Crossing the Finish Line: A Review Article

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I. Introduction

Human capital production in the U.S. economy is no longer what it used to be. Graduation rates for high school and college have fallen (Card and Lemieux 2001; Heckman and Lafontaine 2007). As a result, the rate of growth of the stock of human capital has slowed considerably (Goldin and Katz 2008). At the same time, other countries are improving their educational attainment. Although the United States still has the highest rate of tertiary attainment (Ehrlich 2007), this accomplishment should not be taken for granted. As recently as 1998, the United States ranked third in tertiary graduation rate among the OECD countries. By 2006, it barely made it into the top 10 (OECD 2008). Quantity is only one part of the problem because the human capital produced is also of lower quality. Out of the 30 OECD countries that participated in the 2006 Program for International Student Assessment, U.S. students ranked twenty-fifth (OECD 2007).

Human capital is an important source of long-run growth (e.g., Lucas 1988; Becker, Murphy, and Tamura 1990; Romer 1990; Ehrlich and Lui 1991), so it is necessary to reverse this situation. Following up on the seminal contributions by Schultz (1959), Becker (1964), and Ben-Porath (1967), recent research has shown that the production of human capital starts before birth and continues over the entire life cycle (e.g., Cunha and Heckman 2007). It is produced by families (e.g., Cunha, Heckman, and Schennach, forthcoming) and schools (Rivkin, Hanushek, and Kain 2005; Todd and Wolpin 2007). In the late adolescent and early adulthood years, human capital investments are made via formal schooling (a college or post-baccalaureate education) or in the labor market via learning by doing and on-the-job training (e.g., Keane and Wolpin 1997, 2001, 2006; Cameron and Heckman 1998, 2001; Heckman, Lochner, and Taber 1998; Heckman, Lochner, and Cossa 2002).

The market for higher education has been the focus of much research by economists (e.g., Clotfelter and Rothschild 1993; Hoxby 2004). A

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substantial share of the research focuses on college access, but there are important exceptions that investigate college completion (e.g., Bound, Lovenheim, and Turner, forthcoming). In *Crossing the Finish Line*, Bowen, Chingos, and McPherson (2009) follow the educational path of a cohort of students who started their college education in 1999. In their analysis, the authors focus on college completion as the outcome of interest for several reasons. First, a college diploma certifies that a student has acquired skills that are valued directly in the labor market. There is a difference between spending 4 years at college taking courses randomly and following a track that builds skills through a sequence of courses (e.g., there are specific skills that a student needs to learn to attain a bachelor of science degree in nursing). Second, there may be an option value associated with a college degree (e.g., one is not seriously considered for law school unless one has a college degree). Third, there may be signaling benefits (e.g., a potential employer will know that a person with a bachelor's degree is capable of finishing what he or she starts).

Bowen et al.'s thorough study is based on a novel and rich data set that they compiled. It collects information on students in 68 public universities in the United States that differ considerably in geographic location, resources, and the quality of the student body (selectivity). On the basis of this new data set, the authors document the inequality in college graduation rates according to individual and/or institutional characteristics. Conditional on enrolling in college, students from families in which one parent has a college degree are 11 percentage points more likely to graduate than students from families in which no parent has a college degree. Seventy-five percent of the white male students who enroll eventually graduate. However, only 59 percent of black male students do so. More important, conditional on family and student characteristics, a black female is 17 percentage points more likely to graduate from college than a similar black male, even though both attend the same institution. The authors document large differences in graduation rates by the selectivity of the institution (i.e., by the average Scholastic Aptitude Test [SAT] score of the entering student body). The difference in graduation rates of white male students who enroll in the most selective versus those who enroll in the least selective colleges is more than 20 percentage points.

The natural question that these findings raise is, why do these differences exist? Obviously, a central concern in human capital formation is credit constraints. The book features an extensive discussion about the complexity of financial aid and how it affects graduation rates. The authors estimate that a reduction in net tuition of $1,000 is associated with a 3-percentage-point increase in college completion for the students who come from the poorest families. The same reduction in tuition for the students from the richest families does not change their graduation rates. Partly on the basis of this finding, they recommend a shift of

resources from merit-based to need-based aid. They also summarize research that shows that the graduation rates of students from the poorest families may increase if financial aid is made simpler and more predictable.

Even though financial resources may close the gaps between students from families with different financial circumstances, it is unlikely to explain the large differences between observationally similar male and female black students. It is necessary to consider other factors beyond credit constraints. The authors investigate the role played by high school characteristics as well as the performance in high school of the students who enrolled in college in 1999 and the role both play in explaining college graduation rates. They find that differences in academic characteristics of the high schools explain some of the gaps in graduation rates. They also find that there are many students with top high school grade point averages (GPAs) and SAT/ACT (American College Test) scores who attend less selective colleges. They name this combination of qualified students attending less selective colleges "undermatch," and they associate with it a 15-percentage-point gap in graduation rates. They also show that minority students are particularly likely to be undermatched.

Bowen et al. analyze how well achievement tests that are routinely used by admissions committees predict college performance in practice. Despite its obvious appeals, they show that the scores from standardized tests have much worse predictive power than high school GPA, even when both measures are used in the regressions. This finding is strong evidence that the screening mechanism used by colleges may be flawed, and perhaps higher graduation rates could be attained by reweighting each piece of information according to its informative content.

The authors carefully follow the academic paths of students who start at a 4-year college versus those who start at a 2-year and then transfer to a 4-year institution. Their main conclusion is that students who finish the 2-year college and transfer to a 4-year institution have graduation rates similar to those of the junior students who started at a 4-year institution. More interestingly, they describe specific programs that are designed to increase the graduation rates of black males and Hispanic students.

In the course of reading this work, I found it to be an inspiring book. It aims to answer big questions with important consequences for our future. It was written by scholars who care deeply about how the market for higher education works and the role that universities play in producing human capital. Their knowledge on the subject and their grasp of the literature are truly remarkable. For these reasons, policy makers and researchers working on the market for higher education or on the transition from high school to college will certainly learn a lot from this book.

In this review of the book, I will frame Bowen et al.'s evidence within

an economic framework that sometimes supports some of their policy recommendations. This economic framework will also be used to show that the policy recommendations made in some parts of the book are inconsistent with the evidence reported in other parts. For example, their recommendation on merit-based awards conflicts with the evidence that suggests that peer effects are important. Another example is their reliance on the undermatch concept to prescribe reassignments of students to college. Because of the particular way that undermatch is defined, it does not measure social inefficiencies of an equilibrium assignment, so it should not be used to guide policy recommendations.

The rest of the review is organized as follows. Section II briefly summarizes the evidence presented in the book. Section III discusses three of the factors proposed that may drive the differences the authors document: (1) the importance of cognitive and noncognitive skills, (2) the assignment of students to institutions, and (3) the issues relating to financial aid. The concluding remarks are in Section IV.

II. The Data

Bowen et al. base their analysis on the members of the 1999 entering cohort at 21 prestigious research-intensive public universities scattered throughout the United States (flagships) and all of the 47 public universities in Maryland, North Carolina, Ohio, and Virginia (state system). They divided the flagships into three groups of decreasing selectivity: SEL I, SEL II, and SEL III. The state system is also divided into three groups: SEL A (more selective), SEL B (less selective), and historically black colleges and universities (HBCU). The measure of selectivity used is the mean SAT/ACT score of the student body at entrance.

The 68 institutions in Bowen et al.'s data set enroll 25 percent of full-time freshmen at all 4-year public universities. As the authors point out, the sample is not representative of the 1999 entering cohort. Table 1 compares college graduation rates from their data with those produced

TABLE 1
Comparison between NELS and Flagship Databases: College Graduation Rates

	NELS 1988/2000	State System	Flagships
By quartile of family income:			
Bottom income quartile	40	58	70
Second income quartile	46	59	73
Third income quartile	57	66	77
Top income quartile	72	73	83
By parental education:			
No college	41	57	69
Some college	56	59	71
College degree	67	69	79
Graduate degree	74	75	83

Source.—Bowen et al. (2009).

from the National Educational Longitudinal Study (NELS) data.[1] In NELS data, students from poor families or households in which neither parent had a college education are much less likely to graduate from college than comparable students in either the state system or flagships. The students from better family circumstances (i.e., those who are in the top quartile of family income or with at least one parent who has a graduate degree) graduate at similar rates in the NELS and the state system data. As expected, the students at the flagships graduate at much higher rates across all quartiles of income or levels of parental education. In fact, we see that the lower the income quartile or parental education, the higher the discrepancy between flagships and NELS data. It is important to keep in mind that the novel data used in the book oversample students from disadvantaged backgrounds with unobserved characteristics that increase their chances of graduating or who attend institutions that offer better support to those types of students.

The substantive findings are reported in chapters 3 and 4, which I now summarize. There is a strong correlation between selectivity (average SAT/ACT score at entrance) and graduation rates: 86 percent of the 1999 cohort in SEL I flagship institutions graduated from college within 6 years, whereas only 66 percent in SEL III did so. A similar difference arises in the state system database: 77 percent in SEL A versus 51 percent in SEL B institutions. In chapter 10, the authors revisit this finding and investigate if the differences in graduation rates by selectivity group occur because universities that are not very selective are "dipping too low" and admitting students who are not academically prepared to succeed in college. They find evidence that is inconsistent with this hypothesis. This contrasts with the findings in Bound et al. (forthcoming), who explore cross-sectional and time-series variation. These authors report that, over time, college enrollment rates increased for males and females (more for females than for males) but that the college completion rates decreased for both males and females (more for males than for females). The increase in college enrollment of males is explained by the fact that institutions with fewer resources (e.g., higher faculty-student ratios) started admitting students with weak academic preparation. This phenomenon did not happen for females. This proves that while "dipping too low" is part of the story, it is not the entire story. In my view there are at least two reasons why the evidence presented in Bound et al.'s article is more convincing than the evidence in Bowen et al.'s book. First, the Bound et al. data come from a nationally representative sample. Second, they have time-series variation that can be used to compare the students at the margin of being admitted to college in the 1970s with the ones in 1990s.

There are important differences in graduation rates according to

[1] The information shown in table 1 is based on the authors' data shown in their figs. 2.3a, 2.3b, 3.5, and 3.6.

measures of socioeconomic status (SES) or race/gender of the student. After controlling for initial conditions[2] and university attended, Bowen et al. show that the gap in graduation rates between students from families in which at least one parent had a college degree and students from families in which neither parent had a college degree was 9 percentage points. The same gap is found by comparing students from the top quartile with those from the bottom quartile. In terms of race and gender, the data show that females from any race/ethnicity group are at least as likely to graduate from college as white males, a finding that is consistent with that reported by Goldin, Katz, and Kuziemko (2006). The differences between males and females within a race are substantial for minority groups: after accounting for initial conditions, university attended, and family income, there is a 10-percentage-point gap in graduation rates between black females and black males or Hispanic females and Hispanic males.

Dropping out of college is almost as likely to happen before or after the first 2 years: 44 percent of the withdrawals happen after the students have already completed the first 2 years. Interestingly, grades during the first year in college have high predictive power for withdrawal, even after controlling for SAT/ACT and high school GPA. The natural question is whether this is due to external factors (e.g., individual motivation), behaviors in college (e.g., amount of studying in college), or learning (uncovering one's own tastes or interests regarding a college education).[3] Unfortunately, it is impossible to quantify the importance of each of these components using the data set collected by the authors because there is little to no information on such topics.

In chapter 4, Bowen et al. show how choice of major, time to graduation, and academic performance relate to a student's SES, race, and gender. These outcomes are measured by the students who eventually graduate from college. They find no systematic differences in college major choices by SES or race. A different conclusion arises when the authors consider time to degree. The students who graduate in 6 years were enrolled in 2.4 semesters more than the students who graduate in 4 years, a finding that mirrors that of Turner (2004). The students in the former group attempt 24 and earn 17 more credits than the students in the latter group. On the one hand, the difference between credits attempted and credits earned suggests that failing courses is an important factor in explaining the delay in graduation from college. On the other hand, the larger number of credits attempted is consistent with

[2] By initial conditions I mean high school GPA, SAT/ACT scores, state residential status, race, and gender.

[3] Arcidiacono (2004) estimates a model in which students learn about their ability and how it affects the decision to continue their enrollment in college and, if they decide to stay, what major to choose. Stinebrickner and Stinebrickner (2009) investigate how students form expectations about their academic ability and how this learning affects the decision to drop out.

a model in which the students are learning about their academic vocation, so a higher time to degree would not necessarily mean a negative outcome in the long run. Interestingly, the association between SES and time to degree varies according to the selectivity of the institution. In the more selective flagships and state system universities (SEL I, SEL II, and SEL A), the gap between high- and low-SES students in time to degree is large. However, in less selective institutions (SEL III and SEL B), there is no gap. Virtually half of the gap between SES groups, within an institution in SEL I, SEL II, and SEL A groups, is explained by the differences in initial conditions. Once one controls for parental education and family income, the gaps almost completely disappear for all levels of selectivity of schools.

The findings for how time to degree correlates with race and gender mirror those of graduation. Women of any race/ethnic group are more likely to graduate on time than white or Asian males, even after adding controls for differences in initial conditions, family income, parental education, and institution fixed effects. A black female is 19 percentage points more likely to graduate on time than an observationally equivalent black male. The same difference for Hispanic females and males is 15 percentage points. Among whites, the gap is 13 percentage points. It is impossible not to ask why there are such stark differences between females and males.

III. Factors That Explain the Differences

Bowen et al. investigate how different factors explain the outcomes listed above. Having to choose discussing either all factors at a more superficial level or a few factors at a more detailed level, I have chosen to follow the latter route. I will focus my review on three topics: (1) the importance of cognitive and noncognitive skills, (2) the matching of colleges to students, and (3) the role of financial aid and the market for higher education.

A. The Importance of Cognitive and Noncognitive Skills

Chapter 6 starts by framing in a historical context why standardized tests, such as the SAT/ACT, are so widely used by institutions of higher education. In a diverse country with a decentralized educational system, it would be natural for different high school curricula and grading standards to arise. High school GPAs would then not be comparable across high schools. By construction, standardized tests provide a unique metric of academic aptitude that can be used to compare college readiness of students from very different high school systems. Ironically, when both measures are used in a model of linear prediction of college graduation, Bowen et al. find that high school GPA has stronger power than SAT/ACT scores. This finding is uniform across racial/ethnic

groups, gender, and SES. When SAT/ACT scores are held fixed, a one-standard-deviation increase in high school GPA is associated with an increase of 14.3 percentage points in graduation rates. When high school GPA is held fixed, the same change in SAT/ACT scores predicts essentially no change in graduation rates. SAT/ACT performs better in predicting college GPA, but still not as well as high school GPA. Again, when SAT/ACT scores are held fixed, a one-standard-deviation increase in high school GPA is associated with 11.7 percentile gains in college performance, whereas the reverse exercise predicts only 4.3 percentile gains in the same metric.

Clearly, high school GPA contains information that is not present in the SAT/ACT scores. This is hardly surprising because GPA summarizes information that is collected over the entire high school period. Exams in high school are often open-ended, so the guessing that is possible in multiple-choice exams, which are frequently used in standardized tests, is less of an issue in the GPA. An SAT/ACT score reflects the performance on a test that takes a few hours in a setting that is quite different from the college context. There is also an entire industry that coaches students to improve their SAT/ACT performance, and this may add substantial noise to the score. One possible interpretation is that high school GPA, with all its failures, is still a better measure of the stock of cognitive skills needed to succeed in college.

A nonrival explanation is that GPA contains measures of other skills or competencies. In fact, psychologists have documented the importance of personality competencies in predicting academic performance since the mid-1960s (Gough 1964; Gough and Hall 1964). Economists have increasingly turned their attention to skills other than the cognitive ones (e.g., Bowles and Gintis 1976; Bowles, Gintis, and Osborne 2001; Heckman and Rubinstein 2001; Heckman, Stixrud, and Urzua 2006). As discussed in Borghans et al. (2008), while cognitive skills are usually summarized by a scalar random variable, personality competencies are often described by scores along five different dimensions: openness to experience, conscientiousness, extroversion, agreeableness, and neuroticism, which make up the acronym OCEAN.[4]

There is a large amount of evidence that GPA is also affected by noncognitive skills. For example, Duckworth and Seligman (2005) show that self-control outperforms IQ in predicting GPA in high school. Their findings are complemented by the studies by Wolfe and Johnson (1995), de Fruyt and Mervielde (1996), Furnham, Chamorro-Premuzic, and McDougall (2002), Gray and Watson (2002), Barchard (2003), Langford

[4] The definition and description of the following dimensions of personality competencies follow Borghans et al. (2008). Openness to experience measures the need for intellectual stimulation, change, and variety. Conscientiousness captures the compliance with rules, norms, and standards. Extroversion quantifies the capacity to interact socially. Agreeableness rates the need for pleasant and harmonious relations with others. Finally, neuroticism assesses how much the person experiences the world as threatening and beyond control.

(2003), Conard (2006), and many others that find that conscientiousness is an important predictor of college GPA. Noftle and Robins (2007) show that the predictive power of high school GPA on college grades, conditional on SAT scores, is somewhat reduced, but not eliminated, when they add conscientiousness to the regression equation. It is unsurprising that high school GPA reflects such personality competencies. Conscientious individuals are self-controlled and tend to plan and execute their actions. They are the individuals who demonstrate time and again the capacity to sit still and carry out the work to its end, they come to class regularly and have the discipline to control their impulses, and they can be relied on. It is also true that individuals who score high on conscientiousness tend to score high on "need achievement" (N-Ach), which captures an individual's desire for significant accomplishment, the desire to succeed in competition with others, or the desire to meet self-imposed standards of excellence (e.g., Murray 1938; McClelland et al. 1953). Simply put, people who score high on N-Ach see their accomplishments as the end reward, and they would perform at high levels even if monetary incentives were absent. For these individuals, monetary rewards associated with their achievements are seen as an objective way to measure their success.[5]

As Bowen et al. point out, the findings should be interpreted carefully. In particular, they remind the readers that the question should not be whether to test or not, but what to test. Given the importance of content, their policy recommendation is to consider the information from advanced placement exams as well as high school GPAs. The Educational Testing Service has started considering measuring noncognitive skills (Kyllonen 2008). It is important to remember that the predictive validity of the measures was estimated under the context that SAT/ACT scores are a major piece of information used by the colleges. There is no guarantee that the empirical association between any test and its predictive power of college performance will remain the same when extrapolated to a different situation.

For me, the most important lesson from chapter 6 is not its policy recommendation for how to screen potential candidates, but that success in college is partly the consequence of the cognitive and noncognitive skills that are produced prior to college. The book's findings are an invitation for researchers studying the different stages of human capital production to adopt a longer horizon for the estimation of the impact of intervention analyzed in their studies. This has been done in the literature that evaluates the benefits of early childhood programs on final educational attainment (see, e.g., Heckman et al. 2010). Unfortunately, little is known about how improvements in teacher quality, expansion of school choice sets, establishment of charter schools, or

[5] In fact, the experiments by Segal (2008) confirm that individuals who react to monetary rewards when taking IQ tests tend to score low on conscientiousness.

introduction of merit pay for principals, students, or teachers affects college enrollment and college completion, although there are estimates of their impact on immediate outcomes that are usually measured by scores on standardized testing (see, e.g., Rivkin et al. [2005] for teacher quality; Hastings, Kane, and Staiger [2006] for school choice plans; Dobbie and Fryer [2009] and Hoxby and Murarka [2009] for charter schools; and Podgursky and Springer [2007] for merit pay).

B. The Matching of Students to Colleges

Another important topic discussed by Bowen et al. refers to the allocation of students to colleges. The Consortium on Chicago School Research[6] introduced the concept of mismatch to quantify the quality of the allocation. It is this concept that is used in the book that I introduce next. Let q denote a student's quality (i.e., high school GPA and SAT scores). Let Y denote the random variable that takes the value one if a student is accepted into a selective institution (say, a SEL A institution) and zero otherwise. The set $\overline{Q} = \{q|\ \Pr(Y = 1|q) \geq 0.9\}$ represents the set of students with at least a 90 percent chance of being admitted to a SEL A institution. A student is said to be mismatched if he or she has characteristics $q \in \overline{Q}$ but does not attend a SEL A institution. Obviously, another type of mismatch occurs when a student has characteristics $q \notin \overline{Q}$ but does attend a SEL A institution. The authors term the former (the focus of their attention) "undermatches" and the latter "overmatches." In their book, they define the set $\overline{Q}$ as the set of individuals who are presumably qualified to attend college A.

Bowen et al. find that 40 percent of the students who are presumably qualified to attend a SEL A institution did not do so. Mismatches are more likely to occur with minority groups (blacks and Hispanics) and are negatively correlated with SES as measured by family income and parental education. Seventy-five percent of the mismatched students attended a SEL B institution. The authors estimate that the gap in 6-year graduation rates associated with being mismatched is 8.4 percentage points.

It turns out that this concept does not measure the social optimality of allocations, and I will return to this point below when I discuss the market for higher education. For now, it is important to note that mismatches may occur because of choices made by students (they choose not to apply to or to attend a selective university) or choices made by institutions (they reject presumably qualified students in favor of others). The data show that the mismatches occur mostly because of the choices of students: 64 percent of mismatched students did not even

[6] The Consortium on Chicago School Research is a center at the University of Chicago that conducts research with the goal to inform and evaluate policies in the Chicago public schools. For more information, see the Consortium's Web site at http://ccsr.uchicago.edu/content/index.php.

apply to a SEL A institution; 28 percent of them chose not to attend a SEL A institution even though they had been admitted to at least one; and only 8 percent of them were rejected by the SEL A institution.

Let us start by considering the students who did not even apply to the SEL A institution. Economic theory offers different explanations as to why such equilibrium arises and points to interventions that could produce Pareto improvements and, by coincidence, reduce mismatches. The analysis of college applications goes back to the influential study of Gale and Shapley (1962) and is somewhat related to the marriage problem as studied by Becker (1973) and more recently by Shimer and Smith (2000).[7] College application portfolio problems are discussed in Manski and Wise (1983), Nagypál (2004), Chade, Lewis, and Smith (2009), and Fu (2009). These models show that the choice of colleges an individual applies to depends on the individual's perception and precision of his position in the distribution of abilities. It also depends on the costs of application.

Imagine the problem of a high school senior who is facing the choice of applying to two colleges (A and B) that differ in their selectivity. For the sake of consistency, suppose that college A is more selective than B; that is, college A has a threshold quality (q_A) that is above that of college B (q_B). I assume that college j accepts any applicant with quality $q \geq q_j$, $j = A, B$. The high school senior has four options: (1) he does not apply to any colleges (and gets the certain payoff zero), (2) he applies to college B only, (3) he applies to college A only, or (4) he applies to colleges A and B. From the point of view of the student, the uncertainty he faces regarding his ability makes the outcome of the application process uncertain. Let $\hat{q}$ denote the individual's estimated quality. It is important to distinguish two different information cases. In the first case, all individuals have an unbiased estimator of their own quality, $E(\hat{q}) = q$, but they face different amounts of uncertainty regarding their estimated quality, so that Var $(\hat{q})$ varies across individuals. In the second case, all individuals face the same uncertainty, but $E(\hat{q})$ varies across people and some of them may have biased estimators of their own quality.

In the first case, it is possible that two identical individuals facing different amounts of uncertainty make different application choices. It is interesting to focus on the case in which these individuals are high quality and would be readily admitted to college A if they applied there. If the individual's probability that he will be admitted to college A is lower the higher Var $(\hat{q})$ but the probability that he will be admitted to college B is higher the higher Var $(\hat{q})$, then it is possible that the individual with the imprecise estimate of his quality will not apply to

[7] An extensive analysis of the two-sided matching problem can be found in Roth and Sotomayor (1990).

college *A* and only to college *B*. Uncertainty can drive the individual to take a sure small payoff rather than a risky bigger one.

For this model to reproduce the findings that mismatches are more likely to happen with minority groups or individuals from a lower SES, it would be necessary for them to face different amounts of uncertainty. Perhaps this is true for several reasons. The individuals from minority or low-SES groups tend to have fewer relatives who apply and are admitted to college, so their family members may be unprepared to guide them through the process. They may not know how to plan for college. They may also come from high schools in which guidance on the transition to college may be lacking. For all of these reasons, these students may undershoot when applying to colleges.

In the second case, students from minority or economically disadvantaged groups may apply to less selective colleges because their expectation of their quality is downward biased. They may believe that their high school GPA may be a very noisy measure of their position in the distribution of ability because they may recognize that they do not have a random sample of individuals as their classmates. Rather, they recognize that their classmates are a selected sample of individuals, and their relative position in the distribution may not be informative about their position in the population distribution. As the evidence from chapter 6 shows, SAT scores are, at best, a noisy measure of a student's quality. Now, suppose that the conditions surrounding the application of the SAT scores are such that minority students with quality q are more likely to obtain lower SAT scores than nonminority students with the same quality q. This is the situation in which the measurement error associated with the SAT scores has a negative mean for some groups of the population. If minority students take the lower SAT score at face value, they will concentrate their ex post beliefs about their quality to a value that underestimates their true quality. As a result, they will be more likely not to apply to college *A*.

There is evidence supporting the hypothesis that minority groups may underestimate their skills that determine college aptitude. Katz, Roberts, and Robinson (1965) conducted an experiment in which black students were requested to complete a difficult task, termed an eye-hand coordination test for one group and an intelligence test for another group, with either a black or white experimenter. The performance of the black students depended not only on the framing of the test but also on the race of the experimenter. Black students performed much worse when the task was described as a test of intelligence and the experimenter was white. An important follow-up of their study was the series of experiments by Steele and Aronson (1995) that provided evidence that stereotypes suggesting poor performance, when made salient in a context involving the stereotypical ability, could disrupt performance by producing doubt about one's abilities. This issue, however, is far from

being settled because as Sackett, Hardison, and Cullen (2004) show, it is not clear that the poorer performance measured in the experiments is also found in real-life situations. Furthermore, even if it is true, there is a question of its quantitative importance.

In the types of models described above, it is very important to have application costs; otherwise the models would predict that all individuals would apply to all colleges. The immediate costs of application would be those associated with handling the application forms, providing the financial information, paying the application fee, as well as the mailing expenses. However, this reflects only the direct costs associated with the application process. It is possible that the information in the student's curriculum vitae may also influence the colleges' decision, so their choice would reflect not only the high school GPA and SAT scores but other information beyond that. In this case, any specific action that the individuals take to influence the application outcome should also be counted as application costs. Examples of such actions are payments for the firms that coach students on taking the various standardized tests or the firms that provide application consulting services. These costs can be substantial and perhaps influence application choices as well.

The discussion above shows why some qualified minority students may choose to submit their applications to less selective institutions, but they will at least attend a college, and because of their high quality, they have more than trivial chances to graduate. However, there still is a group of students who do not even apply to college even though they are qualified to do so. The evidence from other studies makes these findings even more puzzling. As shown in Cunha, Heckman, and Navarro (2006), there is a nontrivial mass of high school individuals, with high levels of cognitive skills, who would receive high returns to a college education if they chose to attend and graduate from college, but they do not. Why not?

It is possible to go back to the model described above and introduce heterogeneity in terms of the utilities associated with the attendance of college *A* or *B*, heterogeneity in costs, or all of these options and obtain groups of people who may not even apply to college. But this would not add any additional insights to the analysis. Another possibility is that individuals may use much more information beyond high school GPA and SAT scores to determine whether to apply or not; where to apply to; once admitted, whether to accept any of the admission offers or not; and, if so, which one. Cunha, Heckman, and Navarro (2005) estimate the information set of individuals and show that individuals, in fact, use information beyond that available to the econometrician in order to decide whether to apply to and graduate from college or not. Importantly, this information is orthogonal to cognitive and noncognitive skills as measured in survey data. Unfortunately, the method developed in their paper is not powerful enough to pinpoint what this

extra information possessed by individuals is. It could be due to heterogeneity in preference parameters such as time discounting (Frederick, Loewenstein, and O'Donoghue, 2002), risk aversion (Belzil and Leonardi 2007), heterogeneity in tastes for education or in preferences regarding occupations, or a combination of all of the above. Improving our understanding of how individuals make choices regarding a college education, by combining theory and data, will be crucial to proposing policies that can reduce potential welfare losses that arise because of educational choices that may not be Pareto optimal.

C. Financial Aid and the Market for Higher Education

In chapters 8 and 9, Bowen et al. try to quantify the importance of costs and credit constraints in explaining the gaps in college attainment that they document in chapters 3 and 4. Many economists will find very informative their discussion about sources and eligibility criteria for aid and loans.

From the social point of view, individuals may underinvest in education because they face credit constraints (Becker 1964). Credit markets may fail because human capital, unlike physical capital, cannot be used as collateral (Friedman 1962). If it were possible to do so, then a simple solution would be to sell shares of future earnings in exchange for funds to finance the acquisition of skills. Clearly, such a contract would be subject to moral hazard and adverse selection problems and not enforceable. In such a scenario, a policy that encourages credit for human capital accumulation could lead to efficiency gains. Establishing the existence and the importance of credit constraints to investments in a college education is a very important policy question. Many economists have studied the topic exhaustively, and the evidence from a number of studies is that credit constraints, given the policies that are currently in place, do not constitute a major explanation of the college achievement gaps across individuals from different socioeconomic groups. This is extensively documented in Cameron and Heckman (1998, 2001), Keane and Wolpin (2001), Carneiro and Heckman (2002), Cameron and Taber (2004), and Stinebrickner and Stinebrickner (2008).[8]

Investments in a college education may be suboptimal if the private returns are below the social returns. If that is the case, then a policy

[8] Keane and Wolpin (2001) also show that the relaxation of credit constraints can considerably reduce employment while in college, but they found that the reduction in hours worked had little impact on college attainment. Their findings suggest that the correlation between working while attending college and dropping out of college is driven by selection on unobservable components. Their findings are in line with the evidence from Leslie (1984), but not with the evidence from Stinebrickner and Stinebrickner (2003). The authors in the latter study themselves recommend caution in the interpretation of their results because of the special institutional arrangement of the labor market at Berea College.

that subsidizes the costs associated with the investment in postsecondary education could lead to an equilibrium in which the investments are socially optimal. The book contains a rich and helpful description of the research by Bettinger (2004), Dynarski (2004), and others. It is also surprising that there is very little research on investigating the social returns to a college education, and because resources are scarce, it becomes important to identify the marginal productivity of an extra dollar of aid versus an extra dollar spent on informing families about the sources of aid.

It would be helpful to have an economic analysis of the college market in chapter 8 so that noneconomists could see the complications a university faces when deciding about tuition and how to award financial aid, especially that concerning merit-based aid. Consider the following two paragraphs about merit-based awards written by Bowen et al.:

> Second, many of the universities in our study provide substantial amounts of grant aid to students whose family incomes place them in the top half of the income distribution. Although some of these families qualify for need-based aid, many of them receive "no-need" grants, usually based on test scores and high school grades. In fact, the College Board reports that in 2006–07 only 44 percent of student aid grant dollars at public four-year institutions went to students who had financial need. Nearly 40 percent went to non-need students, and 18 percent went to recruited athletes (including a number, of course, who have need). There is no evidence in our data that grants to more affluent students actually influence the likelihood that these students will graduate—nor is it easy to find such evidence in other studies. It is true, of course, that many of these families struggle to meet costs, but the tuitions they pay at public institutions are already subsidized considerably through the appropriations state governments provide to their universities.
>
> Universities offer awards to students who do not have financial need (according to established standards) partly because they may judge that those standards are too severe but largely in order to attract high-quality students to their campuses. Enrolling such students no doubt adds to a university's prestige and reputation, and improving the quality of the entering class may also improve the education of students in general by raising expectations and improving the academic atmosphere on campus. Nonetheless, the policy of using non-need-based aid is problematic; to the extent that competing institutions offer merit awards to the same students, these offers may simply offset each other and have no effect on students' choice of institution. Moreover, investing in a merit-aid strategy leaves

> fewer dollars available for the alternative strategy of providing better grant support to lower-income students, for whom it does improve graduation probabilities. (190–91)

The fact that merit-based awards are so common is a reflection of the inputs and output in the production function of universities and colleges. Educational institutions are special economic units because their customers are part of the inputs in the production function. In terms of their economic organization, universities and colleges resemble clubs whose precise economic definition is well captured by Groucho Marx's famous quote "I wouldn't want to belong to any club that would accept me as a member." It is because of this fact that many researchers try to quantify the economic significance of peer effects in education, and the extensive evidence the book presents in chapter 10 suggests that they are important indeed.

The fact that their customers are part of the inputs used in the production function of outputs introduces two new dimensions that universities need to consider: (1) different students contribute differently to the final output, and (2) when choosing which college to attend, the more productive students may not consider the positive externality they create to the college experience of the other students. Both difficulties can be resolved if the university is allowed to charge different individuals different net tuitions.

The issue of how much each student should pay in net tuition was elegantly analyzed in Rothschild and White (1995). In what follows, I consider a simple version of their model. Suppose that there are N students of type h and N students of type l. The type h students are high-productivity ones, and the opposite is true for type l students. These two types of students are the only inputs used to produce human capital H. I denote by s_h and s_l the number of type h and type l students enrolled at the university, respectively. Assume that the university's production function is $H = s_h^{\alpha} s_l^{1-\alpha}$, with $\alpha \in (1/(2, 1))$. To make the argument as simple as possible, I assume that all students are enrolled so that the total human capital produced is N and the stock of human capital is equally distributed across all students, so that each student gets one unit of human capital.

The university operates in a competitive market and takes prices as given. Imagine the following thought experiment. The university hires type h and type l students at fixed wages w_h and w_l. Then it uses these inputs to produce human capital. Once the human capital is produced, it sells the output back to students charging a unit price p. Under the conditions stated above, it is easy to show that the equilibrium wages and prices are $w_l = 1$, $w_h = \alpha/(1 - \alpha)$, and $p = [\alpha/(1 - \alpha)] + 1$. However, note that the net price paid by each student is different. The high-productivity student pays p for his unit of human capital but receives w_h for his services, so his net price is $p_h = p - w_h = 1$; the low-produc-

tivity student pays the higher net price $p_l = p - w_l = \alpha/(1 - \alpha) > 1$. The differences in the prices reflect the differences in the productivity that each type of student contributes to the production of the final output. In practice, universities charge different students different net tuition through the merit-based award. Contrary to what Bowen et al. suggest, this mechanism ensures efficiency because it allows the university to internalize the positive externality a type causes to all the other types of students.[9] In contrast to what the authors suggest, the evidence presented in Hoxby and Avery (2004) shows that high-productivity students do react to aid packages offered by institutions, and they are willing to sacrifice better peers for more financial aid.

This simple model that describes the market for higher education shows that the mismatch concept used in chapter 5 may convey a very inaccurate picture of the optimality of the equilibrium assignment of students to institutions; as a result, policies that are put in place to reduce mismatches may lead to a reduction in the human capital produced. To see how perverse outcomes can occur when a policy to minimize mismatches is implemented, suppose that there are two colleges, A and B, as well as 10 students of each type h and l. Let

$$G_A(s_h,\ s_l) = \min\{s_h,\ 9s_l\}$$

denote the production function of college A, and write the production function of college B as

$$G_B(s_h,\ s_l) = \min\{9s_h,\ s_l\}.$$

How should students be allocated to colleges A and B if the society's goal is to maximize the human capital it produces?[10] Let s_h^A denote the number of students who are assigned to college A, and define the quantities s_h^B, s_l^A, and s_l^B in similar fashion. It is trivial to show that the society can accomplish this best by setting $s_h^A = 9$, $s_h^B = 1$, $s_l^A = 1$, and $s_l^B = 9$. With this allocation, it can produce 18 units of human capital. Note that 90 percent of the type h and only 10 percent of the type l students are assigned to college A. If productivity is measured by SAT and high school GPA, college A would be a SEL A college. However, 10 percent of the type h and 90 percent of the type l individuals are assigned to college B (SEL B).

Under the mismatch concept defined by the Chicago Consortium, we would see that there is one student with the credentials to be at college A who is actually in college B. We would also see one student

[9] Research has also shown that there is a trade-off between enrolling students that bring an extra dollar of merit-based aid and enrolling another that adds an extra dollar of need-based aid (see Ehrenberg, Zhang, and Levin 2006). This trade-off can be explained by the different productivities that these different types of students contribute to the production of human capital at the institution level.

[10] I have switched from a Cobb-Douglas production function to a Leontief one because the latter formulation considerably simplifies the algebra. The same conclusions would hold for any two concave production functions.

in college *A* who is not a high-quality student, and this constitutes another mismatch. If this society implemented a policy to minimize mismatches, that policy would switch these two students between colleges *A* and *B*. But when this is done, the output would fall from 18 to zero, and this society would be much worse off even though there would be no mismatches.

Clearly, the example above is an extreme one. It assumes that the production function of output is such that the different types of students are perfect complements in the production function of human capital. However, the point I want to make here is that the mismatch concept as defined by the Chicago Consortium and followed in Bowen et al.'s book does not measure the efficiency of the equilibrium allocation in the market for higher education. Because it fails to do so, it should not be used as a measure of success or as the guiding target of a policy that aims to increase the economic efficiency of the market for higher education.

A different question addressed by the authors refers to how tuition policies affect college graduation rates of individuals from different family income groups. To tackle the question, they consider the following thought experiment that is based on the flagship institutions. Let A_1 and A_2 denote selective universities located in states 1 and 2, respectively. Assume that there are two students, S_1 born in state 1 and S_2 born in state 2. If student S_1 attends college A_1, his tuition is \$5,000 a year. If student S_2 attends college A_2, his yearly tuition is \$6,000. Assuming that states 1 and 2 do not have a reciprocity agreement, if student S_1 chooses to attend college A_2, he has to pay the out-of-state tuition, which is \$25,000. The same is true for student S_2 if he chooses to attend college A_1. Because student S_2 was not born in state 1, he cannot take advantage of the better deal that college A_1 offers, and so he is forced to attend a more expensive college. The question the authors want to answer is, will the higher net tuition that S_2 faces affect his chances of graduating from college? They find that "an increase of \$1000 in annual net price is associated with a decline of 3 percentage points in the six-year graduation rate and a decline of 4.5 percentage points in the four-year graduation rates for students in the lowest income group" (183). They do not find any relationship between net price and graduation probability for students in the third and fourth family income quartiles.

There are important qualifiers to be made about this finding. First and foremost, we have to keep in mind that the impressive data set collected and analyzed by the authors is not representative of this cohort of students, as shown in table 1. The issue here is even more serious because the authors are using only the flagship database. The students from low-income families in these institutions have graduation rates very different from those of the nationally representative sample.

Second, as Bowen et al. recognize in endnote 25, the evidence is not

as conclusive as one might have hoped for because the institutions that charge lower tuition may also have services that increase the graduation rates of low-SES students. Under this hypothesis, the increase in graduation rates of low-income students can be enhanced by investing more resources in these services and not by reducing net tuition prices.

Third, the authors take the demand side for granted when they are analyzing the variation in net tuition policies in flagship universities. The concern I have is that one state may have financial aid more concentrated in flagship institutions whereas another state may have it more dispersed across all institutions, flagship and nonflagship alike. Consider the situation in which state 1 focuses a lot of its aid resources into the flagship institution (A_1), whereas state 2 disperses it across all institutions (A_2 and B_2). As a result, college A_1 is much more generous than college A_2, but college B_2 in state 2 may be much more aggressive at trying to attract high-quality students than college B_1 in state 1. In this case, the high-quality students in state 1 would be concentrated in college A_1, whereas a larger fraction of the high-quality students in state 2 would attend college B_2. As a result, the typical student in college A_1 would be more qualified than his counterpart in college A_2, and the findings the authors report would also reflect this difference in the composition of the clientele, perhaps via peer effects.

Fourth, the fact that decreasing college attendance costs leads to higher graduation rates is only half the story. There is considerable heterogeneity in the returns to a college education. It would be very important to quantify the college returns for the individuals who are affected by the policy (e.g., Imbens and Angrist 1994; Heckman and Vytlacil 2005).

One very important suggestion proposed by Bowen et al. refers to the pricing strategies adopted by universities that are part of the state system. The strategy to charge a uniformly low tuition from all the incoming students is essentially one that subsidizes the education of those who need or deserve that as well as the education of those who do not need and do not deserve that subsidy. It is a policy that transfers resources from poor families (whose children are less likely to go to college) to rich families and may not be socially optimal. It is also a policy that limits the resources public institutions have, which leads to the serious consequence that they become limited in adjusting to changing demand conditions, a point emphasized in Bound et al. (forthcoming).

This policy also prevents institutions from protecting themselves against economic downturns. Public universities rely on state budgets to operate. As shown in Kane, Orszag, and Gunter (2003), higher education appropriations closely follow the business cycle, decreasing in recessions and increasing in expansions. This contrasts with the demand for higher education, which tends to increase during recessions because the opportunity costs are lower. By allowing state universities to charge

higher tuition, they could build a self-insurance mechanism designed to smooth the cyclical patterns of appropriations and avoid the termination of important programs, especially the ones that are proved to increase the graduation rates of low-income students with high returns to a college education. As Wellman, Desrochers, and Lenihan (2009) point out, this policy is under way. In 2002, the revenue from net tuition covered only 39 percent of instructional courses. By 2006, the corresponding figure was 49 percent.

IV. Concluding Remarks

Bowen, Chingos, and McPherson have produced a superb and thorough analysis of the higher education system in the United States. They show that black and Hispanic males as well as students from low-SES backgrounds are being left behind. Their finding that dropping out of college is a fact that is not primarily concentrated in the first 2 years points to the importance of having the services to support the students over their entire college experience. Their work comparing the predictive power of SAT/ACT scores against high school GPA questions the validity of the information used by institutions to screen applicants and challenges society to come up with better mechanisms. These are only some of the many findings that I expect will influence policy in the near future.

Most studies become influential not only because of the lessons they offer but also because of the questions and challenges they raise. Throughout the book, we see that families and students face important informational constraints with respect to where to apply and how to secure financing for a college education. From the student's point of view, college enrollment is a risky investment because it entails uncertainty with respect to graduation as well as to the returns from a college education conditional on graduating. On the other side of the market, institutions face uncertainty with respect to the graduation probabilities of the different applicants they meet and have to cope with the uncertainty of nontuition revenues. My reading of the book is that economists and social scientists should devote more effort to understanding the information frictions in the market and identify interventions that can mitigate the socially inefficient outcomes that arise because of this friction.

An obvious point to be made is that these information frictions introduce a nontrivial trade-off between college access and college completion. If society restricts college access, then it will attain a higher graduation rate, but it will be more likely to incur a type I error: colleges will reject many students who would have graduated had they been accepted. However, if society makes college access easier, then the probability of making a type II error increases: colleges will admit a substantial fraction of students who will not finish college. This reality brings new

challenges that need to be addressed by the profession. How much does it cost to improve information and reduce the probability of both type I and type II errors? What is the balance between type I and type II errors that society wants to attain? To answer these questions we need to not only estimate treatment effect parameters but also come up with testable models that can be used to guide policy. The study by Epple, Romano, and Sieg (2006) takes an important step in this direction.

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