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Subsidizing Enjoyable Education

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Abstract

College education is not only an investment; for many people it also generates consumption benefits. If these benefits are normal goods, then the rich attend college at higher rates than the poor. Furthermore, the marginal poor student is smarter than the marginal rich student. Colleges aiming to attract smart students may therefore charge lower tuition to poorer students, even when the colleges lack market power. Moreover, when the social return to education exceeds the private return, allocative efficiency requires government grants to students to be means-tested.

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1 Introduction

Much literature on higher education concerns the empirical pattern that the poor invest less in education than do the rich. At a National Press Club event in the United States, a former College Board official claimed that "The fact is, the dumbest rich kids have as good a chance of going to college as the smartest poor kids."[1] For statistical data, consider students with test scores in the top third of the class of 1992. Only 68 percent of the low-income, high-test-score youth went on to a four-year college within twenty months of high school graduation, compared with 84 percent for youth with the same test scores from high-income families (Ellwood and Kane 2000). The same pattern holds for the middle and bottom test-score groups.[2]

A common explanation for low college attendance by the poor is capital market imperfections—the poor cannot borrow to finance education.[3] Some empirical work (see, for example, Checchi 2003) finds that credit constraints do limit education achievement among the poor; but Checchi (2003) also finds that participation in education, particularly among women, also increases with family wealth independently of financial constraints. Other evidence casts doubt on the importance of credit constraints. For example, Keane and Wolpin (2001) estimate that borrowing constraints little affect school attendance decisions, but that transfers from parents to children do. Cameron and Heckman (1998), Shea (2000), and Cameron and Taber (2004) also find little evidence for credit constraints affecting schooling.

Here we extend Keane (2002) to examine an additional explanation for low college attendance by the poor which can complement borrowing constraints. Many people find the time they spent at school, and particularly at college, as some of the happiest years of their lives. Some of the pleasure undoubtedly has to do with youth. But some comes from the environment—attractive members of the opposite sex, with many opportunities for meeting them; the opportunity to consume services that appeal to youth (such as concerts, movies, plays, football games, and athletic facilities that appeal to twenty-

[1] See National Association of Student Financial Aid Administrators, news release January 15, 2004, at www.NASFAA.org.

[2] The percentages are 33 for the poor versus 59 for the rich in the middle group, and 15 versus 27 for the bottom group.

[3] For theoretical papers that suppose credit constraints limit education by the poor, see, for example, Becker and Tomes (1986), Fernandez and Rogerson (1995), and Restuccia and Urrutia (2004).

year olds); the beauty of the physical surroundings on many campuses; and so on. In short, attending college is not only an investment, but also a consumption good. If the consumption goods available on campus are normal goods, then the rich are more willing to pay for them than are the poor, and so the rich will attend college at higher rates than the poor. Moreover, this consumption benefit may cause some high-ability persons from poor families to skip college, while low-ability people from rich families do attend college.

The idea that education is not merely an investment but also provides consumption benefits is widely acknowledged. Some empirical evidence shows a consumption value of higher education. Lazear (1977), using data on young males in the United States, finds that individuals with much education (M.A.'s and Ph.D's), pursue education beyond the level that maximizes the present value of future income, suggesting that education has consumption value. The reverse holds for lower levels of education. Heckman, Lochner, and Taber (1999), using data on male earnings in the United States, find that individuals in the second-highest ability quartile enjoy large nonpecuniary benefits from attending college; individuals in the other suffer nonpecuniary costs.[4] Using a larger dataset, Carneiro, Hansen, and Heckman (2003) estimate that, when ignoring psychic gains, fourty percent of college attendees would regret it. Once they account for psychic benefits and costs of attending college, only 8 percent of college graduates regret attending college. The authors conclude, therefore, that much of the gain from college is nonpecuniary.[5] Using Dutch data, Oosterbeek and van Ophem (2000) find evidence that schooling is a good that raises future income and generates utility. Alstadsæter (2004) provides similar evidence for Norway.

We shall apply these ideas to address a puzzling phenomenon in higher education—subsidies to the poor. College tuition and government grants to students are commonly means-tested.[6] The literature offers three main argu-

[4] Judd (2000) argues that if a high-ability student expects his financial return from college to equal the return for an average college student, the finding of a nonpecuniary cost for the highest-ability quartile may arise from the correlation between expectational errors and ability. Also note that the second-highest ability quartile (that is, the group which enjoys a nonpecuniary benefit from college) is particularly relevant for our argument as it contains many marginal college students.

[5] Likewise, they find that many of the persons who decide against attending college would incur a nonpecuniary cost when going to college. We discuss the implications in the concluding section.

[6] See the review of tuition policy and student support in thirteen countries by the Irish Department of Education and Science (2003). See National Center for Education Statistics

ments for such means-testing: capital market imperfections, redistribution, and price discrimination by monopolistic colleges. Although all these arguments are appealing, none is fully satisfactory. First, as argued above, little empirical evidence shows capital market imperfections. Moreover, means-tested tuition fees or grants are inefficient ways to correct capital constraints. Lending to students (with repayment conditional on future income) is the efficient and more equitable way to deal with missing capital or insurance markets (see Jacobs and Van Wijnbergen (2007)). Second, though optimal redistribution may require means-tested grants (Dur, Teulings, and Van Rens 2004), the redistribution argument cannot explain why private colleges in a competitive education market charge different tuition to students with different incomes. Third, exploitation of monopolistic power by colleges is unlikely the full explanation for why tuition varies with income. As Epple, Romano, and Sieg (2006, p. 889) note, "The stylized fact that colleges can extract so much revenue from higher income households is clearly an empirical puzzle given many colleges competing for students. ... More future research is needed to find other compelling explanations for this puzzle."

We provide a new rationale for means testing of college tuition and of government grants to students. Recall that our model implies that a rich person with low ability may be willing to pay for college while a poor person with high ability would not. So colleges aiming to attract smarter students may charge poor students a lower price than rich students. Moreover, when the social return to education exceeds the private return, allocative efficiency requires government grants to students to be means-tested. As we will see, our argument for means-tested tuition requires that the average ability of enrolled students declines with income. For means-tested government grants, it suffices that the marginal poor student is smarter than the marginal rich student, which arises naturally in our model when education provides a consumption benefit.

2 Literature

Since Schultz (1960) and Becker (1964) developed the theory of human capital, economists have largely neglected the consumption benefits from education. Exceptions are Alstadsæter (2003) and Malchow-Møller and Skaksen

(2003) for details about tuition and financial aid to students in the United States.

(2004), who study optimal taxation and financing of education when education yields both a pecuniary and a non-pecuniary return. Both papers employ a representative agent framework and so abstract from heterogeneity in ability and in wealth among agents, which are crucial in our model. Bovenberg and Jacobs (2005) and Alstadsæter, Kolm, and Larsen (2007) allow for consumption benefits from education in a model where agents have heterogeneous ability, but no wealth. Keane (2002) discusses both the consumption benefits of school, and the effects of parental transfers on college attendance; he does not, however, consider how colleges and the government will react to the effect of wealth on attendance.

Our paper relates to Wickelgren (2001). He argues that past discrimination can induce non-discriminatory employers or universities to adopt affirmative action in their hiring or admission decisions—a person who overcame discrimination is likely more able than someone in the same position who faced no such obstacle. Likewise, in our paper, colleges charge lower tuition to poor students, who have higher expected ability than the rich students they displace. This difference in ability, however, stems from the consumption benefits of education rather than from past discrimination.

Gary-Bobo and Trannoy (2007) study universities' admission policies under bilateral asymmetric information—both the university and students have private information about students' abilities. Apart from this difference in the information structure, two other important differences with our paper are that in Gary-Bobo and Trannoy (2007) students do not differ in wealth, and that tuition fees are the same for all students.

De Fraja (2005) argues that high-potential individuals from groups with relatively few high-potential individuals ('disadvantaged' groups) should receive higher government grants, since grants to such people entail lower budgetary cost (lower inframarginal subsidies). As we shall see, such a result also appears in our model. We identify two additional reasons (with one also holding even when the government budget constraint does not bind) for why government should give larger grants to poorer people.

3 Assumptions

We suppose college students differ in two ways. First, students differ in ability, denoted by a. Second, they differ in initial wealth, w. Each person knows his own ability, but colleges or the government do not; the colleges and government can only observe a student's wealth.[7] Ability and wealth are distributed according to the joint density function $f(a,w)$. In Sections 4-6 we assume that the ability distribution is independent of wealth; that is, $f(a,w) = f(a)$ for all w. Section 7 relaxes this assumption.

For simplicity, we consider a two-period model. In period 1 a person decides whether to attend college. In period 2, a person who did not attend college has income a. A person who attended college earns $a + p(a)$, where $p'(a) > 0$: the return to college increases with ability.[8] We also assume that $p''(a) = 0$. As we shall see, this assumption allows us to ignore opportunities to work in period 1 by people who do not attend college.

For further simplicity, let consumption of goods occur only in period 2; since we assume perfect capital markets, the simplification does not affect our results. Consumption in period 2 by a person with initial wealth w who did not attend college is $a + w$. Let college tuition be t. It follows that consumption by a person with initial wealth w who attended college is $a + p(a) + w - t$. In Sections 5-7 we allow tuition to depend on a student's wealth $(t(w))$.

The utility from consuming goods is $v(\cdot)$, with the usual properties: $v'(\cdot) > 0$, $v''(\cdot) < 0$, and $v'''(\cdot) \geq 0$. The consumption benefit from attending college is b. This benefit can reflect the opportunities to date members of the opposite sex, to enjoy the sports facilities, to attend exciting football games, to live away from home, and so on. For convenience, let utility be separable in consumption goods and in the consumption benefit of education.[9]

4 College attendance

A person with ability a and wealth w attends college if

$$v\left[a + p(a) - t + w\right] + b \geq v(a + w). \tag{1}$$

[7] This assumption simplifies the analysis, but is more restrictive than we need. In Appendix B, we allow colleges to observe an imperfect signal of each student's ability (e.g., high school grades or scores on standardized tests), as in Fernandez and Gali (1999) and Gary-Bobo and Trannoy (2007). Our qualitative results are not affected.

[8] Most empirical studies find complementarity between ability and education; see Harmon, Oosterbeek and Walker (2003), and Dur and Teulings (2004).

[9] Allowing b to depend on ability a does not affect our qualitative results. Allowing b to depend on w strengthens the results when $b'(w)$ is positive, but may reverse the results when $b'(w)$ is negative.

Let $\alpha(w)$ denote the ability of a person with wealth w, who, in equilibrium, is indifferent about attending college. The following equation describes, for each level of wealth, the people who attend college:

$$v\{\alpha(w) + p[\alpha(w)] - t + w\} + b = v[\alpha(w) + w]. \tag{2}$$

Since smarter students enjoy a higher return to education, $p'(a) > 0$, a person with wealth w and with ability $a \geq \alpha(w)$ attends college.[10] We also have

Proposition 1: If college education has consumption benefits ($b > 0$), then rich people attend college at higher rates than the poor.

Proof: See Appendix A.

The intuition behind this result is simple. If college has no consumption value ($b = 0$), equation (2) reduces to

$$p[\alpha(w)] = t. \tag{3}$$

A person attends college only if the return to education is higher than or equal to tuition. Since the return to education depends only on a person's ability, not on his wealth, college attendance does not depend on wealth. When, however, $b > 0$, condition (2) implies that some students will attend college even when $p(a) < t$. Though attending college reduces their lifetime consumption of goods, they enjoy the consumption benefit, b, of college. By the concavity of $v(\cdot)$, the marginal utility of consuming goods declines with wealth, so a rich person is more willing than is a poor person to reduce consumption of goods in return for the consumption benefits from college. With uniform tuition, the least able poor student in college will therefore be smarter than the least able rich student ($\alpha(w)$ decreases with w). As the ability distribution is independent of wealth, $f(a, w) = f(a)$, this relation also implies that the wealthy will attend college at higher rates than do the poor and that average ability among college students declines with wealth.

[10] If people who do not attend college work in period 1, equation (2) becomes

$$v\{a^*(w) + p[a^*(w)] - t(w) + w\} + b = v[2a^*(w) + w].$$

Our qualitative results continue to hold when p is a linear function of a. When, however, $p(a)$ is concave, a high-ability person may find the opportunity cost of education to exceed the return to education, and so he may prefer working in period 1 over attending college. We ignore this consideration.

4.1 Evidence

The evidence on the relative ability of the poor and of the rich who attend college is mixed, complicated by conscious efforts of colleges to attract minorities, who are often poor. (The possible effect of affirmative action policies on the average performance of different groups is discussed by Linn (1983) and by Vars and Bowen (1998)). If, for example, colleges admit a smaller percentage of White applicants than of Black applicants, then White students will be more likely to have been selected using stringent, though perhaps informal, criteria.

Some evidence is consistent with this view. Rothstein (2004) finds that the average student from a family with low income is less able than is the average rich student. Similarly, Zwick, Brown and Skla (2004) find that for given scores on the Scholastic Aptitude Test, the poor perform somewhat worse in college than do the rich.

On the other hand, data relating to institutions or periods with little affirmative action suggest that the poor who attend college do better than the rich. A study by the Maryland Higher Education Commission finds that community college students who receive need-based financial aid perform at least as well as their wealthier peers. For example, 74 percent of the low-income students who received financial aid returned for a second year of study at their community college, transferred, or earned a credential, compared to 62 percent of non-recipients. Similarly, 40 percent of new full-time freshman who received need-based financial aid transferred to a public four-year institution and/or earned a community college degree within five years of matriculation, as opposed to about one-third of non-recipients. Similar results hold for Texas.[11]

The history of means-tested financial aid at Yale University offers another instructive example.[12] In the Class of 1957, before Yale offered means-tested

[11] For Maryland, see Janis Battaglini, "A comparison of the retention, transfer and graduation rates of need-based financial aid recipients at Maryland public colleges and universities with the performance of non-recipients," February 2004. (http://www.mhec.state.md.us/higherEd/about/Meetings/EdPolicyMeetings/03-10-04/). For Texas, see "Messing with success." *Houston Chronicle*, March 12, 2005, p. B12.

[12] The following is drawn from "The birth of a new institution: How two Yale presidents and their admissions directors tore up the 'old blueprint' to create a modern Yale," by Geoffrey Kabaservice, *Yale Alumni Magazine*, December 1999. (http://www.yalealumnimagazine.com/issues/99_12/admissions.html).

financial aid and practiced needs-blind admissions, graduates of private high schools (who were overwhelmingly wealthy) constituted over sixty percent of the Class of 1957. But they constituted less than half the membership of Phi Beta Kappa (the most prestigious national honor society) and one-sixth of the membership of Tau Beta Pi (the national engineering honor society). The largest feeder schools (Andover, Exeter, Lawrenceville, Hotchkiss, and St. Paul's, which are all private), sent about twenty percent of the class; but each accounted for only one of the 64 members of Phi Beta Kappa. Other traditional feeder schools such as Groton, Hill, Kent, St. Mark's, St. George's, and Taft contributed no members to Phi Beta Kappa. That is, the richest students were under-represented among the high-achieving students.

In 1963 Yale greatly increased its financial aid, and by 1966 adopted a fully needs-blind admissions policy: Yale no longer rejected qualified applicants who could not afford Yale's costs, eliminated any quota on the number of scholarship students, and eliminated limits on total spending for grants and loans. The class entering in 1966 was composed of 58 percent public school students, a higher percentage than ever before, and a jump from 52 percent the previous year. Financial aid jumped to nearly $1 million, a 30 percent increase in one year; gift aid from the University increased by almost fifty percent. This class entered with higher SAT scores than ever before; a student who scored its mean SAT verbal mark of 697 would have been at the 75th percentile of the class that entered four years before.

5 Means-tested tuition

We turn to the behavior of colleges. The topic becomes interesting if a college prefers to enroll smart students. Such a preference can arise for many reasons. 1) Peer group effects within colleges can make increased attendance by smart students benefit other students (see Rothschild and White (1995) and Epple and Romano (1998)). 2) Faculty may find it more pleasant or interesting to teach smart students, and so a college may attract better faculty, or attract a given quality of faculty at lower cost, the better are its students.[13] 3)

[13] At Yale University, the "faculty was astonished and delighted by the leap in academic ability" of freshmen after it changed undergraduate admission policies in the 1960's. See "The birth of a new institution: How two Yale presidents and their admissions directors tore up the 'old blueprint' to create a modern Yale" by Geoffrey Kabaservice, *Yale Alumni Magazine*, December 1999

Studious students may be less likely to behave in ways (such as drunkenness) which may impose costly legal liability on the college. 4) Smart students may enhance a college's prestige and increase future alumni donations.

We find that a simple but fruitful approach is to suppose that a college's costs decline with the quality of its students. Let a college's cost of educating a student with ability a be $c(a)$, with $c'(a) < 0$. Throughout, we assume perfect competition in the market for college education. Perfect competition implies a tuition schedule that makes a college expect to earn zero economic profits on each student. Hence, the tuition, $t(w)$, charged a student with wealth w must equal the expected cost of educating him, or

$$t(w) = \frac{\int\limits_{\alpha(w)} f(a,w)c(a)\mathrm{d}a}{\int\limits_{\alpha(w)} f(a,w)\mathrm{d}a}. \tag{4}$$

Using (3) and (4), we can verify that when $b = 0$, equilibrium tuition is independent of wealth, or $t'(w) = 0$. Suppose instead that richer students are charged higher tuition, or that $t'(w) > 0$. Then equation (3) would imply that α increases with wealth w. Given that ability is distributed independently of wealth, richer students would on average be smarter. As $c'(a) < 0$, the right-hand side of equation (4) then implies that a college's expected average cost is lower when admitting richer students. So when $t'(w) > 0$, the expected cost per student declines with the wealth of the student body, whereas tuition increases with student's wealth. Clearly, if $t'(w) > 0$, then for some w the zero-profit condition (4) is violated. A similar argument applies for $t'(w) < 0$, and for any other nonuniform tuition policy. Only when tuition is uniform, $t'(w) = 0$, can the zero-profit condition hold for all levels of wealth. With uniform tuition, the average ability of students, and so the expected cost per student, will be independent of the wealth of students. So if attending college has no consumption value, tuition will be uniform. Matters differ when students enjoy college.

Proposition 2: If college education has consumption benefits ($b > 0$), then colleges charge higher tuition to richer students ($t'(w) > 0$).

Proof: See Appendix A.

(http://www.yalealumnimagazine.com/issues/99_12/admissions.html).

The intuition behind Proposition 2 is straightforward. By the concavity of $v(\cdot)$, the marginal utility of consuming goods declines with wealth, so that a rich person is more willing than is a poor person to reduce consumption of goods in return for the consumption benefits from college. With uniform tuition, the least able poor student in college will therefore be smarter than the least able rich student, and poor students will on average be smarter than rich students. As a college's cost of education declines with a student's ability, in the competitive equilibrium colleges charge lower tuition to poorer students. In equilibrium, the rich will nevertheless be over-represented in college. For proportional representation would imply equal expected ability and, so, in a competitive equilibrium, uniform tuition.

In equilibrium, some persons who avoid college are smarter than some who attend college. Since the smarter persons get a higher return from education, aggregate output would be higher if they attended college. When, however, externalities are absent, the equilibrium is Pareto efficient. Forcing a poorer but smarter person to replace a richer but dumber student at the same tuition payment would reduce the utility of both students. Though the smarter person would enjoy a higher rate of return and would enjoy the same consumption benefit from education, the tuition payment reduces the poor student's utility from consumption goods more than it reduces the rich student's utility.

6 Government means-tested grants

So far, we ignored externalities from education. Suppose now that, in addition to the private return $p(a)$, education generates a public return $\lambda p(a)$. Of course, only the private return, not the social return, affects an individual's decision to attend college, or affects a college's tuition policy. Subsidies can correct the resulting underinvestment in human capital. We shall see in this section that the consumption benefit from education implies that optimal subsidies are means-tested rather than uniform.

One reason the social return to education may exceed the private return is taxation. If each student ignores how his education increases government's tax revenues, and if the cost of education is incompletely deductible at the same rate as the return to education is taxed, taxation results in underinvestment in education (see, among others, Boadway, Marceau, and Marchand (1996), Anderson and Konrad (2003), and Bovenberg and Jacobs (2005)).

Education can also generate externalities in production. For instance, if innovation increases with the knowledge which workers gained in college, and innovations are afforded imperfect patent protection, then the private return to education is less than the social return. Such externalities feature prominently in models of endogenous economic growth (Lucas (1988), Romer (1986, 1990)). Recent empirical evidence is found in Moretti (2004), and in Teulings and Van Rens (2007); it is surveyed in Sianesi and Van Reenen (2003).

Consider a government that aims to maximize national output net of the costs of college education.[14] The government's objective is thus to

$$\max \int \int^{\alpha(w)} f(a,w) a \mathrm{d}a \mathrm{d}w + \int \int_{\alpha(w)} f(a,w)[a + (1+\lambda)p(a) - c(a)] \mathrm{d}a \mathrm{d}w. \quad (5)$$

Let government affect behavior by providing grants, $g(w)$, to students, which can be conditioned on their wealth. In equilibrium, demand for college becomes

$$v\left\{\alpha(w) + p[\alpha(w)] + g(w) - t(w) + w\right\} + b = v[\alpha(w) + w]. \quad (6)$$

Tuition is still given by (4). For simplicity, we assume that the government has a given budget, denoted by G, for student grants:

$$\int \int_{\alpha(w)} f(a,w) g(w) \mathrm{d}a \mathrm{d}w \leq G. \quad (7)$$

We will consider both a binding and a non-binding budget constraint.

Consider first education with no consumption benefit ($b = 0$). As we saw in the previous section, in equilibrium all people whose return to education exceeds the tuition then attend college. Moreover, tuition is independent of a

[14] Alternatively, we could assume that the government maximizes social welfare. Since, however, utility is concave in consumption goods, our efficiency argument would be intertwined with redistributive concerns. In particular, optimal student grant policies would not only be driven by allocative efficiency arguments, but also by a desire to equalize incomes. Clearly, such income redistribution is better studied in a framework where the government can use additional redistributive instruments, particularly income taxation. For such analyses, see, among others, Ulph (1977), Hare and Ulph (1979), Dur and Teulings (2004), and Bovenberg and Jacobs (2005).

student's wealth and equals the expected cost of education. Hence, if externalities are absent ($\lambda = 0$), optimal student grants are zero ($g(w) = 0$ for all w): grants would induce people whose return to education is lower than the expected costs of college education to attend college. When the social return to education exceeds the private return ($\lambda > 0$), optimal student grants are positive, so that students internalize the externality of their education on national output. Optimal student grants are independent of student's wealth. If grants varied with student's wealth, students receiving high grants would on average be less smart than students receiving low grants. This pattern would reduce output (since $p'(a) > 0$) and increase the cost of college education (since $c'(a) < 0$) compared to outcomes when the government spends the same budget on uniform grants.

Consider next education with consumption benefits ($b > 0$).

Proposition 3: If college education has consumption benefits ($b > 0$), and the government's budget constraint does not bind, then optimal student grants are means-tested ($g'(w) < 0$).

Proof: See Appendix A.

The intuition behind Proposition 3 follows. The consumption benefit from college implies that with uniform grants (or without grants) some poor people not attending college are smarter than the least able rich student attending college. Since the return to education increases with a student's ability, a grant to a poor student has higher social benefits than a grant to a rich student—it induces smarter students to attend college. As shown in Appendix A, when the government's budget constraint does not bind (the shadow cost of public funds is zero), the grant policy must induce the social return to education to equal the marginal cost of education for the marginal student at any given level of wealth:

$$(1 + \lambda)\, p[\alpha(w)] - c[\alpha(w)] = 0, \tag{8}$$

implying that college education is independent of student's wealth. The tuition charged by profit-maximizing colleges will therefore be independent of wealth. But to induce the poor to attend college, government must provide larger grants to poorer students. This can be seen from equations (6) and (8). Note that the means-testing also holds when $\lambda = 0$, that is, in the absence of externalities. Optimality then has government tax college education for the rich and subsidize college education for the poor, so as to increase national output.

Proposition 4: If college education has consumption benefits ($b > 0$), and the government budget constraint binds, then a sufficient condition for optimality of means-tested student grants ($g'(w) < 0$) is that

$$\frac{\int \int\limits_{\alpha(w)} f(a, w)\mathrm{d}a\mathrm{d}w}{f\left[\alpha(w), w\right]}$$

weakly increases with wealth w.

Proof: See Appendix A.

When the government's budget constraint binds (the shadow cost of public funds is positive), achieving full equality of education by means-tested government grants is not optimal. Consequently, among students in college, average ability declines with wealth, and so profit-maximizing colleges will make tuition increase in student's wealth. For three reasons optimal government grants decrease with student's wealth. First, as with a non-binding budget constraint, in the absence of a grant some poor people who do not attend college are smarter than some rich students, so that the social return to increasing education of the poor is larger. Second, because the marginal utility of income declines with income, the poor respond more than the rich to an increase in government grants. Hence, a given increase in college participation is attained at lower cost.[15] Third, an increase in the grant to rich students involves a higher budgetary cost than a similar increase in the grant to poor students, as the rich are more numerous in college than are the poor ($\int \int\limits_{\alpha(w)} f(a, w)\mathrm{d}a\mathrm{d}w$ increases with w). Clearly, this number should be compared with the number of students at the margin, $f\left[\alpha(w), w\right]$, who respond to an increase in the grant. When the condition in Proposition 4 holds, concentrating grants on poor students reduces the government's cost,

[15] Some evidence shows that the price elasticity of demand for higher education indeed declines with income; see, for example, McPherson and Schapiro (1991) and Kane (1994). However, Cameron and Heckman (1999), Dynarski (2000), and Stanley (2003) find no effect or the reverse effect.

as relatively fewer grants are provided to students who would anyway attend college.[16]

7 Generalization: Ability correlated with wealth

We assumed that the distribution of ability is independent of wealth ($f(a,w) = f(a)$ for all w). Clearly, relaxing this assumption may affect our results.

Consider first our result on a college's tuition policy. We saw that when college is enjoyable, poor students are on average smarter than rich students, and so profit-maximizing colleges make tuition increase with student's wealth. When ability is positively correlated with wealth, such discriminatory pricing need not be profitable. Though the marginal rich student will have lower ability than some poor students, rich students may on average be smarter than poor students. The competitive equilibrium may then have tuition decline with wealth. Only when the consumption benefit from education is sufficiently large, will average ability decline with student's wealth, and so will a competitive equilibrium have tuition increase with student's wealth.

Consider next our result on means-tested government grants. When the government budget constraint does not bind, allowing for more general distribution functions does not affect our result. We see this by inspecting (6) and (8). Equation (8) implies that optimality requires α to be independent of wealth, regardless of how ability and wealth are distributed over the population. Equation (6) then implies that grants should decrease with wealth.

Our result on government grants may differ when the government budget constraint binds. First, the effect of an increase in grants to persons with a given wealth depends on the density of students at the margin for that wealth, $f[\alpha(w), w]$. (See the first term in the first-order condition (A6) in Appendix A.) Second, the rich need not necessarily outnumber the poor in college, and so the cost of inframarginal subsidies may be higher for poorer groups. (See the second term in the first-order condition (A6) in Appendix A.) Thus, the trade-off between increasing the social benefits from education and the budgetary cost of grant provision may be affected. Since, at the margin, poorer students are still smarter than richer students, our main argument, that grants to poorer students have higher social benefits than grants to

[16] This third reason is also identified by De Fraja (2005) as an efficiency rationale for discrimination in education.

richer students, holds. The difference in social benefits increases with the consumption benefit from college. So when the consumption benefit from college is sufficiently large, grants will still decrease with student's wealth.

8 Conclusion

We showed that the consumption benefit from attending college makes rich students, who are most willing to pay for the consumption benefit, especially eager to attend college. Among the poor, only the brightest attend college. Hence, when colleges prefer to enroll smart students, in the market equilibrium tuition will be means-tested. Rich students are nevertheless over-represented in college, and the marginal rich student has lower ability than the marginal poor student. To maximize the social return to education, government should therefore means-test grants. The consumption benefit from college can thus provide a rationale for why both college tuition and government grants to students are means-tested.

While abundant evidence shows consumption benefits from attending college (see our overview of empirical studies in Section 1), some studies find substantial heterogeneity in people's preferences for higher education. For instance, Carneiro, Hansen, and Heckman (2003) estimate that many people who decide against attending college would incur a nonpecuniary cost when attending college. These costs (e.g., the pain of studying) likely arise not from college attendance *per se*, but instead increase with the effort a student devotes to studying. If increased studying increases future income, and if the marginal utility of income declines with its level, then effort will decline with a student's initial wealth. When colleges like diligent students, this income effect on student effort could further induce a college to charge poorer students lower tuition. Our model can thus be extended to allow for both consumption benefits and psychic costs of college attendance, with qualitative results similar to those we reported above.

The general effect we identified can apply in areas outside of college. Consider the effects of moving the German capital from Bonn to Berlin. Bonn was an unattractive location, while Berlin is a highly attractive city in which to work and live. Therefore, governmental offices in Bonn may have attracted officials dedicated to public policy; offices in Berlin would also attract people who want a government job not because they like the job, but for the opportunity to work in Berlin. Or think of a professional conference. Organizers who aim to attract people interested in the substance of the conference may hold it in an unattractive location.

Appendix A

Proof of Proposition 1:

Let (1) hold with equality and replace a with α. Totally differentiating with respect to α and w results in

$$\frac{d\alpha}{dw} = -\frac{v'\left[\alpha + p(\alpha) - t + w\right] - v'(\alpha + w)}{\left[1 + p'(\alpha)\right] v'\left[\alpha + p(\alpha) - t + w\right] - v'(\alpha + w)}. \tag{A1}$$

Note that (2) implies that if $b > 0$, then for all w

$$\alpha + p(\alpha) - t + w < \alpha + w.$$

Hence, since $p'(\alpha) > 0$ and $v''(\cdot) < 0$, the expression in (A1) is always negative. Since the ability distribution is independent of wealth, $f(a, w) = f(a)$, this also implies that college participation increases with w.

Proof of Proposition 2:

Let (1) hold with equality; replace a with α and replace t with $t(w)$. Totally differentiating with respect to α and w results in

$$\frac{d\alpha}{dw} = -\frac{[1 - t'(w)]v'\left[\alpha + p(\alpha) - t(w) + w\right] - v'(\alpha + w)}{\left[1 + p'(\alpha)\right] v'\left[\alpha + p(\alpha) - t(w) + w\right] - v'(\alpha + w)}. \tag{A2}$$

Note that (2) implies that if $b > 0$, then for all w

$$\alpha + p(\alpha) - t(w) + w < \alpha + w.$$

Hence, since $p'(\alpha) > 0$ and $v''(\cdot) < 0$, the denominator of (A2) is always positive. The sign of the numerator depends on the value of $t'(w)$.

Suppose that $t'(w) \leq 0$. Then (A2) implies that $d\alpha/dw < 0$, and so, since $f(a, w) = f(a)$, the right-hand side of (4) increases with w. Since $t'(w) \leq 0$ implies that the left-hand side of (4) weakly decreases with w, for some w the zero-profit condition (4) is violated.

If $t'(w) > 0$, then $d\alpha/dw$ may be positive, namely when $t'(w)$ is very large (see (A2)). A positive $d\alpha/dw$ makes the right-hand side of equation (4) decrease with w. Since $t'(w) > 0$ implies that the left-hand side of (4) increases with w, (4) cannot hold in a competitive equilibrium. Only if $t'(w) > 0$ for all w, but is not too large so that $d\alpha/dw < 0$ for all w, will both the left-hand side and the right-hand side of (4) increase with w. Note that $t'(w) < 1$, because $t'(w) \geq 1$ would imply that $d\alpha/dw > 0$. Note also that $0 < t'(w) < 1$ and $p'(\alpha) > 0$ imply that $-1 < d\alpha/dw < 0$.

Proof of Proposition 3:

The government maximizes (5) with respect to $g(w)$ and subject to (4) and (6). At the optimum, for each w the following condition must be satisfied:

$$-\frac{d\alpha(w)}{dg(w)} f\left[\alpha(w), w\right]\left\{(1+\lambda)\, p[\alpha(w)] - c[\alpha(w)]\right\} = 0, \tag{A3}$$

where

$$\frac{d\alpha(w)}{dg(w)} = -\frac{v'\left\{\alpha(w) + p\left[\alpha(w)\right] + g(w) - t(w) + w\right\}}{\left\{1 + p'\left[\alpha(w)\right]\right\} v'\left\{\alpha(w) + p\left[\alpha(w)\right] + g(w) - t(w) + w\right\} - v'\left[\alpha(w) + w\right]} < 0, \tag{A4}$$

which follows from (6). Since both $d\alpha(w)/dg(w)$ and $f\left[\alpha(w), w\right]$ are nonzero, the first-order condition (A3) reduces to:

$$(1+\lambda)\, p[\alpha(w)] - c[\alpha(w)] = 0. \tag{A5}$$

That is, the optimal grant scheme $g(w)$ is such that for the marginal student from each wealth group, the social return to education equals the marginal cost of education. Clearly, this equality implies that at the optimum $\alpha(w)$ is independent of student's wealth. Tuition $t(w)$ will therefore also be independent of student's wealth; see (4). Totally differentiating (6) with respect to w and g, keeping $\alpha(w)$ and $t(w)$ constant, yields

$$\frac{dg}{dw} = -\frac{v'\left\{\alpha(w) + p\left[\alpha(w)\right] + g(w) - t(w) + w\right\} - v'\left[\alpha(w) + w\right]}{v'\left\{\alpha(w) + p\left[\alpha(w)\right] + g(w) - t(w) + w\right\}} < 0.$$

Hence, the first-order condition (A5) is only satisfied when grants decrease with student's wealth, $g'(w) < 0$.

Proof of Proposition 4:

The government maximizes (5) with respect to $g(w)$ and subject to (4), (6), and (7). At the optimum, for each w the following must hold:

$$-\frac{d\alpha(w)}{dg(w)} f\left[\alpha(w), w\right]\left\{(1+\lambda)\, p[\alpha(w)] - c[\alpha(w)] - \Lambda g(w)\right\} - \Lambda \int \int_{\alpha(w)} f(a, w)\mathrm{d}a\mathrm{d}w = 0, \tag{A6}$$

where Λ is the Lagrange-multiplier for the budget constraint, and $d\alpha(w)/dg(w)$ is given by (A4). The first part of the first-order condition (A6) describes the benefits of increasing grants to students with wealth w. Starting from any uniform grant scheme, $g'(w) = 0$, the marginal benefits of grant provision decrease with student's wealth w, for two reasons:

1) Since $\alpha(w)$ decreases with w, $p'(a) > 0$, and $c'(a) < 0$, the term in curly brackets declines with w.

2) By the concavity of $v(\cdot)$, the term $-d\alpha(w)/dg(w)$ declines with w. We can rewrite (A4) as:

$$\frac{d\alpha(w)}{dg(w)} = -\frac{1}{1 + p'[\alpha(w)] + \frac{-v'[\alpha(w)+w]}{v'\{\alpha(w)+p[\alpha(w)]+g(w)-t(w)+w\}}} < 0.$$

Since $p''(a) = 0$, we need only know how the last term in the denominator varies with w. Straightforward algebra shows that since $v''(\cdot) < 0$ and $v'''(\cdot) \geq 0$, the last term in the denominator increases in w. Hence, $d\alpha(w)/dg(w)$ increases in w (or becomes closer to zero as w increases).

The term $f[\alpha(w), w]$ in (A6) may decrease or increase with w, depending on the properties of the distribution function. The marginal benefits of grant provision decrease with w if $f[\alpha(w), w]$ decreases with w. The second part of (A6) describes the budgetary costs of increasing grants to students with wealth w. Since $\alpha(w)$ decreases with w,starting from any uniform grant scheme, $g'(w) = 0$, the marginal cost of grant provision increases with student wealth w. After dividing the first-order condition (A6) by $f[\alpha(w), w]$, the first part of (A6) always decreases with w; if the condition in Proposition 4 holds, the second part decreases with w. Hence, the condition in Proposition 4 is a sufficient condition for the optimality of means-testing government grants.

Appendix B

Suppose colleges observe not only a student's wealth, but also an imperfect signal of a student's ability, which is also observed by the student (e.g., high school grades or scores on standardized tests). Denote this signal by s. With probability $0 < \sigma < 1$, $s = a$; with the remaining probability, the signal is drawn from the distribution of ability described by the density function

$f(a)$.[17] Tuition can then be conditioned on the student's wealth and on the signal of his ability. Thus, tuition for a student with wealth w and signal s is described by $t(w,s)$. In the perfectly competitive equilibrium, tuition charged a student with wealth w and signal s exactly covers the expected cost of educating such a student. Suppose that among students with wealth w and signal s, those with ability $a \geq \alpha(w,s)$ apply for college. In equilibrium, tuition is then:

$$\begin{aligned}
\text{if } s &\geq \alpha(w,s) \text{ then} \\
t(w,s) &= \frac{\sigma f(s)c(s) + (1-\sigma)\frac{f(s)}{\int f(a)da}\int\limits_{\alpha(w,s)} f(a)c(a)da}{\sigma f(s) + (1-\sigma)\frac{f(s)}{\int f(a)da}\int\limits_{\alpha(w,s)} f(a)da} && \text{(A7.1)} \\
\text{if } s &< \alpha(w,s) \text{ then } t(w,s) = \frac{\int\limits_{\alpha(w,s)} f(a)c(a)da}{\int\limits_{\alpha(w,s)} f(a)da}, && \text{(A7.2)}
\end{aligned}$$

where $\alpha(w,s)$ is implicitly described by

$$v[\alpha + p(\alpha) - t(w,s) + w] + b = v(\alpha + w). \tag{A8}$$

Totally differentiating (A8) implies that

$$\begin{aligned}
\frac{d\alpha}{dw} &= -\frac{[1 - t_w(w,s)]v'[\alpha + p(\alpha) - t(w,s) + w] - v'(\alpha + w)}{[1 + p'(\alpha)]\, v'[\alpha + p(\alpha) - t(w,s) + w] - v'(\alpha + w)}, && \text{(A9)} \\
\frac{d\alpha}{ds} &= \frac{-t_s(w,s)v'[\alpha + p(\alpha) - t(w,s) + w]}{[1 + p'(\alpha)]\, v'[\alpha + p(\alpha) - t(w,s) + w] - v'(\alpha + w)}, && \text{(A10)}
\end{aligned}$$

where subscripts denote partial derivatives. Note that if $b = 0$ and $t_w(w,s) = 0$, then $\frac{d\alpha}{dw} = 0$. Hence, if $b = 0$ and $t_w(w,s) = 0$, the right-hand sides of (A7.1) and (A7.2) are independent of student wealth. Clearly, in equilibrium, so should be the left-hand sides, which implies that $t_w(w,s) = 0$. Hence, as in Section 5, in the absence of a consumption benefit from college, tuition is independent of wealth. We can also verify that when $s \geq \alpha(w,s)$, tuition depends on a student's signal. For suppose it would not ($t_s(w,s) = 0$). Then, the right-hand side of (A7.1) decreases with a student's signal (because

[17] Note that $\sigma = 0$ describes the case in the main text, whereas $\sigma = 1$ describes full information about student's ability.

$c'(s) < 0$), whereas the left-hand side is independent of the signal. It follows that in equilibrium $t_s(w, s)$ must be negative for students with $s \geq \alpha(w, s)$; that is, the better the signal, the lower is tuition. Interestingly, students with signal $s < \alpha(w, s)$ all pay the same tuition (see (A7.2)), which is lower than tuition for students with signal $s = \alpha(w, s)$ or with $s > \alpha(w, s)$ but sufficienly close to $\alpha(w, s)$ (compare (A7.1) with (A7.2)). The reason is that among students with signal $s = \alpha(w, s)$, those of marginal ability $\alpha(w, s)$ are over-represented, whereas students with signal $s < \alpha(w, s)$ have an expected ability equal to the average ability of students with wealth w.

Consider next college which generates consumption benefits, $b > 0$. From (A9), it is clear that if $t_w(w, s) \leq 0$, then $\frac{d\alpha}{dw} < 0$. Hence, if $t_w(w, s) \leq 0$, then the right-hand sides of (A7.1) and (A7.2) increase with student's wealth, while the left-hand sides decrease with student's wealth. Therefore, in equilibrium $t_w(w, s)$ must be positive, both for students with signal $s \geq \alpha(w, s)$ and for those with signal $s < \alpha(w, s)$. When $t_w(w, s)$ is positive but not too large, the higher tuition for richer students just makes up for the higher expected cost of richer students, as in Section 5.

Means-tested tuition does not imply that in equilibrium the marginal student's ability is independent of wealth. As in the main text, proportional representation would imply equal expected ability and, so, in a competitive equilibrium, uniform tuition. Hence, in equilibrium, the ability of the marginal student decreases with wealth, implying that means-tested government grants can increase allocative efficiency, as in Section 6.

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