Expanding Access to Selective Colleges*

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Abstract

This paper studies the effects of expanding high-quality public university capacities on student earnings and welfare. Using a quantitative model of college choice, we find that expanding the most selective colleges by 20 percent increases skilled labor supply by 5.3 percent, aggregate earnings by 0.8 percent, and welfare by 2.2 percent. The gains arise because a large number of high-ability students are rationed out of selective colleges. When admitted, these students graduate at high rates and enjoy substantial earnings gains. The earnings gains generated by expanding college capacity are eight times larger than the fiscal cost of financing it. Unskilled workers also gain from the expansion as the increased supply of skilled labor causes their wages to rise. These findings remain robust when we account for peer effects in student learning.

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"We will admit every qualified student and work for their success, period – no matter how many there are." – Michael Crow, President of Arizona State University, February, 2025

1 Introduction

In this paper, we study the implications of large-scale expansions of high-quality university capacities for student earnings and welfare.

Over the past several decades, the growth in demand for high-quality college seats has outpaced the growth of supply. Admission rates have been falling and getting into high-quality colleges has become increasingly difficult (Bound et al., 2009). Some observers see a college access "crisis" (Gándara et al., 2005).

In response to the increasing difficulty of admission, parents have invested growing amounts of money and time to polish their children's resumes. This "rug rat race" (Ramey and Ramey, 2010) suggests that admission to selective colleges generates large rents. That, in turn, suggests that expanding high-quality college seats might substantially increase total earnings and welfare. One reason why demand has been rising is the high financial return from attending selective public universities. Even marginally admitted students experience substantial earnings gains.[1]

Why has supply not increased more in response to persistent excess demand? For private colleges, and especially for elite colleges, one answer is that college rankings and reputations incentivize colleges to be "selective." Admitting more students would reduce a college's standing relative to peer institutions (Blair and Smetters, 2021).

Public college capacities are governed not by market forces, but by state-level policies. A limited number of public university systems have responded to rising demand by massively increasing capacity. The most prominent example is Arizona State University's Tempe campus, which now enrolls more than 55,000 undergraduates. But overall, since about 1980, high-quality college capacities have not expanded faster than low-quality, or even two-year, capacities.[2] As a result, high-quality colleges face substantial excess demand, while at the same time low-quality colleges have trouble attracting students (Haveman and Smeeding, 2006; Hout, 2009).

[1] See Lovenheim and Smith (2023) for a survey of the relevant literature. While not all studies find large earnings gains, a large majority do.

[2] See Turner (2004, Fig. 1.10), Blair and Smetters (2021, Fig. 2), and Roy and Su (2022).

The arguments against a well-funded expansion of college capacities are rarely clearly articulated. A common concern revolves around cohort crowding. During past enrollment expansions, public funding per student declined and dropout rates increased (Bound et al., 2010). In this paper, we set aside cohort crowding and focus on college expansions that maintain the existing level of expenditures per student. Our model addresses three main concerns about such expansions.

The first concern is that the students who are "pulled in" by a college expansion are *less well prepared* than existing students. Hence, they may not benefit as much from attending selective colleges or may not even graduate. Empirical evidence provides some support for this concern. Bleemer (2024) finds that California students admitted to selective public universities under a top percent rule arrive with weaker academic credentials than typically admitted students.[3] On the other hand, they perform at least on par with existing students who have similar scores. Other studies that use similar admissions cutoffs for causal identification also find substantial earnings gains for marginal students admitted to selective colleges (Hoekstra, 2020). One question that our paper sheds light on is how these findings change when colleges admit large numbers of additional students. To our knowledge, previous research has not studied the implications of large-scale college capacity expansions for the earnings of college graduates.

A related concern involves *peer effects*. If student learning depends on the characteristics of their peers, admitting less qualified students could hinder learning for all students.[4]

Finally, increasing the supply of college graduates could reduce the *college wage premium*. This would reduce the financial return for all students. Bengali et al. (2025) argue that rising supply of college labor is one reason why the college premium has been flat since the year 2000.

We study the implications of expanding the capacities of high-quality colleges using a quantitative *model* of college choice with the following key features. Students are heterogeneous in their human capital, learning ability, financial means, and preferences for attending colleges. Our model allows for the possibility that expanding college enrollment requires colleges to admit students of lower ability. Financial constraints, information frictions, and idiosyncratic college preferences mean that many

[3] Top percent rules automatically admit all students at the top of their high school class to a set of selective public universities. The implementation details vary across states.

[4] Sacerdote (2011) surveys the literature on peer effects.

high-ability students will not enroll in top-quality colleges, even if admitted.

In the model, colleges differ in "quality," which determines how rapidly students accumulate human capital in college and how likely they are to graduate. Student learning benefits from being well-matched with a college. For high-ability students, learning is maximized by attending a top-quality college. But for lower-ability students, choosing a lower-quality college may be better.[5] This *complementarity* between college quality and student ability allows the model to match the empirical finding that the earnings gaps between college qualities are particularly large for high-ability students. It also allows the model to address one of the main concerns about expanding high-quality colleges – that admitting lower-ability students, who are not well-suited for selective colleges, may reduce aggregate earnings.

Finally, in the model, high-quality colleges are selective. They only admit students with sufficiently high ability or human capital. Low-quality colleges, on the other hand, admit all students, in line with evidence that such colleges struggle to fill all available seats (Haveman and Smeeding, 2006; Hout, 2009).

Our *baseline experiment* expands the capacity of top-quality colleges by 20 percent, creating seats for an additional 2 percent of high school graduates. Admissions standards adjust endogenously so that all college seats are filled. College spending is adjusted to keep expenditure per student and therefore learning productivity unchanged. The most selective colleges in our model enroll about 30 percent of four-year college freshmen. The group includes selective private schools, most public flagship universities, and other selective public universities (e.g., Iowa State, NC State, UC-Santa Barbara; see Section 2.3). "Elite" universities, such as Ivy League schools, comprise only a small fraction of this group. We assume that the public sector controls the overall capacity of this college group by setting the capacities of public universities, which account for about 60 percent of the group's enrollment.[6]

To obtain clear intuition for the findings, the baseline experiment abstracts from peer effects that affect learning and from endogenous skill prices that respond to changes in the supply of skilled and unskilled labor. How these model features modify the findings is examined in Sections 5 and 6.

We find that a 20 percent expansion of top-quality colleges raises aggregate earnings by 0.8 percent and welfare by 2.2 percent. Since the expansion mostly benefits middle-

[5] Lovenheim and Smith (2023) survey the empirical evidence on college match.

[6] The question of how private universities might respond to the public capacity expansion is beyond the scope of this paper.

income students, it generates only modest changes in the distribution of earnings and in intergenerational mobility. The aggregate earnings gains are comparable in magnitude to those of major tax reforms.[7] The cost of creating the added college seats is only one-eighth of the implied earnings gain. The reform is therefore self-financing as long as the earnings tax rate exceeds 12.5 percent.[8]

These gains arise because our calibrated model implies substantial excess demand for high-quality colleges. A large empirical literature documents that many high-ability students do not enroll in selective colleges. The literature refers to such students as *undermatched*.[9] Undermatch is also common in our data, where nearly half of all high school graduates in the top test score quartile do not enroll in a selective college. In our model, many (but not all) of these students are rationed out of the most selective colleges. When college capacity expands, most of the added college seats can therefore be filled by high-ability students who previously did not attend four-year colleges. Most of these students successfully graduate from college and therefore enjoy lifetime earnings gains on the order of 50 percent. Since the pool of undermatched high-ability students is large, the mean ability of students admitted to selective colleges declines only modestly, and therefore graduation rates remain high.[10] However, not all undermatched students are constrained by selective admissions. Some prefer lower-quality colleges (Dillon and Smith, 2017). Others are prevented from enrolling in selective colleges by financial or information frictions. These students will not respond to relaxed admissions standards. Thus, our analysis allows for the possibility that college expansions fail to attract some of the undermatched students.

In Section 5, we allow *peer effects* to reduce learning productivity when colleges admit less qualified students. We find that peer effects lower the earnings of top-ability students enrolled in expanding colleges. The effects on other students and on aggregate outcomes are small. The intuition for these findings derives from the complementarity between student ability and college quality that we described earlier. When peer effects reduce the learning productivity of top-quality colleges, high-ability

[7] For example, the 2017 "Tax Cuts and Jobs Act" has been estimated to increase long-run GDP by between 0.4 and 0.9 percent (Barro and Furman, 2018; Chodorow-Reich et al., 2024).

[8] See Appendix C for details.

[9] The definition of undermatch varies across studies in the literature; e.g., Bowen et al. (2009); Hoxby and Avery (2013).

[10] Our findings are in line with Carnevale and Rose (2004, p. 6) who conclude that selective colleges "could in fact admit far greater numbers of low-income students, including low-income minority students, who could handle the work."

students, who benefit from the complementarity, are disproportionately affected. The earnings of lower-ability students change by smaller amounts, so that their enrollment decisions are largely unaffected by the college expansion.

In Section 6, we allow skill prices to respond to increased skilled labor supply by modeling output as a CES composite of college and non-college labor. Expanding the capacity of the most selective colleges by 20 percent lowers the college wage premium by 4.2 percent. Compared with the baseline expansion, slightly fewer students enroll in four-year colleges, which reduces the aggregate earnings gains. At the same time, the wages of non-college workers rise as their labor becomes scarcer. The overall change in aggregate earnings is therefore similar to the baseline case. However, lifetime earnings inequality declines and intergenerational mobility increases.

Our findings suggest that expanding high-quality college capacities generates large earnings and welfare gains at moderate fiscal cost.

1.1 Related Literature

Since college enrollment has been rising in the U.S. for a long time, it is natural to ask whether past enrollment increases were associated with declining cohort quality. Overall, the empirical evidence suggests that this has not been the case. Juhn et al. (2005) and Archibald et al. (2015) show that the size of a graduating cohort is only weakly related to graduates' earnings. Hendricks et al. (2021) find that increasing ability sorting prevented the mean ability of college students from declining over time. However, Carneiro and Lee (2011) find larger effects of cohort size on graduates' earnings.

Student test scores paint a similar picture. Hoxby (2009) and Bound et al. (2010) show that average test scores have remained roughly unchanged since 1972 for four-year colleges of most selectivity levels. These findings suggest that a large-scale expansion of college enrollment may be feasible without substantially reducing the quality of the enrolled students.

Our model implies that admissions constraints bind for many students. Direct evidence that speaks to the number of students who are rationed out of the most selective college sector is scarce. The enrollment changes caused by top percent rules suggest that a substantial fraction of students may be admission constrained. Bleemer (2024) estimates that California's "Eligibility in the Local Context" program caused over 10 percent of barely-eligible applicants from low-opportunity high schools to switch from less-selective public colleges (California State Universities or community colleges) into selective UC campuses. Similarly, Black et al. (2023) find that Texas's Top Ten Percent Rule "pulled in" many students who would otherwise not have attended any four-year college. Indirect evidence comes from growing parental investments intended to improve their children's chances of being admitted to selective colleges (Bound et al., 2009).

A growing literature suggests that even marginally admitted students benefit from enrolling in selective colleges. Studies that exploit admissions cutoffs for identification often find significant increases in graduation rates and earnings (Hoekstra, 2009, Zimmerman, 2014, Mountjoy, 2026, Smith et al., 2026). However, not all studies find significant gains (Mountjoy and Hickman, 2021). Instead of focusing on marginal students with qualifications near admissions cutoffs, our paper considers the implications of large-scale college expansions that attract a broader set of students.

Athreya and Eberly (2021) argue that college access is not valued by students who currently do not enroll. The main reason is that these students would likely fail to graduate. We depart from their analysis by considering quality-differentiated colleges. We find that students do value access to high-quality colleges, where graduation rates are much higher than for the average four-year college.

Fu (2014) also examines the effect of expanding public college capacities on college enrollment (though not on earnings or welfare) using a structural model of college choice. She finds that expanding the capacities of all public colleges, except for the top-quality one in each state, has only a small effect on college enrollment. One reason is that, in her model, these colleges already accept 94 percent of applicants before capacities are expanded. We find that expanding the capacities of more selective colleges has much larger enrollment effects.

Much of the previous literature focused on the demand for college as the main driver of rising enrollment (e.g., Restuccia and Vandenbroucke, 2013; Donovan and Herrington, 2018; Blandin and Herrington, 2022; Krueger et al., 2025). By abstracting from selective admissions, the supply of college seats was treated as elastic. By contrast, our analysis highlights the limited supply of high-quality college seats as an important determinant of college enrollment and graduate earnings.

2 Model

2.1 Model Overview

This paper aims to quantify how large-scale expansions of college capacities affect aggregate earnings and distributional outcomes. For this purpose, we extend the model of Hendricks et al. (2025) to allow for endogenous wages and peer effects in student learning.

The model follows a single cohort of high school graduates through college and work into retirement. High school graduates differ in their learning ability and human capital, which affect the financial returns to college. They also differ in terms of parental background which determines their ability to pay for college. Colleges are places of learning that differ in terms of "quality" q. Better colleges produce more human capital, at least for high-ability students. They also charge higher tuition. Selective four-year colleges are capacity-constrained and admit only students with strong observable credentials.

Students, especially from lower-income backgrounds, face various frictions when selecting colleges. Some students are financially constrained and cannot afford potentially expensive selective colleges. Selective admissions prevent some qualified students from attending high-quality colleges. Lower-income students tend to have lower admissions scores, mainly due to lower human capital endowments. They are therefore less likely to be admitted. Students are also imperfectly informed about the financial returns to colleges that admit them.[11] Finally, students have idiosyncratic preferences for specific colleges. Evidence suggests that many students enroll in colleges that are either close to home or that are attended by friends or peers (Dillon and Smith, 2017). Jointly, these frictions generate undermatch, especially among lower-income students. Some of these undermatched students may enroll in selective colleges when their capacities are expanded.

The timing of events is as follows. At high school graduation, students draw endowments (ability, parental background, etc.). The endowments imply admissions scores z. College q admits all students with admissions scores above the cutoff value $\bar{z}_q$. Selective colleges have limited capacities and set the cutoff values so as to fill all available seats. Students choose a college from the set they are admitted to; or they start to work as high school graduates. At this stage, students imperfectly observe

[11] We explain why information frictions matter in Section 2.6.1.

the quality of admitting colleges.

In each college period, students accumulate human capital. The rate of learning depends on student ability and on college quality. Students also consume and borrow. At the end of each college period, students may drop out or graduate, in which case they become workers. After completing their education, workers solve a simple permanent-income consumption-saving problem. Worker earnings are determined by the human capital they have accumulated at the time they start working and by degree attainment (a sheepskin effect).

The following sections describe these model stages in detail. We discuss our modeling choices in Section 2.9.

2.2 Student Endowments

High school graduates enter the model at age $t = 1$ (physical age 19). They draw a vector of endowments that consists of learning ability a (standard Normal marginal), parental income percentile p, test score percentile g, and human capital stock h_1 (uniform marginal). The endowment correlations are modeled as a Gaussian copula.

Students are also endowed with idiosyncratic preferences for individual colleges $\mathcal{U}_q$. These represent flow utilities received while enrolled in any given college q.

2.3 Colleges

Colleges are differentiated by their "quality," $q \in \{1, 2, 3, 4\}$. Each quality group contains one representative college. Colleges of quality 1 correspond to two-year colleges. Students must exit these colleges after two years without earning a degree. All other colleges are four-year colleges where students may earn bachelor's degrees. Students may attend these colleges for up to six years.[12]

Colleges differ in their human capital production functions, graduation and dropout rates, and in terms of financial variables, such as college costs. These differences are described in Section 2.5. Higher-quality colleges produce more human capital, at least for high-ability students, but may also cost more and impose more stringent graduation requirements. This is the main financial trade-off facing students who decide which college to attend.

[12] We abstract from the option of transferring from two-year to four-year colleges. The main reason is that such transfers are not common in our data.

2.4 Work Phase

It is convenient to describe the life-cycle of a student starting from the last phase, work and retirement. Upon completion of schooling, individuals work from age t_w (the endogenous age after finishing education) to age T_r (physical age 65). Thereafter, workers are retired until they die at age T_l (physical age 80).

Workers begin their careers endowed with state vector $s_w = (h_w, k_w, e, t_w)$ (human capital h, assets or debt k_w, education level e, and age t_w). Education e takes on the values HSG for no college, SC for some college without a degree, or CG for college graduates.

Workers solve a simple permanent-income problem. Taking the education-specific skill price (w_e) and interest rate (R) as given, they choose the stream of consumption flows (c_t) to maximize lifetime utility discounted at rate β. The worker's problem is given by

$$W(s_w) = \max_{\{c_t\}} \sum_{t=t_w}^{T_l} \beta^{t-t_w} \left[\frac{c_t^{1-\theta}}{1-\theta} + \mathcal{U}_e \right] \tag{1}$$

subject to a lifetime budget constraint that equates the present value of consumption with the present value of labor earnings plus initial assets,

$$\sum_{t=t_w}^{T_l} R^{t_w-t} c_t = \sum_{t=t_w}^{T_r} R^{t_w-t} w_e h_w f(t-t_w, e) + R k_w. \tag{2}$$

Period utility depends on consumption c_t and the flow utility from leisure and other amenities $\mathcal{U}_e$ associated with jobs typical of education group e. $\theta \geq 0$ is the inverse of the intertemporal elasticity of substitution.

In the lifetime budget constraint, $w_e h_w f(t-t_w, e)$ denotes earnings at age t. $f(\cdot)$ captures how worker productivity varies with experience $(t-t_w)$. We normalize $f(0,e) = 1$.

2.5 College Phase

While enrolled in college, each period unfolds as follows. Students enter the period with state $s = (a, p, g, \mathcal{U}_q, q, h, k, t)$ containing the fixed endowments drawn at high school graduation $(a, p, g, \mathcal{U}_q)$, college quality q, the time-varying values of human capital h and assets k, and age t.

Students consume and accumulate debt according to the budget constraint

$$c(s) = y(s) + \mathcal{T}(s) + Rk - k'(s) - \tau_{total}(s), \tag{3}$$

where $\tau_{total}(s)$ denotes the net cost of college (tuition minus scholarships and grants), $\mathcal{T}(s)$ denotes parental transfers, $k(s)$ denotes student assets (or debt), and $y(s)$ denotes labor earnings. All financial variables are assumed to depend only on observable student and college characteristics and may therefore be taken directly from the data. Section 2.9 explains this modeling choice. Flow utility in college depends on consumption and on a college-specific, idiosyncratic preference shock $\mathcal{U}_q$. Specifically,

$$\mathcal{U}_{coll}(c, q) = \frac{c^{1-\theta}}{1-\theta} + \mathcal{U}_q + \mathcal{U}_{2y} * \mathbb{I}_{q=1}, \tag{4}$$

where students who attend two-year colleges also receive the fixed flow utility $\mathcal{U}_{2y}$ which captures benefits such as living with parents or flexible class schedules.[13]

While enrolled, students accumulate human capital as described in Section 2.5.1. At the end of each period, students drop out with exogenous probability $\Pr_d(s)$, in which case they start work as college dropouts ($e = SC$) endowed with human capital $h_w = h'$ next period. All two-year college students drop out at the end of year two. With probability $\Pr_g(s)$ students graduate in which case they start working as college graduates ($e = CG$) next period. Four-year college students who have not graduated by the end of year $T_q = 6$ years must drop out. Students who have neither dropped out nor graduated return to college next year.

2.5.1 Learning in College

While enrolled in college, students accumulate human capital according to

$$h' = h + \mathcal{A}(q, a)h^{\zeta}, \tag{5}$$

where learning productivity is given by

$$\ln \mathcal{A}(q, a) = A_q + \phi_q a. \tag{6}$$

A_q denotes the baseline productivity of college q enjoyed by all students. The value

[13] In our dataset, for 90% of two-year college students, the family home is within a fifty-mile radius of their college.

of $\phi_q \geq 0$ determines how much student ability affects learning in college q.

This production structure admits a form of *complementarity* between student ability and college quality. If ϕ_q is increasing in q, the productivity gains from upgrading to a better college increase with student ability. We find that this kind of complementarity is needed for the model to match the patterns observed in earnings data.[14] The complementarity captures the first concern about college expansions mentioned in the Introduction. Inducing low-ability students to upgrade to higher-quality colleges reduces those students' learning productivity. As a result, the marginal return to expanding high-quality capacity may be far below the average return.

2.5.2 Peer Effects

Empirical studies suggest that learning in college depends on the characteristics of students' peers (Sacerdote, 2011). Since expanding selective colleges requires admitting less-qualified students, learning for all students may be reduced. To capture this possibility, our model allows for peer effects in student learning.

Given the limited empirical evidence, we follow Epple et al. (2019) in assuming that learning productivities are a function of the mean ability of students in each college. Recall that log learning productivity is given by

$$\ln \mathcal{A}(q, a) = A_q + \phi_q a. \tag{7}$$

With peer effects, $A_q = \bar{A}_q + \eta_A \bar{a}_q$ and $\phi_q = \bar{\phi}_q + \eta_\phi \bar{a}_q$, where $\bar{A}_q$, $\bar{\phi}_q$, η_A, and η_ϕ are parameters, while $\bar{a}_q$ denotes the mean ability of freshmen in college q. By interacting ϕ_q with student ability, we capture the idea that peer effects disproportionately benefit high-ability students.

2.5.3 Value of Studying

The expected value of studying in college q is given by

$$\mathcal{V}(s) = \mathcal{U}_{coll}(c(s), q) + \beta \tilde{\mathcal{V}}(s'), \tag{8}$$

where $c(s)$ is determined by the budget constraint equation (3), h' is determined by the human capital technology (5), and student debt $k'(s)$ is taken from the data.

[14] Dillon and Smith (2020) document a similar complementarity between student ability and college quality in long-term earnings.

The continuation value is given by $\tilde{\mathcal{V}}(s')$ where

$$\tilde{\mathcal{V}}(s) = \Pr_d(s)\,\mathrm{W}(h, k_w(s), SC, t) + \Pr_g(s)\,W(h, k_w(s), CG, t) + (1 - \Pr_d(s) - \Pr_g(s))\,\mathcal{V}(s). \tag{9}$$

With probability $\Pr_d$, the student drops out and starts work as a college dropout with value $W(., SC)$, defined in equation (1). With probability $\Pr_g$, the student starts work as a college graduate with value $W(., CG)$. With complementary probability, the student remains in college for one more period.

$k_w(s)$ denotes the worker's assets (or debts) at career start. We assume that each student receives a lifetime parental transfer that does not depend on the college attended or on how long the student attends college. While in college, the student receives a portion of this fixed total, $\mathcal{T}(s)$, annually. When the student starts their work phase, the remaining transfers are received as a lump-sum, augmenting $k_w(s)$.

The motivation for this assumption is as follows. If students only received transfers $\mathcal{T}(s)$ while in college (and nothing more when they start working), the annual net cost of college from the student's perspective would be tuition minus transfers, $\tau_{total}(s) - \mathcal{T}(s)$. In the data, this net cost decreases with college quality for higher-income students. Hence, these students would view high-quality colleges as cheaper than low-quality colleges. This implication strikes us as unreasonable. Our assumption that total transfers are independent of college choice avoids this implication. For the students in our model, the net cost of college is simply tuition $\tau_{total}(s)$.

2.6 College Entry Decision

2.6.1 Information Frictions

Our model allows for the possibility that students imperfectly observe college characteristics. We include this information friction for two reasons. First, empirical evidence suggests that a lack of information may be an important reason why high-achieving students, especially those from lower-income families, choose less selective colleges.[15] Second, the information friction allows the model to match empirical evidence that college enrollment is highly sensitive to financial incentives. The studies

[15]"Young people—particularly those from lower-income, immigrant, and/or non-college educated families—may lack good information about the costs and benefits of enrollment, the process of preparing for, applying to, and selecting a college" (Dynarski et al., 2023a, p. 3).

summarized in Dynarski et al. (2023b) imply that a $1,000 increase in annual tuition reduces enrollment by about three to four percentage points. The response is larger for lower-income students. In our model, uncertainty about college quality reduces the expected earnings gains from choosing more expensive, higher quality colleges. This uncertainty increases students' willingness to adjust their college choices in response to changes in tuition costs. We interpret the information friction broadly as capturing the lack of good information about financial returns to different college types, student-college match quality, own learning ability, or admissions probabilities.

We implement the information friction as follows. Each student is admitted to a subset of colleges $\mathcal{S}$. The admissions decision is based on observable student characteristics as described in Section 2.7. Students observe the admissions set $\mathcal{S}$ but are uncertain about the human capital productivity, as well as the dropout and graduation probabilities associated with each four-year college. All other college characteristics, including financial variables and the student's own preferences $\mathcal{U}_q$, are perfectly observed. Students are also able to identify the two-year college.

For each college in the admitting set $q \in \mathcal{S}$, the student draws a quality signal $\hat{q}$. With probability $\pi(p)$, all signals are accurate. With probability $(1 - \pi(p))$, the signals contain no information and the student assigns equal probability to each college in the admitting set so that $\Pr(q|\hat{q}) = 1/n_{\mathcal{S}}$ for each $q \in \mathcal{S}$, where $n_{\mathcal{S}}$ is the number of admitting colleges.

We allow for $\pi(p)$ to depend on parental income because empirical evidence suggests that information frictions affect lower-income students more than higher-income students. We assume that students consider only the quality signal when forming beliefs about college quality. In particular, students do not consider financial variables. If they did, the information friction would disappear.

The expected value of a student who chooses the college associated with signal $\hat{q}$ is given by

$$\hat{\mathcal{V}}(s, \hat{q}) = \pi(p)\mathcal{V}(\hat{s}(s, \hat{q}, \hat{q})) + (1 - \pi(p)) \sum_{q^* \in \mathcal{S}} \mathcal{V}(\hat{s}(s, q^*, \hat{q})) / n_{\mathcal{S}}, \tag{10}$$

where $\hat{s}(s, q^*, \hat{q})$ denotes the perceived state of a student with state s who chooses the college with signal $\hat{q}$ but ends up with the productivity of college q^*.

With probability $\pi(p)$, the student observes the true quality and starts college $\hat{q}$ with state $\hat{s}(s, \hat{q}, \hat{q}) = (a, p, g, \mathcal{U}_{\hat{q}}, \hat{q}, h, k, t)$. With complementary probability, the student expects to start college with finances determined by $\hat{q}$.

2.6.2 College Entry Decision

After high school graduation, students either choose one of the colleges they are admitted to or begin work with education level HSG. Students choose the option that yields the highest expected value:

$$\max\{W(s_w), \{\hat{\mathcal{V}}(s, \hat{q}(q))\}_{\hat{q}(q)\in\mathcal{S}}\}, \tag{11}$$

where the value of working as a high school graduate is obtained from (1). The true college quality implied by the chosen signal $\hat{q}$ is revealed when the student enters college.

2.7 College Admissions

Our model of admissions is broadly based on Hendricks et al. (2021). It captures a number of desirable features in a tractable way. Selective colleges are capacity-constrained and reject academically qualified applicants. In addition to test scores and grades, college admissions consider other indicators of college preparation, such as extracurricular activities or AP exam scores. For a given level of measured ability (e.g., test scores), higher income students perform better according to these indicators (Alvero et al., 2021; Blandin and Herrington, 2022), so that, for a given test score, admission rates to selective colleges rise with family income.

We model admissions as follows. Each student's endowments imply their admissions score z. Colleges aim to attract students with high scores, but are subject to capacity constraints. Each college of quality q therefore admits all students with scores above a cutoff, $z \geq \bar{z}_q$. The cutoffs are set such that all selective four-year colleges are full. Two-year colleges ($q1$) and non-selective four-year colleges ($q2$) admit all students and face no capacity constraints.

Students choose colleges sequentially in order of their admissions scores. The student with the highest z chooses first and is admitted to all colleges. The student with the second highest z chooses next, and so on. As students enroll, college seats are filled. Once a college reaches its enrollment capacity, it no longer admits students. The last student admitted determines the cutoff $\bar{z}_q$. Students with $z < \bar{z}_q$ do not have college q in their admissions set $\mathcal{S}$.

The admissions score z is a linear combination of test score g percentiles and human capital h_1 percentiles. The functional form captures the idea that admissions officers consider not only academic achievement (test scores or high school grades), but also other indicators of college preparation, such as extracurricular activities or AP courses taken. The human capital endowment h_1 proxies for these indicators, which are correlated with student ability and parental background.[16]

Students with low admissions scores are rationed out of selective colleges. This is one reason for undermatch, especially for lower-income students who typically have low human capital endowments at high school graduation.

The sequential college choice algorithm of our model avoids the substantial complications and loss of tractability that would arise in models with student applications (Chade et al., 2014; Fu, 2014) or two-sided matching (Epple et al. 2006).[17]

2.8 Wages

In modeling how wages are determined, we follow much of the literature in assuming that output is produced from two types of labor: college graduates and non-graduates, which includes college non-entrants and dropouts. The labor aggregator is of the constant elasticity of substitution (CES) form and workers are paid their marginal products.[18] Specifically, output is given by

$$Y = \left[\alpha_{HSG} \left(L_{HSG} + L_{SC}\right)^{\rho} + \alpha_{CG} L_{CG}^{\rho}\right]^{1/\rho}, \tag{12}$$

where the skill weights $\alpha_{HSG}, \alpha_{CG} > 0$ are taken as given. The elasticity of substitution between skill types is $\sigma = 1/\left(1-\rho\right)$. Here, L_e is the aggregate labor input of education group e, which is given by

$$L_e = \int_{s_0} \mathcal{E}\left(s_0\right) \mathbb{E}\left\{L|s_0\right\} ds_0, \tag{13}$$

[16] An alternative specification where the admissions score is a linear function of test scores, parental background, and an idiosyncratic noise term yields broadly similar results.

[17] A tractable, competitive model with a continuum of college qualities is developed in Cai and Heathcote (2022).

[18] A recent study using the same approach, which also contains additional references, is Bils et al. (2024).

where

$$\mathbb{E}\{L|s_0\} = \sum_e \sum_{t_w} \Pr(t_w, e|s_0) L(t_w, e|s_0) \tag{14}$$

and

$$L(t_w, e|s_0) = \sum_{t=t_w}^{T_r} f(t - t_w, e) h_w(t_w, e). \tag{15}$$

Each high school graduate draws their endowment vector s_0 from the distribution $\mathcal{E}$. Their college choices imply a probability of starting work at age t_w with education level e denoted by $\Pr(t_w, e|s_0)$. The worker then supplies $L(t_w, e|s_0)$ efficiency units of labor over their lifetime up to retirement age T_r. Labor supply at age t is the product of efficiency f, which depends on experience, and the human capital at work start h_w (see Section 2.4). The labor aggregator assumes that the mass of workers is the same for all ages.

The wage rates are given by the marginal products of labor, so that aggregate earnings equal output, and the skill premium is given by

$$\frac{w_{CG}}{w_{HSG}} = \frac{\alpha_{CG}}{\alpha_{HSG}} \left(\frac{L_{CG}}{L_{HSG} + L_{SC}} \right)^{\rho - 1}. \tag{16}$$

2.9 Discussion of Model Choices

2.9.1 Exogenous Dropout Rates

Since the literature has not come to a consensus about the main reasons why students drop out, it would be challenging to model dropout decisions in a compelling way.[19] We therefore treat dropping out as a response to unobserved shocks that we do not model. This allows our model to match empirical dropout patterns well.

In the baseline model, the payoff from attending a given college does not depend on other students' college decisions. Students therefore do not have an incentive to change study behavior when college capacities expand. In the robustness analysis, we consider the role of peer effects and endogenous skill prices. We discuss how endogenous dropout rates might affect results at that point.

[19] Bound and Turner (2011, p. 605) conclude: "In hypothesizing about why students leave college without receiving a degree, the research literature has posited many ideas ranging from learning about own ability to clear 'mistakes' in the utilization of financial aid or the navigation of complicated collegiate requirements." Other structural models with exogenous dropout rates include Athreya and Eberly (2021) and Hanushek et al. (2014).

2.9.2 Exogenous Consumption and Borrowing

We assume that all financial variables (college costs, transfers, and borrowing) only depend on observables and may therefore be directly taken from the data. In part, we make this choice to ensure that the model correctly captures the observed financials of students with different backgrounds who are enrolled in colleges of different quality levels. In part, the choice is due to data limitations. We lack evidence about how much students would have to pay for colleges that they do not attend in the data. Similarly, we lack evidence on the extent to which parental transfers would cover the additional costs incurred by attending a better college.

One drawback is that our model may understate the importance of borrowing constraints. If some students in the data fail to attend selective colleges because of unobserved financial tightness (e.g., parents are not willing to make substantial transfers to pay for college), our model misses that constraint. Whether financial constraints prevent substantial numbers of students from entering college or choosing selective colleges remains controversial in the literature.[20]

It is worth noting that, in our data, most student borrowing is far from federal student debt limits. About half of all four-year college entrants do not borrow at all. These numbers suggest that, consistent with our model's implications, financial constraints may not be of first-order importance for college choice.

2.9.3 Exogenous Student Endowments

We treat the distribution of student endowments at high school graduation as fixed. To the extent that expanding college access increases the likelihood that a child will attend college, early human capital investment may increase. The pool of qualified college applicants would then expand, further increasing the earnings gains from college expansions. However, it is also possible that easier admissions lead parents to reduce investment in their children as the "rug rat race" becomes less intense. If these investments are inefficient (e.g., arts majors taking advanced mathematics courses in order to polish their resumes), reducing them could be an additional benefit of less competitive college admissions. Studying these effects is beyond the scope of this paper.

[20] One reason why "the literature has yet to reach a consensus on the extent to which constraints discourage youth for recent cohorts" (Lochner and Monge-Naranjo, 2011, p. 237) is that exogenous variation in credit availability is hard to find, given that most U.S. college students have had access to federal student loans for a long time (Dynarski et al., 2023b).

3 Calibration

This section outlines the calibration strategy and summarizes the model fit. Details are relegated to Appendix A.

3.1 Data

Our main data source is the 1997 cohort of the National Longitudinal Survey of Youth (Bureau of Labor Statistics, 2024). The NLSY97 is an ongoing panel dataset that surveys youth born between 1980 and 1984. For each high school graduate, we observe parental income, test scores, the identity of the college attended (if any), financial variables during college, degrees earned, and a time series of earnings.

Financial variables include the net cost of college (tuition net of scholarships and grants), student loans, earnings while in college, and parental transfers. All are reported in year 2000 prices. We map model test scores g into percentile scores on the Armed Forces Qualification Test (AFQT), which most students take around age 18. Leukhina (2023) describes the data in detail.

3.1.1 College Quality Groups

We distinguish between four college quality groups. Quality is measured by mean freshman SAT scores.[21] Quality group 1 (hereafter $q1$) comprises community colleges offering an associate's degree in general education. Quality groups 2 through 4 represent four-year colleges and universities that grant bachelor's degrees. Each group of four-year colleges has approximately equal freshman enrollment.

Quality group 4 comprises Ivy League and selective private schools, most public flagship universities, and other selective public universities (e.g., Iowa State, NC State, UC-Santa Barbara). Quality group 3 includes some flagship universities and directional schools (e.g., University of Connecticut, University of New Mexico, Washington State, University of Central Florida). Quality group 2 includes the least selective public and private colleges (e.g., Eastern Michigan, Texas A&M - Corpus Christi, San

[21] How to measure college "quality" is debated in the literature. The survey by Lovenheim and Smith (2023, Section 4.2) concludes that "[m]ore often than not, approaches using these various measures find consistent results" (p. 39). Other studies that classify colleges based on mean SAT scores include Bowen et al. (2009) and Dillon and Smith (2017). Given that our quality categories are broad, it is unlikely that other commonly used quality definitions would substantially change our findings.

Table 1: College Quality Summary Statistics

		Quality			
	All	**1**	**2**	**3**	**4**
Mean AFQT percentile	63	50	61	73	83
Graduation rate (cond.)	0.44	-	0.53	0.74	0.85
Expenditure per student	-	4,304	8,153	10,166	16,659
Mean tuition	6,704	2,060	6,001	7,349	12,991
Mean net college cost	2,118	795	1,153	2,692	5,590
SAT cutoff	-	-	-	1,033	1,136
Sample size	1,495	586	342	308	259

Note: The table summarizes freshman characteristics by college quality. Quality group 1 comprises two-year colleges. Quality categories 2 to 4 refer to four-year institutions, ranked from least to most selective. "Graduation rate (cond.)" is the fraction of freshmen who graduate within six years. "Expenditure per student" is total college spending per student as defined in Appendix C. "Mean net college cost" is the mean of tuition minus scholarships and grants. "SAT cutoff" is the lowest freshman SAT score among colleges in the quality group. Freshman SAT scores are the average of the 25th and the 75th percentiles for each college.

Diego State, East Carolina, Missouri Valley College). Table 1 shows summary statistics.

3.2 Fixed Parameters and Assumptions

This section summarizes the model parameters that are fixed based on outside evidence. The model period is one year. The gross interest rate is fixed at $R = 1.04$. We set the curvature of utility from consumption to $\theta = 1.5$ and fix the discount factor at $\beta = 0.96$.

Worker experience profiles $f(x, e)$ are estimated using the NLSY's longitudinal earnings histories. Since we only observe roughly the first fifteen years of workers' careers, we extend the profiles by splicing on education-specific experience profiles estimated in Rupert and Zanella (2015).

The skill weights that govern education-specific skill prices $(\alpha_{HSG}, \alpha_{CG})$ are calibrated to match observed worker earnings. We assume that college graduates enjoy a sheepskin effect: $w_{CG} \geq w_{SC}$. The skill price for dropouts is the same as for high school graduates: $w_{SC} = w_{HSG}$. This assumption avoids artificial wage increases for students who attend college for only short periods without learning much.

3.2.1 Colleges

We set college capacities for selective four-year colleges ($q3$ and $q4$) to their empirical freshman enrollment levels. Two-year colleges and non-selective ($q2$) colleges have unlimited capacity.

The probabilities of dropping out of college, $\Pr_d(s)$, and of graduating from college, $\Pr_g(s)$, are both functions of student ability percentiles $\hat{a}$. Specifically, we assume that $\Pr_g(s) = \gamma_{1,q} + \gamma_{2,q}\hat{a}$, where $\gamma_{1,q}, \gamma_{2,q} \geq 0$, and that $\Pr_d(s) = \gamma_{4,q} - \gamma_{5,q}\hat{a}$, where $\gamma_{4,q}, \gamma_{5,q} \geq 0$. All probabilities are truncated into the unit interval. The functions differ across colleges but not by year of college. Students can only graduate after attending a four-year college for at least 3 years. This simple specification results in a good empirical fit.

We directly estimate all financial variables from the data (see Appendix A for details). We assume that most financials do not differ across years for two reasons. First, sample sizes get smaller over time as students drop out, making it difficult to estimate time variation. Second, financial variables in later years may be affected by selection if, for example, students with limited resources drop out at high rates.

3.3 Calibration Strategy

We calibrate 42 model parameters by minimizing a weighted sum of squared deviations between data moments and simulated model moments. This section provides a summary with the details relegated to Appendix A.

The calibrated parameters include the following: endowment correlations and marginal distributions; the preference parameters $\mathcal{U}_{2y}$, $\{\mathcal{U}_e\}$, and the range of $\mathcal{U}_q$, which is drawn from a uniform distribution with mean zero; human capital production functions (A_q, ϕ_q, ζ); graduation probabilities ($\gamma_{1,q}, \gamma_{2,q}$) and dropout probabilities ($\gamma_{4,q}, \gamma_{5,q}$); the weight on g in admissions scores (β_g), and admissions cutoffs $\bar{z}_q$; information frictions ($\pi(p)$ for each parental income quartile); and skill prices (w_e).

Many of the calibrated parameters have no clear observable proxies. The calibration therefore requires a large number of data moments to pin down all parameters. The target moments may be summarized as follows:

1. High school graduate endowments: The fraction of high school graduates in each parental income and AFQT quartile.
2. College enrollment patterns: College entry rates by college quality, parental in-

come and AFQT quartile; mean freshman AFQT percentiles by college quality; freshman enrollments by college quality.

3. College graduation rates: The fraction of entrants who graduate by college quality, parental income and AFQT quartile; the average time to graduation by college quality or AFQT quartile.
4. College dropout rates: The average time to dropout by college quality or AFQT quartile; cumulative dropout rates after year two by college quality and AFQT quartile.
5. Worker earnings: Regressions of log earnings (net of experience effects) on education, college quality, and AFQT quartile.

In addition, we target two quasi-experimental data moments. The first captures the response of college enrollment to changes in tuition. Based on the literature survey by Dynarski et al. (2023b), we target an enrollment change of 3.5 percentage points per \$1,000 annual change in tuition.[22] As explained in Section 2.6.1, this data moment is important for identifying the scale of idiosyncratic college preferences $\mathcal{U}_q$. When college preferences are highly dispersed, college enrollment is insensitive to financial incentives.

The second quasi-experimental moment captures the effect of providing information about college quality to high-AFQT, lower-income students. Our intervention approximates that of Hoxby et al. (2013) who sent information about potential colleges to high school graduates with parental incomes in the lowest tercile and test scores in the top decile. Their intervention treats only about 1.5 percent of high school graduates. This fraction is too small to obtain precise results from our simulated $10,000$ student types. We therefore treat students in the lowest half of the parental income distribution with test scores in the top quintile. Treated students are given full information ($\pi = 1$) about college quality. Based on Hoxby et al. (2013), we target an increase in the college entry rate of 5.3 percentage points. This data moment mainly helps to identify $\pi(p)$ for lower-income students.

In some cases we "slice" the same data in different ways that may appear redundant, but are important to pin down certain parameter values. For example, we run two sets of earnings regressions. One includes all workers. The second focuses on college graduates. The main purpose of the second regression is to estimate complementarities

[22] We set the change in tuition to \$5,000 in an attempt to approximate the magnitude of the tuition changes studied in the empirical literature.

(interactions) between high-AFQT students and top colleges.

The calibrated parameter values are shown in Section A.2. The model implies that AFQT scores and ability levels are highly correlated.[23] The high correlation simplifies the interpretation of the findings.

3.4 Model Fit

Overall, the calibrated model fits most of the targeted moments well. In this section, we highlight a few of the moments that are relevant for the discussion of the results in Section 4. The model fit for the remaining target moments is shown in Appendix B.

Table 2: Earnings Regressions for College Graduates

Regressor	Data	Model
AFQT 2	0.0217 (0.0563)	0.0108
AFQT 3	0.0365 (0.0561)	0.0344
AFQT 4	0.004266 (0.0710)	0.0359
AFQT4-Qual3	0.0641 (0.0709)	0.0641
AFQT4-Qual4	0.207 (0.0858)	0.199
Quality 3	0.0534 (0.0412)	0.0535
Quality 4	0.0793 (0.0548)	0.0793
Constant	2.94 (0.0528)	2.91

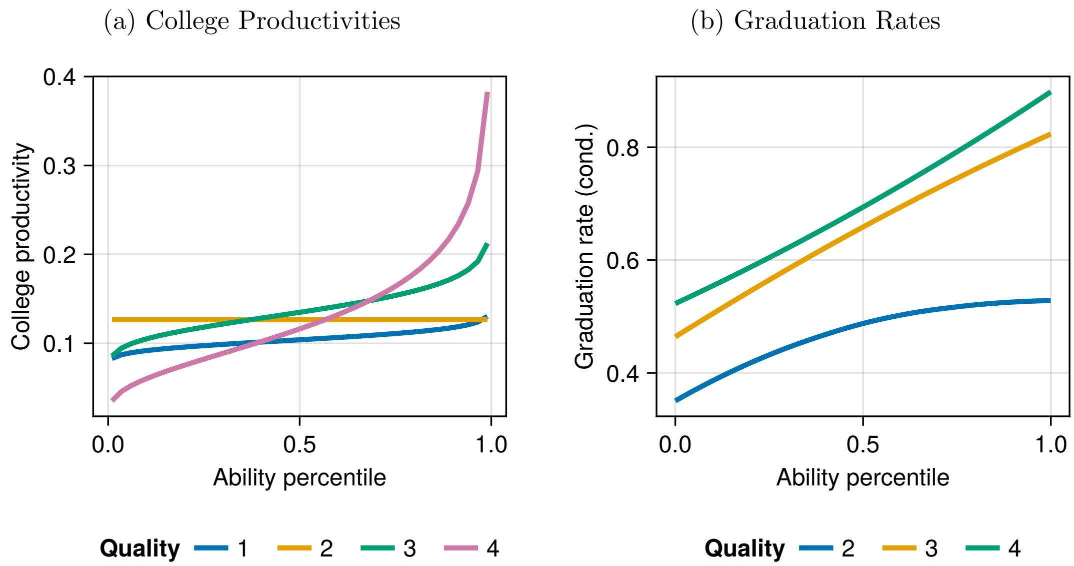
Note: The table shows the coefficients and standard errors (in parentheses) of an earnings regression for college graduates. The dependent variable is log earnings net of experience effects. The regressors include dummies for AFQT quartiles, college quality groups, and selected interactions.

Table 2 shows a regression of college graduate log earnings (net of experience effects) on AFQT and quality dummies and their interactions. The key implication is that the wage "gains" from attending top-quality colleges mostly accrue to top AFQT students. Through the lens of the model, this finding suggests a form of *complementarity* between student ability and college quality. Specifically, the model implies that learning productivity is especially high for high-ability students who attend top colleges (see Figure 1a). Figure 1b shows a similar complementarity for graduation rates. While

[23]The correlation between AFQT and ability is mainly identified by the AFQT coefficients in the earnings regressions. If the model is recalibrated while fixing this correlation at lower values, these coefficients are smaller than in the data. In addition, the model fails to replicate some of the AFQT gradients in college entry rates.

students of all ability levels are more likely to graduate when they attend high-quality colleges, the benefit is largest for high-ability students. These two findings play an important role for understanding the implications of admissions policies. Denying high-ability students access to top colleges reduces aggregate earnings.

Figure 1: Learning Productivities and Graduation Rates

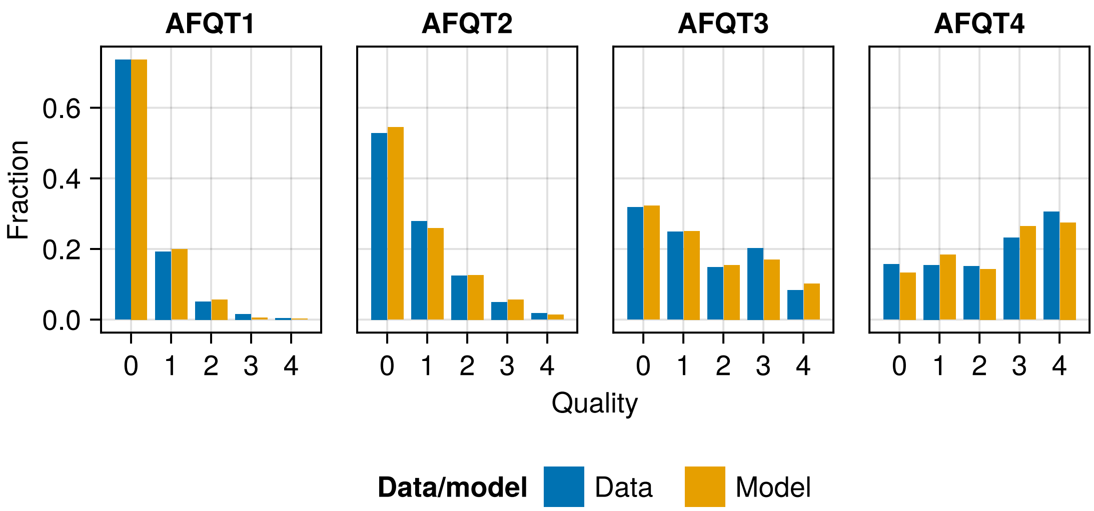


Note: Panel (a) shows learning productivity $\mathcal{A}(q, a)$ as a function of ability percentile for each college quality group. Panel (b) shows the fraction of freshmen starting in each college who later earn bachelor's degrees. Each line represents a LOESS-smoothed scatterplot.

Figure 2 shows that the model accounts for the empirical levels of student-college mismatch. More than half of all high school graduates in the top AFQT quartile do not attend selective ($q3$ or $q4$) colleges. The literature calls these students undermatched.[24] Consistent with the data, Figure 3 shows that undermatch is most prevalent among lower-income students. It follows that there is a sizable pool of mostly lower-income students with high measured ability who could potentially be attracted to selective colleges by appropriate policies. Thus, expanding $q4$ capacities does not necessarily reduce the ability levels of admitted students by a large amount.

[24] The literature employs various definitions of undermatch, but all aim to measure the fraction of qualified students who fail to enroll in appropriately selective colleges. For evidence on undermatch, see Bowen et al. (2009) or Dillon and Smith (2017).

Figure 2: College Quality Choice by Test Score



Note: The figure shows the fraction of high school graduates in each AFQT quartile who choose each college. College quality zero denotes non-entrants.

4 Baseline Results

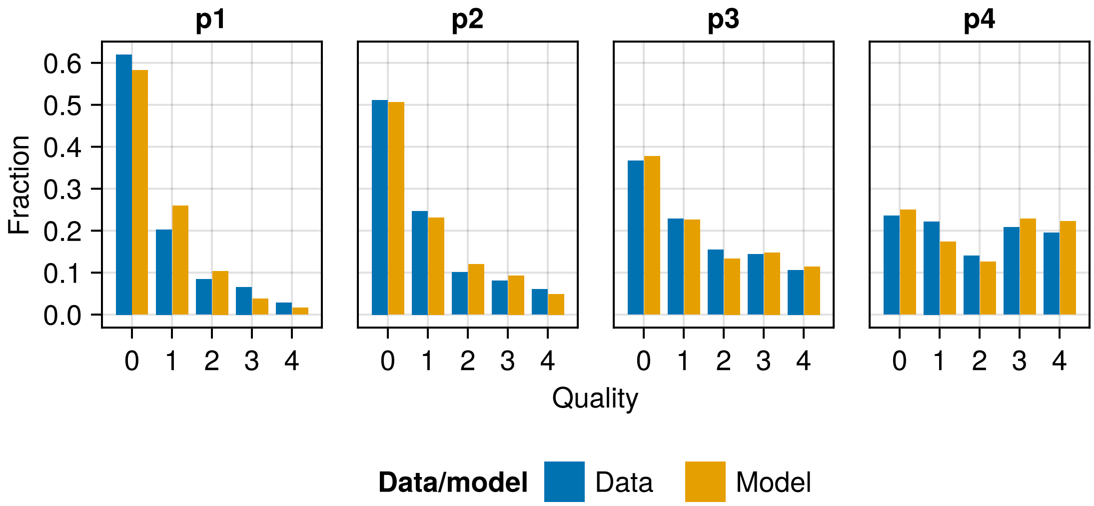
4.1 Counterfactual Experiments

We consider the implications of creating additional seats at top-quality ($q4$) colleges. In the baseline case, $q4$ capacity expands by 20 percent (or 2 percent of the high school graduate population). Admissions standards at selective colleges ($q3$ and $q4$) are adjusted so that all seats are filled. Lower-quality colleges continue to accept all students. We also consider a larger expansion of $q4$ capacity – by 40 percent.

In this section, we start with the simplest case that treats wage rates and learning productivities as fixed. Section 5 adds peer effects that affect learning productivities to the model while Section 6 adds wage rates that respond to labor supply changes as described in Section 2.8. Adding complications one at a time allows us to understand their incremental contributions to the findings.

The counterfactual experiments assume that expanding college capacities does not reduce student learning. During past college expansions, resources per student often declined. This contributed to rising dropout rates (Bound et al., 2010). Implicitly, we assume that public college funding is increased to prevent cohort crowding.

Figure 3: College Quality Choice by Parental Income



Note: The figure shows the fraction of high school graduates in each parental income quartile who choose each college. College quality zero denotes non-entrants.

We do not model how these additional expenditures are financed. We estimate in Appendix C that expanding $q4$ capacities by 20 percent costs about 0.1 percent of aggregate earnings and is self-financing as long as earnings are taxed at an average rate of at least 12.5 percent. This expenditure calculation assumes that the cost per student remains unchanged as capacities expand. Blair and Smetters (2021) argue that rising marginal costs are not likely a major concern, even for elite universities. In part, this is because additional courses can be taught by inexpensive teaching faculty without affecting student learning. We acknowledge that expanding capacity may be difficult when universities are located in major cities where real estate is scarce. However, many high-quality colleges, including land-grant universities, are located in places where land is abundant.

We abstract from the possibility that increasing total undergraduate enrollment may affect the learning experience. Since we assume that expenditure per student remains unchanged, increases in class sizes or student-faculty ratios (cohort crowding) are not a concern. Over the past several decades, enrollment at many flagship universities has expanded substantially. We are not aware of any evidence suggesting that this expansion has qualitatively changed the student experience.

Table 3: Baseline College Expansion

	Baseline	**20 pct**	**40 pct**
	Level	Change relative to baseline	
Aggregate earnings (log)	7.100	+0.8	+1.5
Coll. expenditure / Y	1.31	+0.09	+0.17
Welfare gain	–	+2.2	+4.1
Fraction entering 4y	34.8	+1.8	+3.5
Fraction entering top quality	10.0	+2.0	+3.9
Fraction graduates	23.5	+1.4	+2.6
Mean ability top quality	1.03	−0.11	−0.23
Labor supply CG (log)	12.782	+5.3	+9.8

Note: The table shows the effects of expanding $q4$ capacities by 20 percent or 40 percent, respectively. The "Baseline" column shows the level of each indicator in the calibrated model. The remaining columns show differences relative to the baseline for the college expansions. Y denotes aggregate earnings. "Fraction graduates" is the fraction of the high school graduate population who earn a degree. Changes in fractions are in percentage points; log changes and welfare gains are reported in percent.

The main outcomes that we are interested in are aggregate earnings, aggregate labor inputs (by education), and welfare gains. Aggregate earnings are defined as $Y = \sum_e w_e L_e$, where L_e is the aggregate labor input of education group $e \in \{HSG, SC, CG\}$ (see Section 2.8).

The welfare gains for a counterfactual experiment are defined as follows. We calculate average expected lifetime utility for all students for the baseline case and for the experiment. The welfare gain is then defined as the percentage change in consumption, applied equally to all agents at all ages, that raises average expected utility from the baseline value to the experiment's counterfactual value.

4.2 Baseline Capacity Expansion

Table 3 summarizes the effects of expanding $q4$ capacity by 20 percent. This is the baseline experiment that we discuss in detail. We also consider how the results change for larger capacity expansions.

Even though the expansion directly affects only a small share of the population, its effects are sizable. Aggregate earnings increase by 0.8 percent, which is, as we noted earlier, comparable to the effects of major tax reforms. About one-tenth of a percent of aggregate earnings is spent on funding the additional college seats, leaving a net gain of 0.7 percent.

All of the expansion's first-order effects stem from the entry decisions of students in the third ability quartile (hereafter, $a3$ students) who were previously not enrolled in four-year colleges.[25] These students fill almost all of the newly opened $q4$ seats. The expansion's impact on other students is of minor importance.

To illustrate this point, Figure 4 shows the fraction of students in each ability quartile who choose each college. Across all ability groups, the entry rates for $q2$ and $q3$ colleges remain almost unchanged. As a result, the mean ability levels of students enrolled in these colleges are also unchanged.

By far the largest changes in enrollment occur for $a3$ students. Their admission rates to $q4$ colleges increase substantially (by about 18 percentage points; see Table 4). Even though many "undermatched" students face financial frictions or idiosyncratic college preferences that prevent them from enrolling in top-quality colleges, the $q4$ entry rate of $a3$ students rises by 5 percentage points. The entry of additional $a3$ students reduces the mean ability level of $q4$ entrants, but not by enough to significantly reduce graduation rates.

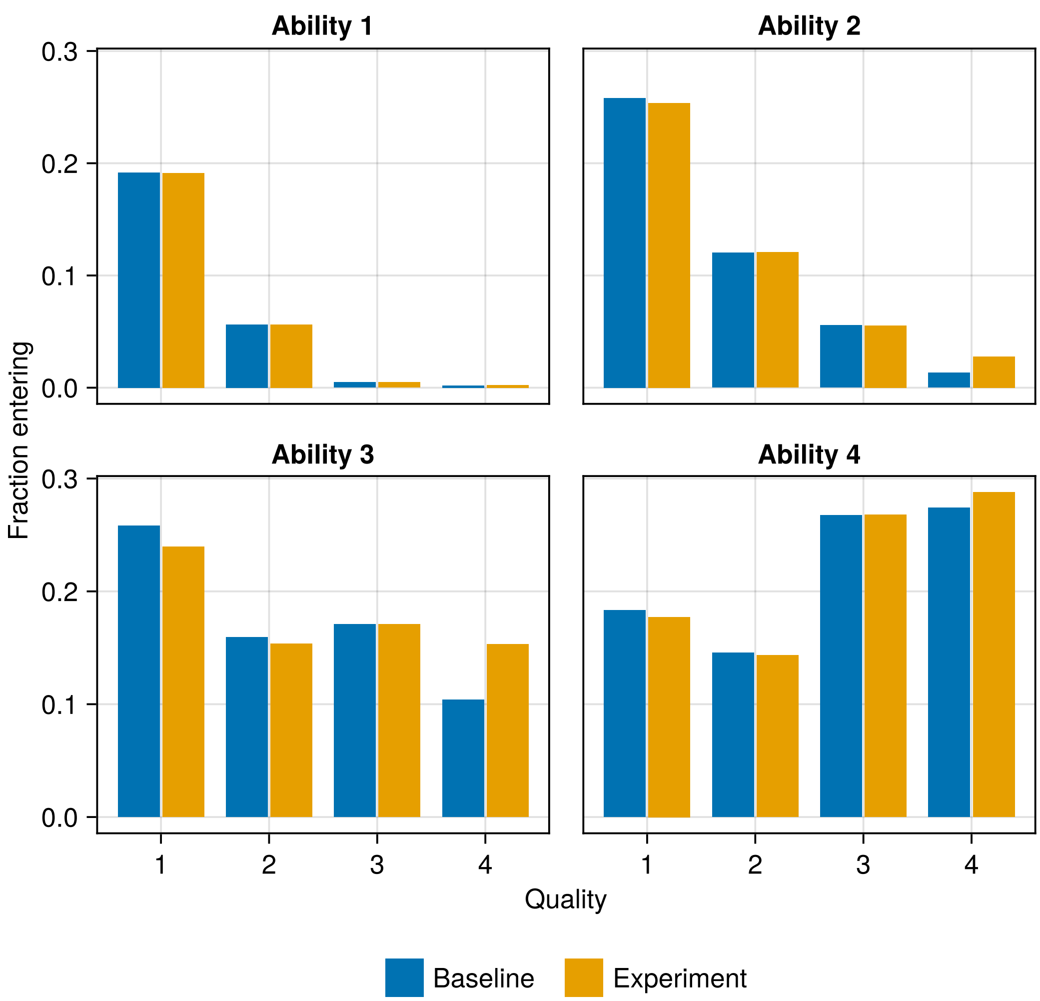
Since most $a4$ students were already admitted to $q4$ colleges before the expansion, their college decisions do not change much. Mainly, a small share switches from not enrolling in any four-year college to $q4$. For lower-ability students, admission rates and therefore college entry decisions are roughly unchanged.

We can now see why a small change in college seats generates a substantial increase in aggregate earnings. Most of the students who fill the additional $q4$ seats were previously not enrolled in four-year colleges and therefore had no chance of earning a bachelor's degree. When they switch into $q4$, they graduate at rates close to 80 percent and enjoy the lifetime earnings premium of a $q4$ graduate, which is close to 50 percent. Since the expansion moves about 2 percent of the population into $q4$, earnings gains of 50 percent for 2 percent of students imply an aggregate earnings increase of about 1 percent.[26] The actual model-implied effect is somewhat smaller because the

[25] Black et al. (2023) find that most of the students "pulled into" UT Austin due to Texas's Ten Percent Rule would not otherwise have attended college.

[26] Consistent with our model results, Black et al. (2023) find that students who were "pulled into" UT Austin by Texas's Top Ten Percent Rule graduated at rates that were comparable to the average

Figure 4: College Quality Choice



Note: The figure shows the fraction of high school graduates in each ability quartile who enroll in each college in the baseline calibration and after a 20 percent expansion of $q4$ capacity (Experiment). Summing across quality groups yields the college entry rate for each ability quartile.

Table 4: Twenty Percent Expansion of Top-Quality Colleges

(a) Changes by Student Ability

Ability	**1**	**2**	**3**	**4**
Fraction admitted to top quality				
Baseline	0.002	0.047	0.352	0.886
Experiment	+0.002	+0.061	+0.178	+0.063
Fraction entering top quality				
Baseline	0.002	0.013	0.104	0.274
Experiment	+0.000	+0.015	+0.049	+0.014
Fraction entering 4y				
Baseline	0.063	0.189	0.434	0.687
Experiment	+0.000	+0.015	+0.043	+0.012
Log aggregate earnings				
Baseline	5.474	5.566	5.750	5.987
Experiment	+0.000	+0.005	+0.019	+0.006
Welfare gain				
Experiment	+0.000	+0.013	+0.056	+0.025

(b) Changes by College Quality

Quality	**1**	**2**	**3**	**4**
Mean ability				
Baseline	0.009	0.297	0.786	1.028
Experiment	−0.012	−0.003	+0.000	−0.115
Graduation rate (cond.)				
Baseline	0.000	0.489	0.739	0.816
Experiment	+0.000	0.000	+0.000	−0.012

Note: The table shows the effects of a 20 percent expansion of q4 capacity. Panel (a) shows student ability quartiles. Panel (b) shows the changes in each college quality.

switching students are of lower ability than the already enrolled $q4$ students and therefore graduate at somewhat lower rates.

The effects of the college expansion scale roughly in proportion to the number of seats created. The last column of Table 3 shows the effects of a 40 percent expansion of $q4$ capacity. They are, across the board, about double the effects of a 20 percent expansion. This is true, in part, because the number of high-ability ($a3$) students who are rationed out of $q4$ colleges is quite large, creating a pool of high-ability undermatched students who are willing to enroll in $q4$ colleges. In other words, even when $q4$ capacities expand substantially, these colleges do not run out of qualified students who face large earnings gains when they gain access to $q4$.

In the Appendix, we examine two robustness concerns about these findings. The first robustness check examines the role of the complementarity between ability and college quality in student learning. We show in Section D.1 that recalibrating the model without this complementarity leaves the aggregate effects of the college expansion nearly unchanged. The main reason is that the complementarity mostly benefits $a4$ students who enroll in $q4$ colleges. The college expansion, however, mostly causes $a3$ students, who benefit far less from the complementarity, to enroll in $q4$ colleges.

The second robustness concern relates to the finding that most of the college seats created by the capacity expansion are filled by students who were previously not enrolled in four-year colleges. An important reason why the model has this implication is that college-specific preference shocks ($\mathcal{U}_q$) are large for many students. Large preference shocks are needed for the calibrated model to replicate the empirical degree of undermatch. Fewer than one-third of $a3$ students attend any selective college, even though many are admitted to $q3$. The model accounts for this fact, in part, by endowing some of these students with preference shocks ($\mathcal{U}_q$) that lead them to forego four-year colleges, unless the financial returns are high, which is the case for $q4$, but less so for $q3$. These students make up a large share of the switchers when capacities expand. We explore in Section D.2 a version of the model where the dispersion of preference shocks is smaller than in the baseline case. We find that far more students switch between four-year colleges. Still, the aggregate outcomes, including the change in aggregate earnings, are similar to the baseline case. The reason is that the high-ability students who switch from $q3$ to $q4$ are, for the most part, replaced by other high-ability students who switch from non-selective colleges to $q3$. As a result, the

UT Austin graduation rate.

earnings gains are more dispersed across students, but not smaller in the aggregate.

4.2.1 Distributional Implications

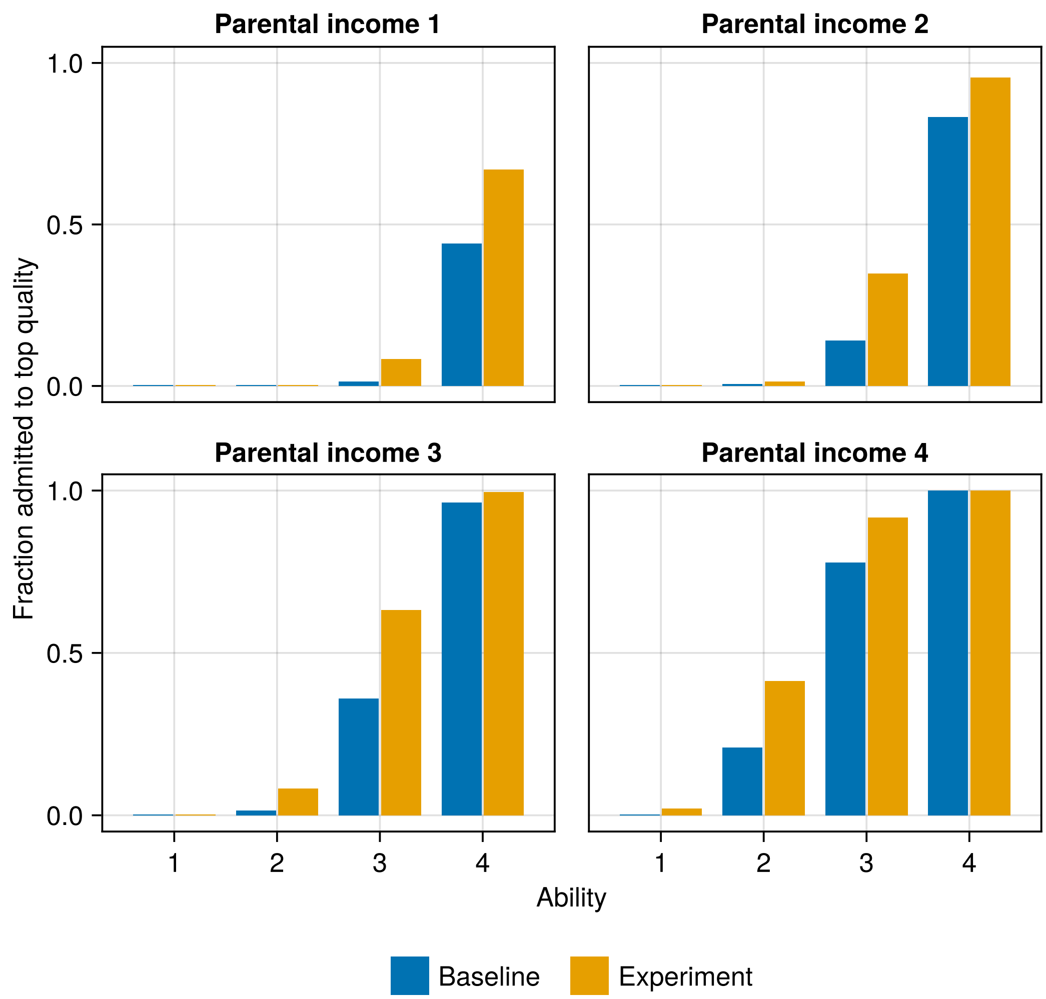
Since the baseline expansion abstracts from peer effects and endogenous wages, students of all ability and parental income levels gain from the expansion. There are no losers. This is not surprising, given that the choice sets of all students (weakly) expand as admissions standards are relaxed. By far the largest gains accrue to students in the 3rd ability quartile who take up most of the additional $q4$ seats (Table 4).

Figure 5 shows how the college expansion affects the admission rates to $q4$ colleges for students in different ability and parental background quartiles. Most of the newly created $q4$ seats are offered to students in the second and third income quartiles. Recall that admissions are based on a linear combination of ability and human capital, which is correlated with parental background, p. Hence, students with high a and high p are mostly admitted to $q4$ colleges, even before the capacity expansion. Students with low a and p are far from the admissions cutoff and are therefore not admitted even after the expansion. The expansion does increase admission rates for lower-income, high-ability $(p1, a4)$ students and for higher-income, lower-ability $(p4, a2)$ students. However, since ability and parental background are correlated, there are few students in those groups. The only large groups that are admitted at substantially higher rates are middle-income $a3$ students.

Given that the expansion mostly benefits middle-income students, it is not surprising that it generates only minor changes in the distribution or intergenerational persistence of lifetime earnings. For example, the 90/10 gap in lifetime earnings rises by about 1 percent. The intergenerational correlation of lifetime earnings is nearly unchanged.

The welfare gains resulting from the capacity expansion are even larger than the earnings gains. Expanding $q4$ capacity by 20 percent increases aggregate welfare by 2.2 percent (Table 3). The gains are largest for students in the 3rd ability quartile (Table 4), who also enjoy the largest earnings gains. The reason why the welfare gains of college expansions exceed the earnings gains is that the students who switch colleges typically have idiosyncratic preferences for attending the expanding college (high draws of $\mathcal{U}_q$). Empirical evidence suggests that these idiosyncratic preferences are important. In survey data, students prefer colleges that are close to home or where family members or friends have previously enrolled. Such preferences appear to be

Figure 5: Fraction Admitted to Top Quality



Note: The figure shows the fraction of high school graduates in each ability and parental income group that are admitted to the top-quality college. The baseline case is compared with a 20 percent expansion of q4 capacity (Experiment).

an important reason for undermatch (Ovink et al., 2018; Cortes and Lincove, 2019). For students who strongly prefer a particular college, selective admissions generate welfare losses, even if attending that college does not increase earnings.

5 Peer Effects

In this section, we assess the quantitative importance of peer effects in student learning. Relative to the baseline model, we now assume that college productivities (A_q and ϕ_q) are functions of mean student ability levels (see Section 2.5.2).

Given that empirical evidence on the strength of peer effects is limited, we consider a range of parameter values. In the main experiment, we assume that, before the college expansion, half of the differences in learning productivities across colleges are due to peer effects, while the other half is exogenous. The implied parameter values satisfy $\eta_A (\bar{a}_4 - \bar{a}_1) = \bar{A}_4 - \bar{A}_1$ and $\eta_\phi (\bar{a}_4 - \bar{a}_1) = \bar{\phi}_4 - \bar{\phi}_1$. It follows that low-ability students (with $a < 0$) may benefit from lower mean student ability (their $\phi_q \times a$ rises when $\bar{a}_q$ falls). This is a form of matching, where students learn more when the ability levels of their peers are more similar to their own.[27] Note that peer effects do not change the baseline equilibrium; they only decompose the differences in A_q and ϕ_q across colleges into exogenous and endogenous parts.

We find that peer effects reduce the earnings gains for high-ability students who attend $q4$ colleges. Otherwise, the changes to baseline results are minor. Our results do not change substantially when we increase the share of the A_q and ϕ_q gaps that are due to peer effects, or when peer effects depend on the ability levels of the weakest students (the 25th percentile instead of the mean).

5.1 Results

Compared with the baseline experiment, peer effects generate only one significant change: the earnings of $a4$ students enrolled in $q4$ decline by 2.5 percent. The earnings of all other students barely change. There are also no significant changes in admission rates or entry decisions for any group of students.

Table 5 summarizes the effects of a 20 percent expansion of $q4$ capacity. Relative to the baseline case, peer effects reduce learning in $q4$ colleges, which dampens the

[27] Sacerdote (2011, p. 254) summarizes empirical evidence on peer effects that are consistent with matching and that disproportionately benefit high-ability students.

Table 5: College Expansion with Peer Effects

	Baseline	**No Peer Effects**	**Peer Effects**
	Level	Change relative to baseline	
Aggregate earnings (log)	7.100	+0.8	+0.5
Coll. expenditure / Y	1.31	+0.09	+0.09
Welfare gain	–	+2.2	+2.1
Fraction entering 4y	34.8	+1.8	+1.8
Fraction entering top quality	10.0	+2.0	+2.0
Fraction graduates	23.5	+1.4	+1.4
Mean ability top quality	1.03	−0.11	−0.12
Labor supply CG (log)	12.782	+5.3	+4.5

Note: The table shows the effects of a 20 percent expansion of $q4$ colleges with peer effects that depend on the mean ability levels of students in each college. The ”no peer effects” column repeats the results for the baseline expansion for reference. Changes in fractions are in percentage points; log changes and welfare gains are reported in percent.

increase in the supply of college graduate labor (L_{CG}). The aggregate earnings gains are therefore smaller, but still substantial at 0.5 percent. The changes in college enrollments and graduation rates are similar to the baseline case.

The intuition for these findings is as follows. In the baseline experiment described in Section 4.1, the mean ability levels of students enrolled in $q4$ decline. Peer effects imply that learning productivities fall in that college. Mean ability levels and therefore learning productivities at other colleges are not directly affected.

It turns out that the reduced $q4$ earnings do not cause a significant number of students to withdraw from that college. Therefore, no new college seats open up for other students. These students have no incentive to change their college choices, given that their earnings are also not affected by peer effects. Overall, peer effects therefore cause almost no reallocation of students across colleges. Hence, the equilibrium effects are nearly the same as the direct effects: the earnings of $q4$ students decline. There are no other significant changes.

Why don't $q4$ students switch out of that college when their earnings decline? For lower-ability students, the answer is that their learning productivities decline very little. Due to the complementarity in peer effects, the productivity term $\phi_q a$ declines significantly only for high-ability students. For these students, earnings do decline, but the earnings gains from attending $q4$ colleges remain quite large. A high-ability student who switches from $q3$ to $q4$ increases their lifetime earnings (discounted to high school graduation) by 12 percent on average.

The reason why peer effects barely affect the earnings of students outside of the top ability quartile is illustrated in Figure 6. It shows the changes in log learning productivities relative to the baseline case for students of different ability levels enrolled in each college. Learning productivities are nearly unchanged for students not enrolled in $q4$. For those enrolled in the top college, learning productivity falls for high-ability students, but rises for low-ability students.

To understand these findings, recall that a student's log learning productivity is given by $A_q + \phi_q \times a$. Peer effects reduce both A_q and ϕ_q. The decline in A_q, which affects all students, is too small to affect earnings much. In the baseline model, the gap in mean ability between $q1$ and $q4$ students is about 1. Expanding capacity by 20 percent shrinks it by only about 10 percent. Since we assume that half of the baseline productivity gaps are due to peer effects, a 10 percent reduction in mean ability gaps reduces the gap in A_q by only 5 percent, from 0.1 to 0.095.

The baseline gap in ϕ_q is larger (0.4). It also shrinks by 5 percent to 0.38. For students of mean ability ($a = 0$), this change does not affect learning at all. But it greatly affects high-ability students. For example, with an ability level that is two standard deviations above the mean ($a = 2$), learning productivity declines by $\Delta A_q + \Delta\phi_q \times a = 0.005 + 0.02 \times 2 = 0.045$. This has a noticeable effect on learning and therefore on lifetime earnings. Hence, only students in the top ability quartile suffer substantially from the lower ϕ_q in the top college.

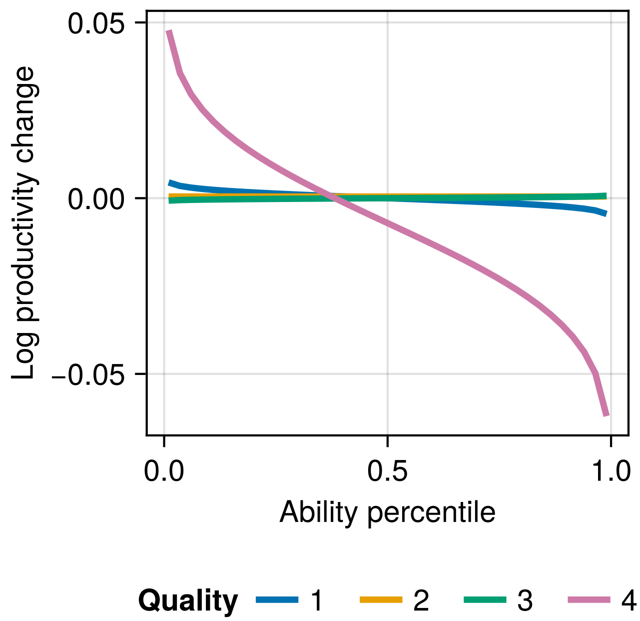
In sum, peer effects have essentially no effect on students' enrollment decisions. They reduce the earnings of top ability students who enroll in $q4$ colleges, but expanding college capacity continues to generate large earnings and welfare gains.[28]

6 Endogenous Wages

In this section, we address a final concern about expanding college capacities. A large increase in skilled labor supply could drive down the college wage premium and

[28]Endogenizing student dropout decisions would likely not change these findings significantly. Peer effects only reduce earnings for high-ability students enrolled in $q4$ colleges. For these students, the payoffs from graduation, and hence the incentives to persist in college, remain very strong.

Figure 6: Changes in Log Learning Productivities



Note: The figure shows the changes in log learning productivity for students of different ability levels enrolled in each college. The changes arise from a 20 percent expansion of top-quality college capacities with peer effects.

reduce the return to college (Bengali et al., 2025).

To address this concern, we replace the exogenous wages of the baseline case with endogenous wages that are determined by the relative supplies of skilled and unskilled labor (see Section 2.8). We set the elasticity of substitution between skilled and unskilled labor to 1.5, which is at the low end of the values estimated in the literature (Bils et al., 2024). Higher elasticities decrease the response of wages to changes in labor supplies and yield results that are closer to the baseline model with fixed wages. We set the skill weights for the CES labor aggregator, α_e, so that the economy prior to the capacity expansion yields the same equilibrium allocation and prices as the baseline model.

Even with an elasticity that is at the low end of the empirical estimates, we find that endogenous wages do not substantially alter the changes in aggregate earnings. As expected, the college expansion reduces the skill premium and dampens the increases in entry, graduation, and therefore earnings, but the effects are not large. Endogenous wages do, however, change the distributional implications of the college expansion.

6.1 Results

Broadly speaking, the effects of college expansions are similar to the baseline case, but somewhat dampened. Table 6 summarizes the main outcomes of interest for a 20 percent expansion of $q4$ capacity.

With increased skilled labor supply, the college wage premium declines by 4.2 percent. The lower skill premium reduces the incentives to enroll in four-year colleges, especially for high-ability students. But the enrollment changes are not large because the earnings gains from attending selective colleges remain substantial.

The entry decisions of most ability groups are very close to the baseline case. Only high-ability students enter four-year colleges at slightly lower rates. As a result, the mean ability levels of students in all colleges are essentially unaffected. Since fewer students start four-year colleges, the number of graduates declines relative to the baseline case (by 0.2 percent). As a result, skilled labor supply expands less (by 4.6 versus 5.3 percent).

The change in aggregate earnings is similar to the baseline case (0.9 vs. 0.8 percent). The difference is small because the earnings losses of college graduates are partly offset by the earnings gains of non-graduates, who benefit from higher unskilled wages.[29]

[29]Endogenous dropout decisions would likely reduce the earnings gains. However, even with the

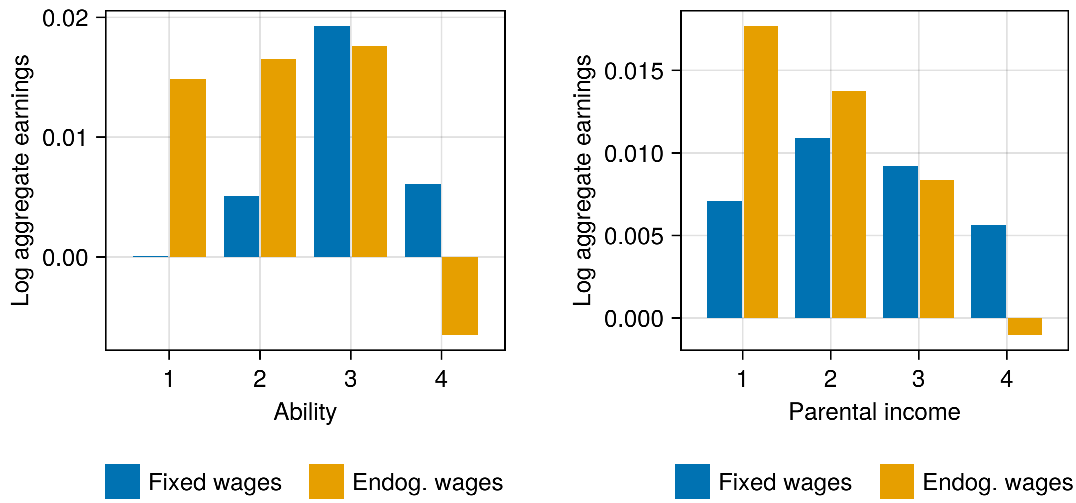
Table 6: Endogenous Skill Premium

	Baseline	**Fixed wages**	**Endog. wages**
	Level	Change relative to baseline	
Aggregate earnings (log)	7.100	+0.8	+0.9
Coll. expenditure / Y	1.31	+0.09	+0.08
Welfare gain	–	+2.2	+3.4
Fraction entering 4y	34.8	+1.8	+1.5
Fraction entering top quality	10.0	+2.0	+2.0
Fraction graduates	23.5	+1.4	+1.2
Mean ability top quality	1.03	−0.11	−0.12
Labor supply CG (log)	12.782	+5.3	+4.6
Labor supply Non-CG (log)	13.518	−1.7	−1.5
Wage CG (log)	2.476	+0.0	−2.5
Wage Non-CG (log)	2.363	+0.0	+1.7

Note: The table shows the effects of expanding $q4$ colleges by 20 percent when wages are set to the marginal products implied by a CES labor aggregator with an elasticity of substitution of 1.5. Changes in fractions are in percentage points; log changes and welfare gains are reported in percent.

Figure 7: Earnings Gains

(a) Ability Quartiles (b) Parental Background Quartiles



Note: The figure shows the changes in aggregate earnings that result from expanding top-quality college capacities by 20 percent. The baseline expansion treats wages as fixed. In the general-equilibrium ("Endog. wages") expansion wage rates are determined by a CES labor aggregator.

6.1.1 Distributional Implications

The college expansion decreases the wages of college graduates, but increases the wages of all other workers. The distributional implications therefore change significantly relative to the baseline expansion. As shown in Figure 7a, aggregate earnings increase by more around 1.5 percent for students outside of the top ability quartile. By contrast, students in the top ability quartile, most of whom are college graduates, experience a reduction in their earnings.

Since ability and parental income are correlated, the college expansion disproportionately benefits lower-income students (Figure 7b), even though their college opportunities expand the least. As a result, measures of intergenerational mobility increase. For example, the lifetime earnings gap between $p4$ and $p1$ students drops by 1.3 percentage points (baseline 27.9 percent). Measures of earnings inequality decline as

reduced college wage premium, the incentives to graduate remain strong, especially for higher-ability students who constitute the majority of all college graduates.

well. For example, the 90/10 gap of lifetime earnings drops by 7.2 percentage points (baseline 97 percent).

Relative to the baseline experiment with fixed wages, the lower dispersion of lifetime earnings increases the aggregate welfare gains. With diminishing marginal utility of consumption, redistributing income from higher-income college graduates to lower-income non-graduates increases average household utility and therefore welfare.

7 Conclusion

This paper studies the effects of large-scale expansions of high-quality public university capacities. We develop a quantitative model of college choice with heterogeneous students, quality-differentiated colleges, and selective admissions. The model is calibrated to match detailed enrollment, graduation, and earnings patterns from the NLSY97.

Our main finding is that expanding selective college capacities generates large earnings and welfare gains at a modest fiscal cost. A 20 percent expansion of top-quality college seats raises aggregate earnings by 0.8 percent and welfare by 2.2 percent. The increase in college expenditures required to finance the expansion amounts to only 0.1 percent of aggregate earnings. The key mechanism is simple. Many high-ability students currently do not attend four-year colleges. When selective colleges expand, these students fill the new seats, graduate at high rates, and earn substantially more over their lifetimes. The pool of such undermatched students is large enough that even sizable expansions do not exhaust it.

We address three common concerns about college expansion. First, we find that newly admitted students are of somewhat lower ability, but the decline is modest and graduation rates remain high. Second, peer effects in learning reduce earnings for top-ability students in colleges that expand, but the effects on other students and on aggregate outcomes are small. Third, endogenous skill prices dampen the gains somewhat, but also redistribute earnings toward lower-income workers, reducing inequality and increasing intergenerational mobility.

Future research should study the role played by college capacity constraints in shaping historical college enrollment trends.

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Appendix

A Calibration

This section describes the calibration in detail.

High school graduates draw a vector of endowments (a, p, g, h_1) from a Gaussian copula. In order to reduce the number of calibrated parameters that govern endowment correlations, we proceed as follows. We draw (a, p) from a bivariate normal distribution with zero means and unit standard deviations. The correlation parameter $(\rho_{a,p})$ is calibrated. We then set $g = \beta_{g,a}a + \beta_{g,p}p + \varepsilon_g$ and $h_1 = \beta_{h,a}a + \beta_{h,p}p + \varepsilon_h$. The error terms $(\varepsilon_h, \varepsilon_g)$ are drawn from independent, standard normal distributions. College admissions scores are a linear combination of h_1 percentiles (with a fixed weight of 0.5) and test score percentiles (with a calibrated weight of $\beta_{z,g}$). We rescale the endowments to have the desired marginal distributions: $p \sim U[0, 1]$, $g \sim U[0, 1]$, and $h_1 \sim U[1, 1 + \Delta h_1]$, where Δh_1 is calibrated.

For each candidate set of parameters, the calibration algorithm calculates the probability of all possible life histories for $10,000$ students. It constructs model counterparts of the target moments and searches for the parameter vector that minimizes a weighted sum of squared deviations between model and data moments.

While the calibration algorithm searches over all parameter values to jointly match all target moments, it may be helpful to think of the following mapping from target moments to parameter values.

- The earnings regressions help identify the human capital technologies.
- Dropout and graduation patterns help identify $\Pr_d$ and $\Pr_g$.
- Because both earnings and graduation depend strongly on g, our calibration assigns a high degree of correlation between a and g. It follows that high-ability students face high financial returns to college quality, which helps the model match the strong correlation between college quality choice and g.
- Dropout earnings premiums help identify the correlation between h_1 and a as well as the dispersion of h_1 (Δh_1).
- The observed joint distribution of g and p disciplines the joint distribution of a and p in the model.
- Preference shocks introduce noise in college selection. Their scale is identified by the observed undermatch of students with high g and high p. These students face

strong financial returns to high-quality colleges and are unlikely to be affected by financial constraints. They forego attending $q4$ due to preference shocks and information frictions. The responsiveness of college enrollment to changes in tuition is also informative about the scale of preference shocks.

- The remaining targets relate to the relationship between college quality choice and parental background (for given g). In the model, higher-income students tend to choose better colleges for three reasons. First, parental income affects consumption in college. Data on financial variables reveal how tight this friction is. Second, information frictions prevent low-income students from entering high-quality colleges. The information friction is calibrated to match the quasi-experimental evidence of Hoxby et al. (2013). Finally, lower-income students are less likely to be admitted to high-quality colleges because they have lower initial human capital. With the scale of preference draws identified, this channel is the residual explanation for the undermatch of the lower-income students, and is identified as such.

A.1 Fixed Parameters

How the fixed model parameters are set is described in the main text. Figure 8 shows the estimated experience-wage profiles. Financial variables are set as follows.

- The annual net cost of attending college, $\tau_{total}(s)$, is the sum of an observed cost $\tau(s)$ and an additional (calibrated) unobserved cost τ_{4y} that is paid by all four-year college students. The observable cost is estimated by regressing tuition charges, net of grants and scholarships, on family income, test scores, and college quality (see Table 7). As expected, observed college costs increase with college quality and parental income, but decline with test scores. The additional cost of attending a four-year college helps the model match the fact that higher income students are more likely to attend such colleges.
- Parental transfers: We set parental transfers, $\mathcal{T}(s)$, to their observed means for each combination of family income quartile and college quality (see Table 8). The lifetime transfer is set to the sum of the transfers received while attending a $q4$ college for six years. The difference between the lifetime transfer and the transfers received while enrolled in college is paid out at the start of work. Students who never attend college also receive the lifetime transfer.
- Student debt: We find that, for given college quality, debt varies little with

AFQT scores or parental incomes. We therefore set debt for all students to the estimated means by college quality and year (see Table 9). We assume that annual borrowing stays constant after year four, which is the last year for which we have enough observations to estimate debt with reasonable precision. In our data, students rarely borrow large amounts. At the end of their fourth year in college, mean debt is just over $10,000 and almost half of students have no debt at all.

- Student earnings: In our data, student earnings vary little with parental incomes or student test scores. We therefore set student earnings to their estimated means for all students in a given college. Earnings are similar for all four-year colleges, but higher for two-year colleges.[30]
- Student consumption: We infer consumption from the student budget constraint. Our data imply that consumption levels are quite low for lower-income students who enroll in selective colleges, suggesting that these students may face binding financial constraints. The reason is that college costs rise with quality, but parental transfers do not. However, higher-income students receive large parental transfers when they enroll in selective colleges, ensuring that their consumption levels are far greater than those of lower-income students.

A.2 Calibrated Parameters

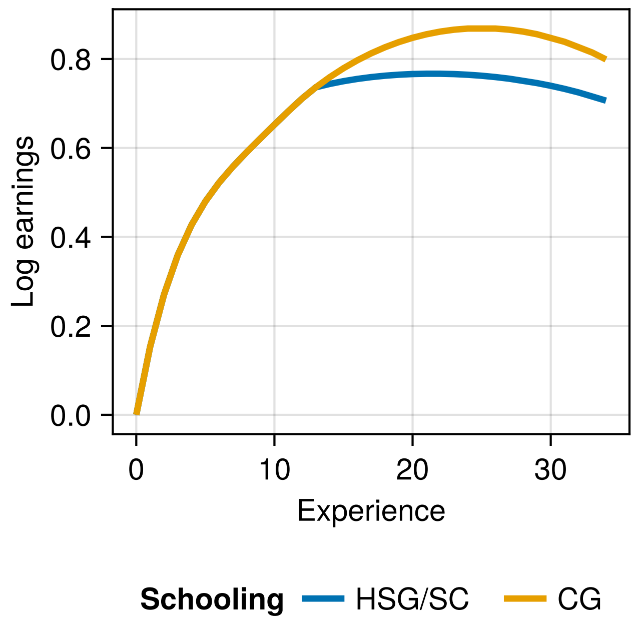
Table 10 through Table 13 show the values of the calibrated parameters. Students' graduation and dropout probabilities are linear functions of ability percentiles. We assume that $\Pr_g(s) = \gamma_{1,q} + \gamma_{2,q}\hat{a}$, where $\gamma_{1,q}, \gamma_{2,q} \geq 0$, and that $\Pr_d(s) = \gamma_{4,q} - \gamma_{5,q}\hat{a}$, where $\gamma_{4,q}, \gamma_{5,q} \geq 0$. All probabilities are truncated into the unit interval. As shown in Figure 9a and Figure 9b, for a given student, attending a higher quality college increases the likelihood of graduating, but reduces the likelihood of dropping out. Taken together, the probability of eventually graduating from college rises substantially with college quality, especially for high-ability students.

B Model Fit

This section shows all target moments used in the calibration, except for those already displayed in the main text.

[30] Average annual earnings by college quality are: $q1: \$8,100, q2: \$5,442, q3: \$4,651, q4: \$4,430$.

Figure 8: Experience Profiles



Note: The figure shows the estimated experience profiles for log earnings.

Table 7: College Costs

Regressor	**Coefficient (s.e.)**
AFQT 2	-261.65 (615.46)
AFQT 3	39.27 (573.69)
AFQT 4	-1,198.1 (629.19)
Quality 2	35.69 (600.22)
Quality 3	1,679.4 (546.53)
Quality 4	4,307.6 (882.17)
Parental income 2	921.85 (1,005.6)
Parental income 3	1,825.0 (974.64)
Parental income 4	2,938.7 (1,023.4)
Constant	-720.65 (801.01)

Note: The table shows the results of regressing the net cost of college on AFQT quartile dummies, parental quartile dummies, and quality dummies. The regression implies negative net costs for some students with low incomes but high test scores. Such cases, where financial aid covers more than the total cost of college, are observed in the data.

Table 8: Parental Transfers

	$p1$	$p2$	$p3$	$p4$
Quality 1	626.6	1,032.1	2,442.7	2,796.4
Quality 2	2,079.1	2,237.4	4,186.2	5,274.6
Quality 3	1,700.3	3,913.6	5,289.6	9,998.7
Quality 4	4,171.0	4,896.5	11,095.6	17,218.7

Note: The table shows mean parental transfers for each combination of family income quartile and college quality.

Table 9: Student Debt

Year	**1**	**2**	**3**	**4**
Quality 1	374.0	794.2	n/a	n/a
Quality 2	2,569.5	5,671.5	7,756.1	10,773.1
Quality 3	2,070.5	4,515.3	7,159.0	10,064.8
Quality 4	2,717.5	5,395.5	7,574.9	11,121.2

Note: The table shows mean student debt at the end of each year in college for each quality.

Table 10: Preference Parameters

Symbol	Description	Value
$\mathcal{U}_e$	Fixed utility at work; by education	3.00, 2.52, 3.52
$\mathcal{U}_{2y}$	Utility from attending 2 year college	8.00
$\Delta\mathcal{U}$	Range of idiosyncratic college preferences	6.00

Table 11: Endowment Parameters

Symbol	Description	Value
$\rho_{a,p}$	Correlation (a,p)	0.336
$\beta_{h,a}$	Weight on ability when drawing h_1	2.49
$\beta_{h,p}$	Weight on parental when drawing h_1	1.58
Δh_1	Range of h endowments	0.120
$\beta_{g,a}$	Weight on ability when drawing g	3.36
$\beta_{g,p}$	Weight on parental when drawing g	0.103
$\beta_{z,g}$	Weight on g in admissions score	0.174
π	Prob of observing true quality	0.284, 0.356, 0.427, 0.490

Note: The probability of observing the true college quality varies with parental income quartile.

Table 12: Financial Parameters

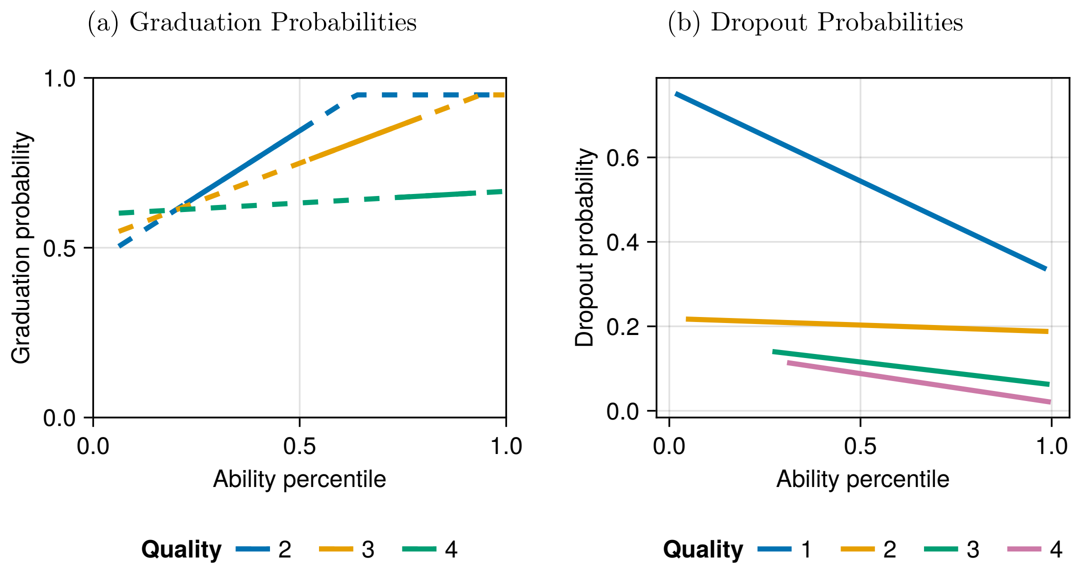
Symbol	Description	Value
τ_{4y}	Cost of attending four year college	4.89
w_{HSG}	Log wage HSG	2.36
Δw	College wage premium	0.113

Note: The college wage premium is the log difference between w_{CG} and w_{HSG}.

Table 13: College Related Parameters

Symbol	Description	Value
A_q	College productivities	-2.26, -2.07, -2.00, -2.15
ϕ_q	Ability scale	0.097, 0.000, 0.195, 0.513
ζ	Exponent on h	0.006

Figure 9: Graduation and Dropout Probabilities



Note: The figure shows the annual graduation and dropout probabilities for students of different ability levels. Students can graduate after attending a four-year college for at least 3 years. The solid sections in the graduation probability plot represent inter-quartile ranges of students enrolled in each college.

B.1 College Entry Patterns

The target moments that characterize college entry patterns are:

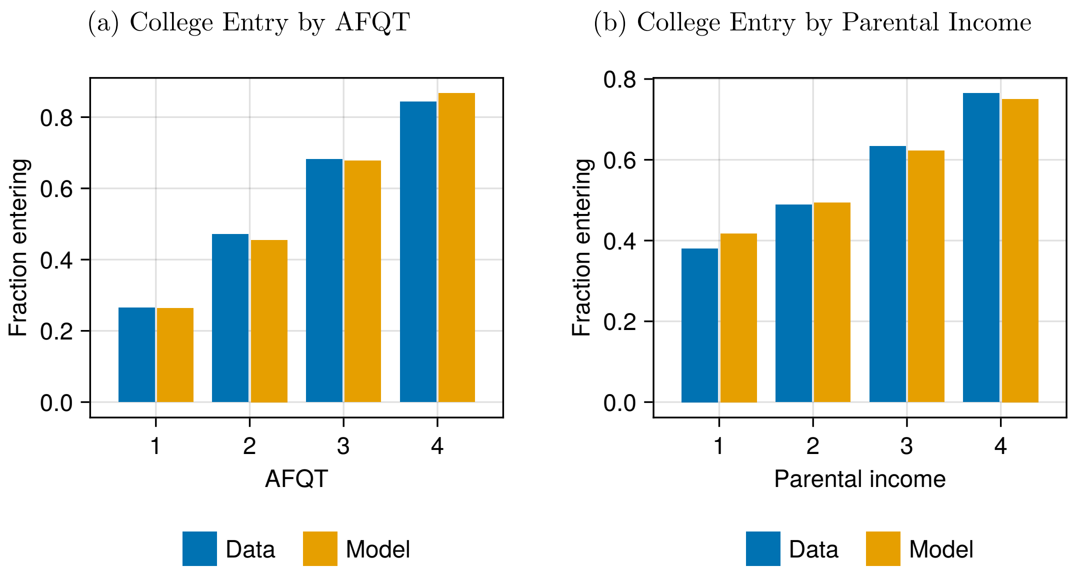
1. College entry rates for each AFQT and/or parental income quartile ((Figure 10) and (Figure 11)).
2. The AFQT distribution of freshmen by college quality (Figure 12)
3. The fraction of freshmen who choose each college quality, by AFQT and parental income quartile (Figure 13).
4. Mean AFQT percentiles of freshmen in each college (Figure 14).
5. Total freshman enrollment by college quality (Figure 15).

B.2 College Dropout and Graduation

Target moments that relate to college dropout and graduation patterns are:

1. The fraction of college entrants that graduate within six years by college quality,

Figure 10: College Entry by AFQT or Parental Income



AFQT quartile, and parental income quartile (Figure 16 through Figure 18).

2. The fraction of college entrants dropping out by the end of the second year by AFQT and college quality (Figure 19).
3. The fraction of college entrants dropping out at the end of each year for each college quality (Figure 20).
4. The average number of years students spend in college before either dropping out or graduating (Figure 21).

B.3 Other Target Moments

Target moments that characterize worker earnings are:

1. The coefficients of a regression of log earnings (net of experience effects) on AFQT and education dummies (Table 14). Even controlling for AFQT scores, college graduates earn far more than dropouts.
2. Mean log earnings fixed effects by education, AFQT, and college quality (Figure 22 through Figure 24).

Scalar target moments are shown in Table 15. The last two rows show the quasi-experimental moments described in the main text.

Figure 11: College Entry by AFQT and Parental Income

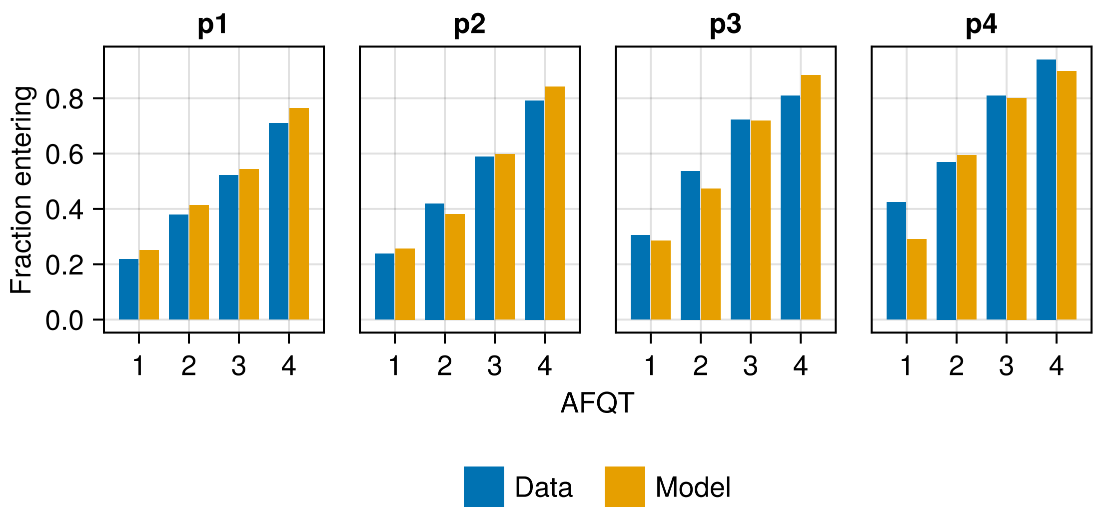


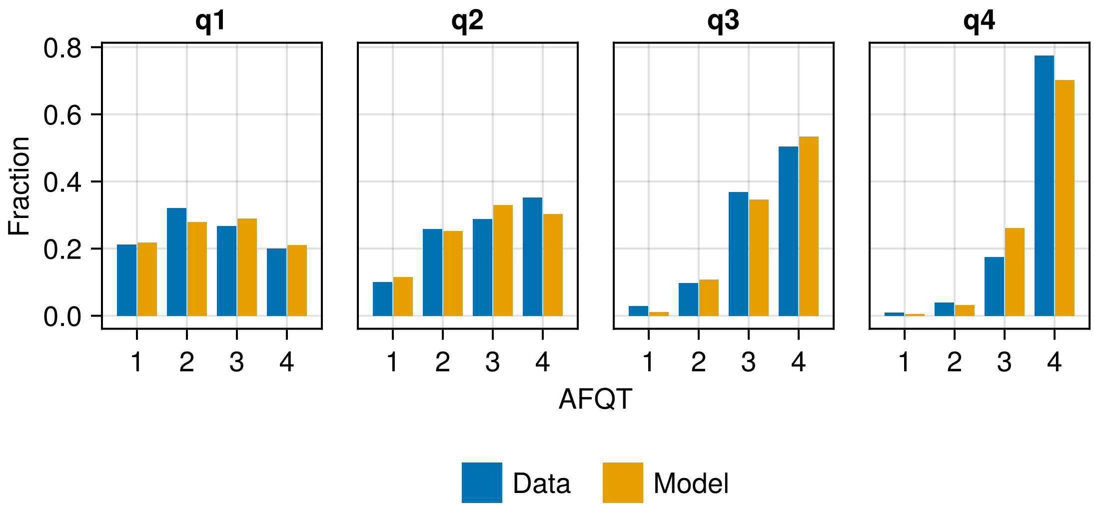
Table 14: Earnings Regressions. All Workers.

Regressor	**Data**	**Model**
AFQT 2	0.102 (0.0198)	0.0237
AFQT 3	0.121 (0.0208)	0.0496
AFQT 4	0.187 (0.0232)	0.138
SC	0.147 (0.0193)	0.163
CG	0.583 (0.0182)	0.590
Constant	2.34 (0.0145)	2.38

1. The "tuition increase" entry shows the change in college enrollment due to a \$5,000 increase in tuition. A random subset of 40 percent of high school graduates receive the treatment. The target moment is based on Dynarski et al. (2023b).
2. The "full information" entry shows the change in college enrollment for lower-income, high-AFQT students who are given full information ($\pi = 1$). The target moment is based on Hoxby et al. (2013).

In both cases, the enrollment changes are calculated as the difference between the mean enrollment change of the treated and the untreated students.

Figure 12: AFQT Distribution by College Quality



Note: For each college, the figure shows the fraction of freshmen in each AFQT quartile.

Table 15: Scalar Target Moments

Description	Data	Model
Graduation rate (cond.)	0.44 (0.01)	0.41
Fraction entering	0.57 (0.01)	0.57
Δ enrollment; tuition $\uparrow$ by \$5,000	17.5	17.5
Δ enrollment; full information	5.3	5.3

Note: The table shows the model fit for scalar target moments. Row 3 shows the decline in enrollment when tuition is increased by $5,000. The data target is based on Dynarski et al. (2023b). Row 4 shows the change in enrollment when full information is provided to students in the lowest half of the parental income distribution with test scores in the top quintile. The data target is based on Hoxby et al. (2013). Standard errors for data moments are shown in parentheses where applicable.

Figure 13: College Quality Choice

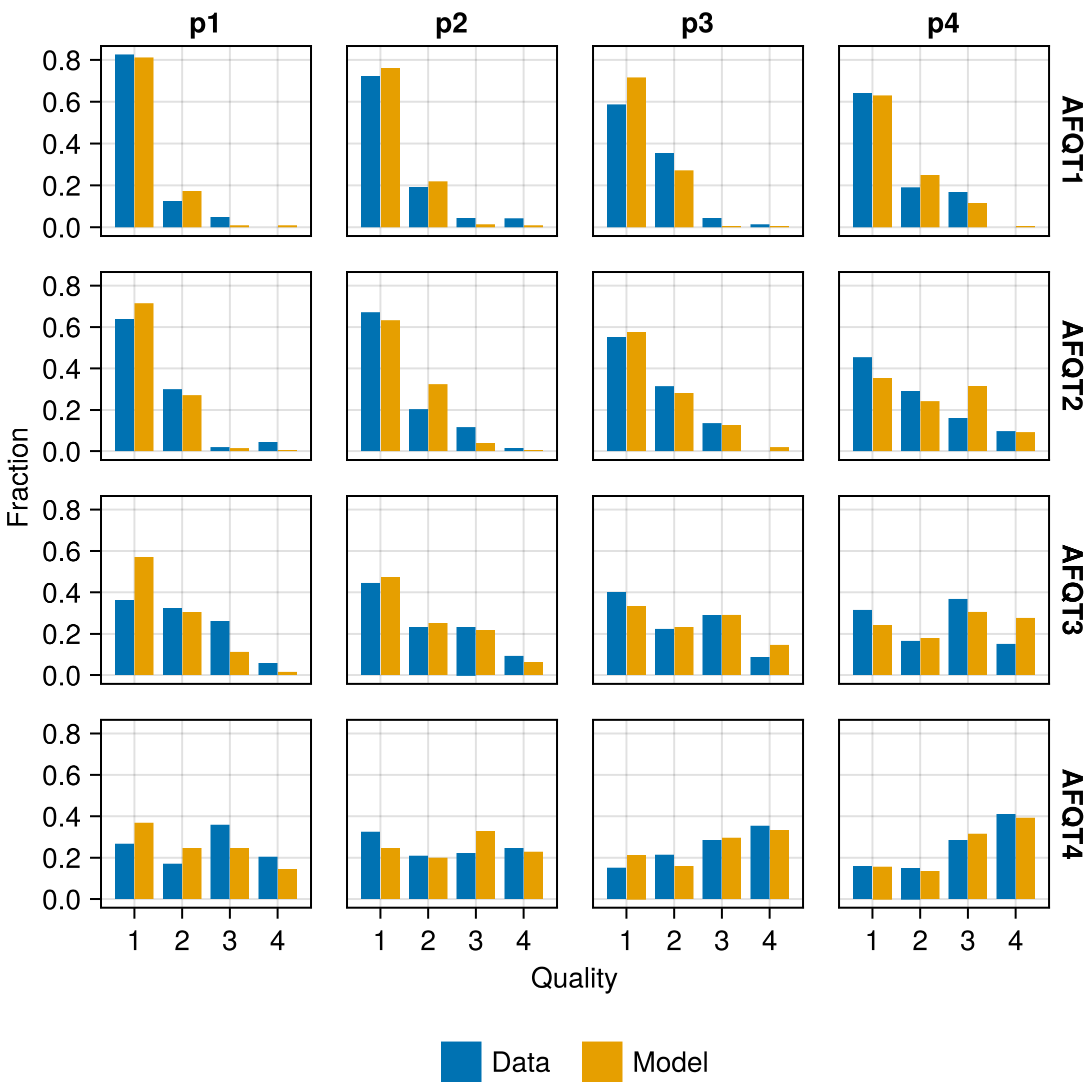


Figure 14: Mean AFQT Percentiles

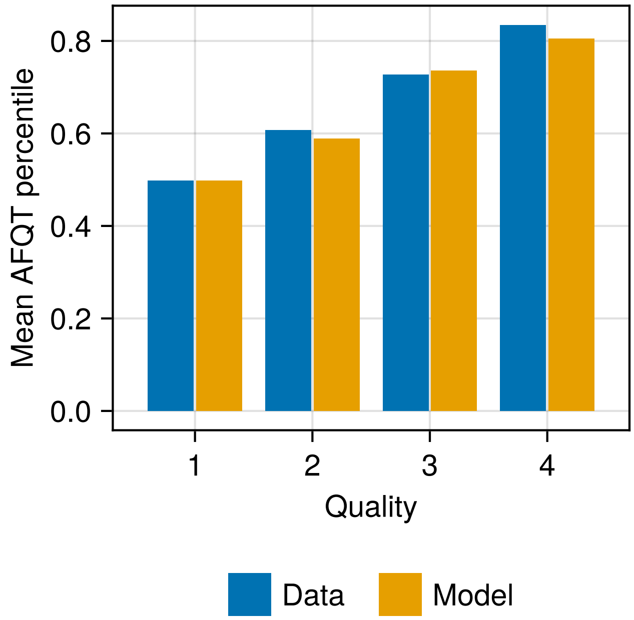
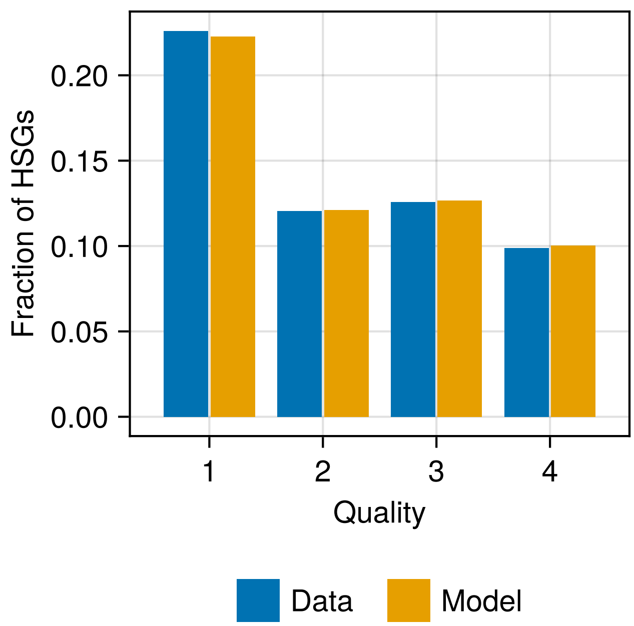


Figure 15: College Quality Choice



Note: The figure shows the fraction of high school graduates who choose each college quality.

Figure 16: Graduation Rates

(a) By AFQT (b) By College Quality

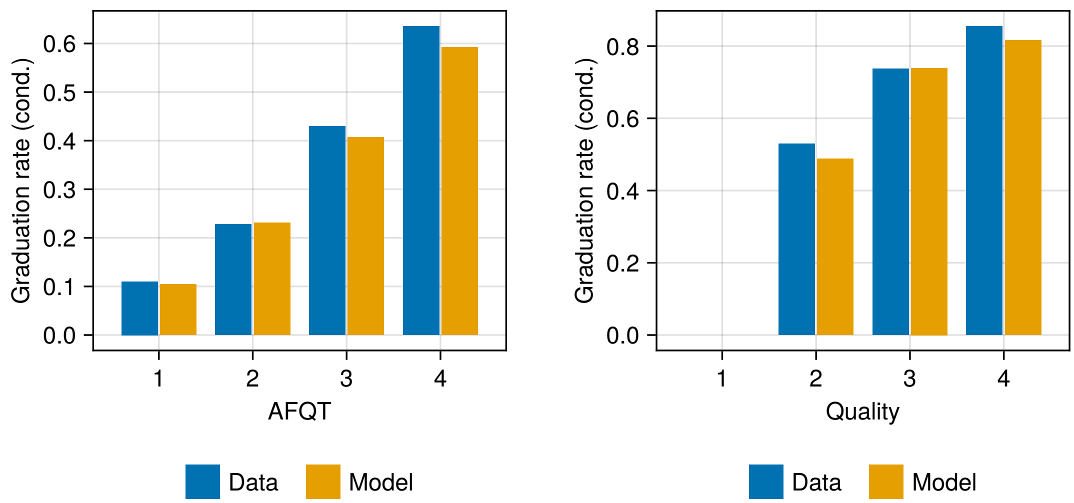
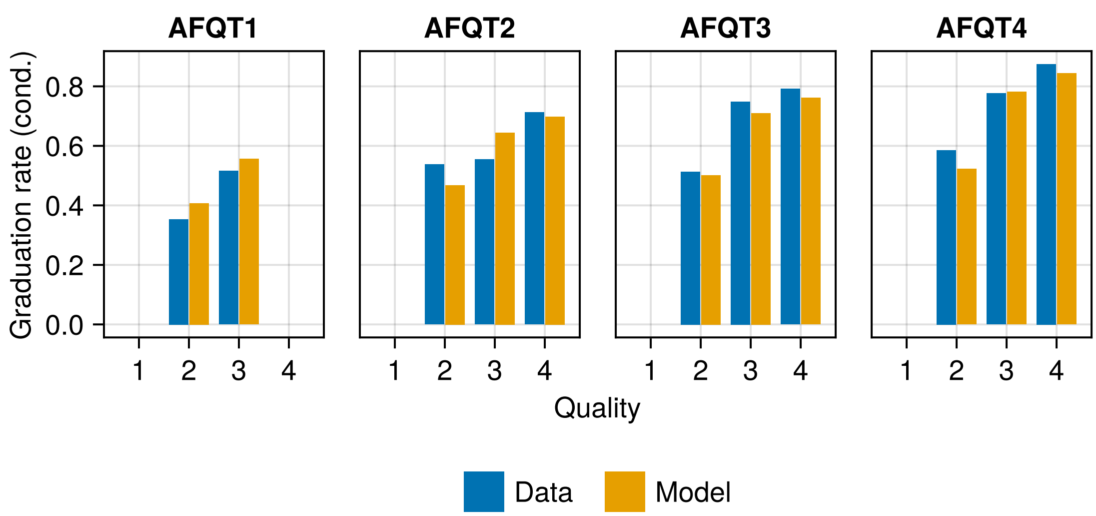


Figure 17: Graduation Rates by Quality and AFQT



Note: The figure shows the fraction of freshmen who later graduate from college for each college quality and AFQT quartile. The data do not contain enough $g4$ freshmen in $q4$ to compute an estimate of their graduation rate.

Figure 18: Graduation Rates by Quality and Parental Income

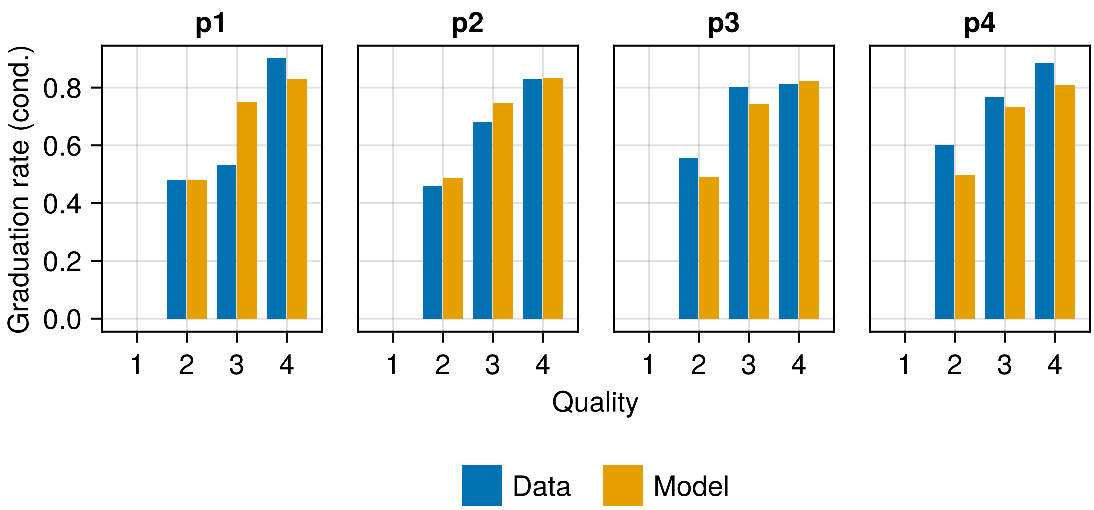


Figure 19: Cumulative Dropout Rates at End of Year 2

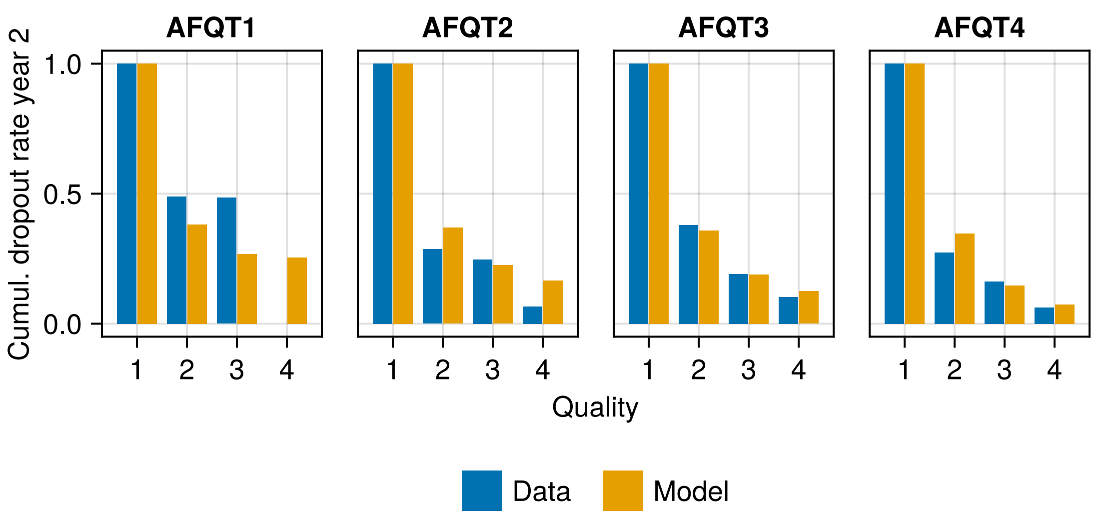
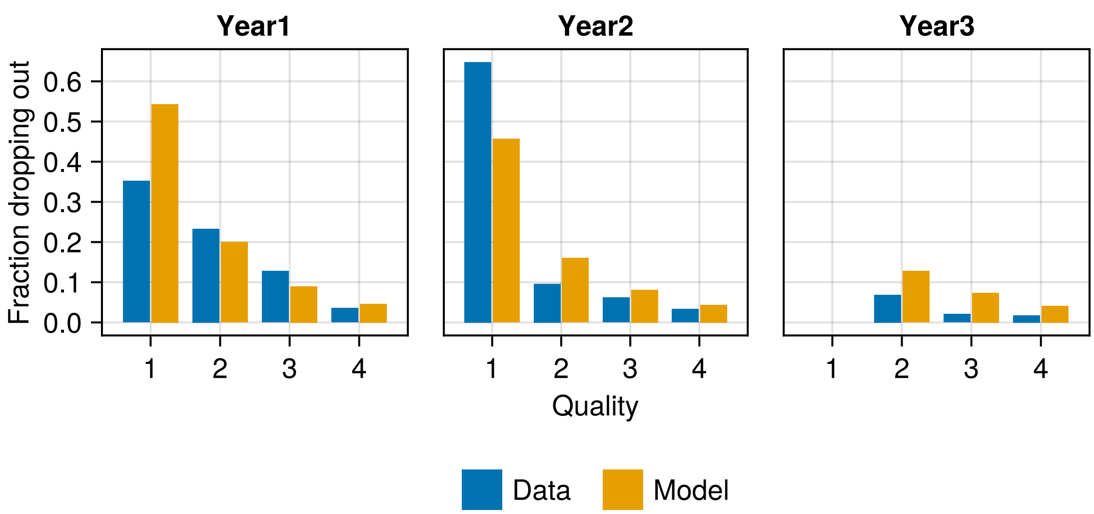


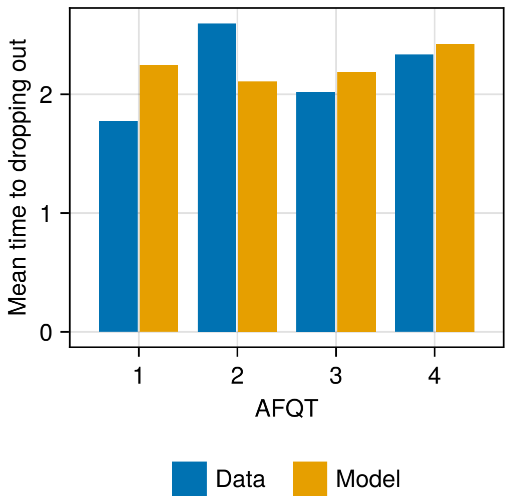
Figure 20: Fraction of Entrants that Drop Out by Year



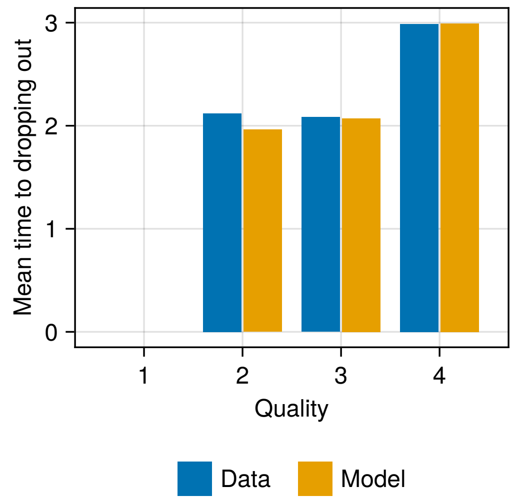
Note: The figure shows the fraction of initial entrants who drop out at the end of each year. In the data, many students attending $q1$ enroll for more than two years. We treat these students as if they dropped out at the end of year two. This creates the appearance of the dropout rate increasing with time. Our model cannot replicate this pattern, but it precisely matches the cumulative dropout rate at the end of year two.

Figure 21: Mean Time to Dropout and Graduation

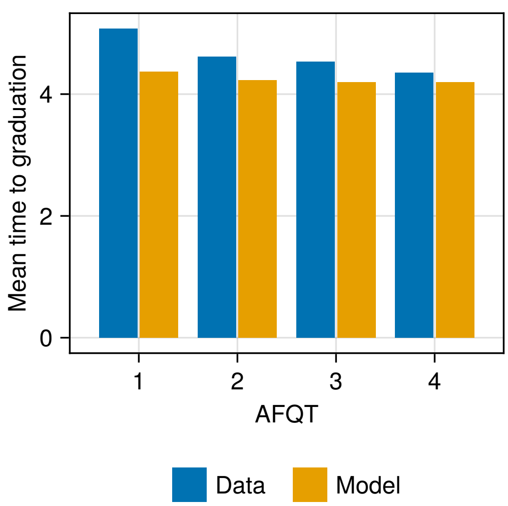
(a) Mean Time to Dropping Out



(b) Mean Time to Dropping Out



(c) Mean Time to Graduation



(d) Mean Time to Graduation

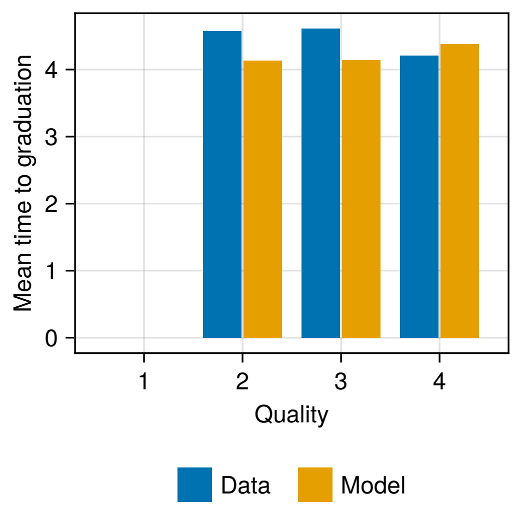
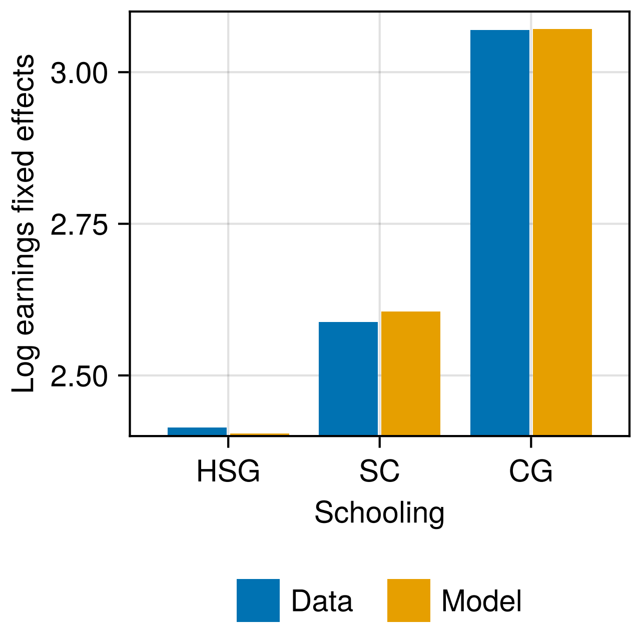
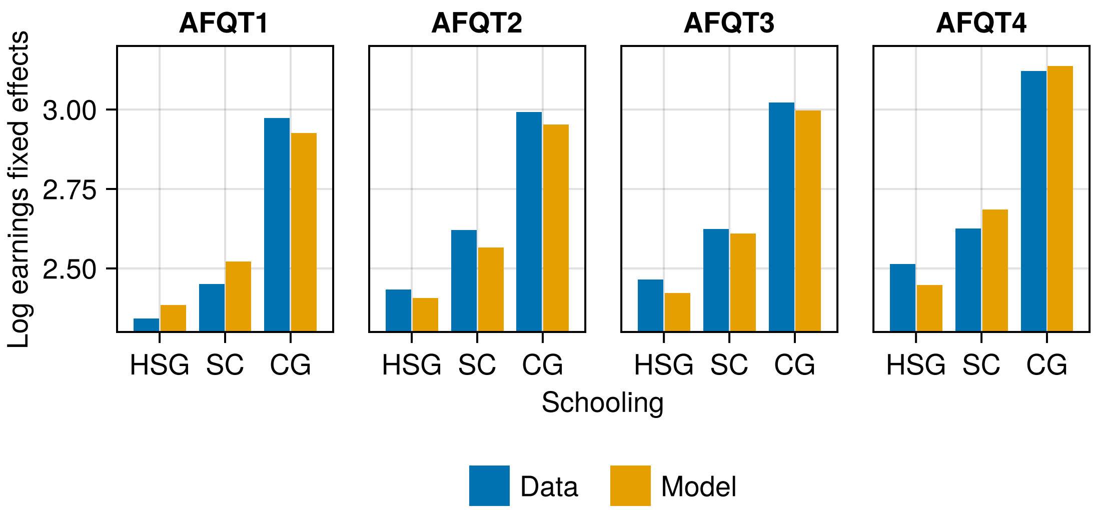


Figure 22: Earnings Fixed Effects by Schooling



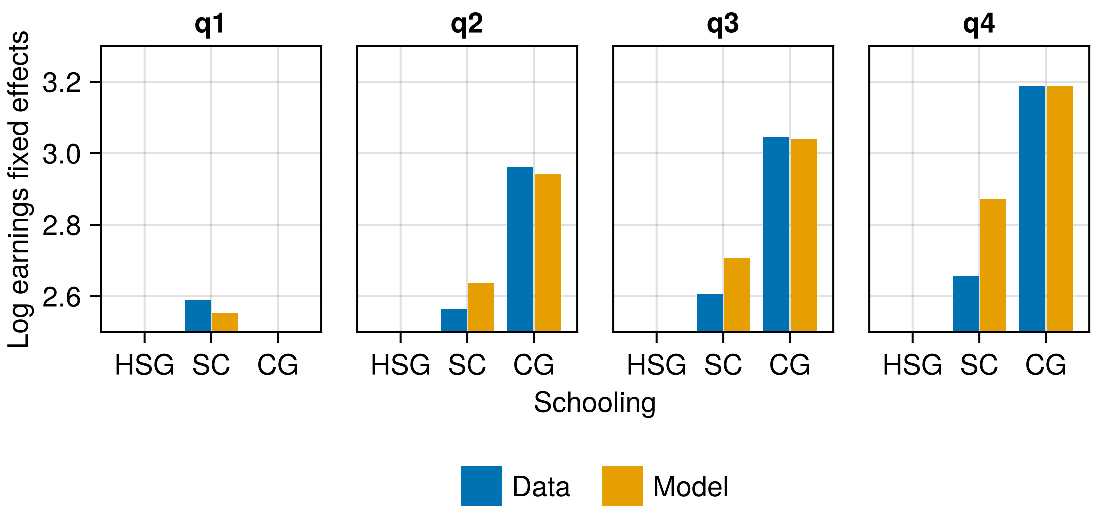
Note: In the data, fixed effects are estimated by regressing log earnings on a quartic polynomial in potential experience. The regressions use panel data and are estimated separately by education group. See Leukhina (2023) for details. In the model, individual log earnings are given by log earnings in the first year of work plus an experience profile that is common to all workers of a given education group. The fixed effect is then simply the level of initial earnings.

Figure 23: Earnings Fixed Effects by Schooling and AFQT



Note: See Figure 22 for the definition of earnings fixed effects.

Figure 24: Earnings Fixed Effects by Schooling and College



Note: See Figure 22 for the definition of earnings fixed effects.

C The Fiscal Costs of College Expansion

We calculate the total fiscal cost of operating colleges as follows. We obtain data on the costs of operating public universities from IPEDS for the year 2000 (U.S. Dept. of Education, 2025). Following Hoxby (2009), expenditures include instructional expenditures, student services, academic support, institutional support, and auxiliary expenditures.[31]

Total expenditure per freshman enrolled in each college quality is calculated as the product of expenditure per student-year and the average number of years that a student spends in the college. For example, the expenditure per year for students enrolled in $q4$ colleges is $\$16,659$. The typical freshman remains in a $q4$ college for four years (averaging across dropouts and graduates). Total expenditure per freshman is then $\$67,144$. Table 16 summarizes the estimated expenditures per student for each college quality.

When college capacities expand, we assume that expenditures expand to hold educational quality constant. Blair and Smetters (2021) argue that expansions would likely reduce costs per student because some fixed costs and research expenditures would not scale in proportion to enrollment. In our calculations, we assume that expenditure per student would stay constant.

We do not model how the additional college costs are financed. The reason is that the implied tax rate changes are very small. To illustrate, consider a 20 percent expansion of $q4$ colleges. As shown in Table 3, total college expenditures rise by 0.1 percent of aggregate earnings. Aggregate earnings rise by 0.8 percent. With an income tax rate of 12.5 percent, the college expansion is self-financing and taxes need not change in order to balance the budget.

If the income tax rate is lower than 12.5 percent, taxes must be raised, but by very small amounts. To see this, consider again the case of a 20 percent expansion of $q4$ capacities. To a first approximation, this induces 2 percent of high school graduates, who were previously not enrolled in any four-year college, to switch to $q4$. Most of these students are from the 3rd ability quartile. The lifetime earnings gap between starting $q1$ and starting $q4$ for $a3$ students is about \$167,000 (discounted to high school graduation). The difference in the total cost per college freshman is below \$60,000. Given that 2 percent of the high school graduate population upgrade, the cost per

[31] Counting all college expenditures, including research funding, would raise expenditures per student by one-quarter for $q1$ colleges and by two-thirds for $q4$ colleges.

Table 16: College Expenditures

Quality	1	2	3	4
Freshman enrollment (pct)	22.6	12.0	12.6	9.9
Annual expenditure per student	4,304	8,153	10,166	16,659
Graduation rate (pct)	0.0	52.9	73.7	85.5
Avg. years in college	2.0	3.4	3.9	4.0
Expenditure per entrant	8,608	27,845	40,111	67,144
Expenditure per graduate	–	52,632	54,417	78,552

Note: The table summarizes the calculation of college expenditures per entrant for each quality. Freshman enrollment is the fraction of the high school graduate population that enrolls in each college. Annual expenditures per student are based on IPEDS data. Average years in college are a weighted average over dropouts and graduates. The cost per entrant is the product of annual expenditure and average years in college. The cost per graduate is the cost per entrant divided by the graduation rate.

worker amounts to less than $0.02 \times \$60,000 = \$1,200$ (over the worker's lifetime). Average lifetime earnings per worker are near $600,000. The implied income tax rate required to finance the college expansion is then around 0.2 percent. Since the tax base increases, the actual tax rate required to balance the budget would be lower. In either case, the changes in tax rates are sufficiently small that abstracting from their effect on household decisions seems justified.

D Robustness Analysis

D.1 No Complementarity in Learning

What role does the complementarity between ability and college quality play for the large earnings gains from expansions? To investigate this question, we recalibrate the model without the complementarity, so that ϕ_q is the same for all q. As a result, the model now fails to match the high earnings of $q4$ graduates with high test scores observed in the data (see Table 2).

As shown in Table 17, expanding $q4$ capacity by 20 percent generates changes in aggregate outcomes that are very similar to the baseline case. The main reason is that, as in the baseline expansion, most of the newly created seats are filled by $a3$

Table 17: College Expansion Without Complementarity in Learning

	Baseline	**Experiment**
	Level	Change relative to baseline
Aggregate earnings (log)	7.090	+0.8
Coll. expenditure / Y	1.31	+0.09
Welfare gain	–	+2.2
Fraction entering 4y	34.6	+1.8
Fraction entering top quality	10.0	+2.0
Fraction graduates	23.3	+1.4
Mean ability top quality	0.98	−0.11
Labor supply CG (log)	12.677	+5.6

Note: The table shows the effects of expanding $q4$ capacities by 20 percent. The "Baseline" column shows the level of each indicator in the calibrated model without complementarities in learning (all colleges share the same ϕ_q parameter). The "Experiment" columns show the differences relative to the baseline for the college expansion. Y denotes aggregate earnings. "Fraction graduates" is the fraction of the high school graduate population who earn a degree. Changes in fractions are in percentage points; log changes and welfare gains are reported in percent.

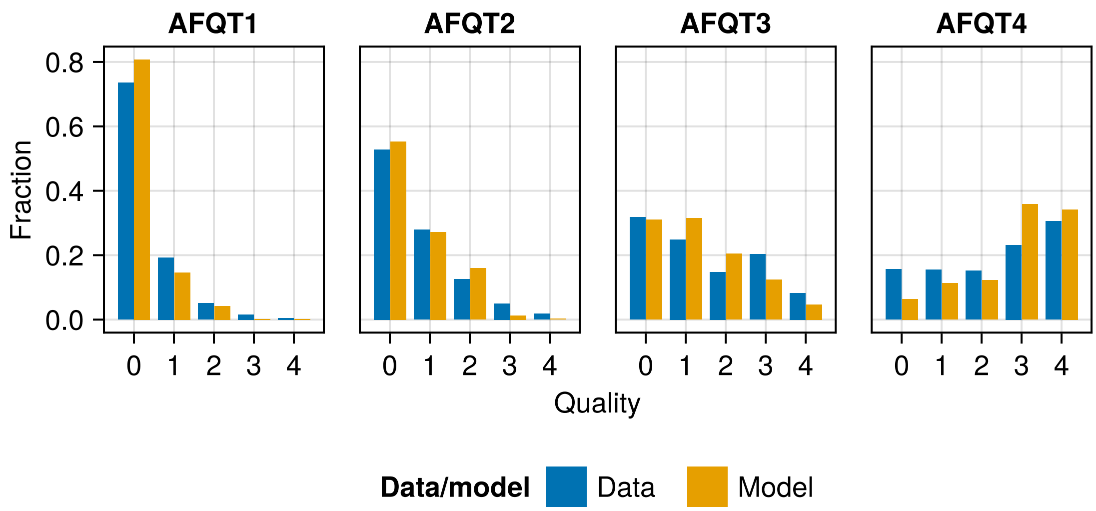
students who were previously not enrolled in four-year colleges. Even without the complementarity, the calibrated model still matches the high earnings observed for these students in the data. As a result, the earnings gain from attending $q4$ colleges is similar to the baseline case, as are therefore the aggregate earnings gains from expanding $q4$ capacity.

D.2 Smaller Preference Shocks

When $q4$ capacities are expanded in the baseline model, most of the new seats are filled by $a3$ students who were previously not enrolled in any four-year college. As explained in Section 4.2, large preference shocks ($\mathcal{U}_q$) are one reason why few students switch between four-year colleges. This section explores a version of the model that bounds the dispersion of these preference shocks at half of the calibrated baseline value.

Smaller preference shocks degrade the model's ability to account for the degree of undermatch that we observe in the data. As shown in Figure 25, compared with the

Figure 25: College Choices With Smaller $\mathcal{U}_q$ Shocks



Note: The figure shows the fraction of students in each AFQT quartile who choose each college quality, where $q = 0$ refers to no college.

data, too many students with high test scores enroll in selective colleges, whereas too many students with low test scores fail to enroll in any college.

When the capacity of $q4$ colleges expands by 20 percent, the model implies that around half of the new seats are filled by students who were previously enrolled in lower-quality four-year colleges. In the baseline model, the fraction was only 25 percent. Still, the changes in aggregate outcomes are similar to the baseline model. Notably, as shown in Table 18, the aggregate earnings gain of 0.9 percent is very close to the baseline case.

Table 18: College Expansion With Smaller $\mathcal{U}_q$ Shocks

	Baseline	**Experiment**
	Level	Change relative to baseline
Aggregate earnings (log)	7.105	+0.9
Coll. expenditure / Y	1.35	+0.08
Welfare gain	–	+2.8
Fraction entering 4y	36.1	+1.6
Fraction entering top quality	10.1	+2.0
Fraction graduates	24.5	+1.4
Mean ability top quality	1.31	−0.09
Labor supply CG (log)	12.881	+5.3

Note: The table shows the effects of expanding $q4$ capacities by 20 percent. The "Baseline" column shows the level of each indicator in the calibrated model with smaller $\mathcal{U}_q$ shocks. The "Experiment" column shows the differences relative to the baseline for the college expansions. Y denotes aggregate earnings. "Fraction graduates" is the fraction of the high school graduate population who earn a degree. Changes in fractions are in percentage points; log changes and welfare gains are reported in percent.