Academic Admissions Standards:

Implications for Output, Distribution and Mobility

Yaakov Gilboa

Sapir College

Moshe Justman

Ben-Gurion University

Abstract

We examine the tradeoffs implicit in academic admissions standards when students are charged cost-based tuition and offered loans that remove liquidity constraints. Lowering entry requirements while holding graduation requirements fixed increases aggregate output and promotes a more equal distribution of wages, but reduces relative income mobility and diminishes the scope for affirmative action. Lowering admissions standards while raising graduation requirements, so that the number of graduates remains constant, has little direct effect on output, distribution or mobility, but again reduces the scope for affirmative action. Income-based affirmative action offers a better tradeoff between output and relative mobility than income-neutral admissions.

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Email addresses: Gilboa <yaakovg@bgu.ac.il>; Justman <justman@bgu.ac.il>

1. Introduction

Recent legislation in Britain aimed at shifting much of the cost of higher education onto students while allowing them to postpone payment until they earn sufficient income (House of Commons, 2004) addresses difficulties that many countries are facing in funding higher education. In many countries public higher education is experiencing severe budgetary pressure as it strives to accommodate growing demand without sacrificing quality or compromising access. Funding arrangements that require students to bear a significant share of the cost of their tuition make it possible to mobilize additional resources for public higher education. The experience of Australia and New Zealand, where such policies are already in place, indicates that this need not limit access to higher education: enrollment rates in these countries are no lower than in countries such as Denmark, France, Germany, Ireland and Sweden that charge little or no tuition (table 1).[1]

This raises the question, whether, when students pay tuition fees that internalize the cost of their education and have available to them loans that remove liquidity constraints, there remains a case in equity or efficiency for applying academic admissions standards to regulate access to higher education rather than relying on the mechanism of the market. With regard to efficiency, Fernandez and Gali's (1999) analysis indicates that such funding arrangements weaken but may not obviate the case for admissions standards, because of the function of higher education as a signaling mechanism. With regard to equity, admissions standards shape the size and composition of the student body and thus affect the future distribution of income and the possibility of social and economic advancement through higher education. Our purpose in this paper is to gauge the magnitude of these effects and so characterize the tradeoffs implicit in admission standards as they affect aggregate output, income distribution and intergenerational mobility.[2]

This is done by simulating different admissions policies within the framework of a calibrated overlapping-generations macroeconomic model that incorporates a centralized system of higher education. Production in the model follows Krusell et al. (2000) in assuming that the elasticity of substitution between capital equipment and unskilled labor is greater than between capital equipment and skilled labor. Higher education performs the dual function of training skilled labor and screening students through the double filter of admissions and graduation standards (Arrow, 1973; Spence, 1973).[3] Employers observe individual ability only imperfectly and therefore pay wages that reflect both their individual productivity and the average productivity of similarly skilled workers.[4] The effect of lowering admissions standards then depends on whether *graduation requirements* are held constant, in which case the number of graduates rises when admissions standards fall; or *the number of graduates* is held constant by raising graduation standards when admissions standards are lowered.[5] In both cases we consider the effect of these policies when they are applied over the time required for a full turnover of the labor force.

Consider first the effect of admissions standards on output when graduation requirements are held constant. This effect is ambiguous in principle because the imprecision of entry indicators results in errors of two types. Worthy candidates, for whom higher education is both privately and socially desirable, but whose entry indicators understate their ability, are denied admission; and less able applicants whose entry indicators overstate their ability are admitted and choose to study, as there are large benefits to be gained from being pooled in the labor market with high-ability skilled workers.[6] Lowering admissions standards reduces errors of the first type while increasing errors of the second type, but our calibrated simulations indicate that the former effect dominates: lowering admissions standards increases aggregate output. This stems from our assumption, following Krusell et al. (2000), that capital equipment is a closer substitute for unskilled labor than for skilled labor.[7]

Next, consider the effect of admissions standards on distribution and mobility. When graduation requirements are held fixed, lowering entry standards increases the number of graduates and diminishes their average ability, which causes the graduate wage premium to fall. This leads to less wage inequality between graduates and non-graduates, measured as a decline in the Gini coefficient, but also undermines the effectiveness of higher education as an instrument of relative income mobility, measured as an increase in the intergenerational correlation of the logarithm of income.[8] Thus, lowering the level of admission standards while holding graduation requirements fixed presents a tradeoff between the advantages of increased aggregate output and greater equality of the wage distribution on the one hand and, on the other hand, the disadvantage of a decline in relative mobility. In addition, lower admissions standards leave less scope for affirmative action in admissions,[9] and we find that income-based affirmative action offers a better tradeoff between relative mobility and aggregate output than income-neutral admissions.

In the second case, when the number of graduates is held fixed—by setting more stringent graduation requirements when admissions requirements are lowered and relaxing them when admissions requirements are raised—the level of admissions standards has no effect on the number of graduates, and so has very little effect on the wage premium, which also leaves wage inequality and relative mobility largely unaffected. Lowering admissions standards while screening more strictly on achievement in coursework aids students from low-income backgrounds only if they are more successful in coursework than in pre-college achievement, but if admissions standards are merit-based there is little reason to expect this to be the case.[10] With regard to aggregate output, some sorting on entry is more efficient than open admissions, as sorting on entry is less costly, and entry indicators generally contain independent information that adds to the accuracy of the signal implicit in the degree. However, we find that the magnitude of this effect is small. Again, sorting more stringently on entry affords more scope for affirmative action.

The approach presented in this paper builds on two important economic perspectives on education: macroeconomic analyses of intergenerational mobility through the accumulation of human capital, in the spirit of Becker and Tomes (1979), Loury (1981), Bénabou (1996), Durlauf (1996), and Hassler and Rodriguez-Mora (2000), to which we add structural detail; and more structured analyses of higher education as a screening mechanism (Arrow, 1973; Spence, 1973; Stiglitz, 1975) characterized by peer-group effects (Danziger, 1990; Loury and Garman, 1993; Epple, et al., 2003), which we extend here to consider macroeconomic tradeoffs between output, equality and mobility in a general equilibrium context.[11] More directly, our analysis of the efficiency of admissions standards bears directly on Fernandez and Gali (1999), which shows that when capacity constraints combine with capital market imperfections, academic screening of applicants is needed to ensure that high-ability applicants from low-income families gain efficient access to education. Finally, the tradeoff we identify between a more equal distribution of income and greater social mobility recalls Checchi et al. (1999), which specifically attributes the greater equality but lesser mobility of Italian society, compared to the United States, to its more egalitarian education system.[12]

The paper is organized as follows: Section 2 describes the analytical model; Section 3 calibrates it to observed empirical values; Section 4 compares different admissions policies as they affect output, distribution and mobility; and Section 5 concludes.

2. The model

We define an overlapping generations model in which parents automatically bequeath innate abilities to their children and invest economic resources in their early development. Children then reach young adulthood with a record of prior achievement that indicates their academic potential. A centralized system of higher education regulates admissions on the basis of this prior indicator, and possibly parental income, and confers a uniform degree on those who choose to study and receive a passing grade. Earning a degree opens the door to employment in skilled jobs. As employers cannot perfectly observe human capital, workers earn a wage equal to a weighted average of the value of their own marginal product and the marginal product of other workers with the same qualification. Young adults anticipate future earnings in deciding whether to study or not, and we require that in equilibrium their anticipations are realized.

2.1 The household, before higher education

Consider an economy with a continuum of households, each comprising a parent and a child. Denote the lifetime income of the parent in household i by y_i, and assume it is distributed lognormally in the population with mean μ_y and variance σ_y^2, ln y_i ~ N

(μ_y , σ_y^2). Denote by a_i the unobservable innate ability of the child in household i and assume that it is positively correlated with parental income:

$$\ln a_i = \ln y_i + u_{ai} \tag{1}$$

where u_{ai} is an independent, normally distributed disturbance term with mean zero and variance σ_{ua}^2.

Parent i invests economic resources b_i in her child's early development but cannot borrow against her child's future income (this is a capital market imperfection that cannot be resolved). Then, assuming parents maximize a utility function that is logarithmic in consumption and education spending, they spend a fixed proportion of their income on the child's early development:[13]

$$b_i = \delta y_i \tag{2}$$

where δ is a positive constant less than one. Innate ability and parental investment in early education together determine the pre-college level of human capital, h_i:

$$\ln h_i = A + \ln a_i + \gamma \ln b_i = A + \gamma \ln \delta + (1 + \gamma) \ln y_i + u_{ai} \tag{3}$$

where A and γ are constants, and (1) and (2) are used to substitute for a_i and b_i. This implies that $\ln h_i$ is also normally distributed, with mean and variance

$$\mu_h = A + \gamma \ln \delta + (1 + \gamma) \mu_y \tag{4}$$

$$\sigma_h^2 = (1 + \gamma)^2 \sigma_y^2 + \sigma_{ua}^2 \tag{5}$$

We assume that individuals know their own human capital h_i but that the admissions process has access only to a stochastic entry score t_i that summarizes their record of prior academic achievement and is positively correlated with h_i

$$t_i = \ln h_i + u_{ti} \tag{6}$$

where u_{ti} is an independent, normally distributed disturbance term with mean zero and variance σ_{ut}^2. After substitution we have

$$t_i = A + \gamma \ln \delta + (1 + \gamma) \ln y_i + u_{ai} + u_{ti} \tag{7}$$

so that t_i is also normally distributed, with the same mean as h_i but larger variance:

$$\mu_t = A + \gamma \ln \delta + (1 + \gamma)\, \mu_y = \mu_h \tag{8}$$

$$\sigma_t^2 = (1 + \gamma)^2 \sigma_y^2 + \sigma_{ua}^2 + \sigma_{ut}^2 \tag{9}$$

2.2 Higher education

There is a centralized system of higher education in the economy that offers a single degree. Admissions requirements to higher education are a function of the observable entry score t_i and parental income y_i. To fix ideas we focus on admissions criteria of the form

$$\phi\, t_i + (1 - \phi) \ln y_i \geq \theta \tag{10}$$

where θ primarily determines the size of the student body and ϕ its composition. We assume that ϕ is positive, so that the left-hand side is always increasing in the entry score t_i, and consider two types of admissions policies with regard to parental income: income-neutral "merit-based" policies that ignore parental income and consider only prior academic achievement ($\phi = 1$); and income-based affirmative action policies that weigh parental income negatively, giving applicants from lower-income households an advantage in admissions ($\phi > 1$).[14] The minimal entry score that an applicant with parental income y_i needs to gain admission is $\underline{t}\,(y_i, \phi, \theta) = [\theta - (1 - \phi) \ln y_i] / \phi$.

Each students pays an annual fee P that equals the cost of tuition. To graduate, students must attend school for T_e years, during which time they cannot work, and earn a passing grade $\underline{s}$. Grades are a stochastic function of human capital:

$$s_i = \ln h_i + u_{si} \tag{11}$$

where u_{si} is an independent, normally distributed disturbance term with mean zero and variance σ_{us}^2. Substitution shows that s_i is normally distributed with the same mean as t and h, $\mu_s = \mu_t = \mu_h$, and a variance of:

$$\sigma_s^2 = (1+\gamma)^2 \sigma_y^2 + \sigma_{ua}^2 + \sigma_{us}^2 \qquad (12)$$

The four variables ln y, ln h, t and s thus have a joint multivariate normal distribution, and by straightforward calculation of the covariances, the correlations between each pair of variables satisfy:

$$\rho_{yt} = (1+\gamma)\, \sigma_y / \sigma_t \qquad (13a)$$

$$\rho_{ys} = (1+\gamma)\, \sigma_y / \sigma_s \qquad (13b)$$

$$\rho_{yh} = (1+\gamma)\, \sigma_y / \sigma_h \qquad (13c)$$

$$\rho_{hs} = \sigma_h / \sigma_s \qquad (13d)$$

$$\rho_{ht} = \sigma_h / \sigma_t \qquad (13e)$$

$$\rho_{ts} = \sigma_h^2 / [\sigma_t\, \sigma_s] \qquad (13f)$$

Students who fail to attain a passing grade drop out of school after T_d years ($T_d \le T_e$) and enter the labor market as non-graduates performing unskilled jobs. Graduation opens the door to skilled jobs.[15]

2.3 Production and wages

Following Krusell et al. (2000) we assume that production in the economy is undertaken by a continuum of identical firms producing a single homogeneous good using the same constant returns-to-scale production function. Aggregate output equals

$$Y = F(H_u, H_s, K_e, K_s) \qquad (14)$$

where H_u is the unskilled human capital of non-graduates, H_s is the skilled human capital of graduates, K_e is the stock of capital equipment, and K_s the stock of capital structures. Let w_u denote the wage per unit of unskilled human capital; w_s the wage per unit of skilled human capital; p_e the rental cost of a unit of capital equipment; and p_s the rental cost of a unit of capital structure. Employers cannot fully or immediately observe individual human capital and so workers expect to earn a lifetime income that is a weighted average of the value of their own marginal product and the average marginal product of all workers in their cohort with the same qualification.[16] Denoting by $0 < \alpha < 1$ the weight of own marginal product in this weighted average, the anticipated net present value of the lifetime income of a young adult choosing not to attend higher education and anticipating a stationary unskilled wage of w_u,[17] equals

$$Y_{ni} = [\alpha\, h_i + (1-\alpha)\, h_u]\, w_u\, (1 - e^{-rT_n})] / r \tag{15}$$

where h_u is the average human capital of non-graduate workers, T_n is the work-life of a worker who chooses not to attend higher education, and r is a discount factor. Young adults who choose to attend university, anticipate that if they fail to graduate they will earn an unskilled wage of w_u for $T_f = T_n - T_d$ years, which, after deducting tuition, yields a net present value of

$$Y_{fi} = -P\,(1 - e^{-rT_d}) / r \; + \; e^{-rT_d}\, [\alpha\, h_i + (1-\alpha)\, h_u]\, w_u\, (1 - e^{-rT_f}) / r \tag{16}$$

If they succeed in graduating, they can expect to earn w_s for $T_s = T_n - T_e$ years with a net present value of

$$Y_{si} = -P\,(1 - e^{-rT_e}) / r \; + \; e^{-rT_e}\, [\alpha\, h_i + (1-\alpha)\, h_s]\, w_s\, (1 - e^{-rT_s}) / r \tag{17}$$

where h_s is the average human capital of a graduate worker.

2.4 The decision to enroll in higher education

Assume that all individuals are risk-neutral, and therefore seek to maximize the expected net present value of their lifetime income given their anticipation of future graduate and non-graduate wage rates and the average levels of graduate and non-graduate human capital; and assume that all individuals share the same anticipated values, which we denote by $\omega = (w_s^e, w_u^e, h_s^e, h_u^e)$. Young adults whose values of y_i and t_i meet the admissions requirements choose to enroll in higher education if they expect this to increase the expected net present value of their lifetime income conditioned on their individual level of human capital and on ω. Denoting the conditional density of s given h_i by $f\,(s \mid h_i)$, individual i expects to gain from attending college if

$$\int_{-\infty}^{\underline{s}} Y_{fi}(\omega) f\left(s \mid h_i\right) ds + \int_{\underline{s}}^{\infty} Y_{si}(\omega) f\left(s \mid h_i\right) ds \;\geq\; Y_{ni}(\omega) \tag{18}$$

where Y_{fi}, Y_{ni} and Y_{si} are defined by equations (15)-(17) and depend on the vector of anticipated values ω. As the probability of successfully graduating and the benefit of a degree increase monotonically in human capital, there is a unique threshold level of human capital $\underline{h}(\omega)$ that satisfies (18) with equality, such that individual i applies to study in higher education if and only if $h_i \geq \underline{h}(\omega)$.

2.5 Equilibrium

We assume that each cohort has measure one and that all capital, labor and product markets are competitive, and focus on an equilibrium in which the value of the marginal product of each of the factor inputs equals its price or wage; all anticipations are realized; markets clear; and the distribution of human capital across graduate and non-graduate labor in each cohort is the same.

To characterize the supply of skilled and unskilled labor, let $g(h, t, s, y)$ denote the joint density of h, t, s and y and assume the admission criterion (10) and the graduation threshold $\underline{s}$ are given. Then the share of graduates in a cohort, given a vector of anticipated values ω, is

$$\varphi_s(\omega) = \int_{\underline{h}(\omega)}^{\infty} \int_{-\infty}^{\infty} \int_{\underline{t}(y)}^{\infty} \int_{\underline{s}}^{\infty} g\left(h,t,s,y\right) ds\, dt\, dy\, dh \tag{19}$$

where, as above, $\underline{t}\,(y) = \underline{t}\,(y,\ \phi,\ \theta)$ is the minimal entry score that an applicant with parental income y needs to gain admission, and $\underline{h}(\omega)$ is the threshold level of human capital given by (18), above which young adults decide to enroll. The share of those who enter university but fail is:

$$\varphi_f(\omega) = \int_{\underline{h}(\omega)}^{\infty} \int_{-\infty}^{\infty} \int_{\underline{t}(y)}^{\infty} \int_{-\infty}^{\underline{s}} g\left(h,t,s,y\right) ds\ dt\ dy\ dh \tag{20}$$

The share of those who do not attend university, either because they choose not to or because they do not meet the entry requirements, is the remainder[18]

$$\varphi_n(\omega) = 1 - \varphi_s(\omega) - \varphi_f(\omega) \tag{21}$$

It follows that the measure of skilled workers in the workforce in steady-state equilibrium is $T_s\ \varphi_s\ (\omega)$, the measure of unskilled workers who enrolled in higher education but failed to graduate is $T_f\ \varphi_f\ (\omega)$, and the measure of unskilled workers who did not enroll in higher education is $T_n\ \varphi_n\ (\omega)$.

Similarly, the total human capital of skilled workers in steady-state equilibrium is

$$H_s(\omega) = T_s \int_{\underline{h}(\omega)}^{\infty} \int_{-\infty}^{\infty} \int_{\underline{t}(y)}^{\infty} \int_{\underline{s}}^{\infty} h\ g\left(h,t,s,y\right) ds\ dt\ dy\ dh \tag{22}$$

so that the average human capital of a skilled worker is

$$h_s(\omega) = H_s(\omega) \,/\, [T_s\ \varphi_s(\omega)] \tag{23}$$

The total human capital of unskilled workers who attended higher education but failed is

$$H_f(\omega) = T_f \int_{\underline{h}(\omega)}^{\infty} \int_{-\infty}^{\infty} \int_{\underline{t}(y)}^{\infty} \int_{-\infty}^{\underline{s}} h\, g\,(h,t,s,y)\, ds\ dt\ dy\ dh \tag{24}$$

and the total human capital of unskilled workers who did not attend higher education is

$$\begin{aligned} H_n(\omega) = T_n \Bigg[& \int_{-\infty}^{\underline{h}(\omega)} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} h\ g\,(h,t,s,y)\, ds\, dt\ dy\ dh \\ & + \int_{\underline{h}(\omega)}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{\underline{t}(y)} \int_{-\infty}^{\infty} h\ g\,(h,t,s,y)\, ds\, dt\ dy\ dh \Bigg] \end{aligned} \tag{25}$$

Consequently, the total human capital of unskilled workers equals

$$H_u(\omega) \;=\; H_n(\omega) \;+\; H_f(\omega) \tag{26}$$

and their average level of human capital is:

$$h_u(\omega) \;=\; H_u(\omega) \,/\, [T_f\, \varphi_f(\omega) \;+\; T_n\, \varphi_n(\omega)\,] \tag{27}$$

Finally, we assume that the supply of capital equipment and capital structures is perfectly elastic at the exogenous prices p_e and p_s.[19]

An equilibrium is then a vector $\omega^* = (w_s^*, w_u^*, h_s^*, h_u^*)$ and stocks of capital equipment and structures, K_e^* and K_s^*, such that:

$$h_s(\omega^*) = h_s^* \tag{28}$$

$$h_u(\omega^*) = h_u^* \tag{29}$$

$$\frac{\partial F}{\partial H_s}(H_u(\omega^*), H_s(\omega^*), K_e^*, K_s^*) \;=\; w_s^* \tag{30}$$

$$\frac{\partial F}{\partial H_u}(H_u(\omega^*), H_s(\omega^*), K_e^*, K_s^*) \;=\; w_u^* \tag{31}$$

$$\frac{\partial F}{\partial K_e}(H_u(\omega^*), H_s(\omega^*), K_e^*, K_s^*) \;=\; p_e \tag{32}$$

$$\frac{\partial F}{\partial K_s}(H_u(\omega^*), H_s(\omega^*), K_e^*, K_s^*) \;=\; p_s \tag{33}$$

3. Calibration

Calibrating the model to observed empirical variables allows us to derive quantitative indications of the tradeoffs between output, distribution and mobility implicit in different admissions policies. We adopt the specific functional form and estimated parameter values in Krusell et al. (2000), a nested Constant Elasticity of Substitution production function:

$$Y = AK_s^{\eta}\{\nu H_u^{\psi} + (1-\nu)[\lambda K_e^{\varsigma} + (1-\lambda)H_s^{\varsigma}]^{\psi/\varsigma}\}^{1-\eta/\psi} \tag{33}$$

with $\eta = 0.117$, $\zeta = -0.495$, and $\psi = 0.401$. This implies an elasticity of substitution of 1.67 between skilled and unskilled labor, and between capital equipment and unskilled labor; and an elasticity of substitution of 0.67 between capital equipment and skilled labor. The remaining parameters are scaling parameters, which are calibrated to 1998 values.

Income, human capital, entry scores and course grades—ln y, ln h, t and s—are assumed to follow a multivariate normal distribution,[20] the parameters of which are related to observed empirical values as follows:

- The mean and variance of the logarithm of parental income, μ_y and σ_y^2, are derived from the distribution of household wage income in the age category 35-54.[21]
- The marginal distributions of entry scores and course grades are assumed to be standardized normal, with $\mu_t = \mu_s = 0$ and $\sigma_t^2 = \sigma_s^2 = 1$. This implies that the logarithm of human capital μ_h also has zero mean.

- The correlation ρ_{yt} between parental income and entry scores is set equal to 0.25—within the range of empirical estimates of the correlation between parental income and pre-college aptitude test scores.[22]
- The correlation between parental income and course grades is assumed to be the same as between parental income and entry scores:[23] $\rho_{ys} = \rho_{yt} = 0.25$.
- The correlation between entry scores and course grades is set equal to:[24] $\rho_{ts} = 0.5$.

The remaining entries of the variance-covariance matrix—σ_h^2, σ_{hy}, σ_{ht}, and σ_{hs}—are then calculated directly from these values (see Appendix A for details of the derivations.) In addition, we set years of study to graduation equal to $T_e = 4$; years of study to failure $T_d = 1$; working years after graduation $T_s = 40$; the household discount rate equal to $r = 4\%$; and tuition and other direct costs of a college education (excluding lost earnings) equal to one third of average unskilled annual earnings.[25]

In calibrating the benchmark case, we assume that admissions are based solely on test scores, and set the entrance threshold equal to $\theta = -0.3$ (three tenths of a standard deviation below the mean), and the final pass score $\underline{s}$ equal to 0.3 (three tenths of a standard deviation above the mean), and set $\alpha = 0.5$. We obtain a first-year enrolment share in higher education of 59.7%, a share of graduates in each cohort equal to 26.9%, a ratio of the average wages of non-graduates to graduates equal to 0.476, and an intergenerational correlation of the logarithm of income equal to 0.369. In comparison, in 1998 the share of individuals of age 25-64 with more than 12 years of schooling in the United States was 54%, the share of college graduates was 27%, and the ratio of non-graduate to graduates wages was 0.492 (Bureau of Labor Statistics and Bureau of the Census, 1999). The consensual estimate of the intergenerational elasticity of income in the United States is "at least 0.4" (Solon, 2002); as offspring's earnings are measured at an earlier age than parental earnings, and so generally have a higher variance, the implicit value for the intergenerational correlation of earnings is lower.[26]

4. Simulations

We now apply our calibrated model to simulate different admissions policies and gauge their effect on output, distribution and mobility after a full turnover of the labor force. First, we hold graduation requirement fixed at $\underline{s} = 0.3$ while varying the entrance threshold θ; and then we vary the admissions threshold θ while adjusting the graduation requirement $\underline{s}$ in the opposite direction so as to hold fixed the share of graduates in each cohort. In each case, we consider both income-neutral merit-based admissions that depend only on entry scores, and income-based affirmative action policies that lower the entrance requirements for applicants from low-income families. For merit-based admissions, we set $\phi = 1$ in equation (10); and for affirmative action we set $\phi = 3.5$, which implies that an applicant i with twice the parental income of applicant j faces an entry threshold that is half a standard deviation higher than applicant j's threshold. For each admissions policy we calculate labor income net of the direct cost of higher education, as a measure of aggregate output; the Gini coefficient, as an inverse measure of inequality; and the intergenerational correlation of the logarithm of income, as an inverse measure of relative social mobility.[27]

4.1 When graduation requirements are held constant

Figure 1 describes the effect of lowering the entry threshold θ while holding graduation requirements fixed, on the share of first-year enrollment and the share of graduates in each cohort, and on the ratio of non-graduate wages to graduate wages, all of which increase when θ falls. Our simulations indicate that unrestricted enrollment, holding graduation requirements fixed at current levels, would result in enrollment rates of 67%, comparable to the high end of the range of enrollment rates in Table 1.

Figure 2 illustrates the increase in net labor income as a function of the enrollment share, showing that aggregate output is maximized when admissions are unrestricted.[28] This strong result reflects the ability to substitute capital equipment for unskilled labor, which increases the aggregate benefits of higher education; as such it depends crucially on the elasticity of substitution between capital equipment and unskilled labor estimated by Krusell et al. (2000) and on the assumption that the supply of capital adjusts elastically to changes in the supply of skilled and unskilled labor.[29] Introducing income-based affirmative action in the form described above causes a decline in aggregate output for a given enrollment share. When admissions are unrestricted, affirmative action has no significance.

Figure 3 illustrates the impact of admissions standards, again represented by the first-year enrollment share, on intergenerational income mobility and on equality of the distribution of income, measured on the vertical scale respectively as a decline in the correlation of log income across generations and a decline in the Gini coefficient. With or without affirmative action, when admissions standards are lowered and first-year enrollment rises, the increase in the number of graduates, and the consequent decline in the wage premium between graduates and non-graduates, narrows the gap between success and failure, resulting in a more equal distribution of wages. However, it also reduces mobility: less selective higher education results in less variance of next-generation income conditioned on parental income. An exclusive education is more effective in advancing high-ability students from economically disadvantaged backgrounds and allowing them, if they succeed in graduating, to move ahead of those with less innate ability but more affluent parents; and this gain more than offsets—in terms of relative social mobility—the loss of those who fail to enter higher education. This accords with Checchi et al.'s (1999) observation that "a centralized and egalitarian school system may not help poor children, and may take away from them a fundamental tool to prove their talent and to compete with rich children." Income-based affirmative action further increases relative social mobility while having a negligible effect on the distribution of income.

Tables 2 and 3 offer another perspective on the effect of enrollment rates and affirmative action on mobility, presenting enrollment and graduation rates by parental income levels for two levels of total enrollment, 40% and 60%, and for merit-based admissions and affirmative action. They confirm that graduation rates are least dependent on parental income—and therefore relative mobility is highest—when affirmative action is combined with exclusive admissions. But they also illustrate the effect that combining affirmative action with low admissions standards has in providing broader access to higher education and increasing the probability that the children of low-income parents attend higher education and graduate.

These findings indicate a tradeoff between, on the one hand, more aggregate output, a more equal distribution of income and broader access to higher education, and, on the other hand, greater relative income mobility. The tradeoff between distribution and mobility is shown in Figure 4.[30] It recalls Checchi et al.’s (1999) comparison between the greater inter-generational income mobility in the United States and the more equal distribution of income in Italy, which they attribute to Italy's comparatively more centralized and egalitarian school system. Comparing this tradeoff between equality and mobility under merit-based admissions and affirmative action we find a clear advantage for affirmative action, as it has little effect on inequality but a strong positive effect on mobility. However, as Figure 2 indicates this is purchased at some cost of aggregate output. The tradeoff between output and mobility implicit in enrollment rates is illustrated in Figure 5, and again shows a clear advantage for affirmative action. Figure 6 shows that aggregate output and greater equality of the wage distribution go hand in hand: both increase when enrollment increases.

4.2 When the number of graduates is held constant

We next consider the effect of varying admissions requirements while holding the share of graduates constant at its benchmark value of 27%, by varying graduation requirement in the opposite direction to entry requirements. Figure 7 describes the necessary increase in the failure rate as first-year enrolment rises, when the graduation requirement $\underline{s}$ is adjusted to hold the number of graduates constant. Figure 8 illustrates the effect of these changes on net labor income as a function of first-year enrollment. Output is maximized at an interior point that utilizes both entry requirements and graduation requirements in determining who graduates. The variation in output under merit-based admissions is small, but restricting admissions under affirmative action results in a significant loss of output. Figure 9 shows the change in intergenerational income mobility and in equality of the distribution of income as a function of the enrollment share. The impact on the distribution of income is very slight, as income distribution is mostly affected by the graduate wage premium, which varies very little when the number of graduates is held constant. However, substantial increases in mobility can be achieved by combining affirmative action with selective admissions. Comparing figures 8 and 9 we find that under affirmative action, admissions standards again present a tradeoff between output and intergenerational mobility. This tradeoff is shown in figure 10.

5. Concluding remarks

In this paper we explore the effect of academic admissions standards on aggregate measures of output, income distribution, and relative income mobility when students are charged cost-based tuition and offered loans that allow them to spread the cost of their education over their working years. To this purpose we define and calibrate an overlapping-generations macroeconomic model that incorporates a centralized system of higher education. We posit a production function in which elastically supplied capital equipment is a better substitute for unskilled labor than for skilled labor, and assume that higher education both teaches production skills and screens candidates through a double filter of admissions and graduation standards. We then simulate admissions policies of two types: policies that vary admissions standards while holding graduation requirements fixed, causing the number of graduates to increase and the graduate wage premium to fall when entry requirements are lowered; and policies that vary graduation requirements in the opposite direction to the change in entry requirements so that the number of graduates is held fixed. For both types of policies we consider both income-neutral, merit-based admissions criteria and income-based affirmative action, gauging their effect on output, distribution and mobility after a full turnover of the labor force.

Our results indicate that in the first case, when graduate requirements are held fixed, unrestricted access to higher education offers the dual benefit of maximizing aggregate output and minimizing wage inequality while having the disadvantage of minimizing relative intergenerational income mobility, measured as the correlation between the incomes of parents and their offspring. Income based affirmative action improves the implicit tradeoff between output and mobility and between distribution and mobility, compared to income-neutral admissions. In the second case, when graduation requirements are changed in opposite direction to the change in entry requirements so that the number of graduates is held fixed, merit-based admissions standards have little impact on output, income distribution or relative mobility while income-based affirmative action offers a tradeoff between output and mobility and between distribution and mobility. In both cases, lowering admissions standards reduces the scope for affirmative action

Appendix A

The variance-covariance matrix of ln h_i, s_i, ln y_i and t_i

The missing elements of the variance-covariance table are the elements incorporating the unobserved variable ln h_i, the logarithm of human capital.

From equation (13a) we obtain

$$1 + \gamma \;=\; \rho_{yt}\, \sigma_t / \sigma_y \qquad \text{(A.1)}$$

and substituting this in equation (13c) gives

$$\rho_{yh} = \rho_{yt} \sigma_t / \sigma_h \qquad \text{(A.2)}$$

implying that

$$\text{cov}(y, h) = \rho_{yh}\sigma_y\sigma_h = \rho_{yt}\sigma_y\sigma_t = 0.181 \qquad \text{(A.3)}$$

after substituting the calibration values from the text. From equation (13f):

$$\sigma_h^{\,2} = \rho_{ts}\sigma_t\sigma_s = 0.5 \qquad \text{(A.4)}$$

and from equation (13d):

$$\text{cov}(h,s) = \rho_{hs}\sigma_h\sigma_s = \sigma_h^{\,2} = \rho_{ts}\sigma_t\sigma_s = 0.5 \qquad \text{(A.5)}$$

Similarly, from equation (13e):

$$\text{cov}(h,t) = \rho_{ts}\sigma_t\sigma_s = 0.5 \qquad \text{(A.6)}$$

Thus all the elements of the variance-covariance matrix can be expressed as functions of the observed correlations and variances.

Appendix B

The conditional joint distribution of ln h_i and s_i given ln y_i and t_i

Given parental income and the prior test score, the joint conditional distribution of the logarithm of human capital and the final exam score have expectations

$$E(\ln h_i \mid \ln y_i, t_i) = E(\ln h) + \frac{1}{(1-\rho_{yt}^2)}\left[\frac{\rho_{yt}(\ln y_i - E(\ln y))}{\sigma_y}(\sigma_t - \sigma_s\rho_{ts}) + (\frac{\rho_{ts}\sigma_s}{\sigma_t} - \rho_{yt}^2)(t_i - E(t))\right]$$

$$E(s_i \mid \ln y_i, t_i) = E(s) + \frac{\sigma_s}{(1-\rho_{yt}^2)}\left[\frac{(\ln y_i - E(\ln y))}{\sigma_y}(\rho_{ys} - \rho_{ts}\rho_{yt}) + \frac{(t_i - E(t))}{\sigma_t}(\rho_{ts} - \rho_{ys}\rho_{yt})\right]$$

and variance-covariance matrix

$$\sigma^2_{\ln h_i|\ln y_i,t_i} = \rho_{ts}\sigma_t\sigma_s - \frac{\rho^2_{yt}\sigma_t}{(1-\rho^2_{yt})}(\sigma_t - \rho_{ts}\sigma_s) - \frac{\rho_{ts}\sigma_t\sigma_s}{(1-\rho^2_{yt})}\left(\frac{\rho_{ts}\sigma_s}{\sigma_t} - \rho^2_{yt}\right)$$

$$\sigma^2_{s_i|\ln y_i,t_i} = \sigma^2_s - \frac{\sigma_{ys}\sigma^2_s}{(1-\rho^2_{yt})}(\rho_{ys} - \rho_{ts}\rho_{yt}) - \frac{\rho_{ts}\sigma^2_{ss}}{(1-\rho^2_{yt})}(\rho_{ts} - \rho_{ys}\rho_{yt})$$

$$\mathrm{cov}(\ln h_i, s_i \mid \ln y_i, t_i) = \rho_{ts}\sigma_t\sigma_s - \frac{\rho_{ys}\rho_{yt}\sigma_s}{(1-\rho^2_{yt})}(\sigma_t - \rho_{ts}\sigma_s) - \frac{\rho_{ts}\sigma_t\sigma_s}{(1-\rho^2_{yt})}\left(\frac{\rho_{ts}\sigma_s}{\sigma_t} - \rho^2_{yt}\right)$$

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Table 1. Net tertiary enrollment rates (%)

Australia	65	Korea	49
Austria	34	Mexico	26
Belgium	32	Netherlands	54
Czech Republic	30	New Zealand	76
Denmark	44	Norway	62
Finland	72	Poland	67
France	37	Slovakia	40
Germany	32	Spain	48
Hungary	56	Sweden	69
Iceland	61	Switzerland	33
Ireland	38	Turkey	20
Italy	44	United Kingdom	45
Japan	41	United States	42

Source: OECD (2003, table C2.1)

Table 2 Enrollment rates by parental income deciles, fixed graduation requirements

	Total enrollment rate: 40%		Total enrollment rate: 60%	
Decile	Merit based	Affirmative action	Merit based	Affirmative action
1	24%	30%	38%	44%
2	30%	34%	48%	52%
3	33%	36%	53%	56%
4	36%	38%	57%	58%
5	39%	40%	60%	60%
6	41%	41%	63%	62%
7	44%	42%	65%	64%
8	47%	44%	68%	66%
9	50%	46%	72%	68%
10	56%	49%	76%	70%

Table 3 Graduation rates by parental income deciles, fixed graduation requirements

	Total enrollment rate: 40%		Total enrollment rate: 60%	
Decile	Merit based	Affirmative action	Merit based	Affirmative action
1	7%	8%	12%	13%
2	11%	11%	17%	17%
3	13%	13%	20%	20%
4	15%	15%	23%	22%
5	17%	16%	25%	24%
6	19%	18%	28%	26%
7	21%	19%	30%	29%
8	24%	21%	34%	31%
9	28%	24%	38%	34%
10	34%	29%	45%	40%
total	19%	17%	27%	26%

Figure 1. The effect of admissions standards on enrollment and graduation shares and the wage ratio when graduation requirements are fixed

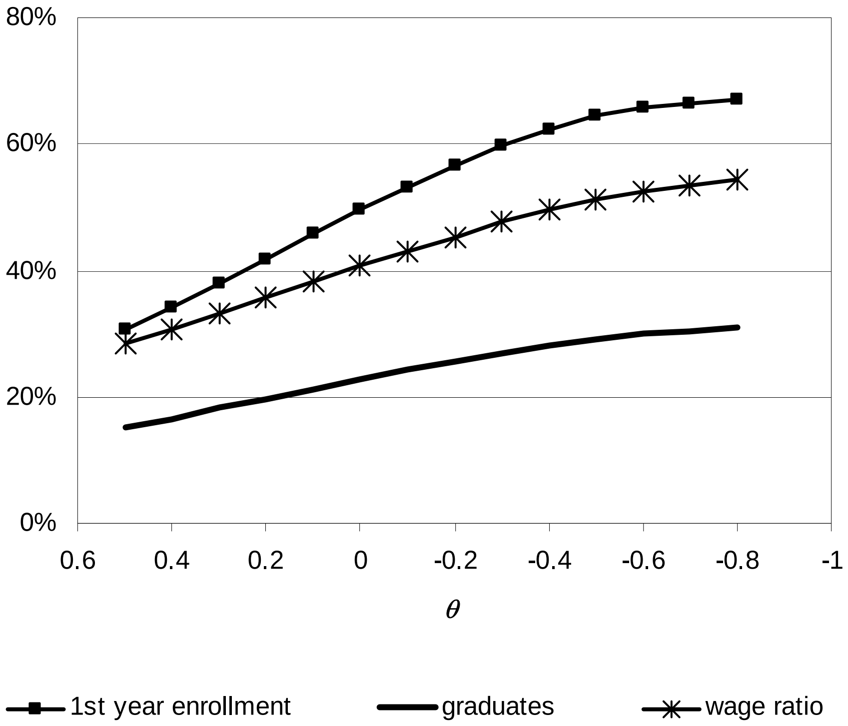


Figure 2. The effect of enrollment on efficiency when graduation requirements are fixed

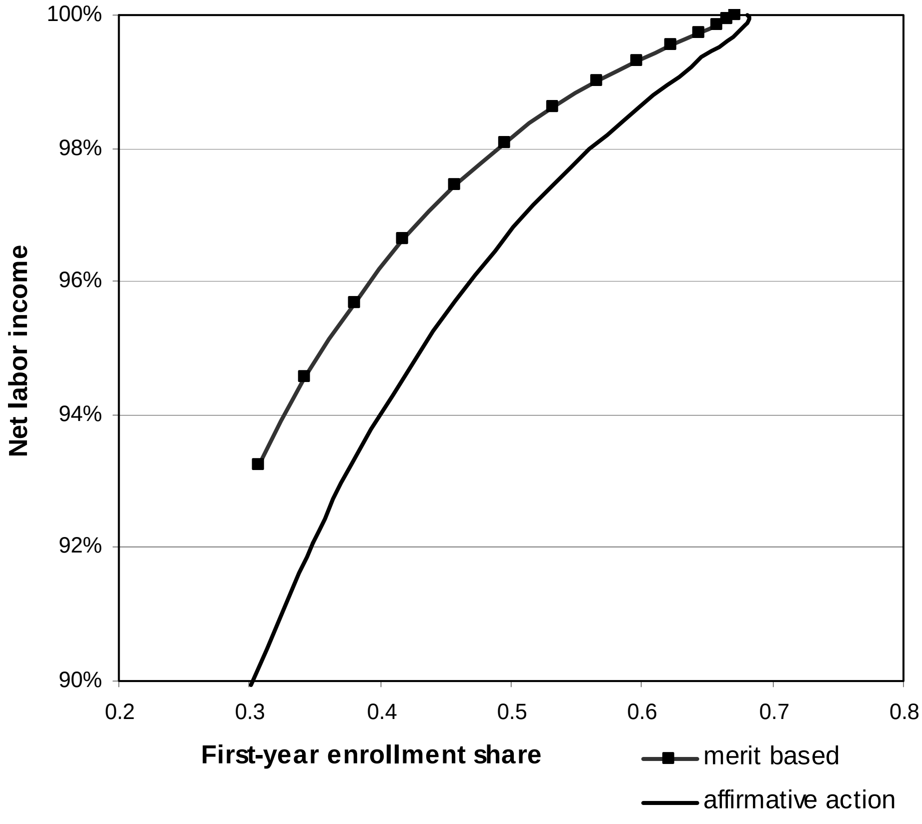


Figure 3. The effect of enrollment on equality and mobility with graduation requirements fixed

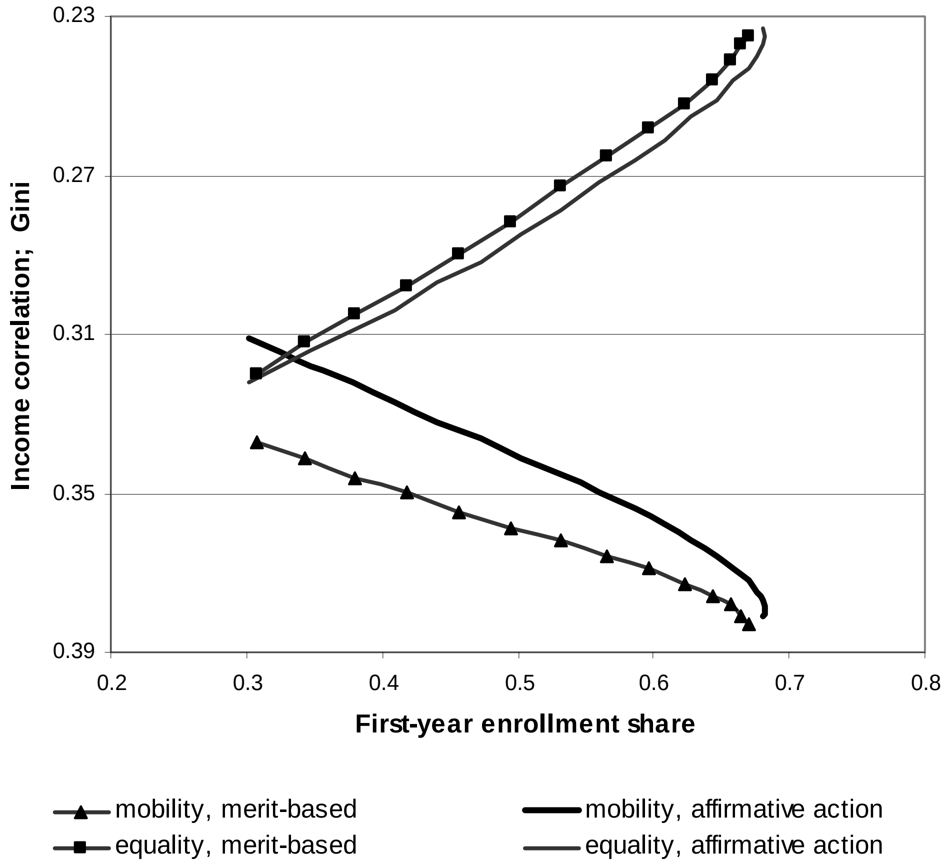


Figure 4. The tradeoff between equality and mobility when graduation requirements are fixed

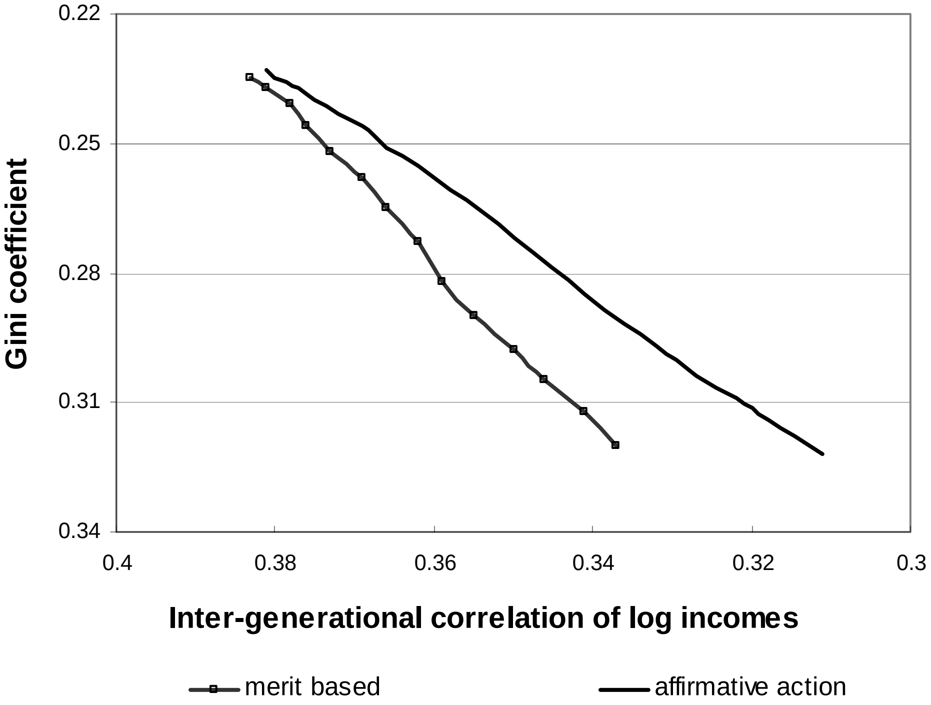


Figure 5. The tradeoff between efficiency and mobility when graduation requirements are fixed

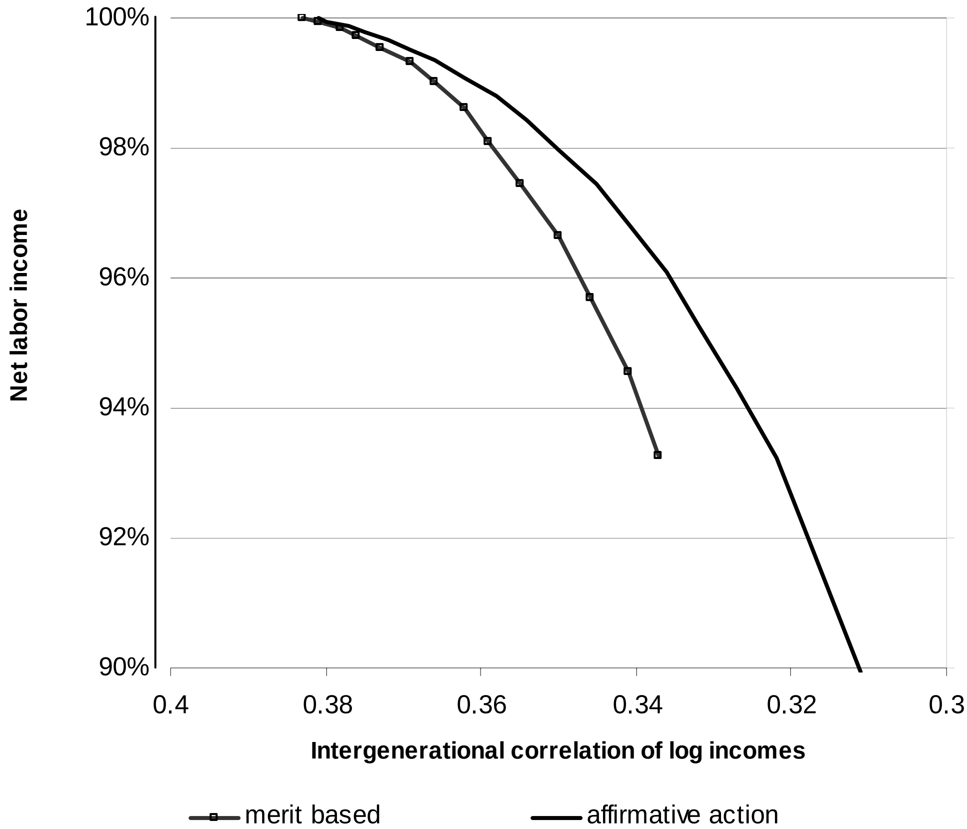


Figure 6. The tradeoff between efficiency and equality when graduation requirements are fixed

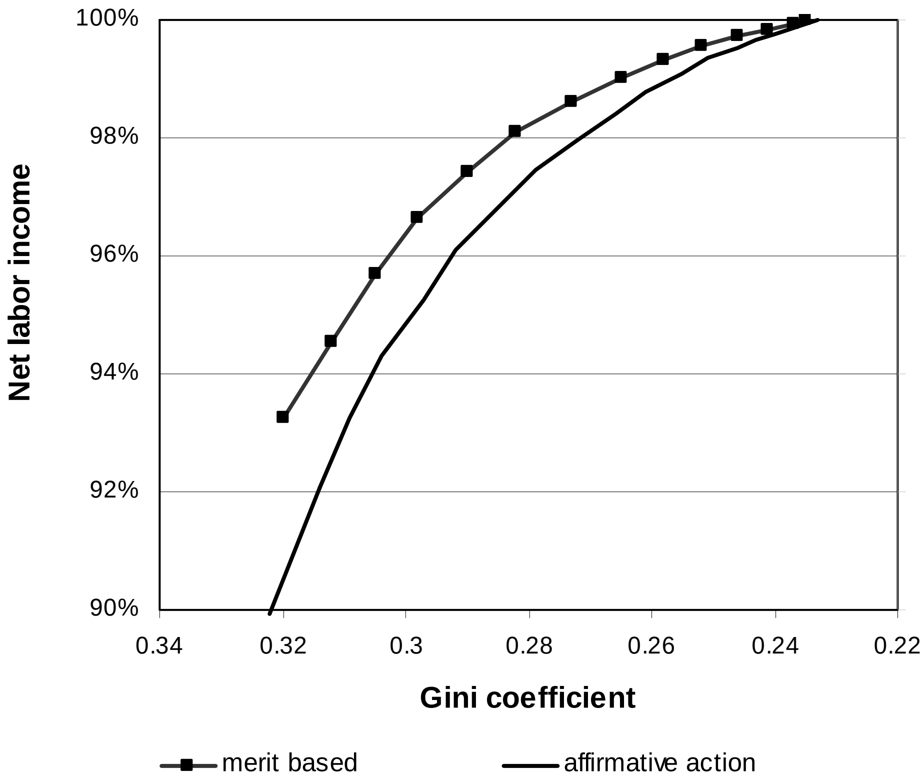


Figure 7. Variation in the failure rate when enrollment rises and the graduate share is fixed

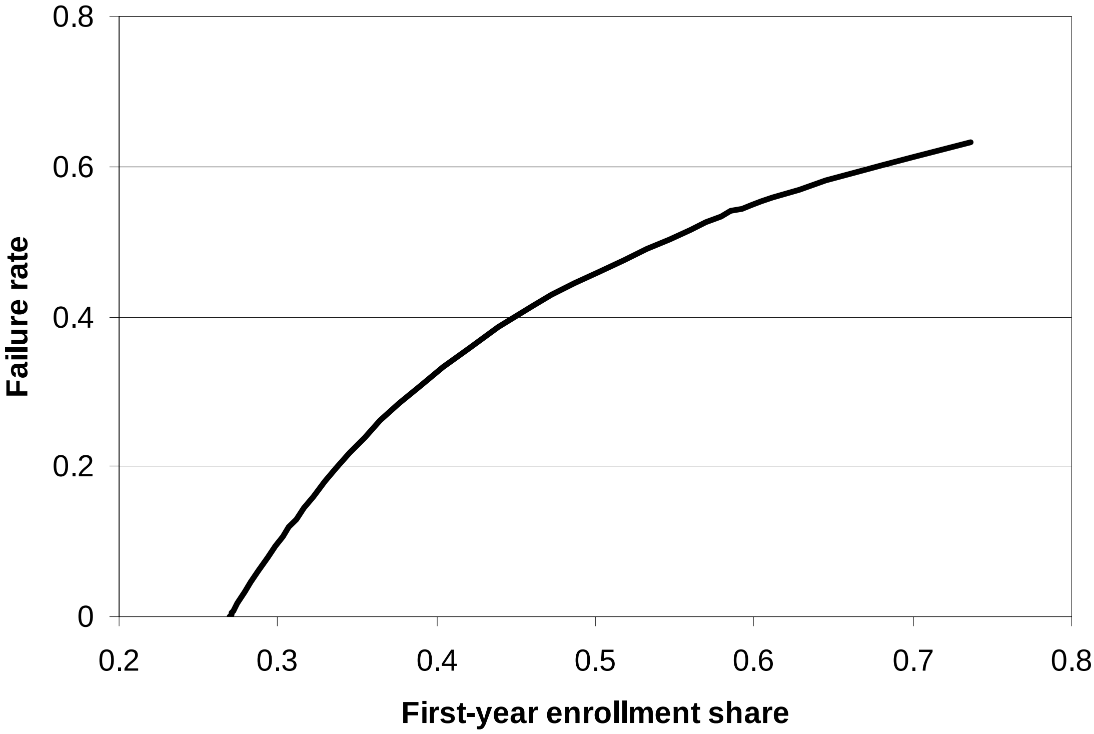


Figure 8. The effect of enrollment on efficiency when the graduate share is fixed

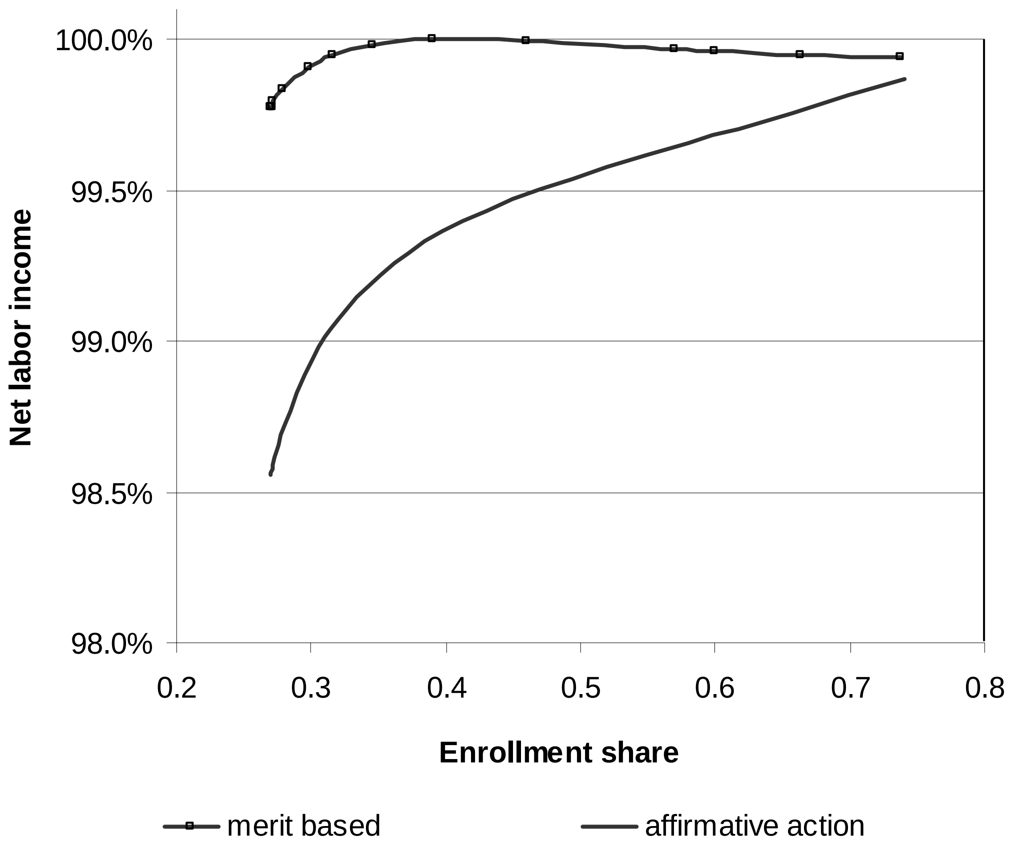


Figure 9. The effect of enrollment on equality and mobility when the graduate share is fixed

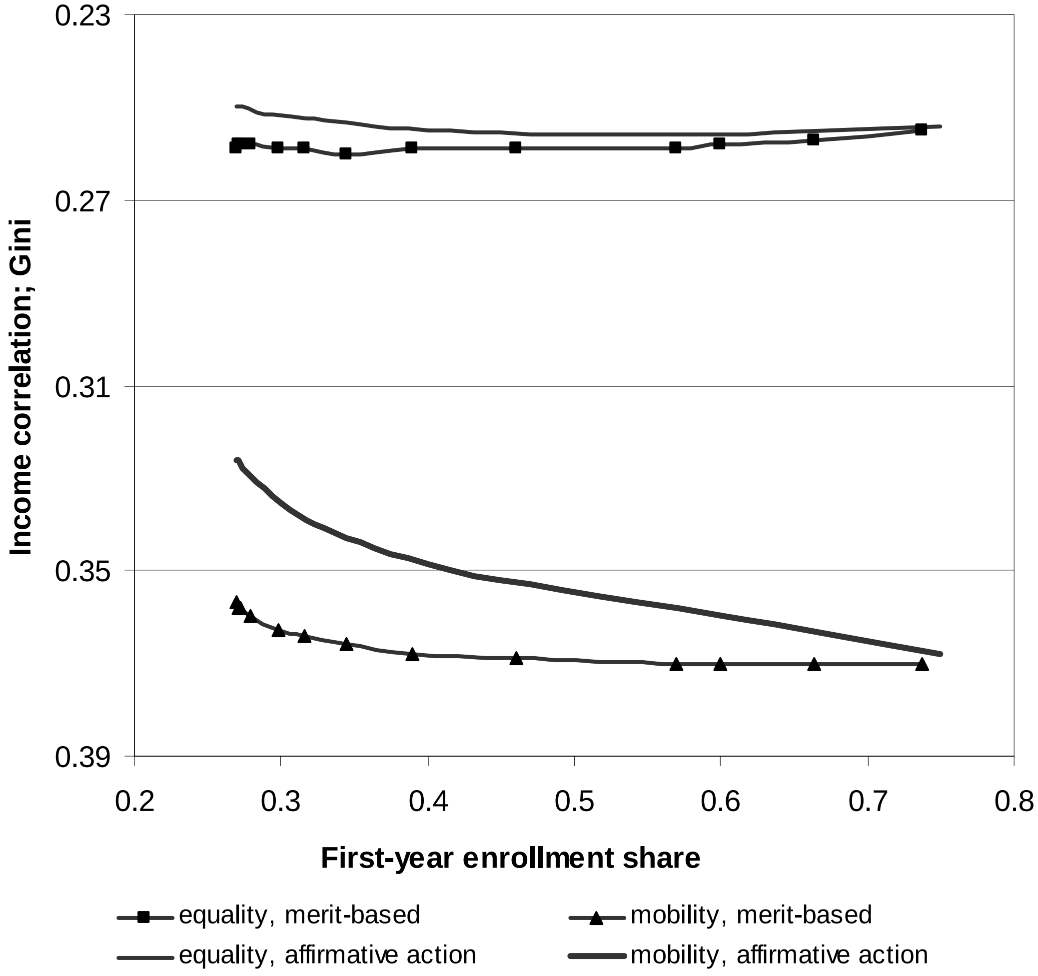
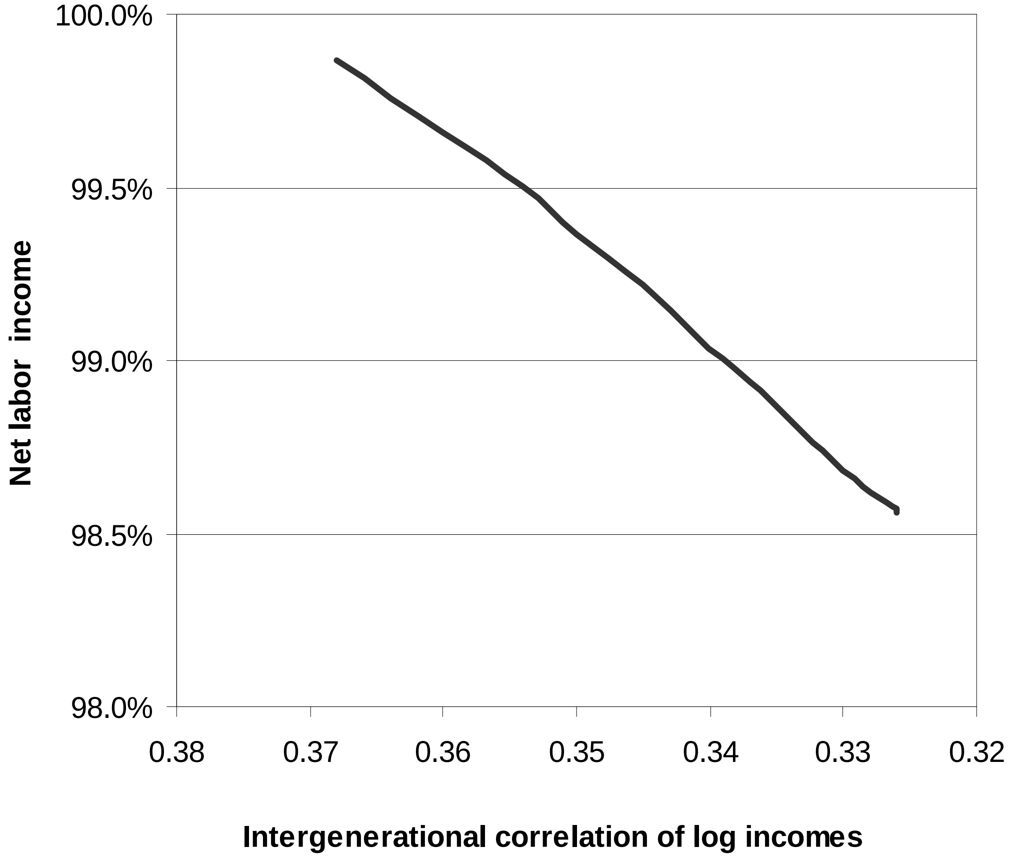


Figure 10. The tradeoff between efficiency and mobility under affirmative action when the graduate share is fixed



[1] On higher education funding in Australia, see Department for Education Science and Training (2004); on New Zealand, see Ministry of Education/Tertiary Education Commission (2003); for an overview of higher education funding in various countries see Department for Education Services (2004). In the United States, where tuition accounts for a substantial fraction of costs, empirical evidence indicates that liquidity constraints have largely been resolved through a combination of student loans, work-study programs, need-based grants and subsidized tuition in public universities (Carneiro and Heckman, 2002; Cameron and Taber, 2004).

[2] Normative conclusions will depend also on perceptions of entitlement and fairness that we do not address here. Free access to higher education may be viewed as a desirable end in itself, irrespective of its economic value; stringent sorting on entry coupled with lax graduation standards may be viewed as inherently unfair, as many of those who fail to gain entry rightly believe that they would have graduated if given the chance (Admissions to Higher Education Steering Group, 2003). In general, normative conclusions will depend on the parameters of the social welfare function (Cremer and Pestieau, 2004).

[3] We assume that acquiring skill by graduating from university is a dichotomous variable and that the direct cost of a degree is constant. Moreover, graduation is a stochastic process affected only by innate ability—we do not model student effort or other aspects of the education process (Betts, 1998). Econometric estimates of the production function of higher education, linking school inputs and selectivity in admissions to measures of education output such as early career earnings or entry to select graduate schools, yield ambiguous results (Ehrenberg, 2004).

[4] This introduces peer-group externalities in the labor market. Peer-group

externalities in the education process do not figure in the model. They are important for the admissions policies of an individual institution concerned only with the performance of its own graduates (Epple et al., 2003) but less so for a centralized public system of education.

[5] In either case, the technical efficiency of the education process is assumed not to be affected by either admissions or graduation standards except as ability affects the probability of graduation. When graduation standards are held fixed we implicitly assume that this ensures the quality of the degree; when they are allowed to vary, opposite variation in admissions standards is assumed to balance it out. Of course, if lower admission standards drag down graduation requirements—a case we do not consider here—the quality of education will decline.

[6] They choose to study despite knowing that their entry indicators exaggerate their ability. We assume that students generally know more about their chances of graduating than the institutions to which they apply. This seems reasonable in general, as universities must sift through large number of applicants with whom they have little personal contact, and applicants have some control over what information admissions officers see.

[7] This result also depends on the supply of capital adjusting elastically to increases in the supply of skilled labor. Simulations not reported here show that if the supply of capital is perfectly inelastic then some restriction of admissions will increase aggregate output.

[8] This is a measure of relative mobility that is closely related to the most common econometric measure of intergenerational mobility—the elasticity of income with respect to parental income. If the variances in log earnings are about the same for parents and their children, this elasticity approximately equals the correlation of log

incomes (Solon, 2002). We use the correlation of log incomes as our measure of mobility rather than the intergenerational earnings elasticity to distinguish more clearly between mobility and distribution. For other approaches to measuring social mobility see the survey by Fields and Ok (1999), who observe that "the mobility literature does not provide a unified discourse of analysis", and a more recent proposal by Benabou and Ok (2001).

[9] In principle, the same selective bias that affirmative action applies to admissions could be applied to help students from disadvantaged backgrounds graduate more easily, e.g., by offering them extra tutoring. Explicitly lowering the graduation bar for disadvantaged students is far less acceptable and would compromise the value of the degree to a greater extent than affirmative action in admissions. We focus in this paper on income-based affirmative action, leaving for future consideration race-sensitive policies, which predominate in the United States (Bowen and Bok, 1998) and benefit a different pool of candidates (Cancian, 1998). Other important criteria that affect admissions in practice but do not figure in our analysis include diversity and non-academic achievement.

[10] Indeed, there is empirical evidence to the contrary. Studies that regress academic achievement on pre-college test scores find that parents' socio-economic status has an added positive effect (Aitken, 1982; Kane and Spizman,1994; see also note 14 below). Of course, if admissions are not merit-based, but take into account parents' financial contributions, for example, then sorting on achievement in coursework offers considerable scope for improvement in equity.

[11] We limit our attention to peer-group externalities in the labor market (see note 4). In other related work, Costrell (1994) focuses on the negative effect of lowering college admissions standards on pre-college scholastic effort; Betts (1998) considers

the effect of graduation standards on distribution, through their effect on student effort in college; Iyigun (1999) emphasizes the importance, for income mobility, of allocating sufficient public resources to elementary and high school education in the early stages of economic development; and Judson (1998) links micro and macro perspectives on the allocation of resources to primary education.

[12] Also on this point, Bertocchi and Spagat (2004) analyze the role of education systems in perpetuating class divisions

[13] They solve: max $U_i = \delta \ln b_i + (1-\delta)\ln c_i$ subject to $b_i + c_i = y_i$ where b_i is education spending and c_i is consumption spending. This could be motivated by direct altruistic regard for the education of one's child or by a desire to increase the child's earning power (in which case the logarithmic form of the utility function implies that parents' spending on education does not depend on the child's innate ability.)

[14] We also simulated admissions policies that rank applicants by expected human capital, and obtained results that are qualitatively very similar to the merit-based admissions policies reported here. Ranking applicants by expected human capital implies weighing parental income *positively* ($\phi < 1$). Analytically, this follows from the observation that the conditional mean of human capital E ($\ln h_i \mid t_i, \ln y_{it}$) is an increasing function of parental income after controlling for entry scores (Appendix B). Empirically, Aitken (1982) and Kane and Spizman (1994), among others, find a positive association between first-year college grades and parental socio-economic status after controlling for psychometric test scores, and Bowen and Bok (1998) find that SAT tests tend to over-predict African-American students' performance.

[15] Graduation is a dichotomous variable—employers do not look at grades, and do not distinguish between those who fail at college and those who do not enroll. The model could be extended to allow graduation to enhance human capital by a variable

factor of $\beta > 1$, so that a person entering college with human capital h_i graduates with human capital βh_i, where β is a function of university inputs. However, it is not possible to identify β from macro data in the present formulation, as skilled and unskilled labor are distinct factors of production; and identifying it from micro data would require an econometric estimate of the production function of higher education, on which there is as yet no agreement (Ehrenberg, 2004, and notes 3 and 5, above). The absence of a quantitative empirical link between education quality and the cost of education prevents us from applying our approach to explore related issues of optimal quality in higher education.

[16] The individual ability of new workers is initially unknown to employers, and so they receive a wage equal to the average marginal productivity of similarly qualified workers in their cohort. Over time, individual qualities are revealed, allowing employers to pay salaries that more closely reflect their workers' individual marginal products. Weiss (1995) reviews empirical evidence on the relative importance of human capital and signaling in determining wages.

[17] In general, factor prices may vary over time. For simplicity, we limit our analysis to an equilibrium in which individuals anticipate stationary factor prices.

[18]
$$\varphi_n(\omega;\theta,\phi,\underline{s}) = \int_{-\infty}^{\underline{h}(\omega)}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} g\left(h,t,s,y\right) ds\, dt\, dy\, dh + \int_{\underline{h}(\omega)}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\underline{t}(y,\theta,\phi)}\int_{-\infty}^{\infty} g\left(h,t,s,y\right) ds\, dt\, dy\, dh$$

[19] Thus we assume that the duration of a generation is sufficient for capital to adjust to changes in the supply of skilled and unskilled labor without a change in its price.

[20] The multivariate normal distribution provides a tractable framework for parametrizing the joint distribution of these variables. The assumption that income

follows a lognormal distribution is common in empirical work, though other assumptions are clearly possible (see, e.g., Harrison, 1981).

[21] In 1998, the median and average values of household wage income in this age category were \$28,750 and \$37,327 (Bureau of Labor Statistics and Bureau of the Census, 1999). This implies parameter values of $\mu_y = 10.266$ and $\sigma_y^2 = 0.522$.

[22] These vary between 0.17 and 0.3 (Hearn 1984, 1991; Owen 1985; Alwin and Thornton 1984; Paulhus and Shaffer 1981).

[23] This is an arbitrary determination. Because of the wide variation in grading standards, it does not seem reasonable to calibrate ρ_{ys}, the correlation in the population at large, to empirical correlations between parental income and college grade-point averages.

[24] Estimated correlations of approximately 0.5 between pre-college aptitude test scores and first-year college grades provide a point of reference for this value (Bridgman, McCameley-Jenkins and Ervin, 2000; Kennet-Cohen, Bronner and Oren, 1998).

[25] Varying the cost of tuition or the number of years to failure had little effect on the simulation results. This is because education costs are small relative to lifetime earnings, and we have assumed that there are no liquidity constraints on financing higher education.

[26] If ε denotes the intergenerational earnings elasticity obtained from a simple regression of son's log earnings y on father's log earnings x, s_y and s_x respectively denote their sample standard deviations, and r_{xy} denotes their correlation coefficient, then $r_{xy} = \varepsilon\, s_x / s_y$ (Johnston, 1972, p. 34). In Solon (1992), $s_x = 0.69$, $s_y = 0.94$ and the multi-year estimate of ε is 0.413, implying a value of 0.303 for r_{xy}. See also note 8 above.

[27] Thus for each triplet θ, ϕ and $\underline{s}$ we numerically solve the fixed point problem described in Section 2.5 and then calculate measures of output, distribution and mobility. In measuring output we also calculated gross domestic product and obtained qualitatively identical results.

[28] This is an aggregate effect: there are, of course, losers as well as gainers when admissions standards are lowered. And as we observe in note 14 above, more output could be achieved by weighing parental income positively in the admissions process, i.e., by setting $\phi < 1$ in (10).

[29] This is evident from simulation results not reported here, which indicate that if the supply of capital is *perfectly inelastic* some use of entry requirements to restrict admissions increases aggregate output. We focus on the case of elastic supply of physical capital because we assume that changes in the stock of skilled human capital are gradual enough to allow the stock of capital equipment to adapt to these changes without a change in price.

[30] In terms of the overlapping-generations model we use, this is a one-period effect. Over a longer time, the tradeoff between relative mobility and inequality may be less steep. Simulations indicate that greater initial inequality in the parent generation results in less intergenerational mobility between parents and children. Hence, a policy that initially increases both mobility and inequality subsequently loses some of this added mobility due to the increase in inequality. This tradeoff between distribution and mobility holds *a fortiori* if graduation requirements are lowered in order to accommodate the lower ability of students (Costrell, 1993), as this must further erode the graduate wage premium.