Selective College Admissions: Implications for Equity and Efficiency*

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WORK IN PROGRESS – COMMENTS WELCOME

Abstract

College admissions are highly meritocratic in the U.S. today. It is not the case in many other countries. What is the tradeoff? On one hand, meritocracy produces more human capital overall if higher ability students learn more in college and if they learn more in higher quality colleges. This leads to a higher overall level of earnings (i.e. greater efficiency, loosely speaking). On the other hand, more meritocracy generates a higher degree of earnings inequality. In this paper, we quantify this efficiency-equality tradeoff.

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[*] The views expressed in this article are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of St. Louis or the Federal Reserve System.

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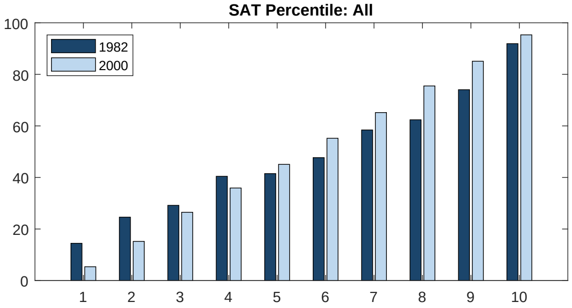
1 Introduction

College admissions are highly meritocratic in the U.S. today. This was not always the case. College admissions requirements were highly idiosyncratic in the mid-1800s; they slowly became more uniform and meritocratic by the mid-1900s and general admissions standards continued to rise (Beale (1970)). This coincides with a notable reversal at the end of WWII documented in Lutz Hendricks and Schoellman (2018) when academic ability became a better predictor for college attendance than family characteristics.[1] The SAT debuted in 1926; by 1960, more than 3/4 of admissions directors considered it "absolutely essential" to their admissions process (Beale, 1970).

Moreover, even conditional on college attendance, college has become more stratified today. The figure below shows that dispersion of average student SAT scores has increased across 4-year colleges in the U.S. between 1982 and 2000.

Figure 1: Average Freshmen SAT Percentile, by Decile of Selectivity



Note: The figure represents the distribution of average freshmen SAT scores in 4-year colleges. All colleges are split into deciles according to their freshmen SAT score in 2000 and using freshmen enrollment as weights. Average SAT percentiles are then depicted for each decile in both 1982 and 2000.
Source: See Section 2

College admissions are also less meritocratic in many other countries today. Many other countries have less meritocratic admissions systems. Some countries have relatively "open" higher education systems; this is true for Germany, where any student who finishes high school can enroll in any (public) university program, except for a few fields prone to chronic overdemand (Westkamp (2013)). France high school completers can similarly attend any public university, though a small, special category of selective institutions (the grande écoles) also exists (Deer (2005)).

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[1] More recently, family wealth has become an increasingly better predictor for college attendance (Belley and Lochner (2007))—potentially caused by a decline in the relative generosity of federal financial aid programs (Lochner and Monge-Naranjo (2011)).

Many countries de-emphasize individual student merit in the name of addressing systemic inequality more aggressively than does the U.S. Chilean universities commonly implement quotas for students that fall under the country's affirmative action PACE program (Millan (2020)); Brazil requires its public universities to reserve half of their spots for low-income and non-white students (Kirakosyan (2014)). Chinese universities, by contrast, set geographic quotas—in a way that favors students from more developed provinces (Guo et al. (2018)).

Why does the degree of stratification of college enrollment and sorting across colleges matter? What do we give up by accepting more meritocracy in college admissions? On one hand, meritocracy produces more human capital overall if higher ability students learn more when accepted to college and if they learn more in more selective colleges. This leads to higher mean level of earnings (i.e. greater efficiency, loosely speaking). On the other hand, more meritocracy generates more inequality.

Our goal in this paper is to quantify this trade-off between efficiency and inequality.

Our approach is to develop a lifecycle model of human capital accumulation that features variation in college quality, admissions standards and college quality-specific human capital accumulation technology (which depends on student ability) and financial constraints. Students enter the model at High School (henceforth, HS) graduation age. Initial endowment heterogeneity features parental income, learning ability, test score and two types of human capital (college h and HS $\hat{h}$). The combination of the two human capital stocks, together with education-specific skill prices w_e, determines one's lifetime earnings. The main objective of the model is to transfer age 18 endowment levels of college human capital h into its levels at age 24 and schooling attainment $e \in \{HS, CD, CG\}$, i.e. HS graduate, College Dropout or College Graduate. Thus, the model delivers the distribution of present value lifetime earnings at age 24. It allows us to disentangle the contribution of various factors –admissions standards being of particular interest to us – to the dispersion of lifetime earnings as of around age 24.

Generally speaking, we know from Huggett et al. (2011) that endowment distribution around that age (they look at age 23) accounts for a large fraction of variation in lifetime earnings. Therefore, our focus on understanding the determinants of age 24 endowments is well warranted, with implications that extend beyond the specific scope of this paper.

Section 2 explains how we categorized all colleges and universities into 4 types appearing in the model, $q \in \{1, 2, 3, 4\}$. The lowest type (Type 1) comprises community colleges offering a transferable associate degree. Four-year institutions are ranked in terms of their freshmen's average SAT score, from lowest to highest, and they are split into three groups based on freshman enrollment. Type 2 comprises the lowest-ranked colleges that account for a third of all freshmen; Type 3 comprises the middle-ranked colleges and Type 4 represents the top-ranked colleges, each with a third of enrolled freshmen.

College quality $q \in \{1, 2, 3, 4\}$ affects net tuition payment and parental transfers. Different college types also feature different human capital production functions, with productivity increasing in q,and different graduation probability functions. In addition, 2-year schools allow students to work more hours while enrolled.

In addition to the endowments described above, students are also endowed with a location. Each location has a 2-year school and one of $q \in \{2, 3, 4\}$ type colleges. Going to a local school features an additional utility component.

Students decide whether and which college to enter, in order of a common admissions ranking which we assume is based on expected learning ability. We do not model college decision making and assume colleges do not observe student ability. But we calibrate the minimum admission criteria, expressed as the minimum required expected learning ability level, for each 4-year type. We assume capacity constraints on types 3 & 4 only: Once the available spots are filled, no more students are accepted there. Thus, students ranked lower in the expected ability distribution may not have their optimal school in their choice set when it's their turn to choose college, even if they satisfy the minimum admissions requirement. Type 1 colleges have an open door admission policy.

The entrants choose study time, courses taken, consumption, etc. each period until they either decide to drop out or are able to graduate. At the end of studies (work start) students have accumulated college human capital and education level. Both matter for their earnings level, as education level determines the skill prices. Note we assume that graduation premium is the same regardless of college, but the amount of human capital earned in college and graduation probabilities do depend on college quality. After the school phase is completed, workers solve a simple consumption/savings decision problem.

We discipline the model by targeting the following moments computed from NLSY 1997 data augmented with Geocode data and official college transcripts.

Our targets can be split into five categories.

- HS graduates' characteristics: joint distribution of parental income and test scores, college entry by parental income and test scores;
- Freshmen characteristics: college sorting by parental income and test scores, fraction of local students by college type;
- College progress characteristics: degree completion, cumulative credits taken, study times and yearly dropouts rates, all tabulated by parental income and test scores;
- Financial variables in college: college costs (tuition net of aid), parental transfers, student work hours, all tabulated by parental income and test scores;
- Earnings: Wage earnings regressions, one estimated on the sample of all HS graduates and one estimated on the sample of college graduates alone. Both are conditioned on parental income and test scores. The latter regression is also conditioned on quality of college.

Our calibration procedure delivers a very good fit of targetted data moments and regressions. We discuss the data patterns in Section +++ where we report the comparison of data and model moments.

In Section 6, we disentangle the influence of initial endowments in determining the dispersion of lifetime earnings upon completion of schooling phase. We find relatively strong (although far from perfect) sorting of students on ability into college and into higher quality colleges. The higher ability students tend to stay in college longer typically completing their degree and accumulating a lot of h. On average, h rises by a factor of 1.44 for CD and 2.36 for CGs and more so for those who graduated from better colleges. Graduation premium is estimated to be about 15%. Therefore, most of the earnings gain associated with college entry and completion is due to changes in h. +++ More results to discuss here.

Initial endowments are not the only variables that matter for college entry, college choice and graduation. Financial constraints and admissions rules, i.e. the ranking of students, play an important role for college entry decisions and student sorting across colleges. From policy perspective, they are also easiest to vary if we are to meddle with the sorting of students across colleges. Therefore, it makes sense for us to quantify the efficiency-equality tradeoff by varying the admissions ranking rule. The outcome of interest is the mean and dispersion of lifetime earnings at age 23. Stronger sorting of students leads to higher mean and higher dispersion.

+++ Discuss the results.

In Section 7, we study the distributional consequences of different admission rules, focusing on the implied changes in the mean level and overall dispersion of lifetime earnings. We consider the following counterfactual admission rules while maintaining the same capacity constraints for $q = 3, 4$:

(1) admission rules that rank students according to their actual learning ability a which generates stronger sorting;

(2) open admission rules that rank students randomly

(3) affirmative action which rank students according to their parents income

+++ Discuss the results in terms of mean level and dispersion of lifetime earnings and welfare.

2 DATA SOURCES

NLSY97 – our main data source – is an ongoing survey that tracks the lives of 8,984 millennials, many of whom entered college around 2000. The NLSY79 follows an older cohort that comprises 12,686 baby boomers, many of whom entered college around 1980.

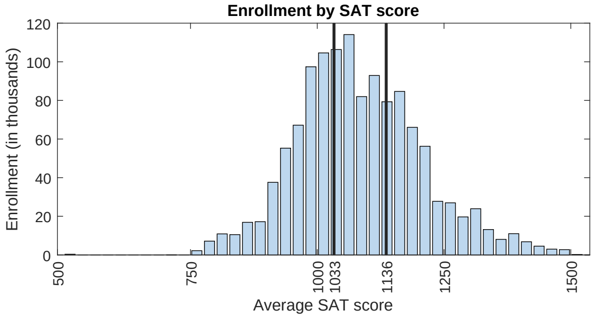
In each survey round, the individuals answer questions on a variety of topics, including education and income. This survey contains complete earnings histories for at least 15 years following college graduation and allows us to identify colleges that students attended and degrees received. All survey participants were also administered an aptitude test that covered numerical operations, vocabulary, paragraph comprehension and logical reasoning.

To rank these colleges on "quality," we compiled a comprehensive data set of over 3,000 colleges and universities in the U.S. and collected information on their average SAT scores and freshmen enrollment in 2000. The main source for this information is the Integrated Postsecondary Education Data System. For colleges with missing reports, we used average SAT scores published in Barron's Profiles of American Colleges and American Universities and Colleges.

We categorized all colleges into four types. The lowest type (Type 1) comprises community colleges offering a transferable associate degree. Four-year institutions are ranked in terms of their freshmen's average SAT score, from lowest to highest, and they are split into three groups based on freshman enrollment. Type 2 comprises the lowest-ranked colleges that account for a third of all freshmen; Type 3 comprises the middle-ranked colleges and Type 4 represents the top-ranked colleges, each with a third of enrolled freshmen.

We will refer to higher-type colleges as higher-quality colleges because better SAT averages not only indicate better learning (and networking) opportunities from one's peers but also strongly correlate with measures of instructional quality (e.g., faculty-student ratios and faculty salaries). We chose to include community colleges in our analysis because over a third of college entrants start in a community college, with 95% of them stating their ultimate goal is a bachelor's degree. According to our classification, higher-type colleges host a more strictly selected group of students, provide higher-quality instruction and cost more. We can now identify the quality type of each college attended by each survey participant. We use responses from both surveys to analyze how postsecondary education decisions and their effects on future earnings have changed over time.

Figure 2: SAT Score by Type



Note: The figure represents the distribution of average freshmen SAT scores in 4-year colleges and marks cutoff values that split colleges into types 2-4.
Source: See text

3 Model

3.1 Overview

The model follows a single cohort from high school graduation through college and work into retirement. Students are differentiated by their endowments. Colleges are differentiated by their qualities and costs.

3.2 Timing

1. A unit mass of high school graduates enters the model at age 19 (model age $t = 1$) and draws endowments (see 3.8.1).
2. Each high school graduate is accepted by a subset of colleges (see 3.6).
3. Students decide simultaneously whether and which college to enter (see 3.7).
4. Students who do not enter college become workers with a high school degree (HSG).
5. Students who enter college, choose study time, courses taken, consumption, etc in each period until they either decide to drop out or are able to graduate (see 3.8.4).
6. Students who drop out becomes workers with education CD. Graduates become workers with education CG.

Workers solve a simple permanent income life-cycle problem. At the start of work (period t_w), agents have accumulated assets (or debts) k, human capital h, and educational attainment $e \in \{HSG, CD, CG\}$. These determine their lifetime incomes. Workers only make consumption-savings decisions (see 3.9).

3.3 Colleges

Colleges are differentiated by "quality" $q \in \{1, \ldots, N_q\}$ and location $\iota \in \{1, \ldots, N_\iota\}$. Each location contains at most one college of each quality. Colleges of a given quality are identical, except for their locations. Colleges of quality 1 are the "lowest" quality and correspond to two year colleges in the data. All other colleges are four year colleges where students may earn college degrees, so they become workers with education CG.

The role of locations for college entry decisions is described in 3.7.

Colleges differ in terms of the productivity of human capital accumulation, their graduation requirements, and their admissions standards. Specifically, a college of quality q specifies:

- a human capital production function and shock process (see 3.5)
- admissions requirements (see 3.6)

- graduation requirements (see 3.8.5)
- tuition net of scholarships and grants as a function of student characteristics (see 4.5)
- parental transfers as a function of student characteristics (see 4.4)
- admissible values for student work times $v \in \mathbb{S}_v(q)$, study times $\ell \in \mathbb{S}_\ell(q)$, and course loads $n \in \mathbb{S}_n(q)$
- the maximum number of periods that a student can be enrolled T_q

The basic trade-offs between good and bad colleges are: Low quality colleges tend to be inexpensive and easy to be admitted to. It is also easier to graduate from them. High quality colleges offer better learning opportunities.

3.4 Timing in college

A period in college unfolds as follows.

1. Students begin the period with assets k, human capital h, and cumulative courses taken $\bar{n}$.
2. Students decide how much to consume c and save or borrow k'.
3. Students decide how much time to spend on work v and study ℓ, and how many courses to enroll in n. These choices determine how much human capital they accumulate.
4. Students who fulfill the college's graduation requirements are given the option to graduate. Broadly speaking, in order to graduate, students must have taken at least $\underline{n}$ courses. Once this requirement is satisfied, the probability of graduation depends on the student's human capital relative to a college specific target amount (see 3.8.5).
5. Students who have reached the end of the permitted college duration T_q must drop out.
6. The remaining students decide whether to study for another period or leave college and become workers.

3.5 Human capital production function

A student who attends a college of quality q can learn up to $h_{q,max}$ units of human capital. That is, upon exiting college, the student's human capital stock will be at most $h_1 + h_{q,max}$. Higher quality colleges offer greater learning opportunities, so that $h_{q,max}$ is increasing in q.

Learning takes place by taking courses. For each course taken, learning is governed by

$$\Delta h = \mathcal{H}\left(h, \hat{\ell}; q, a\right) = A_q \hat{\ell}^{\alpha} e^{\phi a} \tag{1}$$

where $0 < \alpha, \phi < 1$ are parameters. Study time per course is given by $\hat{\ell} = \left(\ell - n\bar{\ell}\right)/n$ where $\bar{\ell}$ is a fixed study time required for each course. Learning productivity A_q depends on how much a student has learned relative to the maximum amount that can be learned in this college:

$$A_q = \left[h_{q,max}^{\gamma} - (h - h_1)^{\gamma}\right]^{1/\gamma} \tag{2}$$

The parameter γ governs the curvature of the productivity decline as $h - h_0 \rightarrow h_{q,max}$.

The total amount learned in a given period is then $\Delta h \times n$, so that end of period human capital is given by

$$h' = h\left(1 - \delta\right) + \Delta h \times n. \tag{3}$$

3.6 College Admissions

The specification of college admissions and of the matching of students to colleges is based on Hendricks et al. (2021) (that would be the Jan 21 AEJ-M paper).

We do not model the admissions decisions of colleges. Instead, we assume that each college is endowed with a cutoff value. Students with expected abilities above the cutoff are accepted until the college's capacity is exhausted. Students with expected abilities below the cutoff are always rejected.

Colleges do not directly observe student abilities. Instead, they observe their parental backgrounds and test scores (high school GPAs). Based on this information, colleges calculate the expected abilities of all students.

Two year colleges are not selective and admit all students.

3.7 College Entry Protocol

Students decide sequentially which colleges they wish to attend (conditional on being accepted). These decisions are made in order of student expected abilities as assessed by colleges.

Colleges have fixed capacities. Once all seats are filled, no more students are admitted, even if they satisfy the admissions threshold.

3.8 Student Problem

3.8.1 *Endowments*

At high school graduation, students are endowed with fixed characteristics $\bar{s}$ which contain:

- ability a
- parental background indicator p
- high school GPA g
- college human capital h_1
- high school human capital $\hat{h}$
- location ι
- tuition shifters for all colleges: $\hat{\tau}_q$

In each location, student endowments are drawn from the same Gaussian copula (details in 4.2). In this draft, we interchangeably use HS GPA and test score.

3.8.2 *Value of HSG*

As pointed out in 3.6, students are admitted to colleges based on threshold values for their expected abilities. Generically, we can write the probability that a student with endowments $\bar{s}$ is admitted to the colleges in set $\mathcal{S}$ as $\Pr_{admit}(\mathcal{S}, \bar{s})$. The value function of a high school graduate is then given by

$$V^{HSG}(\bar{s}) = \sum_{\mathcal{S}} \Pr_{admit}(\mathcal{S}, \bar{s}) V^{admit}(\mathcal{S}, \bar{s}) \tag{4}$$

where $V^{admit}\left(\mathcal{S},\bar{s}\right)$ is the value of being admitted to the set of colleges $\mathcal{S}$.

3.8.3 *College Entry Decision*

Once admitted, a student decides whether to enroll in one of the available colleges or to work as a high school graduate. This decision is subject to i.i.d., mean zero Gumbel preference shocks with scale parameter π. The Bellman equation is given by

$$V^{admit}\left(\mathcal{S},\bar{s}\right)=\max\left\{\left[V^{entry}\left(q,\bar{s}\right)+\mathbb{I}_{local,q}\mathcal{U}_{local}-\pi p_{q}\right]_{q\in\mathcal{S}},V^{HSG}\left(\bar{s}\right)-\pi p_{HSG}\right\} \tag{5}$$

where V^{entry} is the value of starting a college. In particular, $V^{entry}\left(q,\bar{s}\right)=V\left(s,1\right)$ where $V\left(s,t\right)$ denotes the value of studying in period t with state $s=\left(k,h,\bar{n};q,\bar{s}\right)$ where for college starters $k=k_{1}$, $h=h_{1}$, and $\bar{n}=0$.

If the college attended is a local college (its location matches that of the student), the student receives additional utility $\mathcal{U}_{local}$.

3.8.4 *Student decisions*

During each period in college, a student decides how many courses to take n, how much time to spend on studying ℓ and working v, how much to consume c and save (or borrow) k'. The choice sets for work time, study time and $\bar{n}$ depend on the college attended (details in 4.3). The flow budget constraint is given by

$$k'=Rk+wv+z\left(s\right)-\tau\left(s\right)-c \tag{6}$$

where $R=1.04$ is the gross interest rate, w is the wage earned when working in college, z is the transfer received from parents (see 4.4), and τ denotes college tuition net of scholarships and grants (see 4.5). Borrowing is constrained by $k'\geq\underline{k}\left(t+1\right)$. The values of $\underline{k}\left(t\right)$ are set to match federal student loan limits (see 4.3).

The Bellman equation governing the student's decisions is given by

$$V\left(s,t\right)=\max\mathcal{U}\left(c,l\right)+\beta\sum_{h'}\mathbb{P}\left(h'\right)V^{e}\left(s',t\right) \tag{7}$$

subject to the budget constraint (6), the borrowing constraint, and the law of motion for human capital (3.5) which implies a probability distribution over h', denoted here by $\mathbb{P}\left(h'\right)$.

Here, $\mathcal{U}(c, l)$ is the flow utility derived from consumption and leisure $l = 1 - \ell - v$, β is a discount factor, $V^e(s', t)$ is the value function at the end of period t.

3.8.5 *Graduation and dropout*

At the end of each period in college, the student learns whether they must exit college or may continue to study for another period. Students exit college either as college graduates (education CG) or as college dropouts (education CD).

When a student may graduate is determined by a college specific graduation rule. It gives the probability of graduation as a function of the student's human capital and courses taken, $\Pr_g(s, t)$ (see 4.3.3).

Similarly, the probability that a student must drop out is governed by a college specific dropout rule $\Pr_d(s', t)$. In the baseline case, students are allowed to study for at most T_q periods. Thereafter, $\Pr_d(s', t) = 1$.

The value at the end of the college period is therefore given by

$$\begin{aligned} V^e(s', t) = {} & \Pr_g(s', t) \times V^{ws}(\mathbb{I}_{grad}, s', CG, t + 1) \\ & + \left[1 - \Pr_g(s', t)\right] \Pr_d(s', t) \times W(s', CD, t + 1) \\ & + \left[1 - \Pr_g(s', t)\right] \left[1 - \Pr_d(s', t)\right] V^{ws}(\mathbb{I}_{no-grad}, s', t + 1) \end{aligned}$$

where V^{ws} is the value of reaching the work-study decision at the start of the next period. In words:

- With probability $\Pr_g(s', t)$: may graduate and face work/study choice as CG with value V^{ws} (see 3.8.6).
- With probability $[1 - \Pr_g] \Pr_d$, the student must drop out and work as a CD with value W (see 3.9)
- With complementary probability, the student faces the work/study decision as non-graduate.

3.8.6 *Work or study decision*

At the start of each period, students who are not forced to drop out decide whether to study or work next period. For a student who may graduate, the Bellman equation is given by

$$V^{ws}\left(\mathbb{I}_{grad}, s, t\right) = \max\left\{V\left(s,t\right) - \pi p_c, W\left(\hat{s}, CD, t\right) - \pi p_{CD}, W\left(\hat{s}, CG, t\right) - \pi p_{CG}\right\} \tag{8}$$

The student decides between studying one more period with value V. If the student decides not to study, they choose between working as a college graduate ($e = CG$) or as a college dropout ($e = CD$) with value $W\left(\hat{s}, e, t\right)$. That is, students are not forced to graduate in case this lowers their expected utility. This choice is subject to i.i.d., mean zero Gumbel preference shocks with scale parameter π.

The state at the start of work is given by $\hat{s} = (k, h, \bar{s})$, educational attainment (CD or CG) and the age at work start.

3.9 Workers

Workers solve a simplest permanent income problem. They take lifetime earnings as given and choose consumption to smooth marginal utility over time.

3.9.1 *Earnings*

A worker begins their career at age t_w with educational attainment e, assets k, human capital h, and fixed endowments $\bar{s}$. Flow earnings are given by $w_e \tilde{h} f\left(t - t_w, e\right)$ where w_e denotes the education specific wage per efficiency unit of labor, $f\left(t - t_w, e\right)$ is an exogenous experience efficiency profile.

The worker's human capital is a function of the "high school" human capital endowment $\hat{h}$ and the human capital aquired in college h_{t_w}:

$$\tilde{h} = H\left(h_{t_w}, \hat{h}; e\right) \tag{9}$$

$$= (\omega h_{t_w}^{\chi} + (1-\omega)\hat{h}^{\chi})^{(1/\chi)} \tag{10}$$

Specifically, we assume that $\tilde{h}$ is a linear combination of the two types of human capital where more educated "jobs" place a larger weight ω_e on skills learned in college h.

The worker's present value of lifetime earnings is given by

$$Y = w_e \tilde{h} \sum_{x=1}^{T_w} R^{-x+1} f\left(x, e\right) \tag{11}$$

where the duration of the worker's career is $T_w = T_r - t_w + 1$. Workers retire after model age $T_r = 46$ and die at model age $T = 61$. In retirement, workers receive neither earnings nor retirement benefits.

3.9.2 *Worker problem*

The worker chooses the path of consumption c_t that maximizes lifetime utility

$$W\left(\hat{s}, e, t_w\right) = \max_{\{c_t\}} \sum_{t=t_w}^{T} \beta^{t-t_w} u\left(c_t, l_e\right) \tag{12}$$

subject to the budget constraint

$$Y + Rk_{t_w} = \sum_{t=t_w}^{T} R^{t_w - t} c_t \tag{13}$$

where l_e is the fixed amount of leisure (and other amenities) derived from working a job with education e.

[Add job preferences if any +++]

4 CALIBRATION

4.1 Preferences

The utility function is

$$\mathcal{U}\left(c, l\right) = \frac{\left[c + \underline{c}\right]^{1-\phi}}{1-\phi} + \omega_l \frac{l^{1-\zeta}}{1-\zeta} \tag{14}$$

The curvature parameters are fixed at $\phi = 1.0$ and $\zeta = 1.0$ (log utility). The weight on leisure ω_l is calibrated.

In the data, college students consume little compared with their consumption during the work phase. At the same time, few students are close to exhausting their borrowing opportunities. We account for this by reducing the marginal utility of consumption while in college. We do this by giving students free consumption $\underline{c} \geq 0$ while in college. The value of $\underline{c}$ is calibrated.

4.2 Endowments

Ability, parental background, human capital endowments (h and $\hat{h}$), and HS GPA are drawn from a Gaussian copula. We impose restrictions on the correlation matrix to reduce the number of calibrated parameters.

First, students draw (a, p) from a bivariate Normal distribution with calibrated correlation $\rho_{a,p}$. The marginal distribution of ability is $a \sim N(0,1)$ by normalization. We treat p as ordinal (only percentile values are used). Hence its marginal distribution need not be specified.

Next, human capital endowments, are drawn as linear combinations of abilities and parental backgrounds: $\tilde{h}_1 = a + \beta_{h,p} p + \sigma_h \varepsilon_h$ with $\varepsilon_h \sim N(0,1)$. The realizations of $\tilde{h}_1$ are then transformed to have a Beta marginal distribution $\mathcal{B}(\alpha_h, \beta_h)$ over the range $[h_{1,min}, h_{1,max}]$. $h_{1,min}$ is normalized to 1. The remaining parameters are calibrated. The realizations for $\hat{h}$ are drawn analogously, but the calibrated parameters differ from those governing h_1. The lower bound may again be normalized to 1 as the human capital aggregator (9) handles the scaling of $\hat{h}$.

High school GPAs g are also drawn as linear combinations of abilities and parental backgrounds. g is also an ordinal variable without a marginal distribution.

4.3 Colleges

There are $N_q = 4$ types of colleges and $N_\iota = 3$ locations. Each location is endowed with identical populations of high school graduates, with one two year college, and with one four year college.

College wage is fixed at observed level (about \$7 per hour).

Borrowing limits are the maximum amounts students can borrow through federal student loan program (details +++).

4.3.1 *College qualities*

The lowest college quality corresponds to two year colleges in the data. The remaining quality groups are constructed by sorting colleges according to their average freshman SAT scores.

College capacities are set to match enrollments in the data, except that two year colleges have unlimited capacities. [not exactly right]

Table 1: Two and four year colleges

	Two year colleges	Four year colleges
Admissible work hours	[0.0, 10.0, 25.0, 40.0]	[0.0, 7.5, 15.0, 25.0]
Admissible study hours	[15.0, 25.0, 35.0]	[15.0, 25.0, 35.0]
Maximum number of years in college	2	6

Admissible course loads are set to 10 courses per year (30 credits; full course load) or 5 courses per year (half load).

Table 1 reports common characteristics of 2 year and 4 year colleges.

4.3.2 *Human capital production*

Need to describe h shocks. They need to be specified in a way that is independent of grid implementation.

4.3.3 *Graduation rule*

The graduation rule gives the probability that a student may (but is not forced to) graduate at the end of each period in college.

Prob of graduation is 0 until the end of $T_g = 4$ and $\underline{n} = 40$ credits have been earned. The probability of being able to graduate increases linearly in h. It reaches its maximum value of $\Pr_{g,max} = 0.95$ at the common human capital level $h_{g,max}$. The slopes differ across colleges.

4.4 Transfers

Parental transfers are governed by a transfer function that depends on observable student characteristics and college quality. This function is directly estimated from the data.

When students exit college, they receive any unspent transfers as a lump sum payment at work start. The unspent amount is the difference between the transfers they would have received had they attended the most expensive college for the maximum number of year permitted and the transfers actually received.

The idea is that parents adjust future transfers to working children. Without this feature, more expensive colleges would effectively be free to students.

4.5 Tuition

Tuition net of scholarships and grants is comprised of a systematic component and an idiosyncratic component.

The systematic component is given by a function of college quality, HS gpa percentile, parental percentile. All coefficients are calibrated. The idiosyncratic component is a permanent, idiosyncratic, mean zero, uniform random draw. It permanently changes a student's tuition for "good" colleges (qualities 3+) and "bad" colleges (qualities 1-2). The range is calibrated.

4.6 Workers

Wages are calibrated and depend on whether or not the student has graduated from college.

The experience profile is common to all agents and directly estimated from data.

The value of leisure during work differs by educational attainment. It captures a variety of job amenities and is calibrated.

4.7 Targets

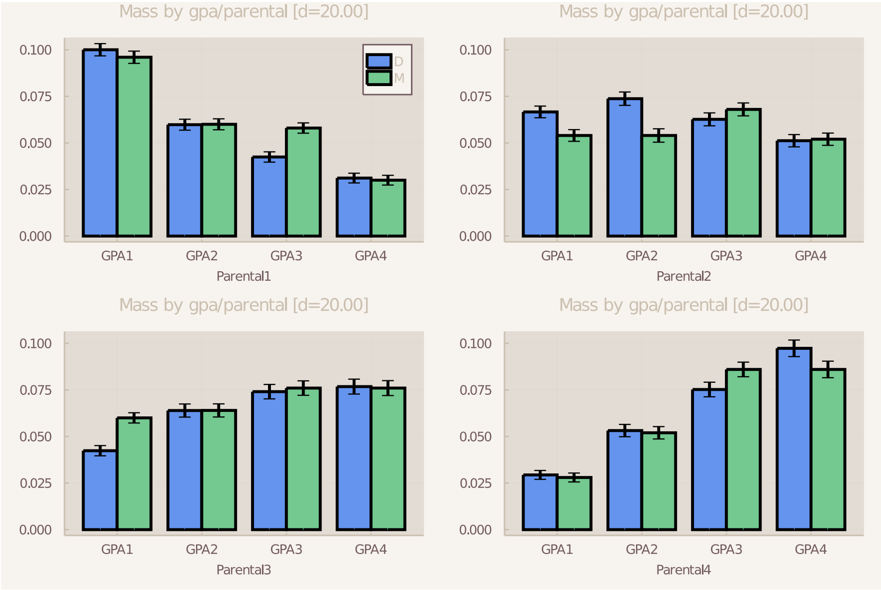
Students enter at age 19 (model age 1). Workers retire at age T^R which we calibrate to 65-19, live until T (calibrated to 80-19).

We calibrate the remaining parameters by targeting the following moments computed from NLSY 1997 data augmented with Geocode data and official college transcripts.

Our targets can be split into five categories.

- HS graduates' characteristics: joint distribution of parental income and test scores, college entry by parental income and test scores;
- Freshmen characteristics: college sorting by parental income and test scores, fraction of local students by college type;
- College progress characteristics: degree completion, cumulative credits taken, study times and yearly dropouts rates, all tabulated by parental income and test scores;

Figure 3: Model Fit: Distribution of HS Graduates



Note: The figure reports model and data mass of HS graduates by parental income quartile and HS gpa.

- Financial variables in college: college costs (tuition net of aid), parental transfers, student work hours, all tabulated by parental income and test scores;
- Earnings: Wage earnings regressions, one estimated on the sample of all HS graduates and one estimated on the sample of college graduates alone. Both are conditioned on parental income and test scores. The latter regression is also conditioned on quality of college.

5 CALIBRATION RESULTS AND MODEL FIT

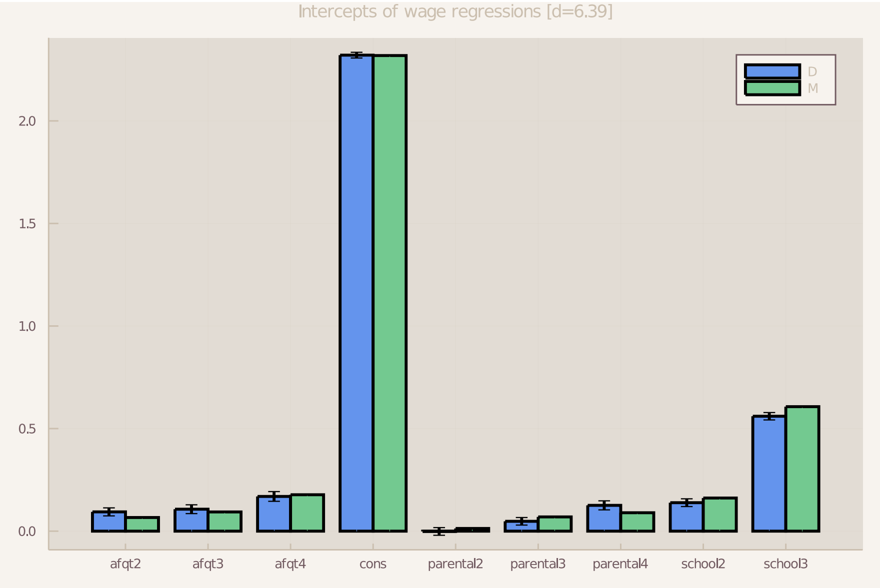
5.1 Model Fit

Our calibration procedures successfully reproduces the empirical targets of interest. We report selected figures in the main text and relegate others to the appendix.

Figure 3 reports model and data mass of HS graduates by parental income quartile and HS gpa.

Figure 4 reports model and data mass of HS graduates by parental income quartile and HS gpa.

Figure 4: Model Fit: Wage Regression, All Students



Note: The figure reports model and data wage regression coefficients.

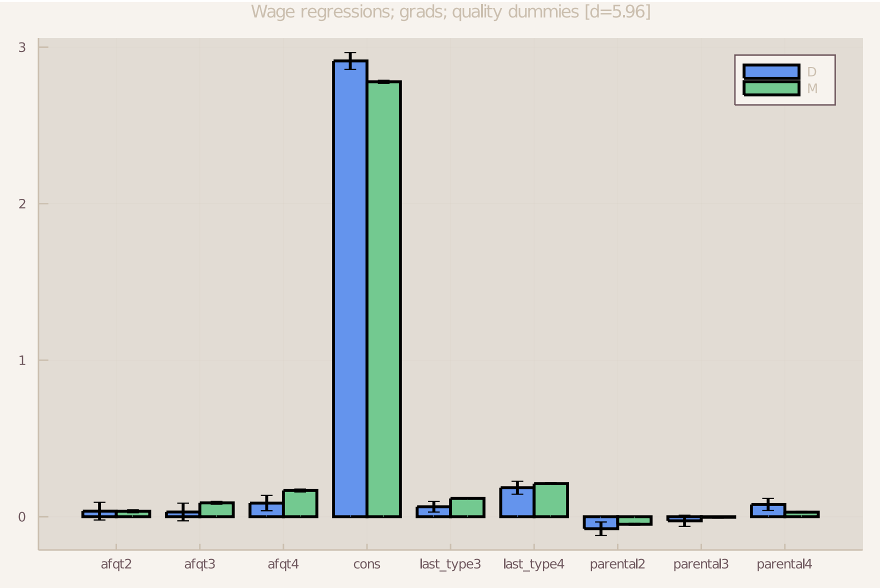
Figure 5 reports model and data wage regression coefficients for College Graduates. Conditional on test scores and parental income, we see that graduating from type 4 college yields about 20% return, relative to a graduation from type 2. The return to type 3 is a bit less. The model is able to generate similar returns to college quality.

Figure 6 reports model and data mass of HS graduates by parental income quartile and HS gpa. We see that entry increases with both HS performance and parental income. The model fit is good, although the HS gpa gradient is somewhat smaller.

Figure 7 illustrates model and data mass of freshmen in each type of college and student sorting on test score across college types. It is clear that students are positively selected into higher quality colleges. If anything, the model predicts a slightly greater test score gradient.

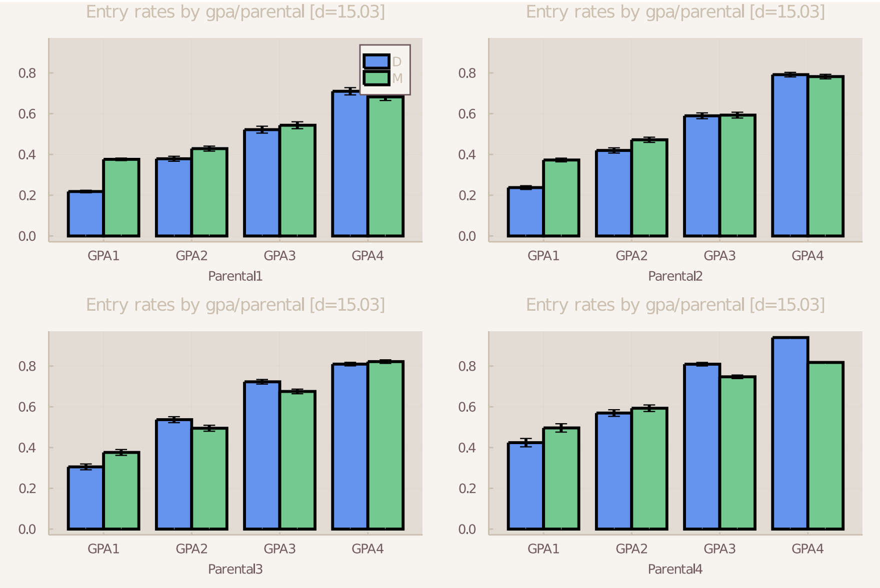
Figure 8 reports model and data freshmen distribution by HS gpa and quality. Higher gpa students tend to enroll in better quality schools. Lower gpa students enroll in

Figure 5: Model Fit: Wage Regression, College Graduates



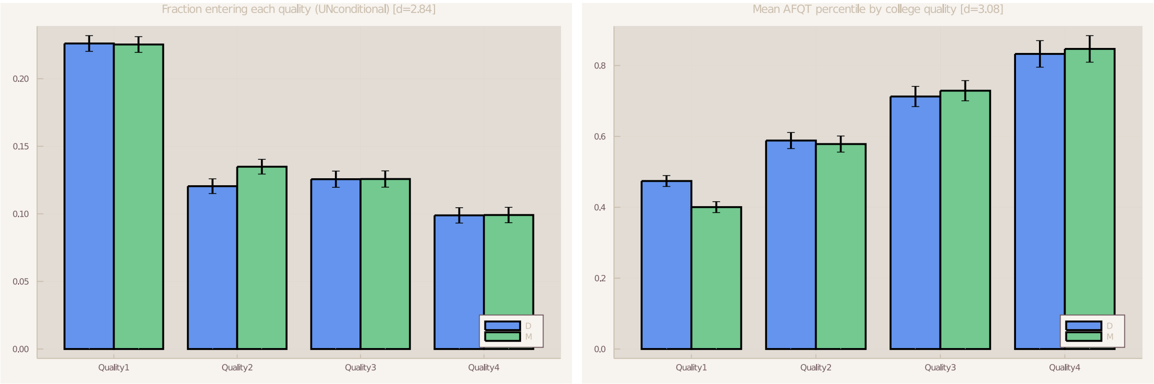
Note: The figure reports model and data wage regression coefficients for College Graduates.

Figure 6: Model Fit: Enrollment by Parental Income and HS gpa



Note: The figure reports model and data enrollment rates by parental income quartile and HS gpa.

Figure 7: Model fit: Sorting



(a) Model Fit: Tuition Regression

(b) Model Fit: Parental Transfers Regression

Note: Panel a reports model and data mass of freshmen in each type of college. Panel b illustrates student sorting on test score across college types.

2y colleges. Over 70% of freshmen with HS gpa in the lowest quartile enrolled in 2y schools.

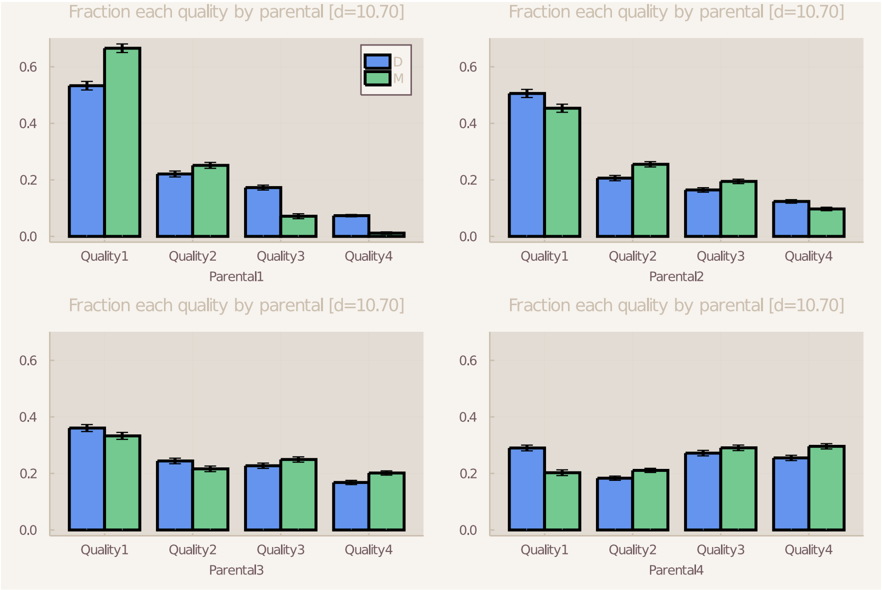
Figure 9 reports model and data freshmen distribution by parental income and quality. Higher income students tend to enroll in better quality schools. Of course, parental income correlates with HS performance. We also target enrollment in each type, by parental income and gpa. The model matches this dimension of sorting relatively well.

Figure 10 The figure reports model and data fractions of students completing a college degree, by HS gpa and college quality. Graduation rates increases with college quality (in both model and data), even if one conditions on HS performance. Interestingly, this is not driven by differences in graduation probabilities. If anything, our model calibrates that it is slightly more difficult to graduate from a better school (conditional on h). In other words, you need to have a greater stock of knowledge to graduate from a better quality school. What drives the increasing graduation rate is positive sorting of students across colleges. Higher ability and higher h students enroll in better schools. It is easier for them to learn and they stick around longer and graduate. Interstingly, study times do not vary systematically across schools, except they are slightly higher for low gpa students attending better schools. The

Figure 8: Model Fit: Soring by HS GPA

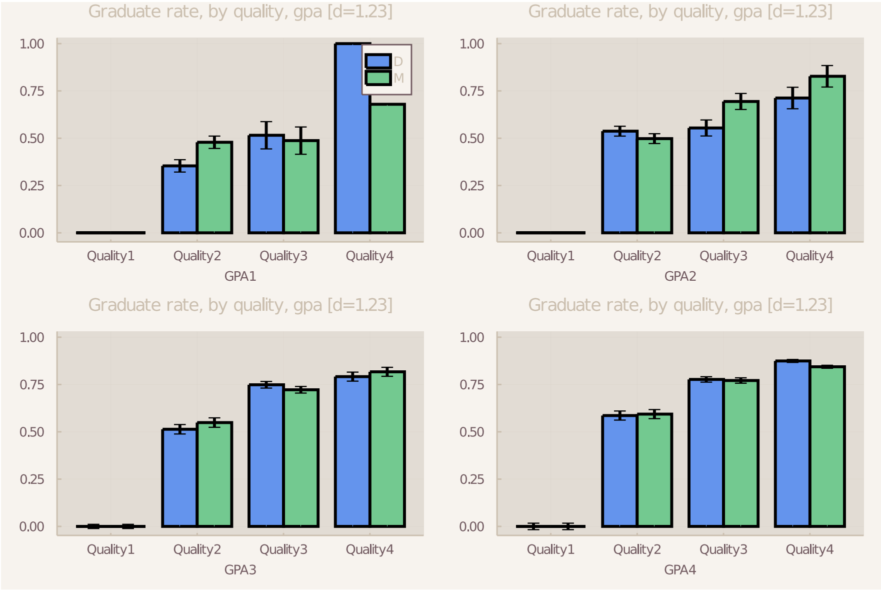
Note: The figure illustrates student sorting by HS GPA across college types.

Figure 9: Model Fit: Sorting by Parental Income



Note: The figure illustrates student sorting on parental income across college types.

Figure 10: Model Fit:



Note: The figure reports model and data fractions of students completing a college degree, by HS gpa and college quality.

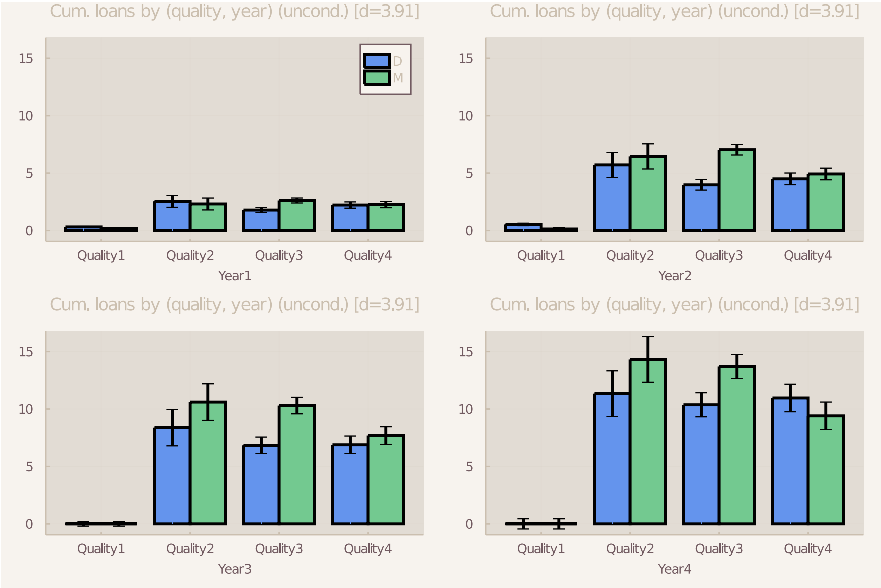
model is able to capture the lack of systematic regularity in study times as well (figure omitted).

The model also accurately captures college debt level, by year and college type (Figure 11). The model also matches course loads and the timing of dropping out. Dropouts tend to happen early and earlier in lower quality schools. These figures are omitted.

5.2 Calibration Results

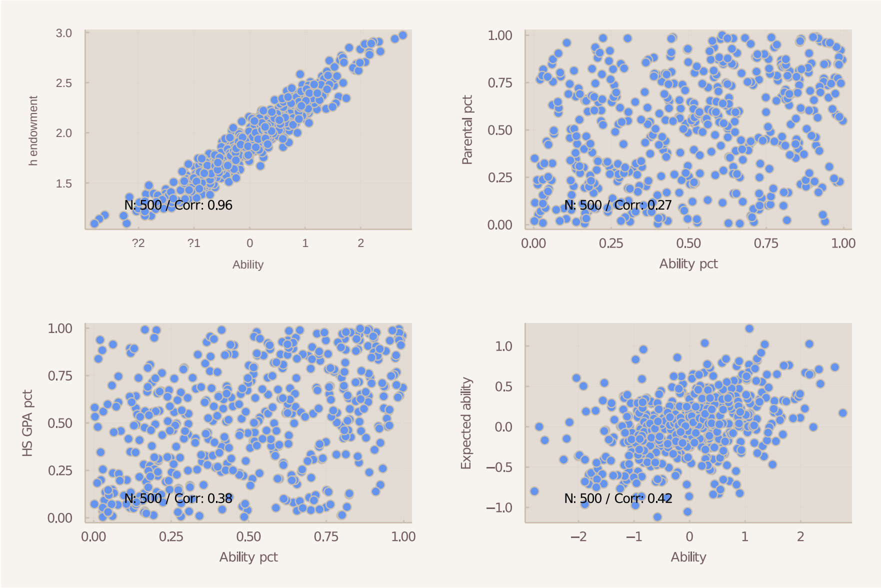
We report preference and initial distribution paramters in Tables 4- 6 in the appendix. Several aspects of the initial endowment distribution are illustrated in Figure 12. We can see that ability and college human capital are very highly correlated. The correlation between ability and expected ability (mean ability given parental income and HS gpa) is 0.42, which means that the admissions ranking based on expected ability will not perfectly align students according to their true ability.

Figure 11: Model Fit: Student Debt



Note: The figure reports model and data student debt, by year in college and by type of college.

Figure 12: Calibration Results: Initial Endowments



Note: The figure visualizes several aspects of the initial endowment distribution.

The present lifetime earnings are given by $w_e\tilde{h}\sum_{x=1}^{T_w} R^{-x+1} f(x,e)$ and they amount to (in thousands) On average, we obtain the present values (in thousands of 2000 dollars) to be 456 for the HS grads, 544 for dropouts and 914 for college grads, although there is a lot of heterogeneity due to $\tilde{h}$ as will be discussed below. The graduation premium ($w_{CG} - w_{HS}$) is calibrated to 0.148, or about 15% (See Table 3). Skill price experience profiles $w_e f(x, e)$ are depicted in Figure 13. The shapes are estimated directly from the data, but the graduation premium is calibrated.

The human capital aggregator $\tilde{h}$is assumed to be a CES function with the curviture parameter reported in Table 3. The weights on the two types of human capital used in this aggregator depend on the education level. We see the weight is higher on college human capital for students with a college degree (0.44). It is lower for HS grads and college dropouts (at 0.32).

Figure 13: Calibration Results: Wage Profiles

Note: The figure reports experience profiles of skill prices, $w_e f(x, e)$ for each education group. There is no dropout premium. Graduation premium is about 15%.

Table 2: Calibration

Symbol	Description	Value
Human capital technology		
α	Exponent on study time	0.865
γ	Exponent on h-h0	0.835
ϕ	Ability scale parameter	0.475
$\bar{\ell}$	Fixed study time	0.009
$h_{q,max}$	Maximum amount that can be learned	1.806 $\mid$ 2.445 $\mid$ 3.346 $\mid$ 4.217

Table 2 reports the calibrated productivity parameters by college type. Higher college types allow for more productive learning, as the maximum attainable human capital increases with school quality. Recall from the human capital production technology that it implies a higher productivity of study time.

Table 3: Calibration

Symbol	Description	Value
w_{HSG}	Log wage HSG	1.85
dw	Log wage gradient	0.148
Human capital aggregator		
ω	Weight on h college	0.324 | 0.444
χ	Curvature of CES aggregator	0.803

6 Accounting for the Dispersion of Lifetime Earnings

we disentangle the influence of initial endowments in determining the dispersion of lifetime earnings upon completion of schooling phase. We find relatively strong (although far from perfect) sorting of students on ability into college and into higher quality colleges. The higher ability students tend to stay in college longer typically completing their degree and accumulating a lot of h. On average, h rises by a factor of 1.44 for CD and 2.36 for CGs and more so for those who graduated from better colleges. Graduation premium is estimated to be about 15%. Therefore, most of the earnings gain associated with college entry and completion is due to changes in h. +++ More results to discuss here.

7 Quantifying the Efficiency-Equality Tradeoff

Initial endowments are not the only variables that matter for college entry, college choice and graduation. Financial constraints and admissions rules, i.e. the ranking of students, play an important role for college entry decisions and student sorting across colleges. From policy perspective, they are also easiest to vary if we are to meddle with the sorting of students across colleges. Therefore, it makes sense for us to quantify the efficiency-equality tradeoff by varying the admissions ranking rule. The outcome of interest is the mean and dispersion of lifetime earnings at age 23. Stronger sorting of students leads to a higher mean and higher dispersion.

7.1 Perfect Sorting on Ability

This hypothetical experiment ranks students on their ability rather than expected ability inferred from their HS performance and parental income. We see that, sorting gets substatially stronger across schools. Graduation rates increase in all college types.

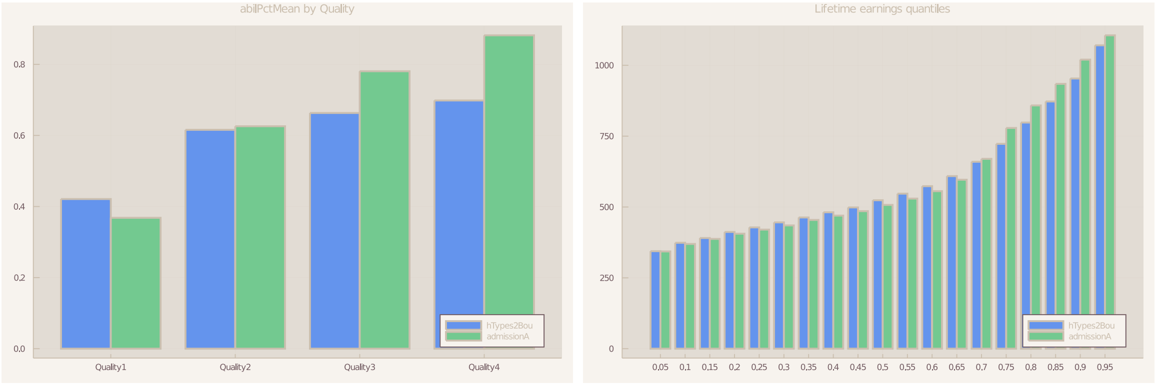
College entry depends substantially less on GPA and parental income as ability takes precedence here, and GPA and parental characteristics no longer play the role of signaling ability. College entry increases for the less affluent and lower HS gpa students. As more of them sort into better schools, their graduation rates rise as well.

Lifetime earnings rise overall. Report the mean increase. +++ The gain is restricted to the top 30% of earners. The middle 30% of the distribution actually earn s bit less, as some of these students comprise higher than average ability students that lost their spots in the more selective schools.

We find that welfare falls among students in the top quartile of GPA (equivalent to about 3% of consumption) and rises by similar consumption equivalent in the two lower quartiles of HS GPA. Similar welfare gains are seen for students differentiated by parental income although losses are slightly smaller for students in the top quartile (2% of consumption) but gains are larger for the lowest quartile (4% of consumption).

Figure 14 and Figure 15 illustrate the results. +++

Figure 14: Perfect Sorting vs. Benchmark

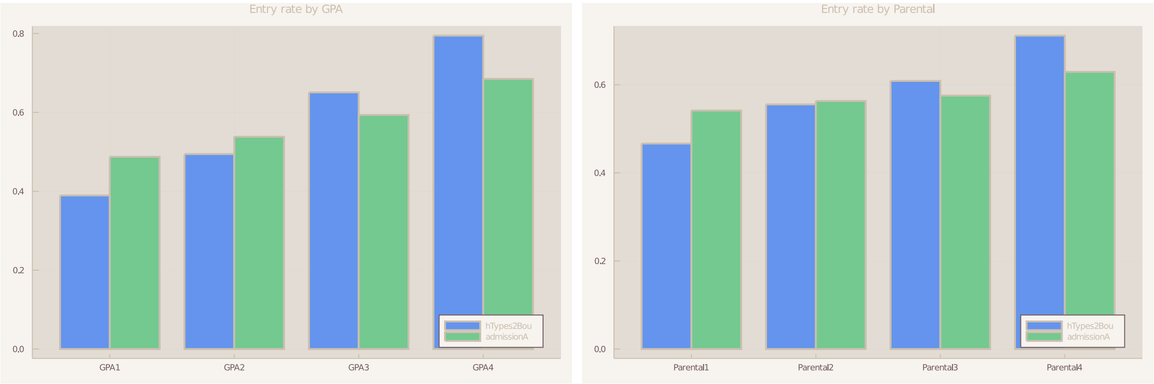


(a) Ability Percentile by Quality

(b) Lifetime Earnings Quantiles

Note: Panel a. Panel b .

Figure 15: Perfect Sorting vs. Benchmark



(a) Enrollment by GPA

(b) Enrollment by Parental Income

Note: Panel a. Panel b .

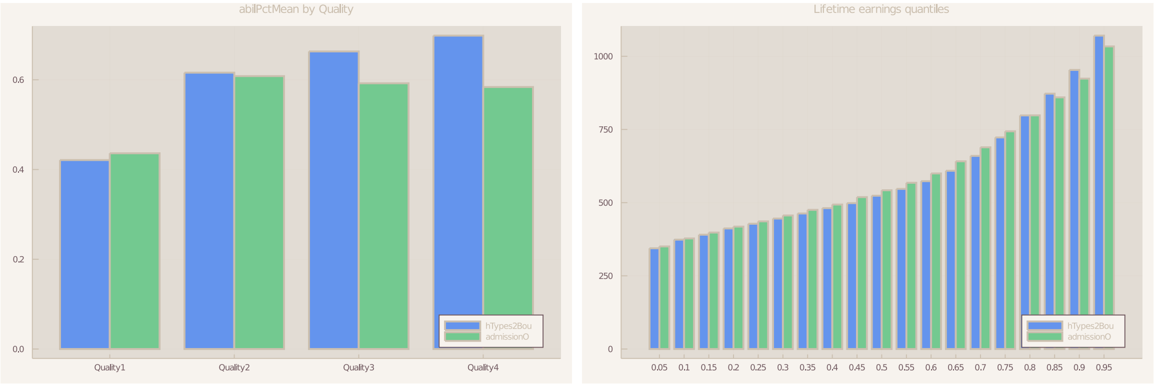
7.2 Open Admission

This counterfactual experiment students are ranked in random order and admission standards are removed. This experiment produces a lot less sorting among 4 year colleges, although sorting into 4 year colleges remains highly selective. This is because there is unlimited capacity in quality 2 colleges, so high ability students can always take that option. Graduation rates among the lowest GPA quartile rises by about 25 percentage points, while it drops by about 15 percentage point among students in the top quartile of HS gpa. The overall lifetime earnings fall substantially although the drop is restricted to the top 20% of earners. Report the mean drop. +++ Everyone else benefits, although very little.

The reason why the fall in earnings is not as drastic as one might expect is because of our assumption of unlimited seats in lower quality 4-years schools. High ability students, even if happen to be ranked last, always have a path to degree in their choic set, although their learning opportunities are limited.

Figure 16 and Figure 17 report selected results. +++

Figure 16: Open Admission vs. Benchmark

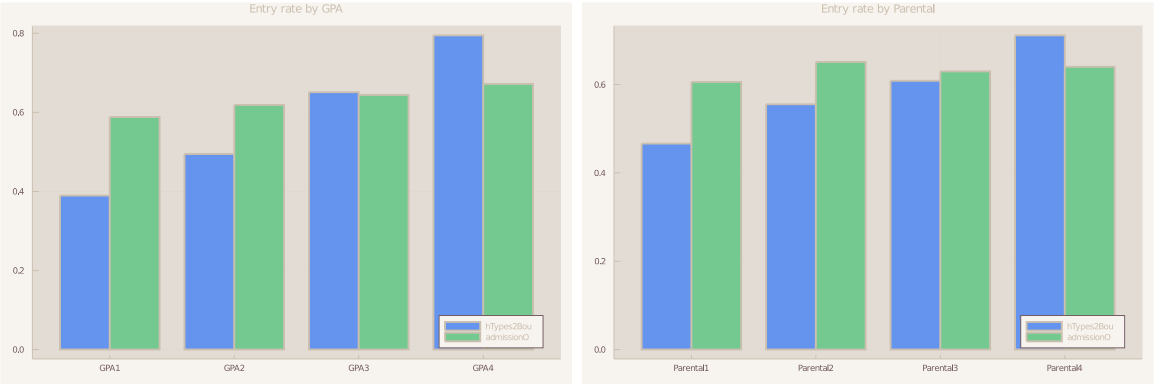


(a) Ability Percentile by Quality

(b) Lifetime Earnings Quantiles

Note: Panel a. Panel b .

Figure 17: Open Admissions vs. Benchmark



(a) Enrollment by GPA

(b) Enrollment by Parental Income

Note: Panel a. Panel b .

7.3 Affirmative Action

+++

8 CONCLUSION

On one hand, meritocracy produces more human capital overall if higher ability students learn more in college and if they learn more in higher quality colleges. This leads to a higher overall level of earnings (i.e. greater efficiency, loosely speaking). On the other hand, more meritocracy generates a higher degree of earnings inequality. In this paper, we quantify this efficiency-equality tradeoff via changing admission rules.

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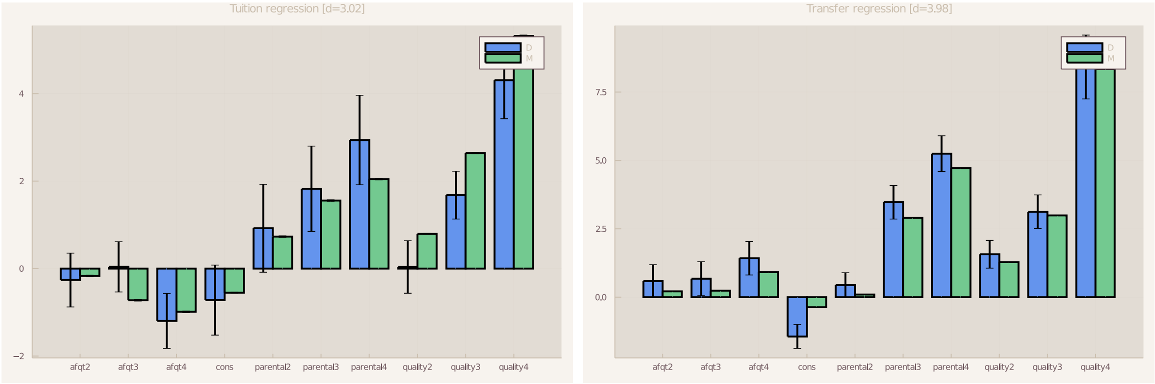
A ADDITIONAL TABLES AND FIGURES



(c) Model Fit: Tuition Regression (d) Model Fit: Parental Transfers Regression

Figure 18: Calibration Results

Note: The figure shows the calibrated wage and transfer functions.

Table 4: Calibration, Preferences

Symbol	Description	Value
Preferences		
ζ	Weight on leisure	2.245
π	Work/study preference shocks	3.036
ℓ_s	Leisure (job amenities)	0.382 | 0.341 | 0.42

Table 5: Calibration, Joint Endowment Distribution

Symbol	Description	Value
$\rho_{a,p}$	Correlation (a,p)	0.307
$\beta_{h,a}$	Weight on ability when drawing h_1	3.482
$\beta_{h,p}$	Weight on parental when drawing h_1	0.162
Δh_1	Range of h endowments	2.287
α_h	Alpha parameter of h Beta distribution	2.997
β_h	Beta parameter of h Beta distribution	4.456
$\beta_{\hat{h},a}$	Weight on ability when drawing $\hat{h}$	0.781
$\beta_{\hat{h},p}$	Weight on parental when drawing $\hat{h}$	1.134
$\Delta\hat{h}$	Range of high school h endowments	2.032
$\alpha_{\hat{h}}$	Alpha parameter of high school h Beta distribution	2.485
$\beta_{\hat{h}}$	Beta parameter of high school h Beta distribution	2.759
$\beta_{g,a}$	Weight on ability when drawing HS GPA	0.436
$\beta_{g,p}$	Weight on parental when drawing HS GPA	0.207
$\Delta\hat{\tau}$	Range of tuition shifter	3.923

Table 6: Calibration, College

Symbol	Description	Value
College entry protocol		
π_e	Preference shock scale for entry decisions	2.593
$\mathcal{U}_{local}$	Utility from attending local college	4.023
Graduation rules		
$h_{g,max}$	h level at which maximum graduation probability is reached	5.23
$\Pr_g$	Graduation probability at h_{min}	0.161 | 0.099 | 0.045
Wages in college		
Δw	Wage boost in two year college	0.607