges after learning their SAT scores. This result holds for several alternative definitions of target colleges as defined by the bandwidth around a student’s actual SAT score.

#### C.4 Continuous GPA

The primary specification in Section 4 presents the decrease in weight that students place on their PSAT scores after their SAT scores are revealed. The specification controls for students’ high school GPAs using fixed effects for each possible reported value (e.g., 3.0, 3.3,...) interacted with an indicator for each period. In this appendix we convert the GPA to a continuous value and examine if there is evidence that students rely on it less after SAT scores are revealed. Students may reduce their reliance on their high school GPAs if they use them to predict their SAT scores.

The results presented in Table C7 are adjusted for time-varying strategies and the unit of measurement for the GPA is hundredths of a GPA point (similar scale used for SAT points). The estimates of updating are nearly identical to the primary specification. After scores are released, students appear to place less weight on their GPAs, as each of the signs is negative and two are statistically significant. Thus, students appear to predict SAT scores using their GPAs, though not to the degree that they do using their PSAT scores. This finding is consistent with PSAT scores being more predictive of SAT scores than are GPAs.

#### C.5 Demographics

Student responses to SAT scores may vary with gender or household resources. For example, students whose parents are unfamiliar with the college application process may respond less to an

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<sup>18</sup>To be clear, if students systematically overshoot after they receive their scores, they might not necessarily be misusing their information. Portfolio choices made after learning one’s SAT score must also take into account the choices made before one has this information. It may be optimal for students to select some colleges above their ability level given that the potential benefits of attending a higher-quality institution might offset the disadvantages of being an underprepared student in that institution.

<sup>19</sup>This can be shown formally through an extension of our model and is available upon request.

information shock if they choose a fixed set of local colleges for geographic or financial reasons. Conversely, students from low-income households may be more responsive to their scores if they rely on having multiple offers of admission in order to negotiate for greater financial aid, do not wish to spend money on low-probability applications, or the SAT substitutes for other forms of college counseling. The results in Table C8 indicate that students of all income ranges update in a way that is statistically significant but modest in magnitude. A specification with interacted effects indicates that, while students from lower-income households update slightly more, the difference is not statistically significant. Likewise, male students have slightly larger coefficients than female students but the differences are not large in magnitude or statistically significant. Among two-time takers, all subgroups exhibit a consistent pattern, with portfolios reflecting the first and second SAT as each is released. Newly released first scores are highly significant and yet-to-be-released second SAT scores are not. These results support the hypothesis that no subgroup of students systematically anticipates future scores.

Table C4: Score Gap Specification

<i>Average SAT of Matriculates</i>	New Colleges Added to Portfolio			Cumulative
	(1)	(2)	(3)	Portfolio (4)
<i>One-Time Takers</i>				
(SAT 1 - PSAT)	0.0115*** (0.0036)	0.0092*** (0.0034)	0.0110*** (0.0036)	0.0110*** (0.0036)
After SAT 1 * (SAT 1 - PSAT)	0.0489*** (0.0038)	0.0497*** (0.0052)	0.0499*** (0.0054)	0.0201*** (0.0048)
Observations	258,036	258,036	258,036	258,036
R-squared	0.247	0.237	0.241	0.267
<i>Two-Time Takers</i>				
(SAT 1 - PSAT)	-0.0297*** (0.0043)	-0.0229*** (0.0034)	-0.0307*** (0.0035)	-0.0225*** (0.0030)
(SAT 2 - PSAT)	0.0319*** (0.0029)	0.0360*** (0.0049)	0.0350*** (0.0050)	0.0127*** (0.0046)
After SAT 1 * (SAT 1 - PSAT)	0.0298*** (0.0043)	0.0245*** (0.0031)	0.0298*** (0.0033)	0.0274*** (0.0031)
After SAT 2 * (SAT 2 - PSAT)	0.0588*** (0.0040)	0.0575*** (0.0051)	0.0590*** (0.0053)	0.0201*** (0.0044)
Observations	334,506	334,506	334,506	334,506
R-squared	0.257	0.257	0.250	0.287
Student Controls (x Post)	X	X	X	X
High School FEs (x Post)		X		
Zip Code FEs (x Post)			X	X

**Note:** This table presents the estimated effect of the gap between students' SAT and PSAT scores on their choice of college portfolios before and after the SAT scores are released. The top and bottom panels present the effects for one- and two-time takers, respectively. Columns (1)-(3) present the change in the average SAT of matriculating students at colleges selected before and after scores are released. Column (4) presents the change in the cumulative portfolio as a result. Student controls include fixed effects for high school grade point average, race, gender, and household income. Each control is interacted with indicators for the post exam periods. Standard errors are clustered at the zip code level. The symbols \*, \*\*, and \*\*\* represent statistical significance at 10, 5, and 1 percent respectively.



Table C5: SAT Dominant States

<i>Average SAT of Matriculates</i>	New Colleges Added to Portfolio				Cumulative Portfolio	
	(1)	(2)	(3)	Adjusted (4)	(5)	Adjusted (6)
<i>One-Time Takers</i>						
PSAT Score	0.114*** (0.004)	0.110*** (0.004)	0.116*** (0.004)	0.132*** (0.004)	0.116*** (0.004)	0.122*** (0.036)
SAT Score	0.138*** (0.004)	0.134*** (0.004)	0.139*** (0.004)	0.157*** (0.005)	0.139*** (0.004)	0.146*** (0.005)
After SAT * PSAT Score	-0.031*** (0.004)	-0.036*** (0.006)	-0.034*** (0.006)	-0.050*** (0.006)	-0.013*** (0.005)	-0.019*** (0.005)
After SAT * SAT Score	0.078*** (0.004)	0.075*** (0.006)	0.077*** (0.006)	0.058*** (0.007)	0.030*** (0.005)	0.0224*** (0.006)
Observations	206,026	206,026	206,026	206,026	206,026	206,026
<i>Two-Time Takers</i>						
PSAT Score	0.076*** (0.004)	0.070*** (0.004)	0.077*** (0.004)	0.090*** (0.004)	0.077*** (0.004)	0.084*** (0.004)
SAT 1 Score	0.104*** (0.005)	0.101*** (0.005)	0.103*** (0.005)	0.119*** (0.006)	0.103*** (0.005)	0.112*** (0.006)
SAT 2 Score	0.106*** (0.005)	0.102*** (0.005)	0.105*** (0.005)	0.123*** (0.006)	0.105*** (0.005)	0.115*** (0.006)
After SAT 1 * PSAT Score	-0.016*** (0.003)	-0.018*** (0.006)	-0.019*** (0.006)	-0.029*** (0.006)	-0.010* (0.006)	-0.015*** (0.005)
After SAT 1 * SAT 1 Score	0.048*** (0.004)	0.054*** (0.007)	0.052*** (0.007)	0.041*** (0.008)	0.025*** (0.007)	0.019*** (0.007)
After SAT 1 * SAT 2 Score	0.009** (0.004)	0.009 (0.006)	0.010 (0.007)	-0.005 (0.008)	0.007 (0.006)	-0.001 (0.007)
After SAT 2 * PSAT Score	-0.039*** (0.005)	-0.035*** (0.006)	-0.040*** (0.006)	-0.051*** (0.006)	-0.017*** (0.005)	-0.023*** (0.005)
After SAT 2 * SAT 1 Score	0.015** (0.006)	0.013* (0.008)	0.013* (0.008)	-0.003 (0.008)	0.023*** (0.006)	0.015** (0.007)
After SAT 2 * SAT 2 Score	0.082*** (0.006)	0.081*** (0.007)	0.083*** (0.007)	0.065*** (0.009)	0.024*** (0.006)	0.014* (0.007)
Observations	284,871	284,871	284,871	284,871	284,871	284,871
Student Controls (x Post)	X	X	X	X	X	X
High School FEs (x Post)		X				
Zip Code FEs (x Post)			X	X	X	X

**Note:** This table presents the estimated effect of newly released SAT scores on a student's choice of college portfolio for alternative specifications. Attention is restricted to students attending high school in states where the SAT is the most commonly taken entrance exam. The top and bottom panels present the effects for one- and two-time takers, respectively. Columns (1)-(4) present the change in the average SAT of matriculating students at colleges selected before and after a student's score is released. Columns (5) and (6) present the change in the cumulative portfolio as a result. The estimates in columns (4) and (6) have been adjusted to account for strategies that are correlated with student aptitude. Student controls include fixed effects for high school grade point average, race, gender, and household income. Each specification includes the interaction of the controls with an indicator for the post exam period. Note that only students who send score reports both before and after taking the SAT are included in the analysis. Standard errors are clustered at the zip code level. Bootstrapped errors are used in columns (4) and (6) to account for the fact that the adjusted outcomes incorporate the estimates of  $\Omega_t$ . The symbols \*, \*\*, and \*\*\* represent statistical significance at 10, 5, and 1 percent respectively.

Table C6: Target Colleges: One- and Two-Time Takers

<i>Average SAT of Matriculates</i>	One-Time Takers (1)	Two-Time Takers (2)
SAT 1 - PSAT	0.0099*** (0.0014)	-0.0035** (0.0014)
SAT 2 - PSAT		0.0144*** (0.0011)
After SAT 1 *   SAT 1 - PSAT	-0.0031 (0.0021)	0.0005 (0.0021)
After SAT 1 *   SAT 2 - PSAT		-0.0002 (0.0021)
Student Controls (x Post)	X	X
Zip Code FEs (x Post)	X	X
Observations	258,424	334,677
R-squared	0.070	0.085

**Note:** This table presents the estimated effect of newly released SAT scores on whether students apply to colleges in their “target” range. The target range is defined as colleges for which the average matriculating student has an SAT score within 5 percent of the student’s score. The treatment is defined as the magnitude of the score shock, which is the absolute value of the difference between a student’s SAT score and PSAT score. Student controls include high school grade point average, race, and household income. Each specification includes the interaction of the controls with an indicator for the post periods. Note that only students who send score reports both before and after taking the SAT are included in the analysis. Standard errors are clustered at the zip code level. The symbols \*, \*\*, and \*\*\* represent statistical significance at 10, 5, and 1 percent respectively.

Table C7: Portfolio Updating with Continuous GPA

<i>Average SAT of Matriculates</i>	One-Time Takers		Two-Time Takers	
	New Colleges (1)	Cumulative Portfolio (2)	New Colleges (3)	Cumulative Portfolio (4)
GPA	0.543*** (0.009)	0.502*** (0.008)	0.555*** (0.012)	0.519*** (0.011)
PSAT Score	0.136*** (0.004)	0.125*** (0.003)	0.091*** (0.004)	0.085*** (0.004)
SAT 1 Score	0.164*** (0.004)	0.152*** (0.004)	0.119*** (0.006)	0.111*** (0.006)
SAT 2 Score			0.129*** (0.005)	0.120*** (0.005)
After SAT 1 * GPA	-0.043*** (0.012)	-0.012 (0.011)	-0.016 (0.015)	-0.004 (0.014)
After SAT 1 * PSAT Score	-0.046*** (0.005)	-0.019*** (0.004)	-0.030*** (0.005)	-0.016*** (0.005)
After SAT 1 * SAT 1 Score	0.053*** (0.006)	0.022*** (0.005)	0.042*** (0.008)	0.021*** (0.007)
After SAT 1 * SAT 2 Score			-0.005 (0.007)	-0.001 (0.007)
After SAT 2 * GPA			-0.042*** (0.015)	-0.008 (0.012)
After SAT 2 * PSAT Score			-0.051*** (0.005)	-0.024*** (0.004)
After SAT 2 * SAT 1 Score			-0.001 (0.008)	0.015** (0.007)
After SAT 2 * SAT 2 Score			0.063*** (0.008)	0.014** (0.006)
Student Controls (x Post)	X	X	X	X
Zip Code FEs (x Post)	X	X	X	X
Observations	257,360	257,360	334,038	334,038

**Note:** This table presents the estimated effect of newly released SAT scores on a student's choice of college portfolio for one- and two-time SAT takers. The PSAT and GPA are interacted with indicators for each post exam period. Columns (1) and (3) present the change in the average SAT of matriculating students at colleges selected before and after students' first and second SAT scores are released. Columns (2) and (4) present the change in the cumulative portfolio as a result. All specifications are adjusted for application strategies. Additional student controls include fixed effects for race, gender, and household income. Each specification includes the interaction of the controls with an indicator for the post exam period. Note that only students who send score reports both before and after taking the SAT are included in the analysis. Standard errors are clustered at the zip code level. Bootstrapped errors are used to account for the fact that the adjusted outcomes incorporate the estimates of  $\Omega_t$ . The symbols \*, \*\*, and \*\*\* represent statistical significance at 10, 5, and 1 percent respectively.

Table C8: Updating by Gender and Household Income

	Gender		Household Income		
	Male (1)	Female (2)	0-50k (3)	50-100k (4)	>100k (5)
<i>One-Time Takers</i>					
PSAT Score	0.125*** (0.005)	0.112*** (0.005)	0.117*** (0.009)	0.101*** (0.008)	0.128*** (0.007)
SAT Score	0.134*** (0.005)	0.147*** (0.005)	0.103*** (0.009)	0.146*** (0.008)	0.159*** (0.007)
After SAT * PSAT Score	-0.039*** (0.008)	-0.024*** (0.008)	-0.038*** (0.013)	-0.027** (0.012)	-0.025** (0.010)
After SAT * SAT Score	0.081*** (0.008)	0.064*** (0.008)	0.084*** (0.013)	0.067*** (0.012)	0.068*** (0.011)
R-squared	0.387	0.332	0.276	0.334	0.3736
<i>Two-Time Takers</i>					
PSAT Score	0.087*** (0.006)	0.068*** (0.006)	0.065*** (0.012)	0.067*** (0.009)	0.076*** (0.007)
First SAT Score	0.099*** (0.007)	0.101*** (0.007)	0.093*** (0.014)	0.096*** (0.011)	0.106*** (0.008)
Second SAT Score	0.099*** (0.007)	0.120*** (0.007)	0.094*** (0.013)	0.117*** (0.010)	0.121*** (0.008)
After SAT 1 * PSAT Score	-0.016** (0.008)	-0.022*** (0.008)	-0.008 (0.017)	-0.011 (0.012)	-0.010 (0.010)
After SAT 1 * SAT 1 Score	0.059*** (0.009)	0.046*** (0.009)	0.034* (0.019)	0.043*** (0.015)	0.058*** (0.012)
After SAT 1 * SAT 2 Score	0.002 (0.009)	0.018** (0.009)	0.019 (0.018)	0.016 (0.014)	-0.002 (0.011)
After SAT 2 * PSAT Score	-0.050*** (0.009)	-0.027*** (0.009)	-0.041** (0.018)	-0.028** (0.014)	-0.038*** (0.011)
After SAT 2 * SAT 1 Score	0.015 (0.010)	0.018* (0.010)	0.011 (0.021)	0.013 (0.016)	0.013 (0.013)
After SAT 2 * SAT 2 Score	0.092*** (0.010)	0.066*** (0.010)	0.092*** (0.020)	0.077*** (0.016)	0.075*** (0.013)
R-squared	0.415	0.369	0.332	0.365	0.440

**Note:** This table presents the estimated effect of newly released SAT scores on choice of college portfolio by gender and household income. The top and bottom panels present the effects for one- and two-time takers, respectively. Each column presents the change in the average SAT of matriculating students at colleges selected before and after a student's score is released. Each specification includes zip code fixed effects interacted with an indicator for the post exam periods. Note that only students who send score reports both before and after taking the SAT are included in the analysis. Note that some students' characteristics are missing from College Board data and thus the subgroup totals do not sum to the number of students in the population. Standard errors are clustered at the zip code level. The symbols \*, \*\*, and \*\*\* represent statistical significance at 10, 5, and 1 percent respectively.