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University Admissions Criteria:

Implications for Output, Distribution and Mobility

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Abstract

Centralized criteria for university admissions, based on prior academic indicators and family income, entail implicit tradeoffs between aggregate output, distribution and intergenerational mobility. To identify these tradeoffs, we define and calibrate a formal model of a centralized university that both screens its graduates and enhances their human capital. We then simulate the effect of varying its admissions criteria, finding that: affirmative action can achieve large gains in intergenerational mobility at little cost in forgone output; lowering admissions requirements reduces wage inequality and inhibits intergenerational mobility; and immigration of unskilled labor increases both inequality and mobility if native output is maximized.

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Abstract

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Introduction

Universities, especially public universities, rarely take a market-based approach to student admissions. Rather than opening their doors to anyone willing to pay the cost of an education, they typically screen prospective applicants on the basis of high-school records, aptitude test scores, matriculation grades and other prior indicators of academic ability, while subsidizing the tuition of some, or all, successful candidates.[1] Such policies are often justified on efficiency grounds, as increasing the contribution of a university education to the total output of the economy.[2] However, they also affect the distribution of income within cohorts and the correlation of income across generations, implying that a choice of admissions policy entails tradeoffs between output, distribution and mobility.[3]

In this paper we investigate these tradeoffs through a formal model in which peer-group externalities in the labor market for college graduates provide the economic basis for applying academic criteria to regulate university admissions.[4] To focus the analysis on aggregate measures of welfare, we stipulate a centralized university system that offers a uniform course of study towards a single degree, and sets entrance requirements that are a function of prior academic achievement and socio-economic background. Young adults who meet these entrance requirements decide whether to attend university and earn a degree with a probability that is correlated with their human capital,[5] or enter the workforce immediately as non-graduates—basing their decisions on their anticipation of future wage rates. Earning a degree opens the door to graduate occupations and proportionately increases graduates' human capital. However, because employers cannot precisely monitor individual productivity, graduate workers earn a lifetime income that is proportional to a weighted average of individual human capital and the average human capital of all graduates.[6] In equilibrium, young adults' initial anticipation of future wages matches actual wages determined by supply and demand in the labor market.

The model is calibrated to observed benchmark values of college enrolment shares, graduation rates, wage levels, and correlations between parental income, aptitude test scores, university grades, and filial income. Simulated variation of the university's admissions policy then provides quantitative indications of the tradeoffs between output, distribution and mobility implicit in different admissions criteria—initially for an economy with a fixed population, closed to migration. We then extend the analysis to allow immigration of non-graduate immigrant labor in fixed quotas under two alternative political regimes that respectively maximize domestic and native output per capita.

We find that lower admissions standards, by lowering the return to higher education, reduce wage inequality within cohorts,[7] but at the same time also inhibit intergenerational mobility. Mobility is best served by combining stringent admissions criteria with income-based affirmative action, which gives the most help to talented applicants from less advantaged backgrounds.[8] Moreover, large gains in social mobility can be achieved with little cost in forgone output, because of the small productivity differential between the infra-marginal applicants from affluent backgrounds who are displaced by affirmative action, and the extra-marginal applicants from disadvantaged backgrounds who benefit from it.[9] This tradeoff between distribution and mobility implicit in the choice of admissions criteria, recalls Checchi et al.'s (1999) characterization of Italy as more equal but less mobile than the United States, which they attribute to its egalitarian university system. In an economy open to migration of non-graduate labor, the same tradeoff is implicit in the selection of political goals. Maximizing domestic output per capita entails a large expansion of higher education, resulting in a more equal but less mobile economy for the native born than maximizing native output per capita, which is achieved by restricting growth in higher education.[10]

The paper is organized as follows: Section 1 describes the analytical model. Section 2 calibrates it to observed empirical values. Section 3 compares different admissions policies, quantifying the tradeoff between output, distribution and mobility; and Section 4 concludes.

1. Description of the model

We posit an economy with a fixed population of households in which parents automatically bequeath innate abilities to their children and invest resources in their early education. Children reach young adulthood with a record of achievement that provides an imperfect indication of their abilities, and may then apply to study at a university that confers a single uniform degree contingent on passing a final examination. The university's admissions criteria are based on this record of achievement and, possibly, parental income.

1.1 The household, before applying for university studies

Consider an economy with a continuum of households of measure one, indexed by i, each comprising a parent and child. The parent is endowed with a (lifetime) income y_i that is distributed lognormally in the population, $\ln y_i \sim N(\mu_y, \sigma_y^2)$. She passes on to her child an unobservable innate ability a_i, and invests resources b_i in her child's early education. We assume that the child's ability is correlated with her parent's income, and to fix ideas posit

$$\ln a_i = \ln y_i + u_{ai} \quad (1)$$

where u_a is an i. i. d. disturbance term, normally distributed with variance σ_{ua}^2 and zero mean. Assuming further that parental utility is a logarithmic function of consumption and education spending, and that parents cannot borrow against their children's future income,[11] parents spend a fixed proportion of their income on children's early education

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

where δ is a common constant.[12] The child's innate ability and her parent's investment in her early education together determine the (unobservable) level of her human capital upon reaching university age:

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

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

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

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

Although human capital is not directly observable at this stage, there are indirect indicators that are available—high school grades, matriculation results, psychometric test scores, and so on—which we assume are summarized by the variable t_i

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

where u_{ti} is i.i.d., and follows a normal distribution with zero mean and variance σ_{ut}^2. Then after repeated substitution,

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

so that t_i is also normally distributed, with mean and variance

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

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

1.2 The university system

There is a single university (or university system) in the economy that offers a single degree course lasting T_e years, for which it charges a fixed fee P that exactly equals the cost of tuition, and sets admissions standards and graduation requirements.[13] Graduation opens doors to jobs that require a college degree, and enhances one's human capital by a factor of $\beta > 1$, i.e., a person entering university with human capital h_i exits upon graduation with human capital βh_i.[14] For simplicity, we assume that acquiring a university degree is a dichotomous variable—employers do not look at final grades, and studying at university without graduating has neither positive nor negative value in the labor market.[15]

The university publicly sets admission requirements that are a function of the indicators t_i and y_i, which are assumed to be observable both by the applicant and by the university. To fix ideas we focus on linear admissions criteria of the form

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

where the threshold parameter θ can be thought of as determining the size of the higher education sector, while the parameter ϕ determines the composition of the student body. We assume that ϕ is non-negative, so that the left-hand side is (at least weakly) increasing in t_i, but parental income may affect admissions in different ways. We consider three types of admissions policies. A university system of fixed size geared to maximizing the expected earnings of its students, ranks applicants by expected human capital, conditional on test scores and parental income; this implies weighing parental income *positively* and setting $\phi < 1$.[16] A university system committed to ranking applicants purely "on merit" weighs only test scores and ignores parental income, setting $\phi = 1$. And a university system that pursues a policy of income-based affirmative action weighs parental income negatively, corresponding to $\phi > 1$ in our formulation.

To graduate, each student must pass a final examination at the completion of her studies. The grade she earns is a stochastic function of her human capital

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

where the i.i.d. u_{si} are normally distributed with zero mean and variance σ_{us}^2; and a minimal grade of $\underline{s}$ is required to graduate. Substitution reveals that s_i is normally distributed with the same mean as t and h, $\mu_s = \mu_t = \mu_h$, and with variance:

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

It follows that the joint distribution of the four variables ln y, ln h, t and s is multivariate normal, and the correlations between pairs of these variables satisfy the following equations.

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

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

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

$$\rho_{hs} = \sigma_h / \sigma_s \tag{13d}$$

$$\rho_{ht} = \sigma_h / \sigma_t \tag{13e}$$

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

1.3 Production and the labor market

We assume a small, open economy with competitive labor and product markets in which a continuum of firms produce a single homogeneous good using two types of human capital: graduate and non-graduate. All firms have the same constant-returns-to-scale production function:

$$Y_j = F(H_{nj}, H_{gj}) \tag{14}$$

where H_{nj} is the amount of non-graduate human capital employed by firm j, and H_{gj} is the amount of graduate human capital it employs. Competitive labor and product markets ensure that all firms pay the same wage rate per unit of human capital, by type of human capital; and constant returns to scale imply that total production in the economy can be represented as a function of total non-graduate and graduate human capital, H_n and H_g

$$Y = F(H_n, H_g) \tag{15}$$

The notional annual wage rates per unit of human capital, w_n for non-graduates and w_g for graduates, are then set equal to the marginal productivity of the two types of labor:

$$w_n = \partial F / \partial H_n \quad (16)$$

$$w_g = \partial F / \partial H_g \quad (17)$$

As F is homogenous of degree one, there is a one-to-one correspondence between the ratio of graduate to non-graduate human capital, H_n / H_g, and the wage rates w_n and w_g.

We assume that the productivity of a worker in a non-graduate job is directly observable and proportional to her human capital h_i, implying that non-graduate i earns an annual income of $w_n h_i$. Thus young adults who choose not to attend university work for T_n years[17] and earn a lifetime income of

$$Y_{ni} = h_i w_n [1 - \exp(-r T_n)] / r \quad (18)$$

while those who choose to attend university but fail to graduate, work for $T_w = T_n - T_e$ years, and earn a lifetime income of

$$Y_{fi} = h_i w_n [1 - \exp(- r T_w)] / r \quad (19)$$

Graduate workers are assumed to produce output that is less tangible, and so their individual marginal product capital is only gradually revealed to employers. To fix ideas, we posit that a graduate worker's lifetime income is proportional to a weighted average of her own human capital, βh_i, and of the average human capital of all graduate workers in her cohort, βh_g[18]

$$Y_{gi} = [\alpha \beta h_i + (1 - \alpha) \beta h_g] w_g [1 - \exp(-rT_w)] / r \quad (20)$$

where $0 < \alpha < 1$ is a fixed parameter, r is a common household discount factor, and T_w is the number of years to retirement after attending university, as above.

1.4 The application decision

We now consider the application decision of a prospective university candidate, and as admissions requirements are public knowledge, we consider only the decisions of prospective applicants who meet these requirements. We assume that all candidates are risk neutral and seek to maximize the expected present value of their lifetime income. At the time of application, each applicant knows her parent's income y_i, her prior test score t_i, the university's admissions and graduation requirements, θ, ϕ and $\underline{s}$, and the tuition fee P. In addition, she forms anticipations regarding the average level of graduate human capital, βh_g^e, and future wage rates, w_n^e and w_g^e, that will obtain when she is in the workforce. We assume that all applicants share the same anticipations, and denote by $\omega = (w_n^e, w_g^e, h_g^e)$ the vector of these anticipated values. A young adult whose values of y_i and t_i meet the university's entrance requirements will apply if her expected net income from studying is greater than her expected net income from not studying, conditioned on these values. Denote by f (ln y, ln h, t, s) the joint multivariate normal density function of ln y, ln h, t and s. Then individual i expects to gain from attending university if

$$\int_{-\infty}^{\infty}\{\int_{-\infty}^{\underline{s}} Y_{fi}(\omega) f(\ln y_i, \ln h, t_i, s) ds + \int_{\underline{s}}^{\infty} Y_{gi}(\omega) f(\ln y_i, \ln h, t_i, s) ds\} d\ln h - P \geq Y_{ni}(\omega) \tag{21}$$

where Y_{fi}, Y_{ni} and Y_{gi}, defined by equations (18), (19) and (20), depend on the anticipated values w_n^e, w_g^e and h_g^e.

1.5 Equilibrium

Equation (21) and the admissions requirement (10) implicitly define for each level of parental income y_i a threshold score $\underline{t}$ (y_i ; ω) contingent on wage and human capital expectations, such that an individual with parental income y_i applies and is accepted for university studies if and only if her test score exceeds $\underline{t}$ (y_i ; ω). The density of children with human capital h who graduate from university is then

$$\varphi_g(h;\omega) = \int_{-\infty}^{\infty} \int_{\underline{t}(y;\omega)}^{\infty} \int_{\underline{s}}^{\infty} f(\ln y, \ln h, t, s) ds dt\, d\ln y \tag{22}$$

The density of children with human capital h who attend university but fail is:

$$\varphi_f(h;\omega) = \int_{-\infty}^{\infty} \int_{\underline{t}(y;\omega)}^{\infty} \int_{-\infty}^{\underline{s}} f(\ln y, \ln h, t, s)\, ds dt\, d\ln y \tag{23}$$

And the density of children with human capital *h* who do not attend university is

$$\varphi_n(h;\omega) = \int_{-\infty}^{\infty} \int_{-\infty}^{\underline{t}(y;\omega)} \int_{-\infty}^{\infty} f(\ln y, \ln h, t, s)\, ds dt\, d\ln y \tag{24}$$

Hence in a stationary steady state, the average level of human capital among graduates is given by:

$$h_g \;=\; \int_{-\infty}^{\infty} h\varphi_g(h;\omega)dh \;/\; \int_{-\infty}^{\infty} \varphi_g(h;\omega)dh \tag{25}$$

In equilibrium we require that the anticipated value of h_g equals its realized value;[19] and the actual wage rates w_n and w_g implied by the ratio of non-graduates to graduates

$$H_n / H_g \;=\; [(\,T_e + T_w\,) \int_{-\infty}^{\infty} h\varphi_n(h;\omega)dh \;+\; T_w \int_{-\infty}^{\infty} h\varphi_f(h;\omega)dh\,] \,/\, [\,T_w\,\beta \int_{-\infty}^{\infty} h\varphi_g(h;\omega)dh\,] \tag{26}$$

conform to the anticipated wage rates, w_n^e and w_g^e.[20]

2. Calibration

Calibrating the model to observed empirical variables provides a quantitative indication of the tradeoffs between output, distribution and mobility implicit in different admissions policies. The four variables ln(*y*), ln(*h*), *t* and *s* are assumed to have a multivariate normal distribution, where parents' income, children's admission test scores and final test scores are observable, but human capital is not. The parameters of the distribution—the means and variance-covariance matrix—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 wages in the age category 35-54.[21] Median household income equals $28,750, implying a value of μ_y = 10.266, and average income is $37,327, implying $\sigma_y^2 = 0.522$.

- The marginal distributions of prior test scores and final exam 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 between prior test scores and final exam grades, ρ_{ts}, is set equal to 0.5, which approximates the correlation between SAT scores and first-year college grade-point-averages (Bridgman, McCameley-Jenkins and Ervin, 2000).[22]
- The correlation between parental income and prior test scores, ρ_{yt}, is set equal to 0.25—near the higher end of the range of empirical estimates of the correlation between parental income and SAT scores, which vary between 0.17 to 0.3 (Hearn 1984, 1991; Owen 1985; Alwin and Thornton 1984; Paulhus and Shaffer 1981). We choose a value near the higher end because in the model ρ_{yt} represents the correlation between family income and SAT scores in the population as a whole, while actual SAT scores are available only for high school graduates considering college studies.
- The ability to interpret reported correlations between parental income and college grade-point averages in the population as a whole is undermined by the wide variation in grading standards. We assume that college grades have the same correlation with parental income as SAT scores, i.e., $\rho_{ys} = \rho_{yt}$ = 0.25.

The remaining entries of the variance-covariance matrix—σ_h^2, σ_{hy}, σ_{ht}, and σ_{hs}—can then be calculated directly from these values.[23]

Continuing the calibration, we set the household discount rate equal to r = 5%; the number of college years T_e = 4; the number of working years after college T_w = 40; and tuition (and other direct costs of a college education, excluding lost earnings) P = 20,000.[24] Production is assumed to follow a Cobb-Douglas function of the form $Y = A_0 H_n^{1-\upsilon} H_g^{\upsilon}$. We set υ = 0.44, equal to the share of college graduates in total labor income, and choose A_0 and β to fit the average wage level in the population.[25] Combining this value of υ with the actual share of college graduates in each cohort—approximately equal to 28%—implies a ratio of the average wages of college graduates to non-graduates of 2.02, which is very close to its actual value.[26] To complete the calibration of the benchmark case, we assume that admissions are based solely on test scores, and set the entrance threshold θ = –0.1 (one tenth 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), so that the share of college enrollees in each age-group equals 55%, which is the actual share of individuals with more than 12 years of schooling in the 35-54 age category, in the United States; and the ratio of college graduates to enrollees equals 50%, again approximately equal to its value in the United States. Finally, we set α = 0.75, and obtain an intergenerational correlation of income of 0.38, which is well within the range of estimated values for the United States (Solon, 1992; among others) and Britain (Atkinson, 1980).[27]

3. Simulation results

We simulate the model initially assuming that the economy is closed to migration and has a fixed population, and then extend the analysis to allow immigration of a quota of non-graduate workers. Three types of admissions policies are simulated in each case:

(1) Output maximization policies that rank applicants according to their expected human capital, which corresponds to setting a value of $\phi = 0.84$ in equation (10);

(2) Policies that rank applicants according to admission test scores ($\phi = 1.00$); and

(3) Explicit affirmative policies that gives positive weight to economic hardship, where we specify, in symmetry to (1), that $\phi = 1.16$.[28]

For each type of admission policy we vary the minimum requirement θ, thus varying the number of college students and graduates in each cohort, and calculate mean income, the admission rate, the Gini coefficient, and the intergenerational correlation of income for each value of θ.

3.1 An economy closed to migration

In an economy closed to migration, increasing the number of college students, hence of graduates, increases the stock of graduate human capital while decreasing the stock of non-graduate human capital, thus lowering the wage ratio (per unit of human capital) between graduates and non-graduates. This applies to all three types of admissions policy.

Figure 1 describes the effect of admissions criteria on output, showing output levels as a function of college enrolment for each of the three types of admissions rankings: expected human capital, test scores and affirmative action.[29] Output is maximized overall by maximizing expected human capital, which is achieved by admitting just under 45% of each cohort to college studies. For other types of admissions policies the output maximizing admissions rate is slightly higher. Unrestricted access to higher education reduces mean income, as individual schooling decisions are not efficient—weaker students ignore the negative externalities they generate for other graduates, and too many are willing to risk failure, though figure 1 indicates that efficiency losses from setting excessively lax admissions requirements—without lowering graduation requirements—are moderate, up to 0.4% of national product.[30] However, overly restrictive policies that shrink higher education far below its optimal size can reduce output substantially. Efficiency differences between the three types of admissions policies holding constant the share of college students are smaller, with affirmative action achieving nearly 99.9% of maximum output at its peak.

Figure 2 highlights two key points regarding the impact of admissions standards on intergenerational income mobility. First, affirmative action has a strong positive effect on income mobility, as might be expected: it results in substantially lower correlation values than other admissions policies that do not favorably treat applicants from disadvantaged backgrounds. Second, under each of the three policy types, raising admissions standards increases mobility (i.e., reduces the intergenerational correlation of incomes). Higher standards that reduce college enrolment rates increase the return to a college education, which especially benefits higher-ability applicants from low-income families. This indicates a tradeoff between broad access to higher education and the greater equality of opportunity implied by a lower intergenerational income correlation.

Figure 3, combining the findings of figures 1 and 2, describes the tradeoff between output and income mobility implicit in the three types of admissions policies under consideration. The three possibility frontiers in figure 3 highlight our previous results: although output is maximized when applicants are ranked by expected human capital, affirmative action nearly achieves maximum output, while offering substantial gains in intergenerational mobility. The envelope of the three curves indicates that there is only a limited tradeoff, in practice, between output and mobility. Maximizing output under affirmative action achieves a level of output and a degree of mobility that can only be improved upon at significant marginal cost: both the shadow price of an increase in mobility in terms of lost output, and of increased output in terms of lost mobility, are substantial.

Figure 4 describes the effect of college enrolment on equality of the wage distribution, measured on the vertical scale as a decline in the Gini coefficient. Lowering admissions standards, and thus increasing college enrolment, decreases the wage ratio between graduates and non-graduates and achieves a more egalitarian distribution of wages. Combining this with the results described in figure 1, we find that increasing the scale of higher education beyond its output-maximizing scale implies a tradeoff between output and equality of the wage distribution, shown in figure 5; beyond this point, achieving a more egalitarian distribution of wages entails some loss of output.

The effect of college enrolment on the distribution of wages and on intergenerational income mobility, described in figures 2 and 4, are combined in figure 6 to highlight the tradeoff between mobility and distribution implicit in the choice of admissions criteria. Relaxing admissions standards to higher education, without lowering graduation requirements, has the dual effect of promoting a more equal distribution of wages, by reducing the college wage premium, while restricting the opportunity for intergenerational income mobility. A restrictive admissions policy, especially when combined with income-based affirmative action, provides greater opportunity for high-ability children from low-income families, though at the same time widening the gap between success and failure. This recalls 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."

3.2 Migration

Assume now that there is a perfectly elastic supply of non-graduate labor at a wage rate that is significantly lower than the domestic non-graduate wage. The government allows a quota of non-graduate immigrants to enter the country, and we assume that the distribution of human capital in the immigrant population is the same as in the native population (before college graduation). Tables 1 and 2 compare the performance of the economy under two alternative political regimes, which differ in the weight each attaches to the welfare of immigrants. Table 1 assumes that—in each type of admissions policy—entrance requirements are set so as to maximize *domestic* output per capita, implicitly treating the welfare of immigrants and of the native born equally. Table 2 assumes that per capita output of the *native-born* population is maximized, thus ignoring the welfare of immigrants. Each table considers the three types of admissions policies for each of four different quota levels: 0% (the closed economy case considered above), 5%, 10% and 20%. Performance measures include native and domestic per capita output, college enrolment rates, Gini coefficients, and intergenerational income mobility in the native population.

Turning first to table 1, we find that opening the economy to migration while maximizing domestic output per capita slightly increases native output per capita while slightly reducing domestic output per capita, under all three types of admission policies. Domestic output is maximized through a large expansion of college enrolment in the native population, which also increases enrolment rates for the domestic population as a whole. This expansion of the higher education sector keeps graduate wages from rising and results in only slight variation in the Gini coefficient and in intergenerational mobility. Comparing the three types of admissions policies when domestic output per capita is maximized, we find that the basic patterns of the no-migration case are retained: Ranking applicants by human capital achieves small gains in output in relation to the other admissions policies, and entails some loss of social mobility.

Maximizing native output per capita produces very different results, presented in table 2. As might be expected, both the rise in native output and the fall in domestic output are steeper, compared to table 1. The greater rise in native output is the result of the small rise in college enrolment among the native born, and its consequent fall as a percentage of the population at large, which increases the return to a college degree. Immigration of non-graduate labor benefits the native born who earn a college degree, while harming those who do not. This generates large increases in inequality both among the native born and in the population as a whole, reflected in substantial increases in the Gini coefficient under all three types of admissions policies. At the same time, maximizing native output increases intergenerational income mobility in the native population, substantially reducing the correlation between the incomes of parents and their children under all three types of admissions policies. Comparing the three types of admissions policies when native output is maximized, we find that, in this case, migration slightly magnifies the differences between policy types, increasing the advantage of human capital maximization in creating output while at the same time increasing the advantage of affirmative action in promoting intergenerational mobility.

Finally, comparing the two political regimes, we find that while the choice of social goals has some effect on total output—though the difference never exceeds one percent—its greatest effect is on distribution and mobility. It presents a sharp tradeoff between the more equal but less mobile policies of maximizing domestic output through large expansion of college enrolment on the one hand, and the less equal but more mobile policies of maximizing native output through restricted growth in higher education on the other hand.

4. Concluding remarks

In this paper we considered how centralized criteria for university admissions affect aggregate measures of output, distribution and mobility, in the context of a formal model in which peer-group signaling externalities in the labor market for college graduates generate excessive demand for college places. Restricting college admissions on the basis of prior indicators of student ability can then increase output per capita, though also increasing inequality in the distribution of income, as it increases the gap between graduate and non-graduate wages, and affecting intergenerational income mobility.

Calibrating our model to observed empirical values provides a quantitative indication of the tradeoffs between output, distribution and mobility implicit in different admissions policies. We find that moderate affirmative action policies that give applicants from low-income families an edge in admissions, without overly increasing college enrolment, can achieve large gains in intergenerational mobility with very little loss of output. Large increases in the number of college students, with or without affirmative action, generate a more equal income distribution but reduce intergenerational mobility.

These results pertain to an economy closed to migration. The effect of opening the economy to non-graduate immigrant labor depends on the social goals that are pursued. If immigrant welfare is weighed similarly to native welfare, so that the government seeks to maximize domestic output per capita, college enrolment is dramatically increased. Conversely, if the welfare of immigrants is ignored, and the government seeks to maximize native output per-capita, growth in higher education is more restricted. Consequently, maximizing domestic output per capita results in a more equal but less mobile economy than one in which native output per capita is maximized.

References

Aitken, N. D. (1982) “College Student Performance, Satisfaction and Retention: Specification and Estimation of a Structural Model.” *Journal of Higher Education* 53(1): 32-50.

Alwin, D. and Thornton, A. (1984) “Family Origins and the Schooling Process: Early vs. Late Influence of Parental Characteristics.” *American Sociological Review* 49: 784-802.

Arrow, K. (1973) “Higher Education as a Filter.” *Journal of Public Economics* 2:193-216.

Atkinson, A. B. (1980) “On Intergenerational Income Mobility in Britain.” *Journal of Post Keynesian Economics* 3(2): 194-218.

Bénabou, R. (1996) “Heterogeneity, Stratification, and Growth: Macroeconomic Implications of Community Structure and School Finance.” *American Economic Review* 86(3): 584-609.

Bertocchi, G. and Spagat, M. (1998) “The Evolution of Modern Education Systems: Technical vs. General Education, Distributional Conflict and Growth.” CEPR Discussion Paper 1925.

Betts, J. R. (1998) “The Impact of Education Standards on the Level and Distribution of Earnings.” *American Economic Review* 88(1): 266-275.

Bridgman, B., McMaley-Jenkins, L. and Ervin, N. (2000) “Prediction of Freshman Grade-Point Average From the Revised and Recentered SAT I: Reasoning Test.” College Board Research Report No. 2000-1, College Entrance Examination Board, New York.

Bureau of Labor Statistics and Bureau of the Census (1999) *Annual Demographic Survey* (March supplement) www.bls.census.gov/cps/ads/sdata.htm .

Cancian, M. (1998) “Race-Based Versus Class-Based Affirmative Action in College Admissions.” *Journal of Policy Analysis and Management* 17(1): 94-105.

Checchi, D., Ichino, A. and Rustichini, A. (1999) “More Equal but Less Mobile? Education Financing and Intergenerational Mobility in Italy and in the US.” *Journal of Public Economics* 74(3): 351-393.

Costrell, R. M. (1993) “An Economic Analysis of College Admissions Standards.” *Education Economics* 1(3): 227-241.

Costrell, R. M. (1994) “A Simple Model of Educational Standards.” *American Economic Review* 84(4): 956-971.

Costrell, R. M. (1997) “Can centralized educational standards raise welfare?” *Journal of Public Economics* 65(3): 271-293.

Danziger, L. (1990) “A Model of University Admission and Tuition Policy.” *Scandinavian Journal of Economics* 92(3): 415-36.

Durlauf, S. N. (1996) “A Theory of Persistent Income Inequality.” *Journal of Economic Growth* 1(1): 75-93.

Epple, D., Romano, R. and Sieg, H. (2000) “Peer Effects, Financial Aid and Selection of Students into Colleges and Universities: An Empirical Analysis.” Duke University Department of Economics Working Paper 00/02.

Fernandez, R. and Gali, J. (1999) "To Each According to … ? Markets, Tournaments, and the Matching Problem with Borrowing Constraints." *Review of Economic Studies* 66(4): 799-824.

Hassler, J. and Rodriguez-Mora, J. V. (2000) "Intelligence, Social Mobility, and Growth." *American Economic Review* 90(4): 888-908.

Hearn, J.C. (1984), "The Relative Roles of Academic, Ascribed, and Socioeconomic Characteristics in College Destinations." *Sociology of Education* 57: 22-30.

Hearn, J.C. (1991), "Academic and Nonacademic Influences on the College Destination of 1980 High School Graduates." *Sociology of Education* 64: 158-171.

Iyigun, M. F. (1999) "Public Education and Intergenerational Economic Mobility." *International Economic Review* 40(3): 697-710.

Judson, Ruth (1998), "Economic Growth and Investment in Education: How Allocation Matters." *Journal of Economic Growth* 3(4): 337-359.

Kane, J. and Spizman, L. M. (1994) "Race, Financial Aid Awards and College Attendance: Parents and Geography Matter." *American Journal of Economics and Sociology* 53(1): 85-97.

Kennet-Cohen, T., Bronner, S. and Oren, C. (1998) "The Predictive Validity of Different Combinations of Components of the Process of Selection for Higher Education in Israel." NITE report no. 249, Jerusalem: National Institute for Testing and Evaluation.

Loury, G. (1981) "Intergenerational Transfers and the Distribution of Earnings." *Econometrica* 49(4): 843-67.

Loury, L. Datcher and Garman D. (1993) "Affirmative Action in Higher Education." *American Economic Review Papers and Proceedings* 83(2): 99-103.

Loury, L. Datcher and Garman D. (1995) "College Selectivity and Earnings." *Journal of Labor Economics* 13(2): 289-308.

Owen, D. (1985) *None of the Above*. Boston: Houghton Mifflin & Company.

Paulhus, D. and Shaffer, D. R. (1981) "Sex Differences in the Impact of the Number of Older and Number of Younger Siblings on Scholastic Aptitude." *Social Psychology Quarterly* 44(4): 363-368.

Razin, A. and Sadka, E. (1995) "Resisting Migration: Wage Rigidity and Income Distribution." *American Economic Review* 85(2): 312-316.

Stiglitz, J. E. (1975) "The Theory of 'Screening,' Education, and the Distribution of Income." *American Economic Review* 65(3): 283-300.

Solon, G. (1992) "Intergenerational Income Mobility in the United States." *American Economic Review* 82(3): 393-408.

Weiss, A. (1995) "Human Capital vs. Signalling Explanations of Wages." *Journal of Economic Perspectives* 9(4):133-154.

[1] Of course, other considerations also affect student admissions: ethnic diversity, geographic location, athletic ability, community service, and so on.

[2] Stringent admissions requirements encourage high school students to invest effort in their studies (Costrell, 1993, 1994; 1997); compensate for peer-group externalities among students (Epple, et al., 2000; Betts, 1998; Loury and Garman, 1995); countervail capital market imperfections that work against able children from low-income families studying in university (Fernandez and Gali, 1999); and if universities can better assess the conditional probability of graduation that the students themselves (Arrow, 1973), admissions requirements prevent weaker students from misguidedly embarking on a course of study in which they have little chance of graduating—for their own benefit, and for the benefit of taxpayers when education is subsidized.

[3] Bertocchi and Spagat's (1998) positive formal analysis of the development of education systems elaborates on the role of educational hierarchies in perpetuating class distinctions.

[4] Thus our analysis abstracts from—and complements—alternative rationales for stringent admissions requirements, indicated in note 2: capital market imperfections, the need to motivate high school students; peer-group externalities in the education process; and the university's better judgment or information.

[5] This follows Arrow's (1973) characterization of the university as a "double filter."

[6] Hence weaker students, ignoring the negative externalities they generate for other graduates, may be willing to pay the cost of their education even when it is not socially efficient for them to attend university.

[7] This is consistent with Costrell's (1994) result, but varies from Betts (1998) finding that raising standards benefits the two ends of the income distribution: the most and the least able. Betts' result derives from his assumption that, although individuals have different productivity levels, wages are solely a function of formal qualifications. Stiglitz's (1975) seminal contribution analyzes the positive political economy of screening in education, and compares the efficiency of politically determined and market-based screening standards.

[8] This is income- or class-based affirmative action rather than the more common race- or ethnically-based policies. As Cancian (1998) has shown, while there is considerable overlapping between the two criteria in the United States, "… class-based affirmative

action would result in a substantially different pool of eligible individuals …” As we hold graduation requirements constant, and only vary entry requirements, our analysis ignores “mismatching” effects addressed by Loury and Garman (1993), who find that blacks “who attend the most selective colleges and perform less well because of mismatching would have had higher earnings had they attended the somewhat less selective group of schools.”

[9] Our focus on the impact of education on income mobility is also related to seminal work on investment in human capital and mobility by Loury (1981), Bénabou (1996) and Durlauf (1996); Hassler and Rodriguez-Mora’s (2000) analysis of the impact of accelerated technological change on intergenerational mobility; Iyigun (1999), on promoting mobility in early stages of economic development by allocating sufficient public resources to elementary and high school education to offset the effect of parental inputs; and Judson’s (1998) analysis of the allocation of resources to primary education, which links microeconomic and macroeconomic perspectives on the role of education.

[10] This adds another dimension to Razin and Sadka’s (1995) work on migration, which contrasts the fiscal effects of unskilled and skilled immigrants on the native population.

[11] We assume that this capital market imperfection cannot be resolved.

[12] Parents have some indication of their children’s ability, but this does not affect their investment in human capital: the logarithmic functional form reflects an agnostic position on whether parents invest more in “stronger” or “weaker” children.

[13] Extending the analysis to allow fees also to depend on test scores and parental income, $P = P(t_i, y_i)$, with negative values of P indicating a stipend, and P allowed to increase in y_i and decrease in t_i, is straightforward, but we found it had little effect on the results, presumably because of our assumption of perfect capital markets for funding college costs, and because college fees are relatively small compared to lifetime income. Analyses that assume university costs are self-financed highlight the potential for test-based stipends to increase efficiency when capital markets are imperfect (Fernandez and Gali, 1999). Relatedly, Danziger (1990) and Epple et al. (2000) have shown that it is in the interest of individual decentralized universities to charge lower tuition to students with high ability because of the positive externalities they are perceived to generate for other students.

[14] The model is readily extended to allow for β to be affected by the quality of the student body and by the university’s graduation requirements (the more stringent the requirements

the greater the productivity gain.) This does not enter our analysis because we do not vary graduation requirements; and because peer group effects are taken to influence labor market outcomes through the signaling effect, rather than by increasing the productivity of the education effort.

[15] These assumptions can also be relaxed without changing the essence of our results.

[16] This follows from the model, as we show in detail in the appendix, where the conditional mean of the logarithm of human capital E (ln h_i | t_i, ln y_{it}) is shown to be a linear function of the prior test score t_i and of the logarithm of parental income ln y_i. It is also supported by empirical findings, e.g., that first-year college grades are positively associated with parental socio-economic status after controlling for psychometric test scores (Aitken, 1982; Kane and Spizman, 1994; among others). Of course, non-linear admissions procedures could also be considered.

[17] Except for the decision to attend university, the supply of labor is assumed to be inelastic.

[18] Typically, a graduate entering the workforce is an unknown quantity and receives a wage equal to the average marginal productivity of skilled workers in her cohort. Over time her individual qualities are revealed and she earns a salary that more closely approximates her individual marginal product.

[19] There exists such a value if the right hand side of (25) varies continuously with the anticipated value of h_g^e, which is satisfied if the density function f is non-atomic, and if $h_g(h_g^e) > h_g^e$ for small values of h_g^e, and $h_g(h_g^e) < h_g^e$ for large values of *he*. This value is unique if (25) implies that h_g is decreasing in h_g^e. This seems intuitively reasonable, as the higher the value of h_g^e the greater are the gross benefits of a university degree and the wider is the applicant pool, which lowers the realized level of h_g.

[20] This need not introduce an additional degree of freedom: if φ_g is increasing in h then h_g uniquely determines H_n/H_g.

[21] Data are from the Annual Demographic Survey (Bureau of Labor Statistics and Bureau of the Census, 1999). The age group 35-54 is taken as representative of the child-rearing years.

[22] Kennet-Cohen, Bronner and Oren report (1998) similar estimates based on Israeli data (corrected for self-selection).

[23] Detailed derivations are given in the appendix.

[24] Varying the cost of tuition had little effect on the simulation results, as capital market imperfections in financing college tuition have been assumed away, and tuition costs are small in comparison to lifetime earnings.

[25] The model does not allow us to separate their individual values; we set $A_0\beta^v = 64{,}936$.

[26] Letting N_g and N_n respectively denote the number of graduates and non-graduates in the workforce, $N_g / N_n = 0.28/0.72 = 0.389$. Then $\upsilon / (1 - \upsilon) = w_g H_g / w_n H_n = 0.44/0.56 = 0.786$, and the ratio of average wages of graduates to non-graduates is:

$(w_g H_g / N_g) / (w_n H_n / N_n) = [\upsilon / (1 - \upsilon)] / (N_g / N_n) = 0.786 / 0.389 = 0.202$

[27] Smaller values of α reduced the intergenerational correlation of incomes, while magnifying the effects described in the following section.

[28] This implies, approximately, that each halving of parental income imparts an advantage of one tenth of a standard deviation in test-score requirements. To see this, let $y_H > y_L$ denote the parental income of two applicants and let t_H and t_L denote their test scores. Their admissions criteria are equal if $1.16t_H - .16 \ln y_H = 1.16t_L - .16 \ln y_L$ which implies

$t_H - t_L = (0.16/1.16) \ln (y_H / y_L) \approx 0.1 \log_2 (y_H / y_L)$.

[29] See also the first columns of table 1 and 2.

[30] The loss is greater to the extent that relaxing admissions standards adversely affects pre-college academic effort (Costrell, 1993), or reduces the efficiency of the education process through actual (not merely perceived) peer-group effects (Epple, et al., 2000).

Appendix: The joint distribution of ln h_i, s_i, t_i and ln y_i

a. The variance-covariance matrix of ln y_i, ln h_i, t_i and s_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

$$1 + \gamma = \rho_{yt}\, \sigma_t / \sigma_y \tag{a1}$$

and substituting this in equation (13c) gives

$$\rho_{yh} = \rho_{yt}\sigma_t / \sigma_h \tag{a2}$$

implying that

$$\text{cov}\,(y, h) = \rho_{yh}\sigma_y\sigma_h = \rho_{yt}\sigma_y\sigma_t \tag{a3}$$

From equation (13f):

$$\sigma_h^2 = \rho_{ts}\sigma_t\sigma_s \tag{a4}$$

and from equation (13d):

$$\text{cov}(h,s) = \rho_{hs}\sigma_h\sigma_s = \sigma_h^2 = \rho_{ts}\sigma_t\sigma_s \tag{a5}$$

Similarly, from equation (13e):

$$\text{cov}(h,t) = \rho_{ts}\sigma_t\sigma_s \tag{a6}$$

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

b. The conditional joint distribution *f* (ln *h*$_i$, *s*$_i$| ln *y*$_i$, *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

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

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

and variance-covariance matrix

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

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

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

Table 1. Comparison of outcomes under different admissions and migration policies at maximum domestic output per capita

Migration quota	0	5%	10%	20%
Human capital admissions criteria				
Domestic output per capita	34,598	34,538	34,474	34,332
Native output per capita	34,598	34,604	34,623	34,724
Percent native population attending college	44.9%	50.6%	55.7%	66.5%
Percent domestic population attending college	44.9%	48.1%	50.6%	55.4%
Native Gini coefficient	0.314	0.312	0.313	0.316
Domestic Gini coefficient	0.314	0.311	0.311	0.312
Native intergenerational income correlation	0.399	0.399	0.398	0.393
Pure test-based admissions criteria				
Domestic output per capita	34,577	34,519	34,455	34,308
Native output per capita	34,577	34,585	34,623	34,721
Percent native population attending college	47.8%	51.8%	55.7%	67.1%
Percent domestic population attending college	47.8%	49.3%	50.7%	55.9%
Native Gini coefficient	0.308	0.311	0.315	0.316
Domestic Gini coefficient	0.308	0.310	0.313	0.312
Native intergenerational income correlation	0.382	0.381	0.380	0.381
Affirmative action admissions criteria				
Domestic output per capita	34,559	34,503	34,440	34,296
Native output per capita	34,559	34,561	34,575	34,664
Percent native population attending college	48.3%	53.6%	58.9%	70.2%
Percent domestic population attending college	48.3%	51.1%	53.5%	58.5%
Native Gini coefficient	0.309	0.308	0.309	0.311
Domestic Gini coefficient	0.309	0.307	0.307	0.308
Native intergenerational income correlation	0.374	0.376	0.377	0.379

Table 2. Comparison of outcomes under different admissions and migration policies at maximum native output per capita

Migration quota	0	5%	10%	20%
Human capital admissions criteria				
Domestic output per capita	34,598	34,524	34,406	34,121
Native output per capita	34,598	34,626	34,707	34,982
Percent native population attending college	44.9%	46.9%	46.9%	48.5%
Percent domestic population attending college	44.9%	44.7%	42.7%	40.4%
Native Gini coefficient	0.314	0.323	0.339	0.362
Domestic Gini coefficient	0.314	0.322	0.335	0.353
Native intergenerational income correlation	0.399	0.396	0.390	0.381
Pure test-based admissions criteria				
Domestic output per capita	34,577	34,500	34,378	34,043
Native output per capita	34,577	34,606	34,686	34,960
Percent native population attending college	47.8%	47.8%	47.8%	47.8%
Percent domestic population attending college	47.8%	45.5%	43.4%	39.8%
Native Gini coefficient	0.308	0.323	0.339	0.367
Domestic Gini coefficient	0.308	0.322	0.336	0.358
Native intergenerational income correlation	0.382	0.373	0.365	0.350
Affirmative action admissions criteria				
Domestic output per capita	34,559	34,477	34,350	34,064
Native output per capita	34,559	34,588	34,668	34,944
Percent native population attending college	48.3%	48.3%	48.3%	50.1%
Percent domestic population attending college	48.3%	46.0%	43.9%	41.8%
Native Gini coefficient	0.309	0.325	0.340	0.362
Domestic Gini coefficient	0.309	0.323	0.336	0.354
Native intergenerational income correlation	0.374	0.364	0.354	0.342

Figure 1. College enrolment and output

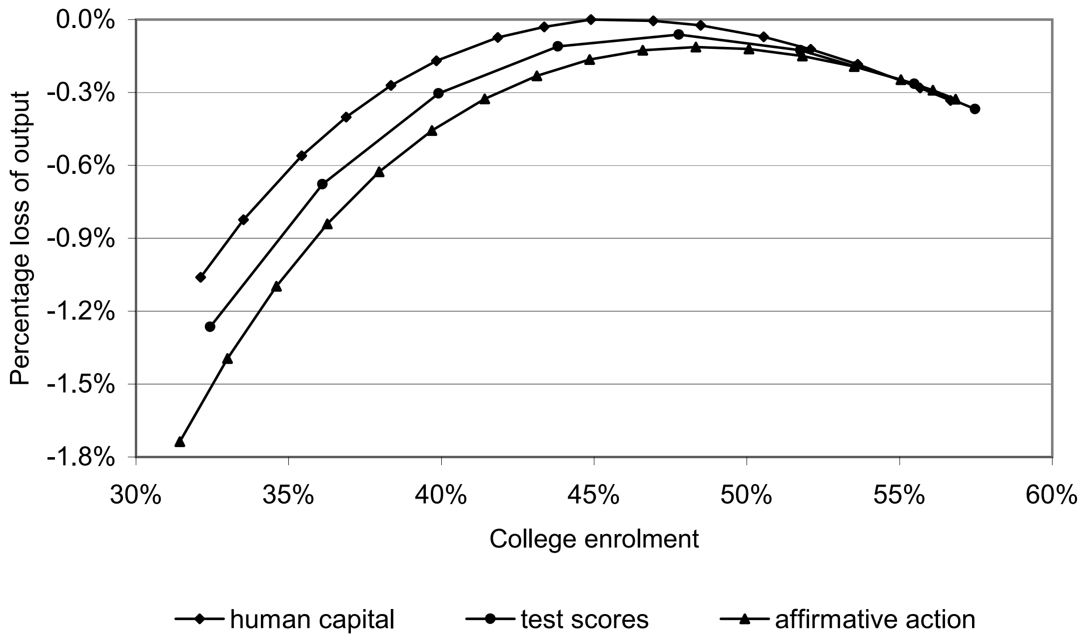

Figure 2. College enrolment and income mobility

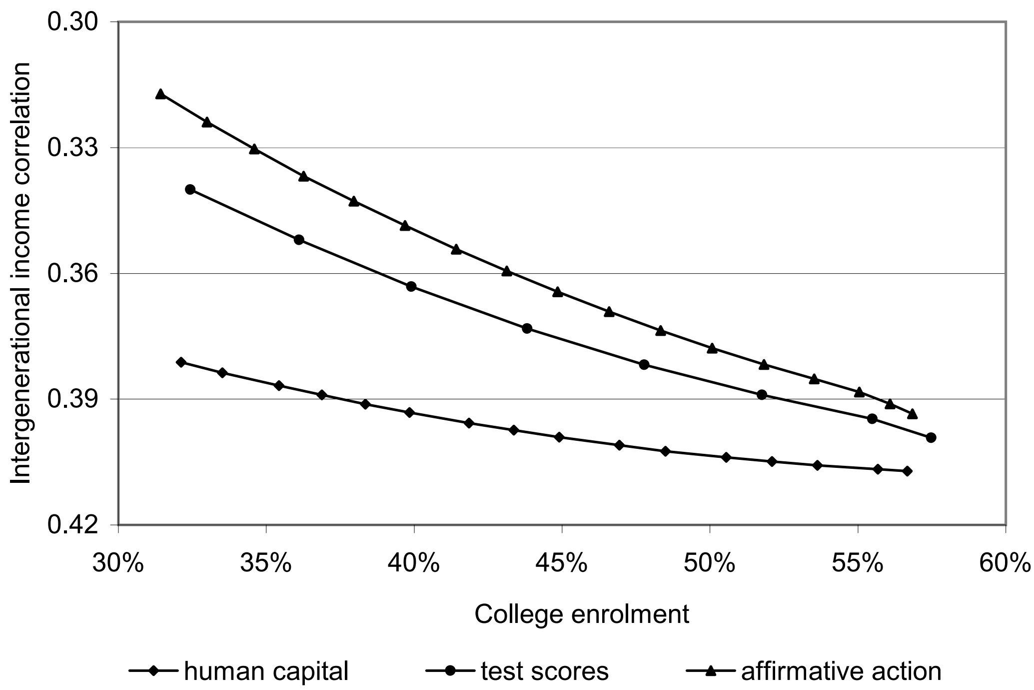

Figure 3. The tradeoff between output and income mobility

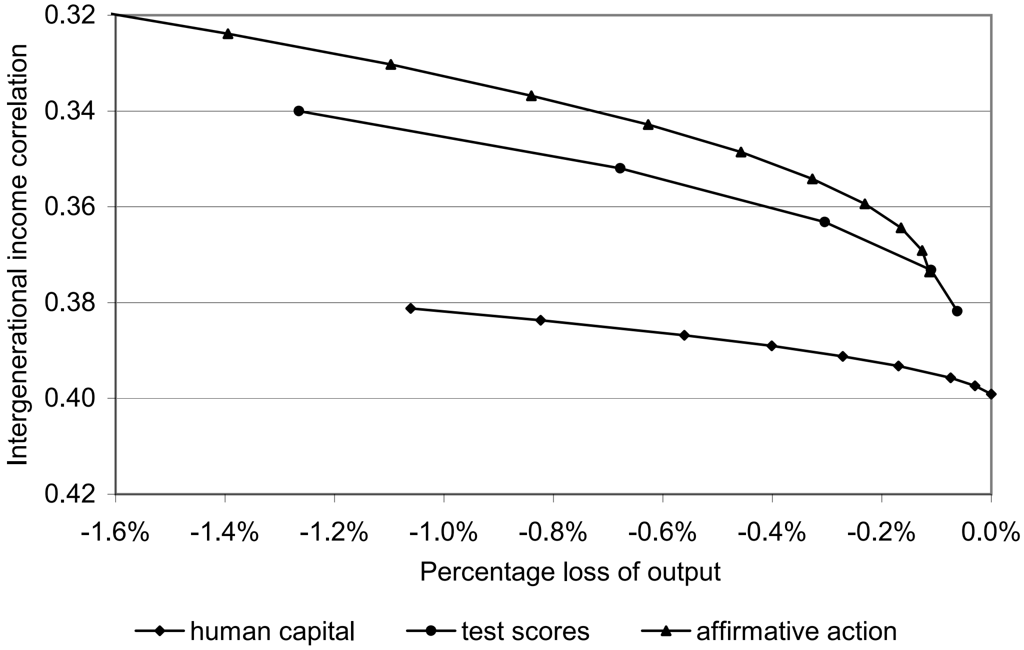

Figure 4. College enrolment and the wage distribution

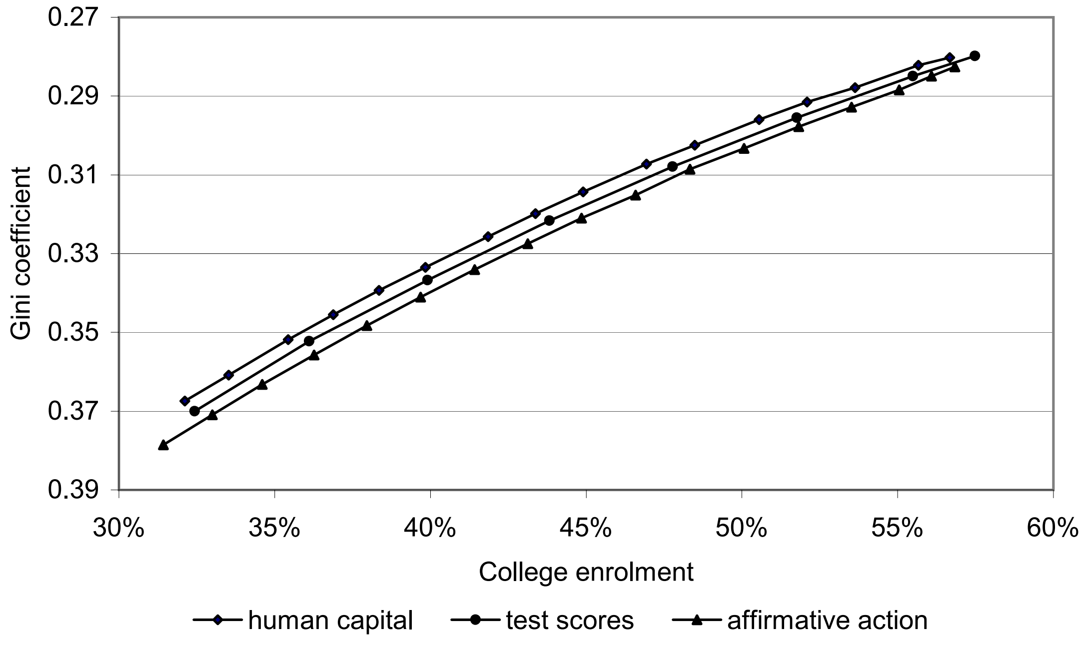

Figure 5. The tradeoff between output and the distribution of wages

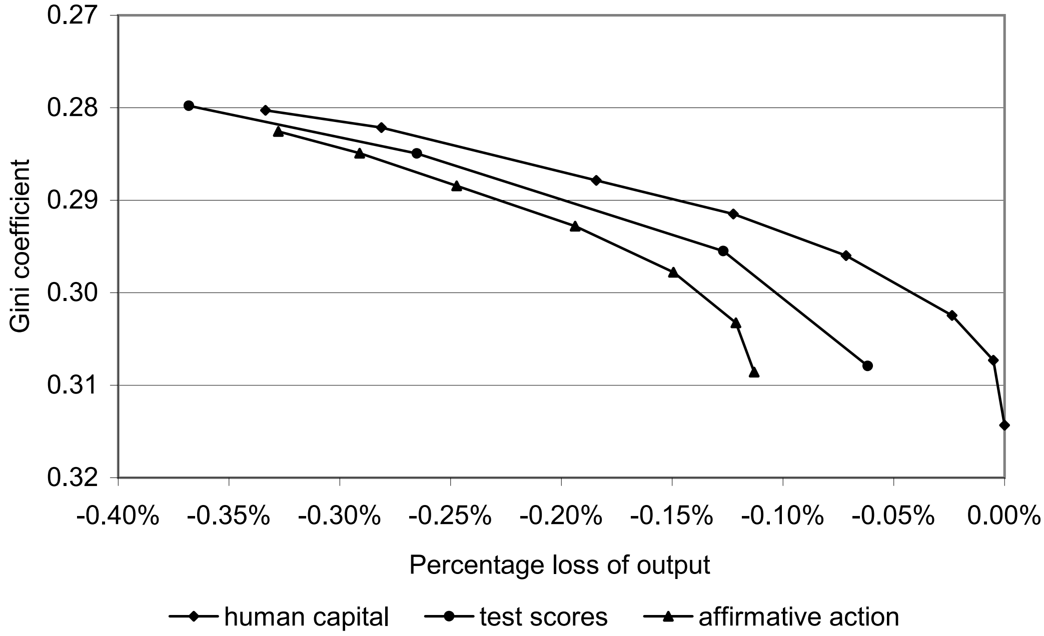

Figure 6. The tradeoff between income mobilty and the distribution of wages