The Rise of For-Profit Higher Education: A General Equilibrium Analysis

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Abstract

For-profit colleges have grown to a sizeable share of the four-year college markets, particularly for nontraditional and online students. The post-graduation outcomes of their students have drawn increasing scrutiny from policymakers. We develop and calibrate a general equilibrium model of college choice, featuring the sorting of heterogeneous students in ability, income, and age across diverse higher education institutions, which differ in objectives, instructional quality, and program types (presential and online). Using U.S. data, we quantify the aggregate and distributional effects of changes in public university subsidies and Pell Grant caps, as well as the impact of gainful employment regulations that tie access to federal funding to graduates' debt-to-earnings ratios. We find that further reductions in public sector subsidies lead to a higher market share of the for-profit colleges. Raising the Pell Grant cap enhances overall welfare, particularly benefiting lower-income students, despite its adverse impact on instructional quality within the for-profit sector. Additionally, we find that for-profit institutions generally prefer to comply with gainful employment standards, but they do so by lowering tuition and instructional quality rather than by improving graduate outcomes.

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1 Introduction

In recent decades, for-profit colleges have risen to prominence in U.S. higher education policy. Despite enrolling at most ten percent of four-year undergraduates, the for-profit sector has accounted for a disproportionately large fraction of federal aid, student lending, and loan defaults,[1] and educates a large share of first-generation and minority students.[2] Following a series of investigations, bankruptcies, and increasing regulatory pressure, the growth of the for-profit sector stalled after the Great Recession,[3] but in 2019 the U.S. Department of Education repealed regulations that held for-profit colleges accountable to gainful employment standards in order to maintain access to financial aid. The current administration is considering reinstating gainful employment legislation,[4] in conjunction with partial student loan forgiveness. In the meantime, for-profit colleges have continued to compete for federal funding, and to educate a large share of low-income, first-generation college students, who accumulate substantial student loan balances.

Aiming to understand how the for-profit sector competes with public and nonprofit universities, we set up and calibrate a general equilibrium model of competition in the four-year college market. We build on the framework of Epple and Romano (1998), Epple, Romano, and Sieg (2006) and Epple et al. (2019) by adding the market for online education, modeling the decisions of nontraditional students, and the interactions between for-profit, public and private nonprofit institutions. Our model introduces for-profit colleges as profit-maximizing

[1] In the 2009/2010 academic year, for example, for-profit colleges accounted for about 10% of total undergraduate enrollment, but received 32 billion dollars in federal student financial aid, or 25% of the total aid. At the same time, for-profit college graduates accounted for 42% of borrowers in default (U.S. Senate, 2012).

[2] In the 2011-2012 academic year, Black or African American students represented 29.8% of for-profit four-year college enrollment, and 15.21% of public college enrollment. At the same time, 61.47% of students at for-profit colleges were first-generation college-goers, compared with 36.95% at public colleges. [Authors' calculations, data from the National Postsecondary Student Aid Study: 2012 Undergraduates]

[3] A U.S. Senate (2012) investigation was triggered by the poor labor market outcomes experienced by veterans benefiting from Post-9/11 educational benefits. Several for-profit colleges were sanctioned for deceptive marketing and recruiting practices, reaching settlements with the Department of Education.

[4] United States Department of Education, Office of Postsecondary Education. Issue Paper 3: Gainful Employment. Session 3: March 14-18, 2022. available at https://www2.ed.gov/policy/highered/reg/hearulemaking/2021/isspap3gainempl.pdf

higher education providers, in contrast to public and nonprofit colleges, which generally operate with balanced budgets, and aim to maximize a combination of academic quality/student achievement and quantity of graduates.[5] We focus on the competition between higher education providers in the four-year college market. While many for-profit colleges started out by providing vocational training and two-year degrees, their educational offerings have grown, particularly through career oriented bachelor's and masters degrees in business administration, nursing or information technology, but also through liberal arts offerings such as bachelor's degrees in history, philosophy, sociology and the arts. While the for-profit share of four-year enrollment in degree granting institutions was only 2.7% in 2000, it had reached 12% by Fall 2010.[6]

Our model features two groups of students: *traditional* and *nontraditional*. Students are also heterogeneous in ability and income. Traditional students are aged 18-24 and have dependent status in financial aid applications. Nontraditional students are older than 24, and independent for purposes of financial aid calculations. While the for-profit market share for traditional students remains low, the rise of for-profit colleges coincided with, and has in turn fueled the growth in nontraditional student enrollment. For example, in 2011, for-profit colleges enrolled about 912,000 nontraditional students in four-year bachelor's degree programs, a 31% market share. In the market for nontraditional students, for-profit colleges compete mainly with public colleges, which had a 48% market share in 2011, and to a lesser extent with nonprofit colleges. Competition between for-profit colleges and the public sector has been spurred by the increasing availability of student loans and financial aid, and rising price tags at public universities, which have become more reliant on net tuition revenue, as they faced decreasing support in the form of public subsidies. We document these

[5]Many for-profit institutions are owned by exchange traded corporations which report profits and have an explicit mandate to increase shareholder value. In contrast, state universities respond to public mandates to increase access to higher education, while private nonprofit institutions (hereinafter called nonprofit, for brevity) generally place a higher weight on academic quality, through selective admission policies and higher instructional spending.

[6]National Center for Educational Statistis, Digest of Educational Statistics 2019, Table 303.25.

developments in more detail in Section 2.

Agents can choose to enroll in *online* or *presential* instruction. In 2012, about 12.5% of four-year students were attending a four-year higher education institution exclusively through 'distance learning', delivered largely through online instruction. We model competition between online and presential higher education providers using a nested logit structure: conditional on the students' online/presential choice, they have a further choice of institutions differentiated by public/private control.

In our model, four-year for-profit colleges maximize profits by choosing levels of tuition and instructional spending, responding to the prices and spending observed at competing public and private nonprofit institutions. We model the public sector as constrained by the level of state-mandated tuition and subsidies, but choosing an optimal level of instructional spending to reach its objective of maximizing aggregate expected student achievement.

We calibrate a quantitative version of the model, which matches matches enrollment market shares, ability rankings across types of students and universities, and observed levels of student borrowing, federal and institutional financial aid. Pricing and instructional spending at for-profit colleges also emerges as an equilibrium outcome of the model. Our analysis focuses on 2012-2014, a period when for-profit colleges experienced a relatively steady market share. At the same time, under gainful employment legislation, cohorts graduating during this period were the first to be evaluated in terms of student debt-to-earnings ratios.

We conduct a gainful employment policy experiment, in which for-profit colleges lose eligibility for federal funding if the debt-to-earnings ratio of their graduates is below a threshold of 12%. We find that for-profit colleges prefer to comply with the debt-to-earnings ratios that allow them continued access to federal funding, but do so by lowering tuition and instructional spending.

In other counterfactual analyses, we consider the effect of changes in public subsidies for higher education and quantify the effects of these policies on for-profit market shares,

instructional spending and average student ability. Another set of counterfactual analyses considers increases in the maximal Pell Grant cap. We find that for-profit colleges capture a large share of the federal Pell Grant increase. This result is partly driven by the fact that for-profit institutions generally attract lower income students who are more likely to be eligible for the means-tested Pell grants. Our simulations further indicate that for-profit colleges would significantly reduce their tuition in order to enroll more Pell Grant eligible students, to whom they would deliver lower levels of instructional spending. Our welfare analysis indicate overall gains as a result of this policy, but a strong redistributive component, as higher income agents incur welfare losses. Lastly, we simulate our model without the for-profit sector. Despite increases in average human capital of college graduates, overall welfare declines, largely driven by significant losses for agents who no longer enroll in college in the counterfactual.

Our work contributes to the general equilibrium modelling of education markets. While Epple and Romano (1998) studies competition between private and public schools in primary and secondary education markets, Epple, Romano, and Sieg (2006) develops and estimates a general equilibrium model of the not-for-profit higher education market. Epple, Romano, Sarpça, and Sieg (2017) and Epple, Romano, Sarpça, Sieg, and Zaber (2019) extend these frameworks by including interactions between public and not-for-profit universities. Kaganovich and Su (2019) analyze university competition in curriculum standards, where universities' objectives differ in the weight placed on quantity of graduates relative to their overall human capital.

Our paper differs from previous work in a few significant dimensions. We introduce the for-profit sector and estimate the cost and elasticity parameters that govern its competitive behavior. Our model distinguishes online and presential instruction, as well as nontraditional students, whose average abilities, incomes, outside options and financial aid packages vary considerably from those of traditional students. Our model features college drop-out, which

allows us to link the enrollment decision to student outcomes. We use our framework to study policy questions such as the effects of changes in federal aid and public university subsidies on enrollment and pricing in the for-profit sector. We find the response of the for-profit sector in our policy experiments to be quantitatively important. In counterfactual Pell Grant increase scenarios, for-profit universities see significant market share increases, which they achieve by lowering tuition and instructional spending, and attracting lower income and lower ability students. The policy leads to a decrease in academic quality, associated with lower instructional spending. This result, driven by the objective of for-profit institutions, stands in contrast to findings from a model where all institutions seek to maximize student achievement. For example, maximal federal aid policy experiments in Epple, Romano, Sarpça, and Sieg (2017) lead to increased attendance among low income and middle- and high-ability students, and increases in instructional spending at private nonprofit institutions.

Our paper also contributes to the literature analyzing the effects of higher education policies in quantitative models. Caucutt and Kumar (2003), Akyol and Athreya (2005), Chatterjee and Ionescu (2012), and Johnson (2013) analyze the effects of tuition subsidies. Ionescu (2009), Lochner and Monge-Naranjo (2011), Chatterjee and Ionescu (2012), Ionescu and Simpson (2016) examine the impact of student loan policies in the context of borrowing constraints. Abbott, Gallipoli, Meghir, and Violante (2019) compare the effects of ability-tested grants and expansion of student loans in a model of inter-generational transfers. We complement this literature by modelling the competition between various types of higher education institutions, which allows us to compare funding policies that target both students and universities. This paper is also related to an empirical literature that has analyzed for-profit colleges and the outcomes of their graduates. Armona, Chakrabarti, and Lovenheim (2018) use an instrumental variable approach that exploits the interaction of labor demand shocks and the local supply of for-profit colleges to evaluate the effects of for-profit attendance

on student outcomes. They find that for-profit enrollment results in higher loan balances and worse labor market outcomes. Our counterfactual results on the effect of subsidy cuts at public schools are similar to findings by Goodman and Henriques Volz (2020), who show that decreases in state appropriations to higher education institutions between 2000 and 2010 led to decreases in enrollment at public colleges, coupled with higher enrollment at for-profit colleges and rising student loan balances. Our paper is also related to work on modeling competition between the public and private sector in pre-college markets, which has been shown to be quantitatively important for equilibrium school quality and student outcomes, particularly in developing countries that have a large private education sector. Neilson (2013) shows a voucher policy targeted at low-income students has a positive effect on private school quality in Chile. Dinerstein et al. (2020) estimate that public school construction in the Dominican Republic led to private school exits and increases in quality for the remaining private schools. Allende (2019) considers a range of policies in terms of equity and efficiency, finding that entry subsidies to high-quality private schools in Peru are the most efficient, while targeted vouchers the most equitable.

More broadly, our paper contributes to the literature analyzing price and quality competition in other markets with nonprofit and profit providers, such as healthcare, child care and long-term care. Our model captures the competitive pressures that keep checks on the prices and quality of for-profit providers, which have been noted in the healthcare industry (Kunz et al. (2020)). Our findings on the cost parameters of for-profit colleges indicate they can quickly scale enrollment, a similar finding to that of Chakravarty, Gaynor, Klepper, and Vogt (2006), who document that for-profits are quicker to enter and more responsive to changes in demand. A key feature of for-profit educational providers is that they provide access, a well understood benefit of for-profit providers in healthcare markets (Beckert and Kelly (2021)).

The paper is structured as follows. In section 2, we present a series of stylized facts on the growth of the for-profit sector. Section 3 lays out our model. We provide details on

the calibration exercise and model fit in Section 4. We discuss the results of counterfactual analyses in Section 5, and conclude in Section 6.

2 The Fast Growth of For-Profit Colleges: Recent Literature and Stylized Facts

In this section, we briefly review the literature on the growth of the for-profit sector, and provide a series of stylized facts on its determinants: increases in online and nontraditional student enrollment; declining levels of state subsidies at public institutions; increasing availability of federal financial aid and student loans. We also present the institutional background for gainful employment legislation.

Nontraditional students represent a large fraction of the total population of four-year college undergraduates (Figure 1, panel A). Between 2001 and 2009, the total enrollment of undergraduate nontraditional students increased from 3.2 million to 4.9 million. The growth of for-profit colleges is closely linked to the participation of nontraditional students, as shown in Figure 1, panel B. The share of for-profit colleges in the nontraditional student market increased considerably, from 5% in 2001 to 31% in 2011. While for-profit colleges attracted a large share of nontraditional students, they reached at most five percent of the traditional student market, in 2009 (Figure 1, panel C). One explanation for the fast rise in market share in the nontraditional student market is that for-profit colleges are offering learning environments suitable for older, nontraditional students, who may have work and family responsibilities. For example, for-profit colleges have lower admission requirements and many for-profit institutions have specialized in offering exclusively distance education. In the market for four-year students attending exclusively online courses, for-profit colleges held a dominant 52 per cent market share in 2012,[7] followed by public institutions (28 per

[7]U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Ed-

cent) and nonprofits (20 per cent). In 2012, the share of four-year undergraduates attending exclusively online was 12.5 per cent (this fraction reached 14.6 per cent in 2019, before the COVID-19 pandemic). This represented a considerable increase from the 1.75 percent of undergraduates enrolled in a bachelor's program exclusively online in 2000.[8] While the growth in online education was sustained by the increasing availability of broadband Internet, it was also boosted by the repeal of the "50 percent rule": prior to 2006, U.S. Department of Education regulations did not allow the share of distance learning students to exceed 50 percent at institutions receiving federal financial aid. While both for-profit and public colleges enrolled less than 7% of students in distance education in 2000, by 2012, 57.5% of students at for-profit colleges were taking exclusively distance education courses, compared to 5.5% of students in the public sector.[9]

Another factor explaining why for-profit colleges captured a larger share of the nontraditional and online student markets was that competing institutions raised prices. Figure 1, panel D shows that nonprofit universities saw the fastest increases in tuition between 2003 and 2013. At the same time, public schools were facing a significant shift in their funding structure. The average per student subsidy at public universities saw considerable decreases, while tuition increased, driving the price of public universities closer to the sticker price charged by for-profit colleges. The effects of public spending cuts on for-profit enrollment have been documented in reduced form analyses. Goodman and Henriques Volz (2020) estimate that for-profit college attendance increases about 2% for a 10% cut in state appropriations. Deming and Walters (2017) find that enrollment and graduation rates at public universities decrease following state policies that decrease subsidies while freezing tuition at

ucation Data System (IPEDS), Table 311.15

[8]U.S. Department of Education, National Center for Education Statistics. A Profile of Participation in Distance Education, NCES 2003–154. Washington, DC: 2002., Table 3.

[9]Data from from 1999-2000 National Postsecondary Student Aid Study indicate that 3.8% of for-profit students were enrolled in distance education, compared to 6.9% of public four-year students. 2012 figures come from NCES Education Digest Table 311.15.Number and percentage of students enrolled in degree-granting postsecondary institutions, by distance education participation, location of student, level of enrollment, and control and level of institution: Fall 2012.

public schools. Several authors have pointed out that capacity constraints at public schools have allowed for-profit schools to capture rising demand. Turner (2006) found higher responsiveness at for-profit colleges than at public schools in adapting enrollment to indicators of aggregate student demand such as the change in the college age population. Cellini (2009) compared Californian communities which either barely passed or barely rejected initiatives to supplement funding for public college education through the issuing of bonds. For-profit colleges were more likely to enter local markets where such initiatives were voted down. In our model, capacity constraints arise because of the convexity of the university cost function, which we allow to vary between public and for-profit colleges, as well as from the educational quality concerns which implicitly limit the growth of public and nonprofit colleges.

The growth of for-profit colleges was also spurred by the increasing availability of federal financial aid and student loans. Between 2000 and 2011, Federal expenditure on Pell Grants increased by approximately 50 per cent on a per capita basis, from 2.87 thousand dollars to 4.3 thousand.[10] When the for-profit market share peaked, in 2007-2008, over 40% of students attending for-profit colleges were financing their studies with private loans, compared to 25% of students in nonprofit colleges and 14% of students in public schools.[11]

Gainful employment

The Gainful Employment rule, passed in its final version in 2014 under the Obama Administration, and repealed in July 2019 under the Trump administration, established standards that career-oriented educational programs needed to maintain in order to access federal student aid. In practice, providers of career-oriented programs included the vast majority of for-profit colleges, as well as non-degree programs at public colleges, primarily community colleges. This legislation was motivated by concerns over the high levels of student debt and

[10]Total Federal Pell Grant spending increased from 11.2 to 40 billion dollars between 2000 and 2011, and the number of beneficiaries increased from 3.9 million to 9.3 million over the same period. Source: College Board, Federal Aid per Recipient by Program over Time in Current and Constant Dollars.

[11]College Board, Share of Undergraduate Students with Private Loans, 1999-00 to 2015-16.

loan defaults experienced by graduates of for-profit colleges.[12] In particular, a U.S. Senate (2012) investigation found that while for-profit colleges advertised their programs as career-oriented, few of their graduates found employment in the field of study or the occupation they had received training for. In turn, this was associated with low earnings, and an inability to repay student loans. The gainful employment legislation required career-oriented programs to provide applicants with more transparent information about the post-graduation experiences of past cohorts, and to comply with a set of metrics related to the debt-to-earnings ratio of their graduates. The standard was a ratio of expected debt payments to total income of no more than eight percent (or 12 percent in the "warning zone"), and a ratio of debt payments to discretionary income of no more than 20 percent. Programs that failed these metrics were given a three year period to improve before losing eligibility for federal financial aid. In 2017, the Department of Education released estimates that showed about eight percent of programs failed to meet the debt-to-earnings measure. According to an independent analysis (TICAS, 2017), these programs enrolled 354,002 students, which had cumulatively borrowed 7.45 billion dollars to attend the programs deemed to be failing or in the warning zone.

3 The Model

In order to understand how for-profit colleges compete with public and nonprofit institutions, we set up a general equilibrium model featuring heterogeneous agents sorting into higher education institutions of varying quality. The potential student population, normalized to 1, consists of two groups of agents: traditional (denoted t) and nontraditional (denoted nt). Let π_t and π_{nt} indicate the proportions of traditional and respectively nontraditional agents in the total population. Potential students are heterogeneous in innate ability a and

[12]The discussion in this paragraph draws from Department of Education. 2014. "Program Integrity: Gainful Employment; Final Rule", Federal Register, vol.79, no. 211, 34 CFR Parts 600 and 668.

in the yearly after-tax income y, which they may use to finance their studies. Let $f_t(a, y)$ and $f_{nt}(a, y)$ denote the joint densities of (a, y) for traditional and nontraditional agents, respectively. An agent is characterized by (a, y, g), where g is an indicator denoting the group the agent belongs to (t or nt).

The higher education sector consists of three types of higher education institutions: public, nonprofit and for-profit, which offer different levels of educational quality and also differ in their objectives. In our empirical application, we model one public university that offers both presential and online instruction, two nonprofit colleges, and two for-profit colleges, one offering presential instruction and another offering exclusively online courses. Agents decide first whether to enroll in presential or online institutions, and then they choose the type of institution.

Let J denote the set of all alternatives, including the no-college option.[13] The outside option is referenced by 0. An agent graduating from college $j \in J$ with quality q_j acquires human capital $h_j^c(q_j, a) = q_j a^\beta$, where $\beta > 0$. This specification captures the fact that more able students will accumulate more skills for the same level of educational quality.

College graduation is uncertain. With probability $d_j(a, g)$, the agent drops out of college and receives human capital $h^d(a) = B_d a^\beta$, where $B_d > 0$. The dropout probability functions are estimated separately for traditional and nontraditional students based on their ability and the institution attended (see section 4.1.2).

The achievement of an agent who does not pursue higher education is $h_{0,t} = B_t$ for traditional students and $h_{0,nt} = B_{nt}$ for nontraditional students.

[13]For expositional convenience we let let J denote both the set of college alternatives, as well as their number.

3.1 Agents' preferences and choices

Preferences and budget constraints. We model the utility of agents deciding whether to attend college or not using a nested logit framework. We group presential institutions in one nest, online programs in a second nest, leaving the option of not enrolling in college as a degenerate nest.

The utility of student (a, y, g) enrolling in college j is given by:

$$U_j(a, y, g, \epsilon_j) = \alpha V_j(a, y, g) + \epsilon_j, \tag{1}$$

where $V_j(a, y, g)$ is the systematic utility component and ϵ_j is an idiosyncratic preference shock for option j, following a GEV distribution.

The agents derive utility from consumption and academic achievement (human capital h). A student of type (a, y, g) might drop out with probability $d_j(a, g)$, or graduate with probability 1-$d_j(a, g)$, and thus the systematic utility component of going to college j is:

$$V_j(a, y, g) = \theta_g^o[(1 - d_j)ln(c_j^c h_j^c) + d_j ln(c_j^d h_j^d)], \tag{2}$$

where θ_g^o is an online preference parameter, allowed to differ among traditional and nontraditional students in the online nest, and normalized to 1 in the presential sector. Consumption and achievement of a college graduate are c_j^c and h_j^c, respectively, and are denoted c_j^d and h_j^d for a college dropout.

Students pay different prices for a college education, depending on their ability and income. For the purpose of financial aid decisions, universities and the government may take into consideration parental income (for traditional students) or own or spousal income (for nontraditional students). Denote by $p_j(a, y, g)$ the price paid per year by a student of type (a, y, g) at college j. This price is net of federal and institutional aid, as well as other sources of

student aid. Thus, $p_j(a, y, g) = T_j - FedAid_j(a, y, g) - InstAid_j(a, y, g) - OtherAid_j(a, y, g)$, where T_j is the sticker price at university j. Federal Aid (Pell Grants and Federal student loans), Institutional Aid, and Other sources of aid (e.g. veteran benefits, private foundations) are modelled as functions of income, ability, and official means-tested eligibility rules, which are estimated separately for traditional and nontraditional students (see section 4.2).

We do not explicitly model student loan taking.[14] However, as described in section 4.2, we estimate separate loan functions for different student groups: traditional low-income, traditional high-income and nontraditional students. We feed the estimated loan functions into the model and calculate the corresponding student loan balances for each agent, which depend on individual income, and the net cost of the chosen college. Thus, student debt in our model responds to changes in the net cost of college as a result of counterfactual funding policies.

Let $\phi_j(g)$ represent the duration, in years, spent in college j by a student from group g. We assume $\phi_j(g) = 4$ if the student graduates, and $\phi_j(g) < 4$ if the student drops out. In the empirical application, the duration of enrollment is predicted for traditional and nontraditional students, as a function of their ability and the institution they attend. While enrolled, students pay the tuition cost $\phi_j(g)p_j(a, y, g)$, as well as non-tuition costs, denoted by $\phi_j(g)NC_j$. The budget constraint of the student of type (a, y, g) enrolled at university j is:

$$c_j(a, y, g) + \phi_j(g)p_j(a, y, g) + \phi_j(g)NC_j = 4y, \tag{3}$$

As agents' income y is net of taxes, we do not include in the model the taxes that fund the subsidy or the student financial aid. However, in the policy experiments, we include a flat proportional income tax and calculate the necessary tax adjustments to maintain a balanced

[14] A richer specification, which we do not pursue in this paper, is to endogenize the student loan taking decision. This could be accomplished in a fully dynamic model, in which educational decisions - and student loan taking and repayment - depend on the expected income stream from various future occupational choices, as in Sauer (1998), Sauer (2004) or Sieg and Wang (2018).

government budget.

Agents who do not enroll in college allocate their entire income to consumption. Thus, the systematic component of the utility from the outside option is $V_0(a, y, g) = \ln(4yh_0)$.

Choice probabilities. We denote the conditional probability that an agent (a, y, g) chooses alternative j from the choice set J as $r_j(a, y, g; T(a, y, g); Q)$, where $T(a, y, g)$ is the vector of tuitions that apply to student (a, y, g) and Q is the vector of available qualities at all universities.

Wages. Wages are a product of individual achievement[15] predicted by the model, $h_j(q_j, a)$, and w, the price per unit of human capital, which is random across agents, reflecting different occupational choices or labor market frictions. The wage of an agent with ability a graduating from college j is then:

$$W(q_j, a) = w * h_j(q_j, a). \tag{4}$$

By the same token, the wage of a college dropout with ability a is equal to $wh_j^d(a)$. Wages of traditional and non-traditional agents with no college education are $wh_{0,t}$ and $wh_{0,nt}$, respectively. We assume w follows a lognormal distribution, with mean $\overline{w}$ and standard deviation s_w.

Besides the random component w, heterogeneity in returns to college is captured in our model through several channels. First, the presence of peer effects leads to an equilibrium in which more able students enroll in better colleges, with higher spending and higher peer quality (the selection effect). Second, in our model, college quality and student ability enter the achievement function in a multiplicative fashion. This specification captures the fact that more able students will accumulate more skills for the same level of educational quality (the skill accumulation effect).

[15] We assume that an agent's achievement is equivalent to the human capital she later provides in the labor market.

3.2 The Higher Education Sector

Colleges differ in the quality of instruction and their objectives. Similar to Epple et al. (2019), the quality of college j is given by:

$$q_j = A_j(\overline{a}_j)^{\gamma_j}(I_j)^{\omega_j}, \tag{5}$$

where $\overline{a}_j$ is the average ability of the student body in college j, I_j is the per student instructional spending, and $A_j, \gamma_j, \omega_j > 0$ are parameters of the quality function that may differ across universities.

The cost function of college j with enrollment N_j and instructional costs I_j is:

$$C(N_j, I_j) = N_j I_j + c(N_j), \tag{6}$$

where $N_j I_j$ is the total instructional spending and $c(N_j) = F + v_1 N_j + v_2 N_j^2$ is a custodial cost function, which captures the fixed costs F (e.g. plant maintenance) and variable costs that depend on student enrollment, $v_1 N_j + v_2 N_j^2$. In section 4.3.3 we provide details on the estimation of college cost functions.

The public sector. There are three types of students at the public university, within each age group g: in-state presential, out-of-state presential and online. The corresponding sticker prices for each program type are T_s, T_{out}, and $T_{p,o}$, respectively. We assume that once enrolled, students cannot switch programs.

The public university receives a subsidy s per student. We do not explicitly model the political process that determines tuition and subsidy levels for the public university, and therefore we assume they are exogenous. However, in the policy experiments we vary them and analyze the corresponding effects.

The public university maximizes the expected aggregate achievement of its students in

the presential programs subject to a balanced budget.[16] Let $\delta_z(a, y, g)$ represent the share of students of type (a, y, g) admitted to group z, where z denotes either in-state or out-of-state. We assume the decisions of the public university are taken at the time of enrollment of the cohort, with a time horizon of four years, taking into account the expected achievement, and the expected revenues and costs.

Given the dropout probability $d_p(a, g)$ at the public university, the expected achievement of an agent of type (a, g) in group z of the presential program is:

$$Eh_z(q_p, a, g) = d_p(a, g)h_p^c(q_p, a, g) + [1 - d_p(a, g)]h_p^d(a), \tag{7}$$

where q_p is the quality of the public presential program, and $h_p^c(q_p, a, g)$ and $h_p^d(a)$ are the corresponding achievements in case of graduation and dropout, respectively.

The university chooses the enrollment N_p and the average ability of the student body $\overline{a}_p$ over the 4-year time period, the instructional spending I_p per student, and the admission functions $\delta_z(a, y, g) \in [0, 1]$, which are the shares of type (a, y, g) that are admitted in group z. Using the notation for conditional probabilities introduced above, $r_{p,z}(a, y, g; T, Q)$ is the probability that type (a, y, g) students enroll in the public university if admitted in group z.

Considering the population weights π_g for traditional and nontraditional students, the objective of the public university is defined as:

$$\max_{\delta_z(a,y,g),\ I_p, N_p, \overline{a}_p} \quad \sum_g \pi_g \sum_z \left[\int \int Eh_z(q_p, a, g)\delta_z(a, y, g)r_{p,z}(a, y, g; T, Q)f_g(a, y)dady \right]. \tag{8}$$

In order to write the budget constraint of the university, let $x_p(a, g)$ represent the expected

[16] Public U.S. universities often have explicit mandates to provide access to in-state residents, and their budgets are decided in advance and subjected to the approval of state legislatures. Their objective to maximize aggregate achievement (as opposed to maximizing reputation or instructional quality) can be understood as aiming to maximize the human capital and therefore future income of their (primarily state resident) students.

time spent at the public university by agent (a, g): $x_p(a, g) = [\phi_p(g)d_p(a, g) + 4(1 - d_p(a, g))]$, where $\phi_p(g)$ is the typical time spent in college by a dropout from the public university. Let $t_{p,z}(a, y, g)$ be the annual tuition, net of institutional financial aid, paid by agent (a, y, g) in group z. The expected total tuition revenue of the public university over four years is:

$$TR_p = \sum_g \pi_g \sum_z \int \int t_{p,z}(a, y, g)\delta_z(a, y, g)r_{p,z}(a, y, g; T, Q)x_p(a, g)f_g(a, y)dady. \tag{9}$$

The budget constraint of the university is:

$$N_p s + TR_p = N_p I_p + c_p(N_p), \tag{10}$$

where $N_p s$ is the total amount of subsidies received by the university, $N_p I_p$ are the instructional costs, and $c_p(N_p)$ captures other costs that are not related to instruction ('custodial costs').

The university maximizes the objective in equation (8) subject to the budget constraint in equation (10), the tuition schedules, the feasibility constraints $\delta_z(a, y, g) \in [0, 1]$, for all student types, and identity constraints on enrollment N_p and average ability of student body $\overline{a}_p$. These constraints imply that the chosen N_p and $\overline{a}_p$ are consistent with agents' choices. The corresponding expressions are developed in Appendix D.1.

The optimization problem of the public university yields endogenous admission thresholds $a^{p,z}_{min}$ for in-state and out-of-state students, such that for the marginal student with $a = a^{p,z}_{min}$, the marginal benefit of admission equates the effective marginal cost of the student. In Appendix D.2 we derive the admission equation for the marginal student in program z:

$$\frac{Eh_z(q_p, a^{p,z}_{min})}{\lambda} + x_p(a^{p,z}_{min})\left[t_{p,z}(a^{p,z}_{min}) + s\right] = x_p(a^{p,z}_{min})\left[I_p + c'_p(N_p)\right] + x_p(a^{p,z}_{min})\frac{\partial q_p/\partial \overline{a}_p}{\partial q_p/\partial I_p}(\overline{a}_p - a^{p,z}_{min}). \tag{11}$$

where $Eh_z(q_p, a_{min})$ is marginal student's expected achievement from enrolling in college and

λ is the Lagrange multiplier associated with the budget constraint in equation (10).

The left-hand side of equation (11) is the marginal benefit of admitting the student with $a = a^{p,z}_{min}$, which includes the monetary value of the student's contribution to the aggregate achievement at the public university (the first term) and the student's contribution to the university revenue (tuition net of institutional aid and the per student subsidy), adjusted for the expected time spent in college (the second term). As in Epple et al. (2017), the effective marginal cost of the student (the right-hand side of equation 11) is the sum of the direct marginal resource cost and the marginal peer cost (negative for students with ability below the college average, positive otherwise), both adjusted by the expected enrollment duration.

The online program. The selection into the public online program is modelled through an exogenous threshold $a^{p,o}_{min}$, which is then calibrated to match the public market share in the online market. The tuition $T_{p,o}$ and spending per student $I_{p,o}$ are also exogenous and set based on observed market data, as described in section 4.3.1 of the quantitative model specification.[17] We allow for different peer effects and spending elasticities in the quality production function of the online program, which is: $q_{p,o} = A_p(\overline{a}_{p,o})^{\gamma_{p,o}}(I_{p,o})^{\omega_{p,o}}$.

For-profit sector. For-profit colleges choose the sticker price and instructional spending per student in order to maximize expected profit. Like the public university, they make decisions over a 4-year time period. They are non-selective, admitting all students who would like to enroll. Students enrolling in the for-profit sector can receive federal financial aid and thus may be paying a net price lower than the tuition charged by the college.

Denote by T_j and I_j the per year tuition and spending at for-profit college j. Let $x_j(a, g)$ denote the expected time spent in college j by agent (a, g). The choice probability of attend-

[17] We treat online public programs as auxiliary activities, as they were much smaller in size during our period of analysis, data on online public education was scarce, and we found their pricing to be typically anchored to the in-state tuition cost (see for example GetEducated.com, List of Online State Universities, https://www.geteducated.com/online-universities/532-online-state-colleges-and-universities/ [accessed Oct 1, 2024])

ing the for-profit college is $r_j(a, y, g; T, Q)$. The problem of for-profit university j is:

$$\max_{T_j, I_j} \Pi_j = \sum_g \pi_g \int \int T_j r_j(a, y, g; T, Q) x_j(a, g) f_g(a, y) da dy - N_j(T_j, I_j) I_j - c(N_j), \quad (12)$$

subject to identity constraints implying that enrollment N_j and the average student ability $\overline{a}_j$ are consistent with agents' choices. The corresponding expressions are developed in Appendix D.3.

In the empirical exercise, we model two for-profit colleges, one offering presential instruction, with tuition $T_{r,p}$ and per student spending $I_{r,p}$ and another offering exclusively online courses, with tuition $T_{r,o}$ and per student spending $I_{r,o}$.

In Section 5.2, we conduct counterfactual simulations where for-profit colleges adjust their behavior in response to gainful employment legislation. This legislation ties access to federal funding to the average debt-to-earnings ratio of the institution's graduates. Under this scenario, for-profit colleges respond to the government mandate by comparing profits from either 1) not complying and following the optimization problem described by equation (12) and identity constraints (with no federal funds available for their students), or 2) complying and continuing to access federal funds, in which case their maximization problem features the additional constraint that the average debt-to-earnings ratio of graduates must be 12% or lower (a threshold set by the policymaker).

Nonprofit sector. While our focus is on the interaction between public and for-profit institutions, we do not explicitly model the pricing and spending decisions of nonprofit colleges. Since nonprofit institutions' behavior influences public colleges' decisions, these additional effects on for-profit sector are omitted in our framework. Nonetheless, the presence of nonprofit institutions in our model indirectly influences the pricing and spending decisions of for-profit colleges in equilibrium.

In our empirical analysis, we include two types of nonprofit universities: Group I for high

tuition and Group II for low tuition. The sticker prices and per-student spending, denoted as T_{e1} and I_{e1} for Group I, and T_{e2} and I_{e2} for Group II, are treated as exogenous and based on observed data. We model price discrimination in college tuition, which is an important feature of the nonprofit sector (see Epple et al. (2017), Epple et al. (2019), Fillmore (2023)). To this end, we estimate different institutional aid functions by ability, income and student group (traditional and nontraditional) for different groups of colleges (see Table A5). Thus, in equilibrium, students enrolled in nonprofit institutions pay different prices, according to their type. In order to capture the selective admission at higher ranked nonprofit colleges, we introduce an exogenous admission threshold for this group of institutions (Group I). Consequently, the average ability of the student body, enrollment and resulting quality in the nonprofit sector are endogenous, determined in equilibrium by student sorting across institutions.

Summarizing the institutional features which determine student sorting, Group I nonprofit colleges have an explicit threshold a^{e}_{min}. Public institutions are selective, and admission is determined by equation (11) for presential education and a threshold $a^{p,o}_{min}$ for the public online program. Only the lower cost nonprofit college and the two for-profit colleges have open enrollment, with admission being determined in equilibrium by price and financial aid functions at these institutions. Similar to Epple et al. (2017) and Fillmore (2023), however, lower cost nonprofit colleges compete with other institutions by seeking to attract high-quality applicants through institutional aid.

3.3 Equilibrium

The exogenous elements of the model are: (i) the relative sizes of the two groups of potential students, π_t and π_{nt}; (ii) the joint distributions of ability and income, $f_t(a, y)$, $f_{nt}(a, y)$; (iii) the distribution of the preference shocks ϵ_j; (iv) the sticker prices at the public university, $\{T_s, T_{out}, T_{p,o}\}$, for in-state presential, out-of-state presential and online programs, respec-

tively, and the per student spending at public online program $\{I_{p,o}\}$; (v) the sticker prices $\{T_{e1}, T_{e2}\}$ and per student spending $\{I_{e1}, I_{e2}\}$ at nonprofit colleges; (vi) the dropout probabilities $d_j(a, g)$ and enrollment duration functions $\phi_j(g)$; (vii) the university cost functions; (viii) financial aid functions; (ix) the state subsidy s.; (x) the admission ability thresholds at Group I nonprofit college (a^e_{min}) and online public program ($a^{p,o}_{min}$).

Definition 1. *Given (i)-(x), the equilibrium is a vector of university qualities* $\{q_j\}$*, enrollments* $\{N_j\}$ *, average ability of student body* $\{\overline{a}_j\}$*, prices and per student spending at for profit colleges, per student spending and admission functions at the public university* $\{\delta_z(a, y, g)\}$ *, and the conditional probabilities* $r_j(a, y, g)$*, such that, for all* $j \in J$*:*

1) students make the optimal choice, taking as given the university quality and price vectors, admission thresholds at the public and the elite nonprofit school, and public policies;

2) the public university chooses the optimal admission functions, given the qualities and prices of the other colleges, student choice probabilities and public policies;

3) for-profit colleges choose the optimal level of spending and tuition, given the qualities and prices of the other colleges, student choice probabilities and public policies.

In the following, we calibrate and numerically solve for the equilibrium. The algorithm used to find the equilibrium is described in Appendix B.

4 Quantitative Model Specification and Fit

We calibrate/estimate the parameters of the model in order to reproduce key features of the U.S. higher education sector and student outcomes. We focus on the academic year 2012/2013. We model one representative public university with a presential and online program, two nonprofit and two for-profit colleges.[18] In sections 4.1-4.3 we describe the ex-

[18]This parsimonious specification does a good job in matching the key moments in the data. A more granular data split across multiple institutions quickly becomes unfeasible, as data on online education and nontraditional students is limited.

ternally calibrated parameters of the model, using values obtained or estimated from outside sources. These parameters are summarized in Table 1. In section 4.4 we describe the remaining parameters that are jointly determined and the targeted moments used in calibration. Table 2 shows the targeted statistics and Table 3 the resulting jointly calibrated parameters.

4.1 Agents

4.1.1 Population of potential students

Relative group sizes. Our population is composed of two groups of potential students: traditional and nontraditional. We calibrate the relative sizes of the two populations (π_t, π_{nt}) using data from the American Community Survey (ACS) 2000-2015 yearly samples. For traditional students, we count the number of 18-24 year olds who have attained at least ninth grade as the potential pool of undergraduates.[19] To assess the size of the nontraditional potential student population, we consider individuals aged 25-45, who do not hold a college degree and have attained at least ninth grade.[20] We set $\pi_t = 0.35$ and $\pi_{nt} = 0.65$.

Ability distributions. We fit a normal distribution to Armed Forces Qualifications Test (AFQT) data from the National Longitudinal Survey of Youth (1997).[21] Observing the AFQT scores of potential traditional and nontraditional students in the NLSY97 data, we find that nontraditional students have average AFQT scores 0.3 standard deviations lower than those of traditional students. Given that we have normalized the mean of the traditional student ability distribution to 1, this translates into a mean standardized ability of 0.93 for nontraditional students. The distribution fit is shown in Appendix Figure A1.

Income distributions. Universities and the federal government consider dependent stu-

[19] Students with at least nine grades of education can potentially qualify for a GED diploma. Many universities accept GED certification in lieu of a high school diploma.

[20] We focus on ages 25-45 as the observed school enrollment in the ACS drops below five per cent of the age cohort after age 45.

[21] We have considered several other functional forms, we prefer the normal distribution because of its good fit, tractability and similarity to the functional form used by Epple et al. (2017).

dents' parental income when determining financial aid. We therefore use the family income in households with a seventeen year old present. We use data from the 2012-2014 American Community Survey, and adjust for taxes.[22] When applying for Federal Student Aid (FAFSA), nontraditional students are considered "independent", and their relevant income is their own (and their spouse's, if married). For nontraditional students, aged 25-45, we perform the same tax-adjustment to the (family) income they report in the ACS. We find that a three parameter log-normal distribution best fits the data (Appendix Figure A2).

Correlation of income and ability distributions. We set the correlation between income and ability at 0.3. This figure corresponds to the correlation between parental (family) income and AFQT scores in the NLSY97 for traditional students, as well as the correlation between own wages and AFQT scores for nontraditional students at the enrollment-weighted average age of nontraditional students.[23]

4.1.2 College students

Dropout probabilities. We estimate dropout probabilities using data from the Beginning PostSecondary Students 2012/2017 survey, separately for dependent and independent students, institution types, and ability categories. Values are shown in Appendix Table A8.

Non-tuition costs. To quantify non-tuition costs, we add up room and board and transportation expenses data from the College Board 2013 Annual Survey of Colleges for the school year 2012/2013. For students enrolled in exclusively online education, we adjust non-tuition costs to reflect the lower transportation costs and lower room and board costs corresponding to the higher fraction of students living with their parents.

Average enrollment duration. We quantify the average duration of enrollment for students who eventually drop out using the Beginning PostSecondary Students 2012/2017 survey,

[22] Tax adjustment information uses brackets from Congressional Budget Office (2016).The Distribution of Household Income and Federal Taxes, 2013. www.cbo.gov/publication/51361

[23] We find the enrollment-weighted average age of nontraditional students to be 32, based on NCES Digest of Education Statistics 2014, Table 303.45.

which records the status of the 2011/2012 entering cohort every year after enrollment. We then aggregate information on the fraction of students who are no longer enrolled. We assign dropouts the number of years completed before the drop out decision, and we calculate a weighted average based on the duration of enrollment and the year-by-year data on fraction of students dropping out. We perform this calculation separately by institution for dependent and independent students. The resulting average durations are presented in Appendix Table A9.

4.2 Subsidies and financial aid

Public sector subsidies. The per capita average state, endowment and local appropriations for public four-year colleges are extracted from IPEDS 2013.

Federal grants. The Pell Grant Program is the main source of federal need-based financial aid. The amount an individual may receive under this program is calculated taking into account the cost of attendance, which includes college tuition and non-tuition costs and the "Expected Family Contribution"(EFC), a stepwise function of household assets, income, and living expenses, which is set separately for dependent and independent students. We approximate this function for the period of analysis (Appendix Table A2), using data from the NPSAS:2012, and taking into account the cap on the maximum amount of federal financial aid, which stood at 5,500 dollars in 2013.

Federal student loans. Subsidized Stafford loans are the most common type of federal loan, providing a low interest rate and a repayment grace period while students are enrolled in college. The total amount students can borrow in Stafford is capped. Students whose financing needs exceed the cap can additionally borrow at an unsubsidized Stafford rate, access other federal loan programs (such as the PLUS loans) or take out private loans. The amount borrowed is likely to differ between traditional and nontraditional students because of different parental support and eligibility rules. To obtain predicted federal student

loan balances, we use the NPSAS: 2012 and regress total Federal student loan balances on parental income (or family income, for nontraditional students) and net tuition. The resulting regression coefficients are shown in Appendix Table A3.

State financial aid. We include the average amount of state financial aid based on NPSAS:2012 for different parental or own income categories for traditional and respectively nontraditional students. Values are shown in Appendix Table A4.

Institutional financial aid. Estimates of institutional financial aid at nonprofit colleges are obtained from the NPSAS: 2012, based on family income and rank in the SAT distribution, which we take as a proxy for ability. Average values are shown in Table A5 in the Appendix. Institutional aid at public colleges is generally smaller and exhibits less variation. Using NPSAS:2012, we impute public institutional aid according to a matrix of income and ability (proxied by standardized SAT scores). Values are presented in Appendix Table A6.

Other sources of financial aid. Following the NPSAS:2012 nomenclature, we consider 'outside sources' of financial aid to be the sum of outside grants (private or employer), private commercial or alternative loans and federal Veterans' benefits and military tuition aid. Using NPSAS:2012 data, we predict (see Appendix Table A7) the amount of outside sources as a function of parental or family income and the net cost of attendance, separately by student type (traditional/nontraditional) and institution type.[24]

4.3 Colleges

4.3.1 Tuition and instructional spending

Public sector. The exogenous elements in the public sector are the sticker prices at the public university, $\{T_s, T_{out}, T_{p,o}\}$, and the per student spending at the public online program $\{I_{p,o}\}$. We use College Board 2013 data on in-state and out-of-state sticker price at the

[24]Outside sources of aid may differ across institutions. For example, some for-profit colleges have institutional arrangements in place to facilitate student access to private loans, and disproportionately serve students who use veteran benefits to finance their education.

public institution. We set online tuition at the public university at the in-state average, as we find most schools allow online students to qualify for the in-state price.[25] To evaluate instructional spending at the public online program we use information from public sector institutions reporting in IPEDS 2013 that more than 70 per cent of their students were attending exclusively online.

Nonprofit sector. The sticker prices $\{T_{e1}, T_{e2}\}$ and per student spending $\{I_{e1}, I_{e2}\}$ in the nonprofit sector are exogenous in the model.[26] We use IPEDS data for the 2013 academic year to distinguish between two groups of nonprofit institutions, high and low tuition. We use the undergraduate enrollment-weighted median tuition level (28,090 dollars) as the threshold between higher and lower priced colleges, and proceed to find the corresponding average instructional spending in each group. The corresponding values are shown in Table 1.

4.3.2 Institutional quality production functions

We need to parametrize the quality production functions of colleges: $q_j = A_j(\overline{a}_j)^{\gamma_j}(I_j)^{\omega_j}$. The productivities A_j are estimated in the joint calibration, described in section 4.4.

Peer effect elasticities. We assume that presential institutions have the same peer effect elasticity, $\gamma_p = 0.15$, as in Epple et al. (2017). Similarly, we assume a common peer effect at online institutions, γ_o.[27] To assess the magnitude of the peer effect coefficient for online institutions, we use College Scorecard Data for cohorts 2004-2014 and regress the log of

[25] This is an approximation based on the list of programs reviewed by GetEducated.com, List of Online State Universities, https://www.geteducated.com/online-universities/532-online-state-colleges-and-universities// [accessed Oct 1, 2024].

[26] The prices ultimately charged by these institutions depend on institutional financial aid, which is modeled as a function of individual ability and income, and discussed in the previous section.

[27] Peer effects can operate in distance education through a number of channels, including discussion boards, social networks, study groups, and peer grading interactions. Bettinger, Liu, and Loeb (2016) analyze data from a large online university that quasi-randomly assigns students to classes based on the date of enrollment. They document homophily (same-gender and same region interactions are more common) as well as positive effects of exposure to more active online discussion with peers on the probability of passing the course, grade performance, and likelihood of enrolling in the next academic term. Huber, Lane, and Lakhani (2020) similarly find that age-based homophily has a positive effect on course completion. Studying an online business skills course offered by an elite U.S. business school, they find the presence of same-age peers can have a significant impact on course engagement and persistence.

earnings six years after graduation on average SAT scores and instructional spending, separately for mostly presential (fraction enrolled exclusively online less than 20 %) and mostly online institutions (fraction enrolled exclusively online greater than 70 %). For presential institutions, the effect of the average SAT score on log earnings is 0.836, while it is 0.508 for online institutions. We use the ratio of these coefficients to adjust the peer effect elasticity for online institutions to be 60% of the peer effect at presential ones, under the assumption that the correlation between remaining unobserved factors is similar at online and presential institutions. Consequently, we set the peer effect elasticity $\gamma_o = 0.6\gamma_p = 0.09$ for the public and the for-profit online institutions. This is a crude estimate, and we present robustness checks in Appendix Tables A10 for a range of values of the peer effect coefficient at online institutions.

Spending elasticities. We set the elasticity of instructional spending parameter in the university quality function at nonprofit institutions to $\omega_e^I = \omega_e^{II} = 0.155$ as in Epple et al. (2017), and proceed to estimate elasticity parameters for other institutions, as described in the joint calibration section.

4.3.3 Estimation of college cost functions

We estimate cost functions for the three sectors for which institutional decisions (spending, tuition) are the result of optimization within the model: the public sector, presential and online for-profits. To approximate the custodial cost function, we use the IPEDS Delta Cost Project dataset, which provides detailed information on cost categories for a rich panel of universities. We include "academic support", "student services", and "institutional support" in the variable custodial cost component, and approximate fixed costs F using the expenditures for operation and maintenance of plant category, which includes items such as utilities, fire protection, property insurance, etc. These values are shown in Table A1 in Appendix A.

First, in order to estimate v_1 and v_2, the parameters of the custodial cost function, we use

a balanced panel from the IPEDS data, restricted to baccalaureate granting universities.[28] We expect universities to differ greatly in cost structures, and we attempt to deal with the underlying heterogeneity by estimating fixed effects regressions, capturing within-university variation in the effect of enrollment on custodial costs. In practice, we estimate the following regression separately, for each of the three college groups:

$$Cust_{iz} = \alpha_z + \gamma_t + c_1 k_{zt} + c_2 k_{zt}^2,$$

where $Cust_{zt}$ is the custodial costs per capita in year t at institution z, α_z is a university fixed effect, γ_t an academic year fixed effect, and k_{zt} represents university z's market share in enrollment in year t.

Next, we translate the resulting estimated functions into aggregate annual cost functions at the level of the university groups in our model. Thus, $v_1 = c_1$ and $v_2 = c_2 \sum_{z=1}^{Z} k_z^2$, where Z denotes the total number of universities in the group and k_z is the average enrollment market share of college z over the panel period (1987-2015). As other analysts estimating such custodial cost functions, (Epple et al. (2017); Gordon and Hedlund (2017)), we find it necessary to set $c_1 = 0$ to approximate an increasing cost function. Per capita fixed costs obtained from IPEDS as expenditures for the operation and maintenance of plant category are translated from a per capita basis to be consistent with our measure of enrollment in the model (fraction of the population). Parameters of the annual cost functions are shown in Table 1. In simulations, we aggregate the estimated yearly cost functions over four years to account for the fact that universities make decisions over this period.

[28] Universities are "multi-product" firms, with research and student enrollment/graduation as notable outputs, along other functions such as public service, university hospitals, etc. In this paper, the output we focus on is student enrollment, as competition between the for-profit and public sectors targets student enrollment, and much less so other dimensions of public school activity such as research. As such, in estimating cost functions, we exclude doctoral/research universities, master's colleges, and specialized institutions such as theological seminaries, medical schools, military schools, and schools of art, music, etc. In practice, this restriction involves focusing on baccalaureate colleges, as classified under the Carnegie 2000 methodology.

4.4 Jointly determined parameters

In the following we describe the remaining parameters of the model that are jointly calibrated.

Utility function. We calibrate the utility weighting parameter α and the online education preference parameters ($\theta_{o,t}$ and $\theta_{o,nt}$). In order to match out-of-state enrollment in the public sector, we introduce a preference parameter for out-of state education, $\nu > 1$, common across agents. This parameter captures the willingness to pay more for out-of-state education — individuals may value the experience of going to a different state for college. In equilibrium, a fraction of agents enrolling in the public sector will choose the out-of-state option. As Epple et al. (2017) point out, the higher price tag associated with out-of-state enrollment at public universities also introduces an additional option for lower ability students not accepted at the in-state price to enroll in a public university paying the higher out-of-state price. As we do not model multiple state universities, out-of-state education is introduced as a more expensive track, in order to better match the behavior of the public sector.

Quality production functions. We normalize the productivity of presential for-profit colleges ($A_{r,p} = 1$) and calibrate the productivities of the other colleges (A_p, A_e^I, A_e^{II}, and $A_{r,o}$). We also calibrate the instructional spending elasticities at the public presential program ω_p, for profit presential and online colleges: $\omega_{r,p}$, and $\omega_{r,o}$. We set the spending elasticity at the public online program $\omega_{p,o} = \omega_{r,o}$.

Achievement functions and outside options. We calibrate the parameter β in the achievement function for college education, the achievement parameters B_t, B_{nt} of the outside option for traditional and nontraditional students, respectively, and the productivity parameter B_d in the achievement function of college graduates.

Admission thresholds. We also calibrate an admission threshold parameter a_{min}^e, which reflects the minimal ability threshold for admission to Group I nonprofit institutions, and a threshold for admission to public online institutions, $a_{min}^{p,o}$.

Other parameters. We additionally calibrate the dissimilarity parameters within the presential and online nests of college choices (λ_p and λ_o).

Summing up, there are 19 parameters to be calibrated. The parameters are chosen such that the baseline equilibrium of the model matches key characteristics of the U.S. higher education market. The targeted data moments and data sources are shown in Table 2. More details about the calculation of moments are provided in Appendix C.

The parameters are determined by minimizing the distance between the target moments in the data and the simulated moments implied by the model.[29]

Table 3 shows the jointly determined parameters. The elasticity of spending per student is lowest at online for-profit schools $\omega_{r,o} = 0.125$, slightly higher at for-profit presential colleges and highest for public schools $\omega_p = 0.156$.[30] This pattern could reflect fundamental differences in the skills production function across sectors, for example instructor training. For-profit colleges employ fewer Ph.D. holding instructors, and are more reliant on part-time and temporary staff. This suggests that increases in instructional spending may not lead to large changes in the quality of instruction at for-profit colleges compared to other institutions.

We find the estimated productivity parameters in the quality production functions (A_p, A_{e1}, A_{e2}, $A_{r,o}$) to generally follow the expected pattern given by the instructional spending ranking. These productivity parameters capture other aspects of quality determination, besides peers and instructional spending, that are not included in the model, such as research activity, academic support, university industry networks, professors' teaching abilities. As these other determinants of quality are generally correlated with resources spent on instruc-

[29] We minimize the following function:

$$\Phi = \arg\min_{\Phi} [M(\Phi) - M_d][M(\Phi) - M_d]',$$

where Φ is the vector of parameters, $M(\Phi)$ is the vector of simulated moments and M_d is the vector of target moments.

[30] The value of 0.156 we find for ω_p is very close to the value of 0.155 that Epple et al. (2017) find when calibrating the college quality functions of nonprofit schools.

tional spending and average ability of the student body, we expect the productivity ranking to follow the ranking of these two dimensions. Indeed, we find that high tuition nonprofit institutions exhibits high productivity, followed by the public sector, the presential for-profit sector and the lower tuition nonprofit group. The online for-profit sector stands out, exhibiting relatively high productivity, which we understand to reflect a high degree of operational efficiency.

As expected, we find that the outside option achievement parameter for nontraditional students (B_{nt}) is higher than for traditional students (B_t), reflecting the greater labor market experience of nontraditional students. Also, the online preference parameter is higher for nontraditional than traditional students ($\theta_{o,nt} > \theta_{o,t}$), likely reflecting the greater flexibility of online programs sought by older students who may have family responsibilities. The dissimilarity parameter in the presential education nest (λ_p) is higher than in the online nest (λ_o), indicating less correlation in unobservables between choices of presential institutions than between online institutions.

Identification. While all parameters are jointly determined by the targeted moments, it is possible to narrow down their (partial) source of identification. For instance, the preference parameter for out-of-state education ν is identified by the share of out-of-state students in total enrollment. The value of the utility weighting parameter α is affected by prices of for-profit colleges, as the ability to set higher prices is sensitive to the weight on the deterministic part of utility. Also, the value of individual ability elasticity β in the achievement function of college graduates is mostly affected by the college graduation premium and the proportion of agents that enroll in college, since a change in β affects the return from college education. The values of ω_p, $\omega_{r,p}$, and $\omega_{r,o}$ are mainly identified by instructional spending in the respective institutions, while the relative quality parameters (A_p, A_e^I, A_e^{II}, and $A_{r,o}$) are determined by the market shares of the respective institutions across the two student groups.

Figure A3 illustrates the sensitivity of selected parameters, discussed below, to changes

in the data moments that are important for pinpointing them. The sensitivities are obtained by repeating the joint calibration, modifying one moment at a time while keeping all others unchanged. The figure illustrates that the outside option achievement parameters B_t, B_{nt} are determined by the shares of enrolled agents in the traditional and nontraditional populations, respectively. The achievement parameter for college dropouts B_d is identified by the college graduation premium. The preference parameters for online education ($\theta_{o,t}$ and $\theta_{o,nt}$) are identified mainly by the share of students attending online programs in total enrollment, as well as by the share of online students in total nontraditional enrollment. The admission threshold a^e_{min} at Group I nonprofit institutions is identified by the average ability of traditional students at nonprofit Group I relative to the public college, while the threshold at the public online program $a^{p,o}_{min}$ is determined by moments related to online programs.

The relative sensitivities of preference and admission policy parameters to market share moments offer insights into the comparative importance of these channels in student sorting between the for-profit and public sectors. For example, the admission policy parameter for the nonprofit group (a^e_{min}) is more sensitive to changes in the public sector's market share than to those in the for-profit sector. This indicates that admission policies in the nonprofit sector play a relatively greater role in shaping the public sector's market share. This is due to the fact that for profit institutions compete with nonprofit colleges mainly in the presential market. Thus, a^e_{min} is more sensitive to changes in the for-profit share of the total presential market than to changes in the overall for-profit market share. As expected, the preference parameters $\theta_{o,t}$ and $\theta_{o,nt}$ are most responsive to moments associated with the online market. Specifically, $\theta_{o,t}$ is more sensitive to changes in the share of public students attending online, while $\theta_{o,nt}$ is most responsive to shifts in the share of non-traditional students in the online for-profit market.

4.5 Model fit

Table 4 illustrates the model predictions about the equilibrium distribution of students across sectors by ability and income. Panel A compares market share data from IPEDS 2013 with model predictions. The model does a good job of matching market shares, many of which are however directly or indirectly targeted moments. Panels B and C display model predictions about moments not targeted in estimation. In panel B, we compare market shares by levels of student ability, while in panel C we focus on student incomes.

Panel B uses data from NPSAS:2012, which allows for a breakdown of student distribution by SAT score. We split the sample into six groups, based on standard deviations of the SAT score. We then compare the distribution of students across universities within these groups to the model's predicted student allocation across colleges, based on our measure of standardized ability (outlined in Section 4.1.1).[31] The model does a good job of capturing the declining market share of for-profit colleges for higher levels of SAT/ability for dependent students. At the same time, it captures the fact that high ability students are more likely to enroll in private nonprofit institutions. The model underperforms at the extremes of the ability distribution, particularly for low SAT/low ability students. This is likely a reflection of the higher weight that other aspects of students' backgrounds play in university admissions, particularly at nonprofit institutions, that are not captured by the model (for example, diversity).

Panel C compares model fit across sectors and student income levels. We use data on the distribution across institutional sectors by level of income from NPSAS: 2012. The model generally captures the preference of higher income traditional students for nonprofit institutions. For lower income nontraditional students, the model underpredicts enrollment at nonprofit institutions. This likely reflects the complex nature of the admissions process at nonprofit institutions.

[31] Note the SAT is an imperfect proxy for the ability measure in our model, as SAT-taking students are likely higher ability than the overall population.

5 Policy Experiments

Our model delivers human capital predictions, which we use in section 5.1 to predict wages. We then use the calibrated model and the wage predictions to perform counterfactual policy experiments with a potentially large impact on the for-profit sector. In section 5.2, we simulate the response of colleges in our model to gainful employment legislation tying access to federal aid to debt-to-earnings ratios. In section 5.3, we quantify the impact of changes in subsidies and tuition at public universities, and in section 5.4 we vary the generosity of the Pell Grant cap. Lastly, in section 5.5 we simulate the model without the for-profit sector.

The effects of simulations on model moments are shown in Table 5. We use an equivalent consumption measure to evaluate the change in welfare in counterfactual experiments relative to the baseline. Specifically, for each agent we calculate the percentage change in baseline consumption required to equate baseline utility with that in the counterfactual scenario. Based on the choices of agents in our experiments, in Table 6 we show the average equivalent consumption change for different groups (and their respective share in total population): new enrollees, students who switch institutions, students attending the same institution, those who no longer enroll in college, and individuals who never enroll. For all counterfactual experiments, we also consider distributional aspects, by calculating average consumption-equivalent changes for low-, medium-, and high-income groups (Table A13). We also report equivalent consumption changes measured in dollars in Table A14. Lastly, we assess the impact of the policies on student loan balances (Table 7) as well as on human capital and its determinants, the average ability of the student body and institutional quality (Table 8). Figures 2 and 3 display enrollment changes across different groups of institutions, broken down by traditional and nontraditional students.

5.1 Wage predictions

As outlined in Section 3.1, graduates' wages are modeled as the product of two components: a random term w and an individual achievement or human capital term predicted by the model, $h_j(q_j, a)$. We assume that w is log-normally distributed with mean $\overline{w}$ and standard deviation s_w, which are chosen to match the empirical mean and standard deviation of wages for college graduates as observed in the data.

We predict wages for the 2012 graduating cohort four years after graduation, in line with Department of Education proposed rules for gainful employment legislation.[32] In practice, we obtain information on earnings four years after graduation from the Baccalaureate and Beyond 2008 survey, which conducted a 2012 follow-up of the 2008 graduating cohort. We inflate the 2012 earnings to 2016 values using an index of real wage growth.[33] The resulting empirical mean and standard deviation of graduates' wages are 44.2 and 51.9 thousand dollars, respectively.

Let $\overline{h}$ be the mean achievement of college graduates in the baseline equilibrium. Thus, the average and standard deviation of graduate wages implied by the model are: $\overline{W} = \overline{w}\overline{h}$ and $S_W = s_w\overline{h}$, respectively. Using the empirical mean and standard deviation of college graduates' wage distribution, we pin down $\overline{w} = 44.2/\overline{h}$ and and $s_w = 51.9/\overline{h}$. Next, we generate the random component w for each agent and multiply it with the agent's achievement to predict a wage for each college graduate.

5.2 Gainful Employment

We simulate the response of for-profit colleges to a gainful employment policy that would tie access to federal funding to students' debt-to-earnings ratios post-graduation. We use

[32] "The third and fourth award years prior to the award year for which the D/E rates are calculated" (US Department of Education, Issue Paper 3: Gainful Employment, Session 2: February 14-18, 2022.)

[33] U.S. Bureau of Labor Statistics, Employed full time: Median usual weekly real earnings: Wage and salary workers: 16 years and over [LES1252881600Q], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/LES1252881600Q

predicted loan balances for each student from the model, and forecast loan repayments under a 15-year loan repayment schedule, using a 4.15% interest rate.[34]

We calculate the debt-to-earnings ratio for each individual, by dividing predicted loan repayments by predicted wages. We then calculate the average debt-to-earnings ratios for each institution in our model.

The policy scenario we consider is the loss of federal financial aid for colleges with an average debt-to-earnings ratio of graduates higher than 12%. Under this regulation, colleges choose tuition and spending levels that yield the highest profit from two options: 1)non-compliance with the regulation, which is described by the optimization problem in the baseline model, and 2) compliance with the regulation, which introduces an additional constraint that the average debt-to-earnings ratio of graduates must be 12% or lower.

In simulations, we find that both for-profit institutions prefer to comply with the regulation and reduce their tuition in order to reach the 12% debt-to-earnings cut-off (see column II in Table 7). As they are now more affordable, for-profit colleges see increased enrollment, while the market share of the public college and other institutions decreases, as shown in Figure 2 panels (a) and (b).

At the same time as they are reducing tuition, both institutions cut instructional spending (Table 5). Therefore, while the policy achieves its goal of lowering debt-to-earnings ratios, given that for-profit institutions lower tuition, its impact on educational quality and on the overall human capital of students is negative (see Table 8). The presential for-profit institution attracts lower ability students, to whom it delivers lower levels of instructional spending. The online for-profit institution sees a slight increase in the average student ability, but decreases instructional spending and the overall result is a 1.28% decrease in institutional quality.

Despite the decrease in human capital, the policy results in small positive welfare gains,

[34]This figure corresponds to the average of the Stafford subsidized interest rates for years 2011/2012 through 2019/2020.

generated by the higher consumption resulting from lower prices at for-profit colleges. Table 6 column I shows the consumption-equivalent welfare effects of the counterfactual scenario. The largest welfare gains are enjoyed by college switchers, who benefit from the lower prices of for-profit colleges: traditional students gain 5% of baseline consumption, while nontraditional students 3.7%. Students who remain enrolled at the same institution also see welfare gains, particularly those enrolled at the now cheaper for-profit institutions. New enrollment is small (0.23% and 0.18% of of traditional and non-traditional populations, respectively). New enrollees enjoy welfare gains of 2% of baseline consumption for traditional students, and 4.6% of consumption for nontraditional students. Equivalent consumption changes in dollars (Table A14) show gains of 200 dollars per traditional student and 70 dollars per nontraditional student.

As a result of the gainful employment policy, the average student debt decreases by about 0.4% for traditional dropouts and by 1.41% for nontraditional dropouts (Table 7). Nontraditional graduates also see a 1.73% reduction in their loan balances. While for-profit colleges lower pricing to reach the target of 12% debt-to-earnings ratio, all other colleges see modest decreases in the debt-to-earnings ratio, generated by the reallocation of lower ability (and higher loan balance) students to the now cheaper for-profit colleges.

5.3 Subsidy Changes in the Public Sector

In this set of counterfactual experiments, we consider changes in the funding structure of public universities resulting from state subsidy cuts. Such changes have been frequent over the past decades: as illustrated in Figure 1 panel (d), per capita subsidies have been steadily declining, being replaced by higher net tuition in the budget mix of public universities.

Subsidy cut and tuition increase in the public sector. In the first scenario, we implement a 2,000 dollar subsidy cut at public schools, coupled with a tuition increase in the same amount. The cost increase at public schools leads to a decrease in the overall enrollment

of traditional students from 28.34 to 26.38%, as shown in Table 5. At the same time, the public university share of traditional student market drops from 65.84% to 55.95%. The public university also responds by enrolling a higher share of students paying the higher out-of-state tuition (an increase from 14.69 to 17.06%).

The reallocation of students across institutions is illustrated in Figure 2 panels (b) and (c). The public institution loses significant market share, particularly among traditional students, who choose the less expensive nonprofit institution, while most nontraditional students enroll in for-profit colleges. As shown in Table 6, 2.57% of traditional agents switch colleges and 2.30% of them no longer enroll. Among nontraditional agents, 0.34% are switchers and 0.54% no longer enroll.

The presential for-profit institution slightly decreases tuition and instructional spending, while the online institution slightly increases prices and spending. Overall, the for-profit sector market share grows from 11.29% to 14.15%, most of the growth coming from the presential institution, which lowered tuition and increased its share of the presential market from 5.05% to 6.82%. The magnitude of the effect of state subsidy cuts on for-profit enrollment is somewhat larger than findings by Goodman and Henriques Volz (2020), who estimate that enrollment in the for-profit sector increases by 0.3-0.7 percentage points following a 10% cut in state appropriations. Scaling our results, we find a 1.47 percentage point increase in for-profit overall enrollment for a 10% decrease in subsidies.[35]

The overall welfare effects of the policy are negative. Consumption-equivalent measures in Table 6 column II indicate a decrease in baseline consumption of 0.4%. Individuals choosing to no longer enroll as a result of the policy incur losses of about 1-3% of baseline consump-

[35]The larger magnitude of the effect of subsidy cuts in our context is explained by the presence of an online public option. In the counterfactual at hand, higher tuition at the public institution leads to higher tuition for the public online option as well. As such, the public college is losing market share to the for-profit sector in both the presential and online markets. In simulations in which we do not increase the cost of the online public option, we find a 0.48 percentage point increase in for-profit overall enrollment for a 10% decrease in subsidies at the public institution under this counterfactual.

tion.[36] Students switching colleges and those who remain enrolled at the same college also experience welfare losses. For the latter, the losses are concentrated among public students, who now have to pay higher tuition and experience lower levels of instructional spending.

Subsidy cut and tuition cap in the public sector. We simulate a counterfactual under which public institutions are faced with a 2,000 dollar subsidy cut as well as a tuition freeze. As shown in Table 5 column III, the public market share drops to 59.25%. The public sector responds by significantly decreasing the level of instructional spending, from 11.87 to 9.7 thousand, and slightly raising the fraction of students attending online, from 4.76 to 5.24%. For-profit colleges see an increase in market share from 11.29 to 11.93%, with the presential for-profit increasing its share from 5.05 to 5.54% while at the same time slightly raising tuition, as it is now in a better position to compete with the resource-deprived public school.

The patterns of college switching under the subsidy cut and tuition cap counterfactual are similar to the previous scenario, under which public institutions were allowed to raise tuition, but the magnitudes are more muted, as can be observed from Figure 2, panels (e) and (f). The welfare effects shown in Table 6 are also similar, but smaller in magnitude. However, under this counterfactual, the small fraction of students who no longer enroll in college see welfare gains. These students enroll if subsidies at the public university are higher, but prefer the outside option if the public college is underfunded.

The debt per earnings ratio at the public institution increases by 4.23% in this scenario (Table 7). This is caused by lower predicted earnings, given the fact that average student body ability and institutional quality decrease in response to the subsidy cuts (Table 8). Other institutions experience lower debt-to-earnings ratios, benefiting from the outflow of higher-ability students from the public sector.

Subsidy increase and tuition decrease in the public sector. In this scenario we supplement subsidies per capita at the public institution by 2,000 dollars, allowing it to reduce tuition by

[36]For all counterfactuals in section 5.3, equivalent consumption changes in dollars in Table A14 closely track patterns in percentages of baseline consumption.

an equal amount. The market share of the public institution increases from 62.7 to 70.28% (Table 5 column IV). As shown in Figure 3 panels (a) and (b), the public institution mainly attracts traditional students from the less expensive nonprofit institution, and nontraditional students from the online for-profit. Out-of-state enrollment decreases from from 14.69% to 12.76% . The subsidy is financed by a 0.87% income tax, and the resulting increase in overall enrollment leads to additional tax revenue needs for Pell Grants, which are financed through a 0.08% direct tax on income.

Traditional students experience welfare gains, particularly among new enrollees, who gain 5% of baseline consumption, as shown in Table 6. Most agents, who do not attend college, however experience negative welfare effects, as they pay higher taxes in this counterfactual. This leads to overall negative effects among nontraditional agents, despite nontraditional college-goers enjoying positive gains. Decreasing tuition at the public institution leads to lower overall debt and debt-to-earnings ratios (Table 7), while the average ability of the student body at the public institution is lowered by newly enrolled students (Table 8).

5.4 Pell Grant increases

Raising the cap on Pell Grants is a popular policy prescription for increasing college access and affordability.[37] In our policy simulations, we raise the Pell Grant from 5.5 thousand, its 2013 baseline, to 7.5 thousand and we also double it to 11 thousand dollars. In these scenarios, we keep the 2013 Expected Family Contribution schedule (Appendix Table A2), which implies a phasing out of Pell Grant benefits for wealthier families and individuals. For example, at a maximal cap of 7.5, families with incomes above 70,000 dollars would not benefit from the Pell Grant increase. As such, the Pell Grant scenarios involve a strong redistributive component, supporting college access mostly for lower income students.

[37]This policy featured as one of the Biden administration campaign promises, and has rallied support from many organizations, which have formed the #DoublePell coalition (https://doublepell.org/).

Raising the Pell Grant cap result in considerable increases in overall enrollment for traditional as well as nontraditional students (Table 5, columns V and VI). Under a doubling of the Pell Grant cap, enrollment of traditional students increases by 7.3 percentage points from 28.34% to 36.11% of the cohort (a 25% increase), while that of nontraditional students reaches 10.44%, almost doubling from the baseline of 5.47%. Figure 3 panels (c)-(f) illustrate the reallocation of students across sectors under the Pell Grant cap simulations. The majority of new traditional students choose the public presential institution, while nontraditional students prefer the online for-profit, particularly when the Pell Grant cap is doubled. Overall, for-profit colleges capture a large part of the increase in enrollment. The share of traditional students enrolled in for-profit schools increases from 11.29% to 21.86 % (see Table 5), with remarkable market share gains in the nontraditional student market, where for-profits grow from 26.98% to 49.3% under the Pell cap doubling scenario. The online for-profit colleges are particularly apt at capturing the Pell Grant surplus, attracting new students by reducing tuition from 11.55 to 7.76 thousand dollars. While substantially increasing market share by lowering prices, online for-profits also significantly reduce instructional spending, from 2.21 to 0.77 thousand per capita.[38]

Overall, institutional quality is lowered, as the average ability of the student body decreases, given the lower ability of marginal students (Table 8). At the same time, institutional quality is negatively affected by the strategic response of for-profit colleges, which decrease instructional spending. The Pell Grant cap increases thus have the unintended consequence of leading to increased price competition and a race to the bottom in the for-profit market in terms of instructional quality. In the new equilibrium, the public institution also finds it optimal to slightly reduce instructional spending.

[38]Such a low level of instructional spending is not uncommon for online education providers. Costs per completer for massive open online courses (MOOC) can be as low as 74 dollars per participant (Hollands and Tirthali (2014)). Columbia Southern University, an online for-profit, had a full-time equivalent enrollment of 20,842 students in 2009, to whom it provided an average of 334 dollars in instructional spending, according to IPEDS data.

The impact of the increase in the Pell grant cap on student debt is mixed. The average debt of traditional student graduates increases, despite the lower net cost of attending college, as the marginal students are coming from low income backgrounds.[39] For nontraditional students, predicted loan balances decrease. Net tuition decreases for nontraditional students not just because of the Pell Grant increase, but also because a large share of the new nontraditional students attend for-profit colleges, which lower tuition to attract more students.

Consumption-equivalent estimates of the welfare effects are overall positive, as shown in Table 6, columns V and VI, and amount to an average of 0.77% of baseline consumption when the Pell Grant cap reaches 7.5 thousand, and to 2.29% when the cap is doubled. New enrollees enjoy significant welfare gains when the cap is doubled, of up to 75.36% of baseline consumption for traditional students, and 45.28% for nontraditional students. Under the doubling of the Pell grant cap, the college switchers, who can attend better colleges given the increased grants, enjoy gains of 19.19% and 17.02% of baseline consumption for traditional and respectively nontraditional students. Meanwhile, non-college goers see negative welfare effects, as they pay higher taxes to cover the cost of the program. A negligible percentage of agents—less than 0.15% of traditional agents and less than 0.03% of nontraditional agents—opt not to enroll in the scenario where the Pell Grant cap is doubled.[40] The policy has a strong redistributive component: the net welfare effects are negative for all traditional agents with incomes above 70 thousand dollars, as well as for nontraditional agents with incomes above 30K (see table A13). Expressed in dollars, the equivalent consumption changes (shown in Appendix Table A14) are negative, except for lower-income traditional students.

[39] Our reduced form debt prediction based on the estimates in Table A3 increases in the net cost of attendance and is higher for lower income individuals.

[40] These are marginal agents with weak preferences for college enrollment, for whom small downward changes in the institutional quality lead them to prefer the no-college option.

5.5 No For-Profit Market

We simulate a new equilibrium, excluding the for-profit sector. Results in Table 5 show that enrollment drops by 1.1% for traditional students (from 28.34% to 28.03%) and 14.1% for nontraditional students (from 5.47 to 4.7%). The public institution attracts most switchers, and its market share in overall enrollment grows from 62.70% to 71.79%. Additional income taxes of 0.18% are needed to finance the increased enrollment at the public institution.

As shown in Table 6, the overall welfare effects of shutting down the for-profit sector are negative, reflected by a decrease of 0.44% of equivalent consumption in baseline. The largest losses are coming from those no longer enrolled, who lose about 15-16% of baseline consumption, as well as from switchers, some of whom are now paying higher tuition at nonprofit institutions. Stayers and those not attending colleges also experience welfare losses, as they now pay higher taxes to finance the subsidized public institution. Stayers also experience small welfare losses from the deterioration of institutional quality at the lower tuition nonprofit institution. As shown in Table 8, the public college sees an increase in institutional quality, despite a decrease in the average student body ability. As it is now competing solely with nonprofit institutions, the public college sets instructional spending higher. Overall, the human capital of dropouts and graduates increases by 0.86% and respectively 1.18%. Student debt decreases across the board (see Table 7), particularly for nontraditional student dropouts (-3.51%) and graduates (-0.70%). At the same time, given the shifts in the student population, all other institutions see increases in the debt-to-earnings ratio of their students.

Overall, the small negative welfare effects point to the fact that for-profit colleges provide *access* to students who would otherwise not pursue higher education. They also reduce the need to increase capacity and subsidies at public colleges. The welfare analysis does not however take into account the negative consequences of debt default, given the higher debt-to-earnings ratios of graduates of for-profit colleges, or other positive externalities resulting from larger college attendance.

6 Robustness Checks and Validation Exercise

Crowding out of institutional student funding by higher Pell Grants caps. Increases in Pell Grants may trigger crowd out responses in institutional financial aid at nonprofit and public institutions. Epple et al. (2017) estimate that about 40% of Pell Grant increases may be crowded out by reductions in institutional financial aid at nonprofit colleges. Turner (2017) finds that institutions capture up to 20% of Pell Grant aid, with much smaller crowd out levels at public institutions, of up to 5%. We re-estimate the Pell Grant counterfactual involving a doubling of the maximal cap under the assumption that 40% of the additional Pell Grant financial aid at nonprofit institutions and 5% at public institutions is crowded out by reductions in institutional financial aid. Results are presented in column VIII of Table 5, and are generally similar to the magnitudes in the no crowd out scenario, however with smaller increases in overall enrollment and a larger market share at public institutions. Market shares, spending and tuition at for-profit colleges change only slightly from the no crowd-out scenario, reflecting the fact that these institutions are less responsive to the actions of the more expensive nonprofit institutions, who display the crowd-out response, but target a different segment of the market.

Alternative utility specification. In the baseline model, the utility weights on agent's consumption and achievement are the same. An alternative specification allows for a different weight on achievement in the utility function, reflecting the fact that college achievement translates into labor market earnings gains after graduation, and the decision-maker may discount delayed gains. As college duration is four years in our model, we use a specification that weights achievement at $0.96 = (0.99)^4$, where the one-year discount factor is 0.99. Thus, the specification becomes $V_j(a, y, g) = \theta_g^o\{(1-d_j)[ln(c_j^c)+0.96ln(h_j^c)]+d_j[ln(c_j^d)+0.96ln(h_j^d)]\}$.

We simulate the model using this alternative specification and present results in Table A11. Discounting achievement results in very similar moments, with a slight decrease in

nontraditional enrollment and an increase in traditional enrollment. This is consistent with the fact that the alternative specification puts a higher relative weight on current consumption, which is preferable to traditional students who enjoy the consumption afforded by the higher parental income, and less so for nontraditional students, who rely on their own (and spousal) income. The shifts in traditional vs. nontraditional enrollment do not however lead to fundamental shifts in market shares or tuition and spending at for-profit colleges.

Quantitative importance of changes in public sector policies for the growth of the for-profit sector. Our model and counterfactual analyses indicate that changes in tuition and instructional spending at public universities facilitated the growth of for-profit colleges. In order to analyze the quantitative importance of this channel, we perform a counterfactual exercise in which we investigate how our model performs at predicting market shares in 2004. Thus, we simulate the model using the 2004 levels of per student subsidy and Pell grant cap, tuition, non-tuition costs and instructional spending at public colleges and nonprofit colleges. Between 2004 and 2012, the higher education market experienced significant changes in subsidies and higher education prices. Levels of these variables in 2004 and 2012 (our baseline) are summarized in Table A15.

The results of the counterfactual exercise are presented in Figure A4 and Table A16. In Figure A4 we show the evolution of market shares by type of institution for nontraditional and traditional students (panels (a) and (b), respectively), contrasting the data and the changes predicted by the model. Our model matches the shifting patterns in nontraditional market shares away from public and nonprofit to for-profit institutions, and similar, albeit much smaller shifts in traditional enrollment market shares between these institutions.

As we can see from Table A16, the for-profit market share has grown from 4.43% in 2004 to 11.29% in 2012 (the later value is matched by our baseline model). Next, we feed in the model the 2004 level of public subsidies, spending and tuition levels in the public and nonprofit sectors, and predict a for-profit market share of 7.04% for that year. Consequently,

the model accounts for nearly 62% of the observed change in for-profit market share between 2004 and 2012. The remaining change can be attributed to other significant factors, such as shifts in income distribution and technological advancements in the online sector.

In column 4 of Table A16 we show the model predictions of 2004 market shares across institutions and student groups when we change only the subsidy and tuition in the public sector, keeping pricing at nonprofit institutions at the 2012 levels. This enables us to quantify the relative importance of price changes at nonprofit colleges compared to changes in tuition and subsidies at public institutions in explaining the growth of the for-profit sector. Our results point to a much larger impact of changes in public subsidies on the overall for-profit market share. Changes in subsidies and pricing in the public sector still explain 52% of the change in for-profit market share observed in the data. This result is in line with for-profit institutions directly competing in pricing with the cheaper public colleges than with nonprofit institutions.

7 Conclusion

We set up and calibrate a quantitative model of the higher education market to study the role of for-profit institutions for student enrollment and academic achievement. The framework features heterogeneity in college quality and agents' ability, income and traditional/nontraditional status. We distinguish between presential and online education. The model matches key features of the competitive environment for public and for-profit four-year colleges: levels of enrollment for traditional and nontraditional students, levels of tuition and instructional spending, and sorting of students by ability and income into these institutions. Our estimated variable cost parameters for online for-profit institutions indicate their ability to rapidly increase enrollment in response to changing market circumstances.

Our policy experiments suggest further subsidy cuts at public schools are likely to in-

crease the for-profit market share. We find that Pell Grant cap increases would be a boon to lower-cost for-profit colleges, which would capture a large share of the increased federal funding, enrolling more students by further lowering tuition, but also offering lower levels of instructional spending. Despite the negative effect on decreased instructional quality at for-profit institutions, our welfare analysis however suggests that raising Pell Grant caps results in higher aggregate welfare, particularly for lower income students. The policy however involves significant amounts of redistribution, and leads to negative effects for higher income students.

In our gainful employment legislation scenario, we find that for-profit colleges prefer to adjust their tuition downward, attempting to comply with maximal student debt-to-earnings ratios. However, they lower instructional spending in the process, leading to decreases in the average human capital of students. These findings suggest that gainful employment policies should be accompanied by minimal instructional quality standards.

Several interesting aspects of competition in the higher education market are limited in our modeling exercise, and are left for future research. A richer model could include endogenous student loan take-up and drop-out behavior, as well as a higher count of competing institutions. We also look forward to more data becoming available on the online education offerings of public and nonprofit colleges.

References

Abbott, B., G. Gallipoli, C. Meghir, and G. L. Violante (2019). Education policy and intergenerational transfers in equilibrium. *Journal of Political Economy 127*(6), 2569–2624.

Akyol, A. and K. Athreya (2005). Risky higher education and subsidies. *Journal of Economic Dynamics and Control 29*(6), 979–1023.

Allende, C. (2019). Competition under social interactions and the design of education policies. *Job Market Paper*.

Armona, L., R. Chakrabarti, and M. F. Lovenheim (2018). How does for-profit college attendance affect student loans, defaults and labor market outcomes? *National Bureau of Economic Research Working Paper No. 25042*.

Beckert, W. and E. Kelly (2021). Divided by choice? For-profit providers, patient choice and mechanisms of patient sorting in the English National Health Service. *Health Economics 30*(4), 820–839.

Bettinger, E., J. Liu, and S. Loeb (2016). Connections matter: How interactive peers affect students in online college courses. *Journal of Policy Analysis and Management 35*(4), 932–954.

Caucutt, E. M. and K. B. Kumar (2003). Higher education subsidies and heterogeneity: A dynamic analysis. *Journal of Economic Dynamics and Control 27*(8), 1459–1502.

Cellini, S. R. (2009). Crowded colleges and college crowd-out: The impact of public subsidies on the two-year college market. *American Economic Journal: Economic Policy 1*(2), 1–30.

Chakravarty, S., M. Gaynor, S. Klepper, and W. B. Vogt (2006). Does the profit motive make Jack nimble? Ownership form and the evolution of the US hospital industry. *Health Economics 15*(4), 345–361.

Chatterjee, S. and F. Ionescu (2012). Insuring student loans against the financial risk of failing to complete college. *Quantitative Economics 3*(3), 393–420.

Deming, D. J. and C. R. Walters (2017). The impact of price caps and spending cuts on US postsecondary attainment. Technical report, National Bureau of Economic Research.

Dinerstein, M., C. Neilson, and S. Otero (2020). The equilibrium effects of public provision in education markets: Evidence from a public school expansion policy. *Job Market Paper*.

Epple, D., R. Romano, S. Sarpça, and H. Sieg (2017). A general equilibrium analysis of state and private colleges and access to higher education in the US. *Journal of Public Economics 155*, 164–178.

Epple, D., R. Romano, S. Sarpça, H. Sieg, and M. Zaber (2019). Market power and price discrimination in the US market for higher education. *The RAND Journal of Economics 50*(1), 201–225.

Epple, D., R. Romano, and H. Sieg (2006). Admission, tuition, and financial aid policies in the market for higher education. *Econometrica 74*(4), 885–928.

Epple, D. and R. E. Romano (1998). Competition between private and public schools, vouchers, and peer-group effects. *American Economic Review*, 33–62.

Fillmore, I. (2023). Price discrimination and public policy in the US college market. *The Review of Economic Studies 90*(3), 1228–1264.

Goodman, S. and A. Henriques Volz (2020). Attendance spillovers between public and for-profit colleges: Evidence from statewide variation in appropriations for higher education. *Education Finance and Policy 15*(3), 428–456.

Gordon, G. and A. Hedlund (2017). Accounting for the rise in college tuition. *Education, skills, and technical change: Implications for future US GDP growth*, 357–394.

Hollands, F. and D. Tirthali (2014). MOOCs: Expectations and reality. full report for the center for benefit-cost studies of education.

Huber, L., J. Lane, and K. R. Lakhani (2020). Learning with people like me: The role of age-similar peers on online business course engagement.

Ionescu, F. (2009). The federal student loan program: Quantitative implications for college enrollment and default rates. *Review of Economic Dynamics 12*(1), 205–231.

Ionescu, F. and N. Simpson (2016). Default risk and private student loans: Implications for higher education policies. *Journal of Economic Dynamics and Control 64*, 119–147.

Johnson, M. T. (2013). Borrowing constraints, college enrollment, and delayed entry. *Journal of Labor Economics 31*(4), 669–725.

Kaganovich, M. and X. Su (2019). College curriculum, diverging selectivity, and enrollment expansion. *Economic Theory 67*(4), 1019–1050.

Kunz, J., C. Propper, K. E. Staub, and R. Winkelmann (2020). Assessing the quality of public services: Does hospital competition crowd out the for-profit quality gap? *CEPR Discussion Paper No. DP15045*.

Lochner, L. J. and A. Monge-Naranjo (2011). The nature of credit constraints and human capital. *American Economic Review 101*(6), 2487–2529.

Neilson, C. A. (2013). Targeted vouchers, competition among schools, and the academic achievement of poor students. *Job Market Paper*.

Sauer, R. M. (1998). Job mobility and the market for lawyers. *Journal of Political Economy 106*(1), 147–171.

Sauer, R. M. (2004). Educational financing and lifetime earnings. *The Review of Economic Studies 71*(4), 1189–1216.

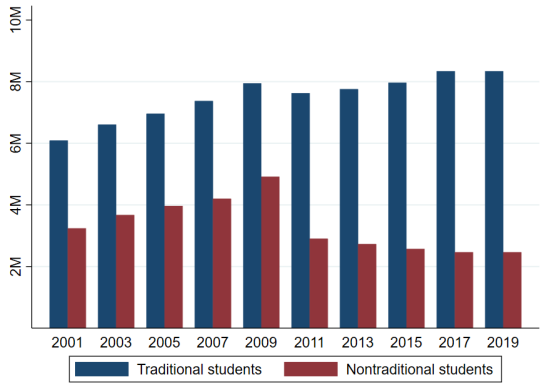
Sieg, H. and Y. Wang (2018). The impact of student debt on education, career, and marriage choices of female lawyers. *European Economic Review 109*, 124–147.

Turner, L. J. (2017). The economic incidence of federal student grant aid. *Working Paper*.

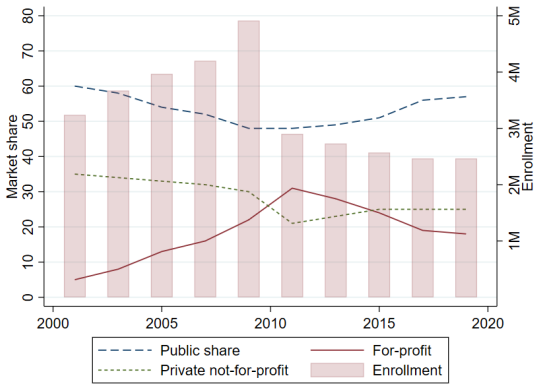
Turner, S. E. (2006). For-profit colleges in the context of the market for higher education. *Earnings from learning: The rise of for-profit universities*, 51–68.

U.S. Senate (2012). For profit higher education: The failure to safeguard the federal investment and ensure student success. health, education, labor, and pensions committee. one hundred and twelfth congress, second session (July, 30, 2012). s. prt. 112-37.

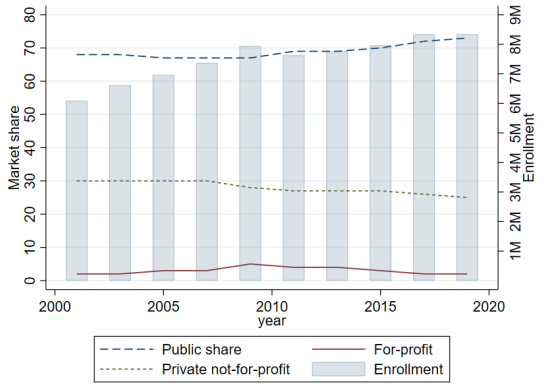
Figure 1: Trends in the Four-year College Market



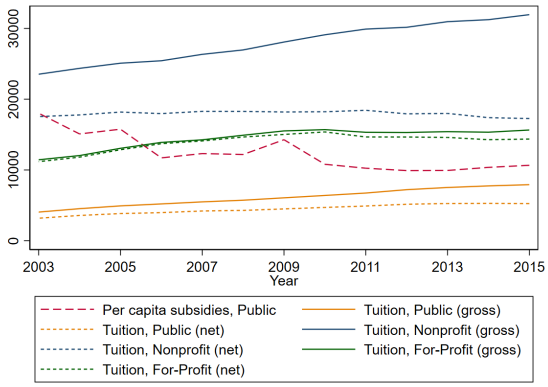
(a) Traditional and nontraditional student enrollment



(b) Market share, nontraditional students



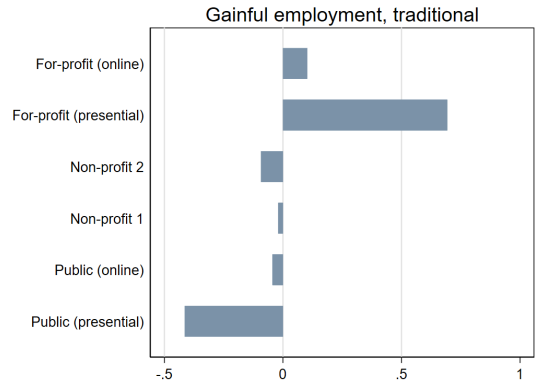
(c) Market share, traditional students



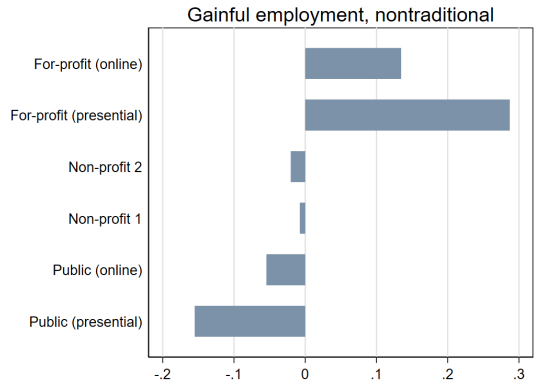
(d) Changes in tuition and public subsidies

Notes: U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS). Data is restricted to four-year degree granting institutions participating in Title IV federal financial aid programs.

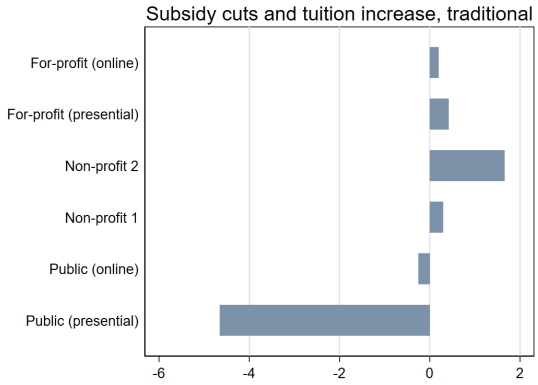
Figure 2: Counterfactual Scenarios: Changes in Enrollment by Institution Type (I)



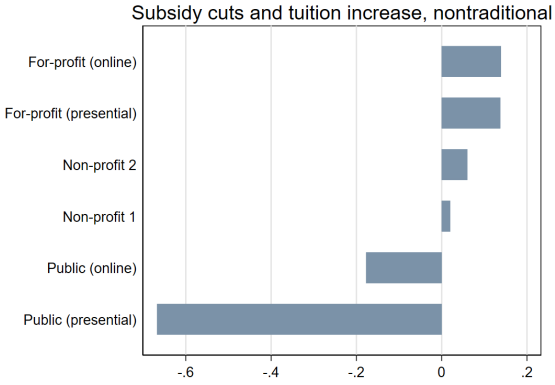
(a) Gainful employment, traditional



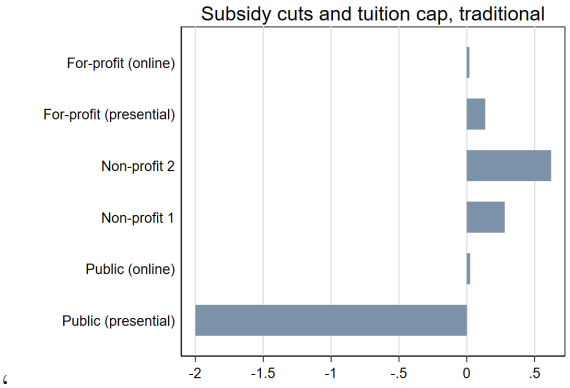
(b) Gainful employment, nontraditional



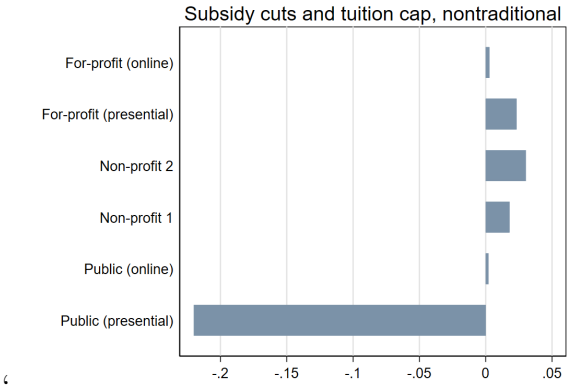
(c) Subsidy Cut and Tuition Increase, traditional



(d) Subsidy Cut and Tuition Increase, nontraditional



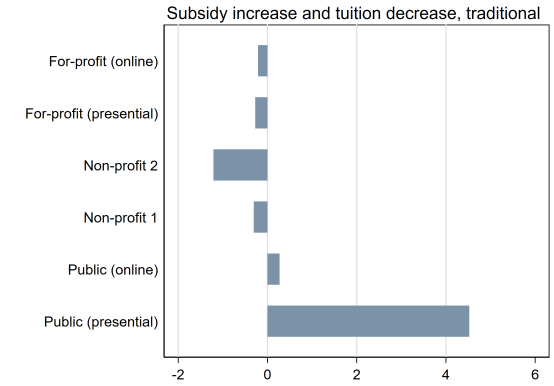
(e) Subsidy Cut and Tuition Cap, traditional



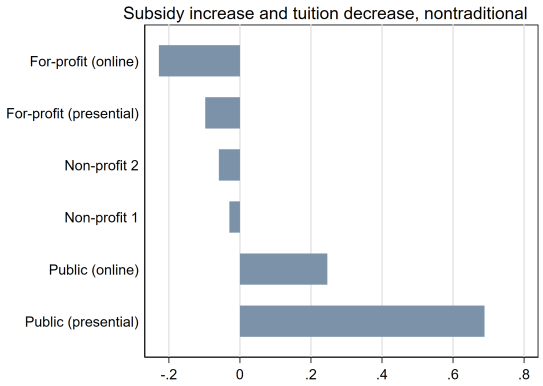
(f) Subsidy Cut and Tuition Cap, nontraditional

Notes: Figures illustrate enrollment changes in response to policy experiments (in percentage points out of the overall population of traditional and nontraditional students).

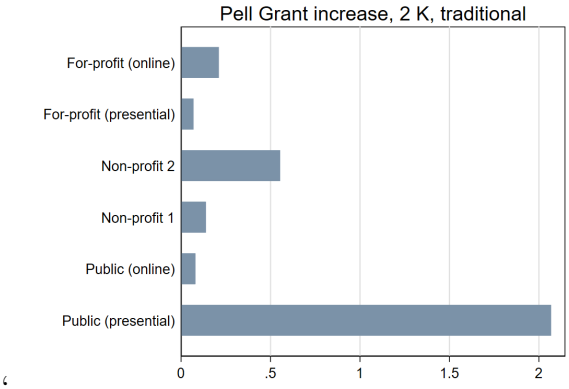
Figure 3: Counterfactual Scenarios: Changes in Enrollment by Institution Type (II)



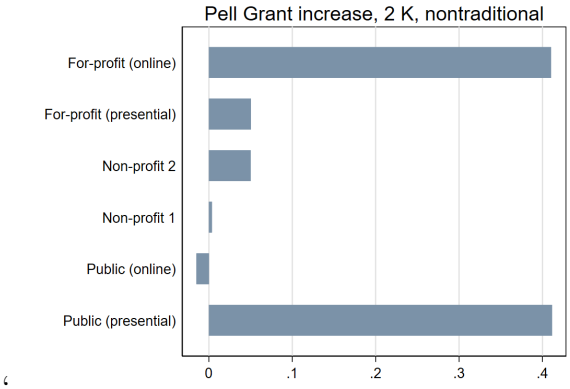
(a) Subsidy Increase and Tuition decrease, traditional



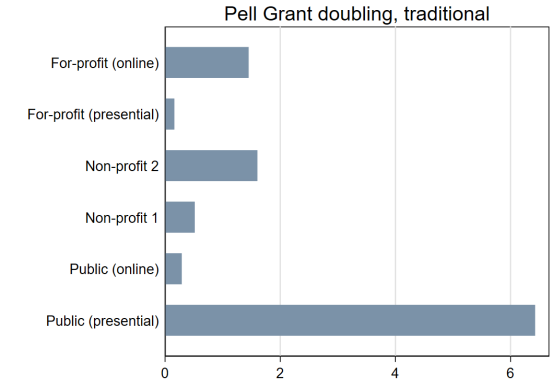
(b) Subsidy Increase and Tuition decrease, nontraditional



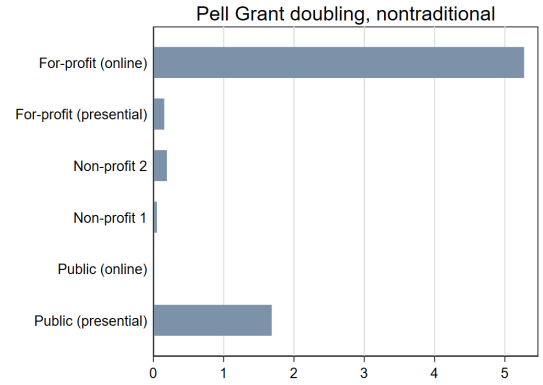
(c) Increase in the Pell Grant cap to 7.5K



(d) Increase in the Pell Grant cap to 7.5K



(e) Increase in the Pell Grant cap to 11K



(f) Increase in the Pell Grant cap to 11K

Notes: Figures illustrate enrollment changes in response to policy experiments (in percentage points out of the overall population of traditional and nontraditional students).

Table 1: Externally Calibrated Parameters

Description	Parameter	Value	Source
Relative group sizes			
Traditional/Nontraditional	π_t; π_{nt}	$0.35; 0.65$	ACS
Ability distributions			
Traditional		$ln(a_t) \sim N(1, 0.18)$	NLSY97
Nontraditional		$ln(a_{nt}) \sim N(0.93, 0.19)$	NLSY97
Income distributions			
Traditional		$ln(y_t + 7.69) \sim N(3.95, 0.76)$	ACS
Nontraditional		$ln(y_{nt} + 7.82) \sim N(3.49, 0.71)$	ACS
Income-ability correlations	ρ	0.3	NLSY97
Tuition at public school	$T_s, T_{p,o}$ T_{out}	8.9 (in-state and online) 22.2 (out-of-state)	College Board[a]
Public school subsidy per capita	s	10.3	IPEDS
Tuition at nonprofit schools	$T_{e1}; T_{e2}$	$35.4; 14.57$	IPEDS
Instructional spending,			
nonprofit	$I_{e1}; I_{e2}$	$18.6; 5.78$	IPEDS
online public program[b]	$I_{p,o}$	4.7	IPEDS
Nontuition costs[c]	NC	10.25;11.25;7.25	College Board[a], NPSAS:12
Custodial cost function -public	F_p; $c_{1,p}$; $c_{2,p}$	0.4 ; 0 ; 42	IPEDS, estimated
Custodial cost function -private for-profit Group I	F_r; $c_{1,r}$; $c_{2,r}$	0.02; 0 ; 62.38	IPEDS, estimated
Custodial cost function -private for-profit Group II	F_r; $c_{1,r}$; $c_{2,r}$	0.05 ; 0; 8.44	IPEDS, estimated
Peer effect elasticity, presential	γ_p	0.15	Epple et al. (2017)
Peer effect elasticity, online[d]	γ_o	0.09	College Scorecard, estimated
Instructional spending elasticity, nonprofit	ω_e	0.155	Epple et al. (2017)
Federal grants		see Table A2	NPSAS: 12
Federal loans		see Table A3	NPSAS: 12
State financial aid		see Table A4	NPSAS: 12
Institutional financial aid		see Tables A5, A6	NPSAS: 12
Other sources of aid		see Table A7	NPSAS: 12

Notes: Monetary values in thousands of dollars. See text for full description of sources. a. College Board, 2014. Trends in College Pricing, Table 1A. b. 2012/17 Beginning Postsecondary Students Longitudinal Study (BPS:12/17), tabulations for undergraduates enrolled in bachelor's programs. b. Average instructional spending for public four-year institutions where 70 per cent or more of students attended exclusively through distance education. c. See text for full description of non-tuition costs. NC=10.25 for public and for-profit group I; 11.25 for nonprofit colleges; 7.25 in the case of online instruction, as we adjust the average non-tuition costs reported by the College Board to account for lower transportation costs and the higher fraction of students residing with parents (we use parental coresidence data by institution type and tuition group from NPSAS:12). d. See section 4.3.2 for estimation/calibration details.

Table 2: Moments Targeted in the Joint Calibration

Target moment	Data	Model
Enrollment, traditional students (% population)[a]	28.8	28.3
Enrollment, nontraditional students (% population)	5.4	5.5
Market shares[a]		
For-profit schools, % overall enrollment	10.7	11.3
Nonprofit Group I, % total nonprofit	50.1	50.9
Public, % traditional market	68.9	65.8
For-profit presential, % presential market[b]	5.2	5.0
For-profit, % nontraditional market	29.6	26.9
Online enrollment, % nontraditional market[c]	21.3	23.4
Nontraditional students, % for-profit online[d]	73.7	72.6
Public sector, % overall enrollment	63.8	62.7
% Public students attending online[c]	4.7	4.8
% Public students attending out-of-state[e]	15	14.7
Instructional spending, public institutions[f]	10.2	11.9
Instructional spending, for-profit presential	4.9	4.9
Instructional spending, for-profit online	2.2	2.2
Tuition, for-profit presential [g]	15.1	15.3
Tuition, for-profit online	11.5	11.6
Average student ability ratio, nonprofit Group I/public (traditional)[h]	1.1	1.2
College graduation premium[i]	1.8	1.7

Notes: a. Enrollment market shares by type of student and institution are based on NCES Digest of Education Statistics, Tables $dt15_302.60$ and $dt15_303.50$, Spring 2012. Market shares for the two groups of colleges in the for-profit and not-for-profit sectors are based on IPEDS Delta Cost project data for 2012. Breakdown of nontraditional and traditional enrollment based on NPSAS:12. b. The for-profit Group I (presential) and Group II (online) shares are calculated based on fraction undergraduates attending for-profit online institutions, NPSAS:12. c. Overall online enrollment and by institution based on NCES Digest of Education, Table 311.15, Fall 2012. d. Breakdown of high tuition/low tuition nonprofit institutions based on median tuition in IPEDS 2012; enrollment share by traditional/nontraditional and low/high tuition group based on NPSAS:12. e. NPSAS:12 f. Instructional spending values are obtained from the IPEDS 2013. g. IPEDS 2013. h. Using NPSAS:12 data, the abiliy ratio is proxied as the SAT composite score ratio of students enrolled at nonprofit Group I and those enrolled at public universities. i. American Community Survey 2012, ratio between the wage and salary income of individuals aged 22-64, holding a bachelor's degree, and the wages and salary income of individuals whose highest attainment was "1 or more years of college credit, no degree".

Table 3: Calibration: Jointly Determined Parameters

Quality function public school		
Productivity	A_p	1.098
Spending elasticity	ω_p	0.156
Quality function nonprofit school		
Productivity, Group I	A_{e1}	1.272
Productivity, Group II	A_{e2}	0.996
Quality function for-profit schools		
Spending elasticity, presential	$\omega_{r,p}$	0.139
Spending elasticity, online	$\omega_{r,o}$	0.125
Productivity, online college	$A_{r,o}$	1.498
Achievement function: Individual ability elasticity	β	0.951
Achievement outside option, traditional	B_t	4.333
Achievement outside option, nontraditional	B_{nt}	5.973
Utility weighting parameter	α	3.815
Out-of-state preference parameter	ν	1.013
Admission threshold, non-profit Group I	a^e_{min}	3.269
Admission threshold, public online	$a^{p,o}_{min}$	2.722
Online preference parameter, traditional	$\theta_{o,t}$	0.912
Online preference parameter, nontraditional	$\theta_{o,nt}$	0.951
Dissimilarity parameter, presential education nest	λ_p	0.382
Dissimilarity parameter, online education nest	λ_o	0.203
Achievement parameter, college dropouts	B_d	1.244

Notes. See section 4.4 for the description of parameters.

Table 4: Model Fit: Market Shares by Student Ability and Income

	Data					Model				
	Pub	NFP	FP	Pub-O	FP-O	Pub	NFP	FP	Pub-O	FP-O
A.Enrollment										
Dependent	66.4	26.9	2.0	2.5	2.1	63.5	28.5	3.15	2.3	2.51
Independent	44.6	21.3	12.8	4.5	16.8	49.1	19.1	8.48	4.9	18.5
B. SAT distribution[a]										
Ability, dependent										
<-1	66.6	23.9	6.5	2.8	0.2	72.4	13.8	6.1	0	7.6
$[-1,0)$	70.5	23.8	2.2	3	0.5	73.4	16.6	4.6	0.5	5
$[0,1)$	68.3	27.9	0.9	2.6	0.3	75.3	15.6	3.6	3.8	1.7
$[1,2)$	61.2	35.9	0.6	2.2	0.1	44.2	50.9	1.4	2.6	1
>2	40.9	57.1	0.3	1.8	0	34.7	62.5	0.7	1.5	0.6
Ability, independent										
<-1	54.2	14.6	18.4	2.4	10.4	52	6	9	0	32
$[-1,0)$	59.2	17.8	11.9	3.6	7.4	51	9	11	0	29
$[0,1)$	65.4	16.7	8.7	4.6	4.6	58	8	9	6	19
$[1,2)$	55.9	23.8	11.5	5.1	3.7	45	27	7	7	14
>2	70	13.6	8.2	7.6	0.7	37	45	6	5	12
C. Income distribution										
Income, dependent										
0-30	68.4	23.9	4.6	2.4	0.8	68.1	21.0	0.6	6.4	3.9
30-50	65.4	28.9	3.3	2.2	0.2	65.4	25.0	3.1	2.9	3.6
50-70	68.8	27.2	2.2	1.7	0.1	59.5	32.4	4.9	2.01	3.2
70-100	67.9	28.7	1.2	2	0.2	52.4	39.4	5.5	1.4	2.6
>100	65.1	32	0.8	2	0.1	47.7	45.2	4.5	0.9	1.7
Income, independent										
$0-30$	54.5	17.8	15.9	1.9	9.9	58.3	2.6	2.5	10.7	25.9
$30-50$	44.9	17.8	19.8	4.4	13.1	56.7	1.1	9.4	4.2	20.7
>50	36.9	27.7	13.4	9.4	12.5	40.6	22.4	10.9	2.36	13.7

Notes: *a.* Panel B compares the distribution of standardized SAT scores by institutional control from NPSAS:2012 with the model's predicted student allocation across colleges based on standardized ability. SAT ranges are: <-1: 400-801; [-1,0): 802-997; [0,1):998-1192; [1,2):1193-1388; >2: 1389-1600. Data sources: Panel A: U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), 2013. Panels B and C: U.S. Department of Education, National Center for Education Statistics, 2011-12 National Postsecondary Student Aid Study (NPSAS:12).

Table 5: Counterfactual Scenarios: Changes in Targeted Moments

Moment	Baseline	Counterfactuals							
		I	II	III	IV	V	VI	VII	VIII
		Gainful Employment	Subsidy cut & Tuition increase	Subsidy cut & Tuition cap	Subsidy increase & Tuition decrease	Pell Cap 7.5 K	Pell Cap 11K	Pell Cap 11 K, crowd-out	No for-profit colleges
Enrollment, % traditional student population	28.34	28.39	26.38	27.56	30.62	30.72	36.11	35.37	28.03
Enrollment, % non-traditional student population	5.47	5.61	5.16	5.38	5.81	6.09	10.44	10.25	4.70
Market shares									
For-profit schools, % overall enrollment	11.29	13.91	14.15	11.93	8.78	12.12	21.86	22.65	-
Nonprofit Group I, % total nonprofit	50.98	51.32	46.30	49.82	55.09	49.29	46.89	52.56	50.43
Public, % traditional market	65.84	64.47	55.95	61.85	73.34	66.17	65.96	70.08	70.48
For-profit, % presential market	5.05	7.37	6.82	5.54	3.86	4.96	4.69	5.17	-
For-profit, % nontraditional market	26.98	31.65	32.37	27.80	21.57	29.35	49.30	50.56	-
Online enrollment, % nontraditional market	23.38	23.79	24.44	23.85	22.09	25.37	46.40	47.04	13.41
Nontraditional students, % for-profit online	72.57	72.64	71.33	72.30	73.13	74.12	84.37	50.56	-
Public sector, % overall enrollment	62.70	60.61	53.36	59.25	70.28	62.59	56.58	59.11	71.79
% Public students attending online	4.76	4.48	4.02	5.24	5.56	4.50	4.32	4.12	7.84
% Public students attending out-of-state	14.69	14.98	17.06	14.49	12.76	13.20	10.25	10.00	14.35
Instructional spending, public	11.87	12.10	11.86	9.70	11.74	11.76	11.38	11.29	11.99
Instructional spending, for-profit I (presential)	4.88	4.69	4.28	4.89	5.35	4.72	4.52	4.34	-
Instructional spending, for-profit II (online)	2.21	1.99	2.00	2.21	2.51	1.90	0.77	0.77	-
Tuition at for-profit colleges, I (presential)	15.31	11.64	13.84	15.46	16.45	14.88	14.38	13.95	-
Tuition at for-profit colleges, II (online)	11.55	10.54	11.29	11.56	12.56	10.30	7.76	7.81	-
Ability ratio, nonprofit Group 1/ Public	1.24	1.24	1.24	1.24	1.24	1.25	1.26	1.26	1.24
College graduation premium	1.66	1.66	1.66	1.64	1.66	1.66	1.65	1.65	1.67
Tax financing additional subsidies[a] (%)	0	0	0	0	0.87	0.18	0.62	0.68	0.18
Tax financing Pell Grant increase (%)	0	0	0	0	0.08	0.47	2.35	2.21	0

Notes: Counterfactual experiments are presented in section 5. Counterfactual I implements a gainful employment policy that restricts access to federal funding to institutions with debt-to-earnings ratios in excess of 12 per cent. Counterfactual II involves a 2,000 dollar decrease in per capita subsidies at public universities coupled with an equal increase in public school tuition per capita. In Counterfactual III, a 2,000 subsidy cut at public institutions is coupled with a tuition freeze. Counterfactual IV implements a 2,000 subsidy increase, along with a tuition decrease in the same amount. Counterfactual V is a 2,000 dollar increase in the Pell Grant cap, from 5,500 to 7,500. Counterfactual VI is a doubling of the Pell Grant cap to 11,000 dollars. Counterfactual VII examines a crowding-out effect at nonprofit and public institutions, where increased Pell Grants lead to a reduction in institutional financial aid. Counterfactual VIII excludes for-profit institutions from the model. a. Note taxes finance *additional* subsidies. In counterfactuals which result in lower spending on subsidies or Pell Grants, we do not model potential tax reductions.

Table 6: Counterfactual Scenarios: Consumption-Equivalent Changes by Educational Choices

	I Gainful employment		II Subsidy cut & Tuition increase		III Subsidy cut & Tuition cap		IV Subsidy increase Tuition decrease		V Pell Cap 7.5 K		VI Pell Cap 11 K		VII No For-profit colleges	
	% cons.	% pop.	% cons.	% pop.	% cons.	% pop.	% cons.	% pop.	% cons.	% pop.	% cons.	% pop.	% cons.	% pop.
All	0.08	100	-0.40	100	-0.17	100	-0.38	100	0.77	100	2.29	100	-0.44	100
A. Traditional agents:	0.11	100	-0.88	100	-0.41	100	0.33	100	-0.34	100	2.04	100	-0.46	100
New enrollees	2.05	0.23	4.04	0.05	-	-	5.06	3.02	6.20	3.32	75.36	10.14	4.60	0.02
Same college	0.22	34.93	-2.45	30.70	-1.22	33.60	2.07	33.51	2.43	35.25	5.77	34.59	-0.14	31.89
Switched colleges	5.03	0.65	-2.48	2.57	-0.06	1.05	3.47	1.99	8.40	0.28	19.19	0.83	-5.73	2.68
No longer enrolled	-	-	-2.80	2.30	0.16	0.93	-2.31	0.08	-4.93	0.04	-4.52	0.15	-16.09	0.99
No college	0	64.19	0	64.37	0	64.42	-0.95	61.40	-0.65	61.09	-2.97	54.28	-0.16	64.40
All traditional	0.11	100	-0.88	100	-0.41	100	0.33	100	-0.34	100	2.04	100	-0.46	100
B. Nontraditional agents:														
New enrollees	4.58	0.18	4.19	0.04	-	-	4.78	0.62	5.97	0.96	45.28	5.50	-2.83	0.004
Same college	0.63	7.41	-1.69	6.77	-0.59	7.44	1.04	7.21	2.63	7.53	6.26	7.33	-0.18	5.09
Switched colleges	3.68	0.24	-1.00	0.34	-0.77	0.09	1.15	0.33	7.81	0.11	17.02	0.28	-6.49	1.48
No longer enrolled	-	-	-3.08	0.54	0.09	0.13	-3.02	0.11	-3.86	0.01	-4.10	0.03	-15.30	1.08
No college	0	92.17	0	92.31	0	92.35	-0.95[a]	91.73	-0.65	91.38	-2.97	86.85	-0.16	92.34
All nontraditional	0.06	100	-0.13	100	-0.04	100	-0.77	100	0.05	100	2.13	100	-0.42	100

Notes: % cons. shows the percentage change in baseline consumption needed to equate the utility of the agent in the counterfactual scenario to the utility in the baseline. For traditional and nontraditional agents, % pop. indicates the fraction in the respective group of agents. Values displayed are averages for observations trimmed at the 1st and 99th percentiles of the income distribution. [a] Several estimates of the impact of counterfactual scenarios on the welfare of individuals not attending college are exactly the same for traditional and nontraditional students. This results from the fact that agents not attending college are only impacted by the introduction of a *proportional* income tax needed to fund increases in public funding in counterfactual scenarios. Given the log utility function, this results in a proportional change in baseline consumption that is the same for traditional and nontraditional students.

Table 7: Counterfactual Scenarios: Changes in Predicted Student Debt

	Baseline	Gainful employment		Subsidy cut & Tuition increase	Subsidy cut & Tuition cap	Subsidy increase & Tuition decrease	Pell Cap 7.5 K	Pell Cap 11 K	No For-Profit Colleges
			% relative to baseline						
Debt/earnings ratios									
Public	5.89	5.85	*-0.68*	*1.87*	*4.23*	*-1.02*	*1.53*	*8.15*	*2.99*
Public, online	7.04	6.83	*-2.98*	*-3.13*	*-1.00*	*0.43*	*-7.53*	*-13.35*	*1.87*
Nonprofit group I	3.01	3.00	*-0.33*	*-2.33*	*-2.38*	*1.66*	*-1.66*	*-3.65*	*0.68*
Nonprofit group II	6.95	6.89	*-0.86*	*-2.73*	*-2.21*	*2.3*	*1.01*	*3.88*	*15.34*
For-profit, presential	12.67	12.00	*-5.29*	*-0.95*	*-1.77*	*0.24*	*-0.95*	*-4.26*	-
For-profit, online	12.24	12.00	*-1.96*	*-1.72*	*-0.08*	*3.51*	*-5.64*	*7.5*	-
Debt per graduate, traditional	14.60	14.60	*-0.05*	*0.76*	*0.11*	*-0.50*	*0.03*	*0.78*	*-0.21*
Debt per graduate, nontraditional	23.40	23.00	*-1.73*	*4.24*	*0.78*	*-5.07*	*-5.28*	*-19.53*	*-0.70*
Debt per dropout, traditional	6.79	6.76	*-0.41*	*0.87*	*0.08*	*-0.62*	*-0.17*	*0.77*	*-0.03*
Debt per dropout, nontraditional	*10.91*	*10.76*	*-1.41*	*5.12*	*0.60*	*-5.92*	*-5.80*	*-19.97*	*-3.51*

Notes: See section 5.2 for details on the calculation of debt-to-earnings ratios.

Table 8: Counterfactual Scenarios: Changes in Human Capital Components (% Relative to Baseline)

	Gainful Employment	Subsidy cut & Tuition increase	Subsidy cut & Tuition cap	Subsidy increase & Tuition decrease	Pell Cap 7.5 K	Pell Cap 11 K	No For-Profit Colleges
Institutional quality[a]							
Public	-0.01	-0.26	-3.14	-0.20	-0.22	-0.93	0.14
Public, online	0.01	0.04	0.00	-0.02	-0.03	-0.12	0.05
Nonprofit group I	0.00	0.00	0.01	0.00	0.00	-0.01	0.00
Nonprofit group II	0.02	0.01	0.01	-0.03	-0.09	-0.25	-0.04
For-profit, presential	-0.62	-1.87	0.03	1.31	-0.51	-1.15	-
For-profit, online	-1.28	-1.12	0.02	1.51	-1.87	-13.21	-
Average ability of the student body							
Public	0.07	0.09	-0.27	-0.17	-0.51	-1.75	-0.17
Public, online	0.05	0.45	0.02	-0.28	-0.36	-1.31	0.52
Nonprofit group I	0.01	0.01	0.03	0.00	-0.01	-0.08	-0.01
Nonprofit group II	0.11	0.05	0.07	-0.20	-0.59	-1.67	-0.29
For-profit, presential	-0.32	-0.21	0.05	0.21	-0.22	-0.69	-
For-profit, online	0.09	0.97	0.04	-1.05	-0.57	-10.24	-
Average human capital of graduates	-0.47	0.06	-1.44	-0.67	-1.11	-6.30	1.18
Average human capital of dropouts	-0.08	0.20	0.03	-0.22	-0.58	-4.35	0.86

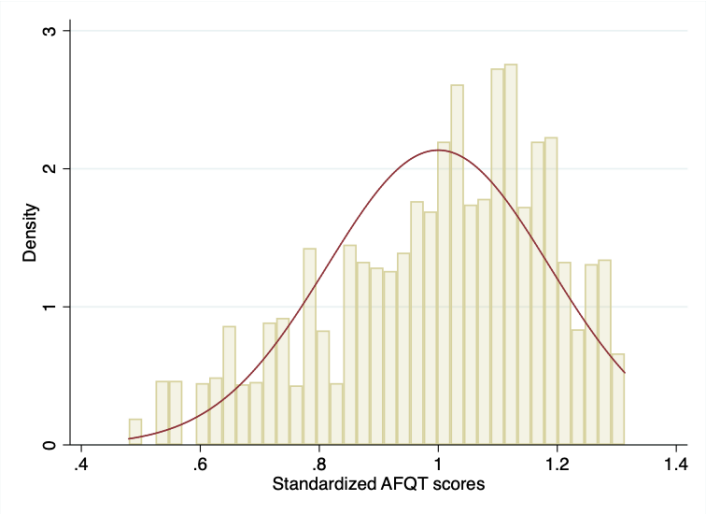
Notes: In our model, an agent graduating from college $j \in J$ with quality q_j acquires human capital $h_j^c(q_j, a) = q_j a^\beta$, where $\beta > 0$. Agents who drop out of college receive human capital $h^d(a) = B_d a^\beta$. Institutional quality is given by: $q_j = A_j(\overline{a}_j)^{\gamma_j}(I_j)^{\omega_j}$, where $\overline{a}_j$ is the average ability of the student body in college j, I_j is the per student instructional spending, and A_j, γ_j, $\omega_j > 0$ are parameters of the quality function that may differ across universities.

Appendix

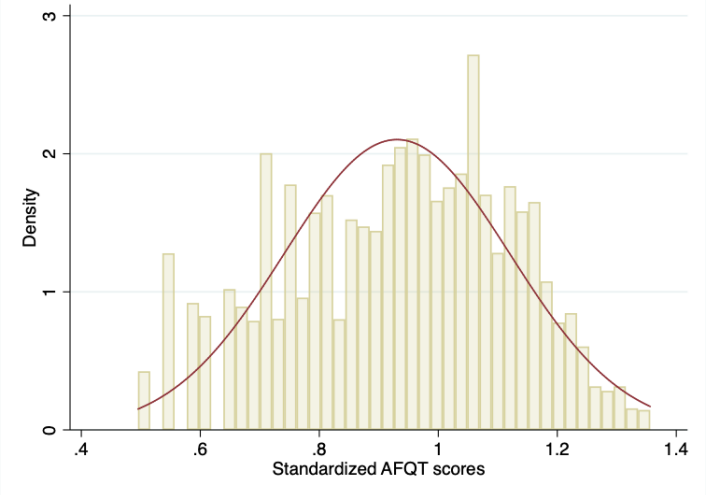
A Additional tables and figures

Figure A1: Fitted Ability Distribution

A. Traditional students



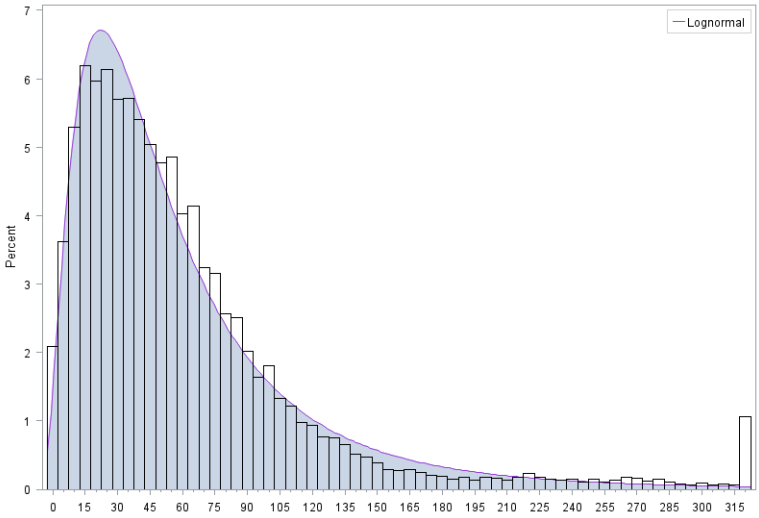
B.Nontraditional students



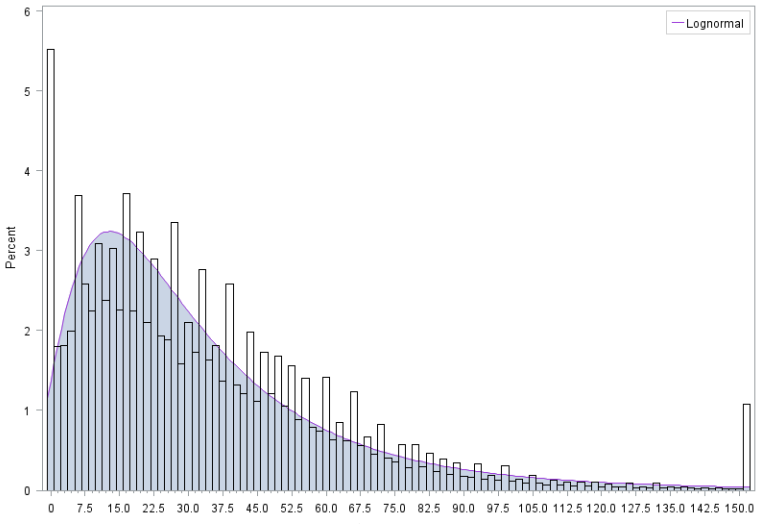
Notes: National Longitudinal Survey of Youth 1997, Armed Force Qualifications Test (AFTQ) data standardized to mean 1. Normal distribution fit.

Figure A2: Fitted Income Distribution

A. Traditional students

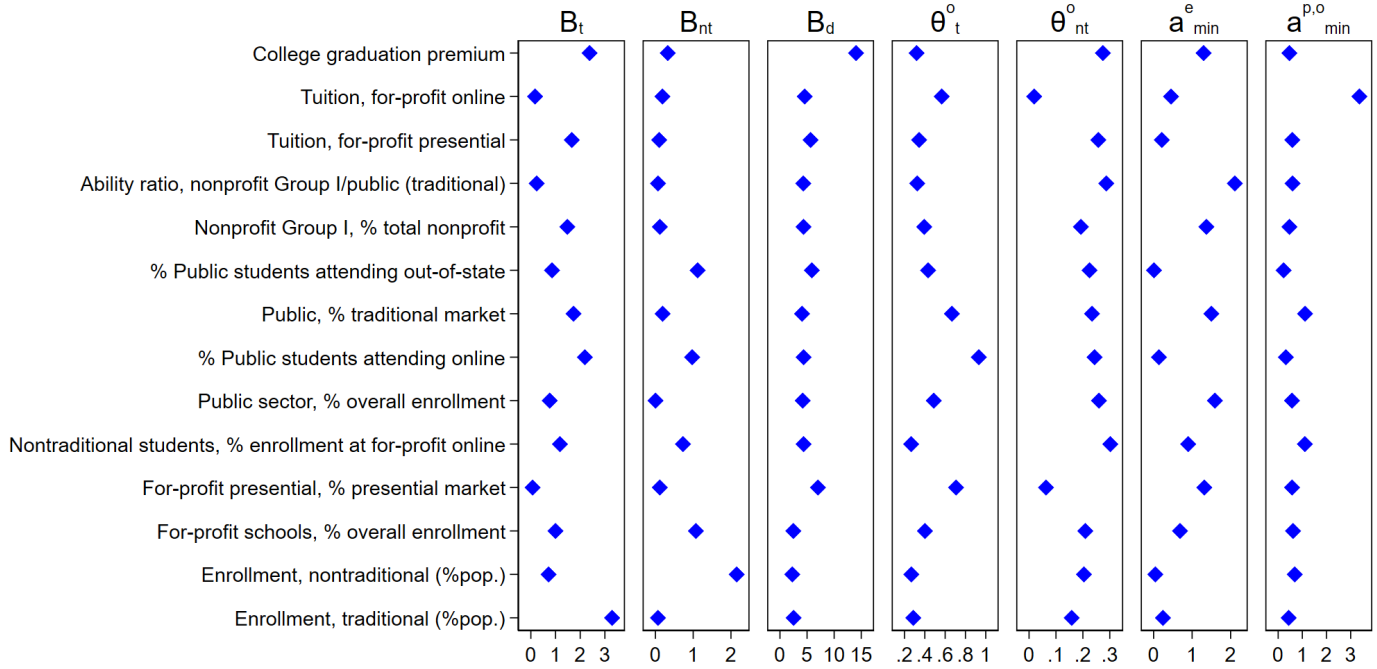


B. Nontraditional students



Notes: Source: American Community Survey 2012-2014 tax-adjusted data on yearly income. Three parameter lognormal fit displayed. Top one percent of incomes are capped.

Figure A3: Change in Parameters for a 10% Change in Moments



Notes: Figure plots the proportional change (after re-calibration) in selected model parameters for a 10% change in each moment, keeping the other moments unchanged. See Table 2 for moment sources. Five out of 19 moments are not shown on the graph as they are not influential for the parameters shown (their impact on the parameters is not one of top 4 highest impacts). The baseline values of the parameters are shown in Table 3, and discussed in section 4.4. B_t and B_{nt} denote the outside achievement options for traditional and respectively nontraditional students. B_d is the achievement parameter for college dropouts. $\theta_{o,t}$ and $\theta_{o,nt}$ are the preference parameters for online education for the traditional and respectively nontraditional students, and a^e_{min} and $a^{p,o}_{min}$ denote the admission threshold parameters at the Group I nonprofit and the online public university.

Table A1: Per Capita Custodial Costs (Thousands, 2015 Dollars) by Institutional Control, Selected Years

	Public		Private not-for-profit		Private for-profit	
Year	Operations	Services	Operations	Services	Operations	Services
1996	1.45	4.38	2.35	8.95	1.48	6.42
1998	1.60	5.22	2.04	9.90	2.10	7.51
2002	1.75	5.17	2.09	10.90	2.34	4.69
2012	1.72	5.83	2.22	12.03	1.63	4.84

Source: IPEDS, balanced panel of institutions 1996-2002, Carnegie Classification 31-33. The operations category includes expenses that are fixed costs associated with plant maintenance, while the Services category designates variable custodial costs per capita. In practice, we use fixed costs for 2012 and the 1987-2015 panel for the estimation of custodial cost coefficients.

Table A2: Expected Family Contribution (EFC) functions

Income group (top category)	EFC, Traditional	EFC, Nontraditional
15	0.244	0.875
20	0.336	2.709
25	0.471	3.143
30	1.071	3.349
35	1.537	4.220
40	2.666	5.395
45	2.927	5.884
50	4.185	5.730
55	4.814	6.428
60	6.214	7.423
70	8.238	8.347
80	10.705	10.503
>80	27.060	13.487

Source: Authors' analysis, NPSAS:2012 data. Sample restricted to U.S. citizens enrolled in bachelor's degree programs. Figures indicate thousands of dollars.

Table A3: Federal Student Loan Functions

	Intercept	Income coefficient	Net cost coefficient
Traditional, parental income <=70k	4.052	-0.005	0.049
	(0.113)	(0.003)	(0.011)
Traditional, parental income >70	3.621	-0.005	0.015
	(0.090)	(0.000)	(0.005)
Nontraditional	4.269	-0.017	0.208
	(0.142)	(0.004)	(0.020)

Source: Authors' analysis, using NPSAS:2012 data. Sample restricted to U.S. citizens enrolled in bachelor's degree programs. Figures indicate thousands of dollars. Standard errors in parantheses.

Table A4: State Financial Aid Functions

Traditional		Nontraditional	
Parental income	State financial aid	Own (and spousal) income	State financial aid
[0,30]	2.085	[0.10]	0.915
(30,60]	1.637	(10,20]	0.515
(60-80]	0.945	(20,30]	0.39
(80-120]	0.591	(30,50]	0.276
>120	0.434	>50	0.1

Source: Authors' tabulations, using NPSAS:2012 data. Figures indicate thousands of dollars. Sample restricted to U.S. citizens enrolled in bachelor's degree programs.

Table A5: Institutional Financial Aid Functions, Nonprofit Schools

	Group I, High tuition		Group II, Lower tuition	
	Intercept	Income coefficient	Intercept	Income coefficient
(type of student/ ability group)				
Traditional, < -1	16.669	-0.034	5.593	-0.002
	(0.891)	(0.007)	(0.772)	(0.007)
Traditional, [-1,0)	16.604	-0.028	7.468	-0.002
	(0.738)	(0.005)	(0.474)	(0.004)
Traditional, [0,1)	15.781	-0.023	7.920	-0.001
	(0.738)	(0.003)	(0.561)	(0.004)
Traditional, [1,2)	18.237	-0.030	10.289	-0.015
	(1.101)	(0.006)	(1.550)	(0.008)
Traditional, > 2	22.233	-0.057	16.384	-0.045
	(3.337)	(0.018)	(4.045)	(0.022)
Nontraditional, ≤ 0	10.842	-0.080	-	-
	(1.747)	(0.151)	-	-
Nontraditional, ≤ -1	-	-	3.658	-0.041
	-	-	(0.612)	(0.021)
Nontraditional, [-1,0)	-	-	3.868	-0.046
	-	-	(0.715)	(0.012)
Nontraditional, > 0	8.743	-0.022	4.088	-0.055
	(2.297)	(0.093)	(0.842)	(0.016)

Source: Authors' analysis, using NPSAS: 12 data. Sample restricted to U.S. citizens enrolled in bachelor's degree programs. High and low tuition groups are defined as below/above average tuition. Figures indicate thousands of dollars. Standard errors in parantheses.

Table A6: Institutional Financial Aid Functions, Public Four-year Colleges

	SAT score, standard deviations			
	<-1	[-1,1]	(1,2]	>2
A.Traditional, by parental income:				
[0,30]	1	1.13	2.7	4.31
(30,65]	1.1	1.18	2.2	2.9
(65,106]	0.7	0.8	1.6	3.17
>106	0.4	0.77	1.56	2.48
B. Nontraditional, by own (and spousal) income:				
0,20	0.47	0.54	0.82	0.78
(20,50]	0.35	0.3	0.3	0.3
>50	0.2	0.2	0.2	0.2

Source: Authors' tabulations, using NPSAS:2012 data. Figures indicate thousands of dollars. Sample restricted to U.S. citizens enrolled in bachelor's degree programs.

Table A7: Outside Sources of Aid Functions

	Traditional			Nontraditional		
	Intercept	Income coefficient	Net cost coefficient	Intercept	Income coefficient	Net cost coefficient
Public	1.206	0.000	-0.006	0.815	-0.002	0.135
	(0.056)	(0.001)	(0.008)	(0.081)	(0.002)	(0.032)
Nonprofit	4.075	0.005	-0.095	2.397	-0.006	0.069
	(0.265)	(0.001)	(0.014)	(0.478)	(0.005)	(0.044)
For-profit	1.484	0.023	-0.079	1.665	0.005	0.114
	(0.364)	(0.008)	(0.039)	(0.225)	(0.003)	(0.036)

Source: Authors' analysis, using NPSAS:2012 data. Figures indicate thousands of dollars. Outside sources are defined as the sum of outside grants (private or employer), private commercial or alternative loans and federal Veterans' benefits and military tuition aid. Sample restricted to U.S. citizens enrolled in bachelor's degree programs.

Table A8: Dropout Functions

Traditional	Ability (s.d.)	%Dropout	Nontraditional	Ability (s.d.)	%Dropout
Public, presential	<-1	0.5820	Public, presential		
	[-1,0)	0.441		<0	0.743
	[0,1)	0.328		>0	0.612
	[1,2)	0.281			
	>2	0.154			
Not for profit group I			Not for profit group I		0.278
	<-1	0.349			
	[-1,0)	0.303			
	[0,1)	0.239			
	[1,2)	0.172			
	>2	0.092			
Not for profit group II			Not for profit group II		
	<-1	0.674		<-1	0.782
	[-1,0)	0.529		[-1,0)	0.792
	[0,1)	0.405		[0,1)	0.632
	>2	0.281		>1	0.463
For-profit, presential			For-profit, presential		0.594
	<-1	0.687			
	[-1,0)	0.651			
	[0,1)	0.5959			
	>1	0.601			
For-profit, online		0.780	For-profit, online		0.636
Public, online		0.612	Public, online[a]		0.676

Source: Baccalaureate and Beyond, 2012/2017. Figures indicate the fraction of students who did not attain a bachelor's degree or are not still enrolled as of June 2017, by type of first four-year degree granting institution in 2011-12 and standard deviations of ability, proxied by the SAT derived composite score.

Table A9: Average Duration of Enrollment, Years

	Traditional	Nontraditional
Public, presential	1.83	2.03
Not for profit	1.86	2.08
For-profit, presential	1.61	2.18
Public, online	1.83	1.83
For-profit, online	1.90	1.93

Notes: Beginning Postsecondary Survey 2012. Table shows the average duration of enrollment among students who eventually drop out and fail to complete their bachelor's degree program.

Table A10: Sensitivity Analysis: Jointly Estimated Parameters for Different Values of the Peer Effect Elasticity at Online Institutions, γ_o

		γ_o=0.09 *(baseline)*	γ_o=0.06	γ_o=0.03
Quality function public school				
Productivity	A_p	1.098	1.081	1.065
Spending elasticity	ω_p	0.156	0.152	0.159
Quality function nonprofit school				
Productivity, Group I	A_e^I	1.272	1.235	1.169
Productivity, Group II	A_e^{II}	0.996	0.984	1.005
Quality function for-profit schools				
Spending elasticity, presential	$\omega_{r,p}$	0.139	0.141	0.145
Spending elasticity, online	$\omega_{r,o}$	0.125	0.123	0.124
Productivity, online college	$A_{r,o}$	1.498	1.462	1.458
Achievement function: Individual ability elasticity	β	0.951	1.005	0.983
Achievement outside option, traditional	B_t	4.333	4.382	4.278
Achievement outside option, nontraditional	B_{nt}	5.973	5.978	5.943
Utility weighting parameter	α	3.815	3.816	3.719
Out-of-state preference parameter	ν	1.013	1.013	1.014
Admission threshold, non-profit Group I	a_{min}^e	3.269	3.293	3.074
Admission threshold, public online	$a_{min}^{p,o}$	2.722	2.733	2.692
Online preference parameter, traditional	$\theta_{o,t}$	0.912	0.916	0.914
Online preference parameter, nontraditional	$\theta_{o,nt}$	0.951	0.953	0.953
Dissimilarity parameter, presential education nest	λ_p	0.382	0.374	0.368
Dissimilarity parameter, online education nest	λ_o	0.203	0.196	0.194
Productivity parameter, college dropouts	B_d	1.244	1.147	1.140

Notes. See Table 3 and section 4 for the description of parameters.

Table A11: Target Moments - Robustness to Alternative Utility Specifications

	Weights for c and h	
	Equal (baseline)	Unequal
Enrollment, traditional students (% population)	28.3	28.60
Enrollment, nontraditional students (% population)	5.5	5.37
Market shares		
For-profit schools (% overall enrollment)	11.3	11.17
Group I nonprofit out of total nonprofit	50.9	50.47
Public, % traditional market	65.8	66.03
For-profit Group I, % presential market	5.0	5.16
For-profit, % nontraditional market	26.9	27.01
Online enrollment, % nontraditional market	23.3	23.88
Nonprofit Group II, % nontraditional market	72.5	73.29
Public sector, % overall enrollment	62.7	62.96
Instructional spending, public institutions	11.8	11.89
Ability ratio, nonprofit Group I/public (traditional)	1.2	1.22
Tuition at for-profit colleges, Group I (presential)	15.3	15.36
Tuition at for-profit colleges, Group II (online)	11.5	11.46
Instructional spending, for-profit Group I (presential)	4.8	4.78
Instructional spending, for-profit Group II (online)	2.2	2.23
% Public students attending online	4.7	4.96
% Public students attending out-of-state	14.7	14.92
College graduation premium	1.7	1.67

Notes: See section 5.3 for description of robustness exercise.

Table A12: Counterfactual Scenarios: Crowding out of Institutional Student Funding in the Pell Grant Increase Scenario, 11 K

A. Consumption-Equivalent Changes		
	% welfare	% of population
All	2.15	100
Traditional	2.27	100
Nontraditional	2.09	100
New enrollees, traditional	15.42	9.99
New enrollees, nontraditional	76.27	5.43
Same college choice, traditional	6.31	34.63
Same college choice, nontraditional	5.66	7.33
Switched colleges, traditional	15.64	0.79
Switched colleges, nontraditional	19.34	0.28
No longer enrolled, traditional	-3.45	0.16
No longer enrolled, nontraditional	-4.86	0.04
No college,traditional	-2.90	54.43
No college,nontraditional	-2.90	86.92
B. Debt and human capital predictions		
	Amounts ($)	% rel. to baseline
Debt per graduate, traditional	14.72	0.81
Debt per graduate, nontraditional	18.88	-23.95
Debt per dropout, traditional	6.85	0.83
Debt per dropout, nontraditional	8.76	-19.75
Institutional quality		
Public		0.14
Public, online		0.05
Nonprofit group I		0.00
Nonprofit group II		-0.04
Average student body ability		
Public		-0.17
Public, online		0.52
Nonprofit group I		-0.01
Nonprofit group II		-0.29

Notes: Values displayed for equivalent consumption changes are averages for observations trimmed at the 1st and 99th percentiles of the income distribution. a. Student debt per capita is calculated as the total amount of student loans divided by the overall number of agents in the economy. b. Institutional quality, labeled q in our model, is given by: $q_j = A_j(\overline{a}_j)^{\gamma_j}(I_j)^{\omega_j}$, where $\overline{a}_j$ is the average ability of the student body in college j, I_j is the per student instructional spending, and $A_j, \gamma_j, \omega_j > 0$ are parameters of the quality function that may differ across universities.

Table A13: Counterfactual Scenarios: Consumption-Equivalent Changes by Income Group

	Gainful Employment	Subsidy cut & Tuition increase	Subsidy cut & Tuition cap	Subsidy increase & Tuition decrease	Pell Cap 7.5 K	Pell Cap 11 K	Pell Cap 11 K, crowd-out	No for-profits
	Percentage of baseline consumption:							
All income groups								
Traditional	0.11	-0.88	-0.41	0.33	0.78	2.30	2.27	-0.46
Nontraditional	0.06	-0.13	-0.04	-0.77	-0.34	2.05	2.09	-0.42
All	0.08	-0.40	-0.17	-0.38	0.05	2.13	2.15	-0.44
0-30 K								
Traditional	0.10	-1.27	-0.28	1.40	2.27	8.39	8.42	-0.34
Nontraditional	0.06	-0.14	-0.02	-0.72	-0.23	5.41	5.46	-0.30
30-70 K								
Traditional	0.15	-0.87	-0.44	0.08	0.65	1.32	1.19	-0.49
Nontraditional	0.07	-0.14	-0.07	-0.81	-0.43	-2.28	-2.24	-0.53
>70 K								
Traditional	0.08	-0.44	-0.50	-0.55	-0.73	-3.26	-3.24	-0.57
Nontraditional	0.06	-0.10	-0.09	-0.89	-0.67	-3.10	-3.05	-0.72

Notes: Values indicate percentage of baseline consumption agents would need to gain/lose to equate utility in counterfactual and baseline scenarios. Trimming at the 1st and 99th income percentiles.

Table A14: Counterfactual Scenarios: Consumption-Equivalent Changes in Dollars

	Gainful Employment	Subsidy cut & Tuition increase	Subsidy cut & Tuition cap	Subsidy increase & Tuition decrease	Pell Cap 7.5 K	Pell Cap 11 K	Pell Cap 11 K, crowd-out	No for-profits
All income groups								
Traditional	0.20	-1.21	-0.93	-0.66	-0.33	-2.71	-2.71	-1.13
Nontraditional	0.07	-0.13	-0.07	-1.12	-0.67	-3.14	-3.07	-0.66
All	0.12	-0.51	-0.37	-0.96	-0.55	-2.99	-2.94	-0.83
0-30 K								
Traditional	0.07	-0.75	-0.17	0.66	1.23	3.95	3.96	-0.24
Nontraditional	0.04	-0.07	-0.01	-0.47	-0.20	-0.83	-0.80	-0.19
30-70 K								
Traditional	0.23	-1.25	-0.66	-0.19	0.60	0.87	0.68	-0.85
Nontraditional	0.11	-0.19	-0.09	-1.51	-0.89	-4.37	-4.29	-0.87
>70 K								
Traditional	0.31	-1.68	-2.14	-2.74	-3.27	-14.70	-14.48	-2.49
Nontraditional	0.18	-0.35	-0.27	-3.39	-2.53	-11.73	-11.51	-2.57
Untrimmed, all income groups								
Traditional	0.20	-1.22	-1.03	-0.77	-0.44	-3.14	-3.12	-1.20
Nontraditional	0.07	-0.13	-0.06	-1.16	-0.70	-3.25	-3.17	-0.70
All	0.12	-0.51	-0.40	-1.02	-0.61	-3.21	-3.16	-0.87

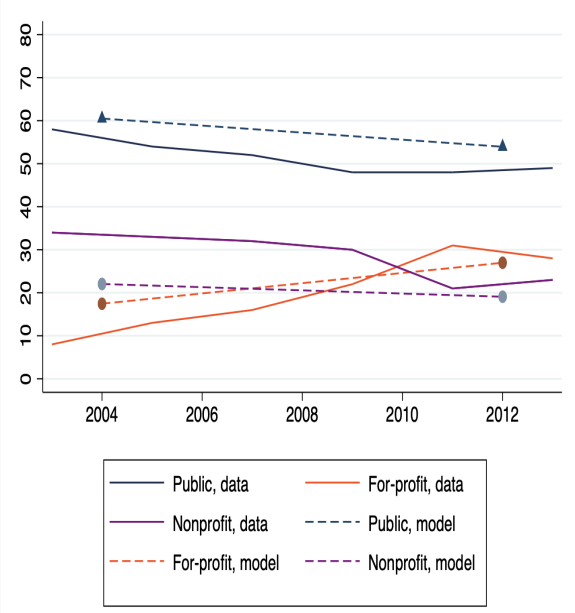
Notes: Values in thousands of dollars. Trimming at the 1st and 99th income percentiles.

Table A15: Historical Changes in College Costs and Financial Aid Used in Validation Exercise

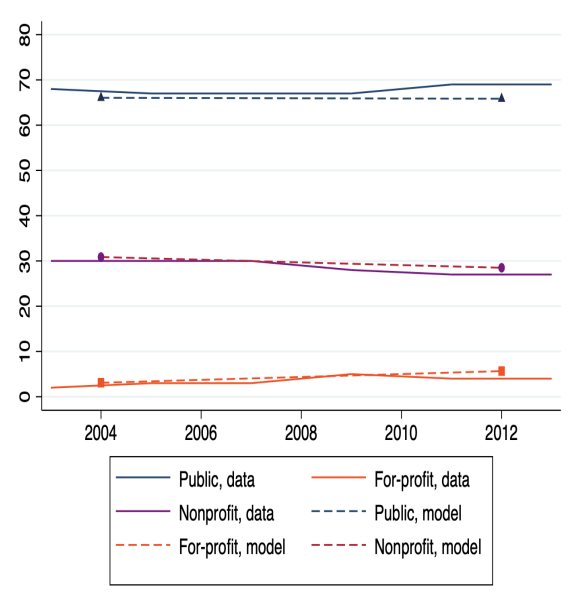
	2004	2012
Tuition, public	5.8	8.9
Subsidy per capita, public	15.1	10.3
Out of state tuition	16.6	22.2
Instructional spending, public online[a]	3.01	4.7
Pell Grant cap	5.14	5.5
Non-tuition costs		
Public and for-profit, presential	8.4	10.15
Public and for-profit, online	5.7	7.00
Nonprofit	9.6	11.25
Nonprofit I, tuition	17.6	36.9
Nonprofit I, instructional spending	21.2	29.9
Nonprofit II, tuition	6.3	17.9
Nonprofit II, instructional spending	8.3	15.2

Source for data moments: U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS). See notes for Table 2 for further detail on sources. Figures in thousands of 2013 dollars. a. Instructional spending data for public online not available in 2004, imputed as proportion of tuition following the same ratio as in 2012.

Figure A4: Evolution of Market Shares by Student Group and Sector: Data and Model predictions



(a) Market shares, nontraditional market



(b) Market shares, traditional market

Table A16: Market Shares in 2004 and 2012: Data and Model Predictions

	2012 data (baseline)	2004 data	2004 model	2004 model (nonprofit 2012 prices)
For-profit, total	11.29	4.43	7.04	7.72
Public, total	62.69	63.89	64.52	78.53
For-profit, traditional	5.66	1.94	3.09	3.47
Public, traditional	65.84	68.11	66.05	82.10
For-profit, nontraditional	26.97	7.61	17.45	19.11
Public, nontraditional	53.94	58.13	60.50	68.98

Notes: Moment source data: U.S. Department of Education, National Center for Education Statistics,Integrated Postsecondary Education Data System (IPEDS), Spring 2004 .

B Computation of equilibrium

1. Pick starting values for the enrollment and mean ability of the student body at all institutions (six in total), instructional spending at the public presential college, and the value of Lagrange multiplier corresponding to the budget constraint of the public university;

2. Given starting values, we calculate the utilities for not enrolling in college, and expected utilities for all colleges. Given the net costs, we check whether the student affords to attend. In the case of the public university and nonprofit Group I, we check whether the student is admitted or not;

3. Given the expected utilities of the other options, for each for-profit college we calculate spending per student and tuition that maximize expected profits. We then calculate the corresponding students' expected utilities for each for-profit college;

4. Calculate the spending per student I_p , enrollment N_p and implied average ability $\overline{a}_p$ that maximizes the expected total human capital at the public university;

5. Calculate the expected utilities and the resulting choice probabilities for each option;

6. Update enrollments and the average ability at each college, spending and the budget constraint multiplier at the public university, and iterate until convergence.

C Data Sources for Targeted Moments

Enrollment data and market shares. The enrollment rate of 18-24 year olds in four-year colleges is the average reported by NCES for the 2012-2014 period. To calculate enrollment for nontraditional students, we divide total enrollment reported by age group in the NCES Digest by the total potential nontraditional student population. We use the NCES education digest tabulations by level of institutional control to calculate market shares for 2013.

Tuition and instructional spending. We target the instructional per student spending in the presential public program (I_p), and sticker prices and per student spending at the two for profit institutions. Data on the average student spending at public presential programs and per capita instructional expenditure and average tuition by type of institutional control in the for-profit sector are collected from IPEDS 2013. We classify for-profit colleges into two groups based on the fraction of students enrolled in exclusively distance education, using data from IPEDS 2013. The online group consists of institutions where more than 70 per cent of students are classified as attending through exclusively distance learning. In the resulting online group, 91 per cent of students attend through exclusively distance learning, while in the residual presential group only 12.8 per cent of students are attending exclusively online.

Ability ratios. To proxy the ability ratio between Group I nonprofit students and public students, we turn to NPSAS:12, and take the average of composite SAT scores for U.S. citizen undergraduates enrolled in four-year bachelor's programs.

College graduation premium. Using American Community Survey 2012 data, we calculate the ratio between the wage and salary income of individuals aged 22-64, holding a bachelor's degree, and the wages and salary income of individuals whose highest attainment was "1 or more years of college credit, no degree".

D Technical model details

D.1 Identity constraints in the optimization problem of the public university:

$$N_p = \sum_g \pi_g \sum_z \int\int \delta_z(a,y,g) r_{p,z}(a,y,g;T,Q) x_p(a,g) f_g(a,y) da dy \tag{13}$$

$$\overline{a}_p = \frac{1}{N_p}\left[\sum_g \pi_g \sum_z \int\int a\delta_z(a,y,g) r_{p,z}(a,y,g;T,Q) x_p(a,g) f_g(a,y) da dy\right]. \tag{14}$$

N_p is the enrollment and $\overline{a}_p$ the average ability of student body at public university.

D.2 Derivation of admission equation for marginal student at the public university

The Lagrange function of the university problem is:

$$\begin{aligned}
L = &\sum_g \pi_g \sum_z \left[\int\int Eh_z(q_p,a,g)\delta_z(a,y,g) r_{p,z}(a,y,g;T,Q) f_g(a,y) da dy\right] + \\
&\lambda\left[\sum_g \pi_g \sum_z \int\int t_{p,z}\delta_z(a,y,g) r_{p,z}(a,y,g;T,Q) x_p(a,g) f_g(a,y) da dy + N_p s - N_p I_p - c_p(N_p)\right] + \\
&\eta\left[\overline{a}_p N_p - \sum_g \pi_g \sum_z \int\int a\delta_z(a,y,g) r_{p,z}(a,y,g;T,Q) x_p(a,g) f_g(a,y) da dy\right] + \\
&\Omega\left[N_p - \sum_g \pi_g \sum_z \int\int \delta_z(a,y,g) r_{p,z}(a,y,g;T,Q) x_p(a,g) f_g(a,y) da dy\right].
\end{aligned}$$

We compute first the derivatives with respect to I_p and $\overline{a}_p$. For simplicity, we suppress the subscript p.

$$L_I = q_I \sum_g \pi_g \sum_z \left[\int \int \frac{dEh_z}{dq} \delta_z(a,y,g) r_z(a,y,g;T,Q) f_g(a,y) dady \right] +$$
$$\lambda q_I \sum_g \pi_g \sum_z \int \int t_z \delta_z \frac{dr_z}{dq} x(a,g) f_g(a,y) dady - \lambda N_p -$$
$$\eta q_I \sum_g \pi_g \sum_z \int \int a \delta_z \frac{dr_z}{dq} x(a,g) f_g(a,y) dady -$$
$$\Omega q_I \left[\sum_g \pi_g \sum_z \int \int \delta_z \frac{dr_z}{dq} x(a,g) f_g(a,y) dady \right] = 0.$$

$$L_{\overline{a}} = q_{\overline{a}} \sum_g \pi_g \sum_z \left[\int \int \frac{dEh_z}{dq} \delta_z r_z(a,y,g;T,Q) f_g(a,y) dady \right] +$$
$$\lambda q_{\overline{a}} \left[\sum_g \pi_g \sum_z \int \int t_z \delta_z \frac{dr_z}{dq} x(a,g) f_g(a,y) dady \right] +$$
$$\eta N_p - \eta q_{\overline{a}} \sum_g \pi_g \sum_z \int \int a \delta_z \frac{dr_z}{dq} x(a,g) f_g(a,y) dady -$$
$$\Omega q_{\overline{a}} \left[\sum_g \pi_g \sum_z \int \int \delta_z \frac{dr_z}{dq} x(a,g) f_g(a,y) dady \right] = 0.$$

Setting $L_I = 0$ and $L_{\overline{a}} = 0$ we obtain:

$$\frac{q_{\overline{a}}}{q_I} = -\frac{\eta}{\lambda}. \tag{15}$$

Taking the first derivative with respect to N yields:

$$L_N = \lambda \left[s - I - c'(N) \right] + \eta \overline{a} + \Omega = 0. \tag{16}$$

Dividing by λ, we obtain:

$$s - I - c'(N) + \frac{\eta}{\lambda} \overline{a} = -\frac{\Omega}{\lambda}. \tag{17}$$

Next, we write the first variations with respect to $\delta_z(a,y,g)$, the admission function to group z (in-state or out-of-state):

$$L_{\delta_z} = \pi_g E h_z(\cdot) r_z f_g(a,y) + \lambda \pi_g t_z r_z x(a,g) f_g(a,y) - a\eta \pi_g r_z x(a,g) f_g(a,y) - \Omega \pi_g r_z x(a,g) f_g(a,y) = 0.$$

Rearranging terms in L_{δ_z} and dividing by λ, we obtain:

$$\pi_g r_z f_g(a,y)\left[\frac{Eh_z(\cdot)}{\lambda}+x(a,g)\left(t_z-\frac{\eta}{\lambda}a-\frac{\Omega}{\lambda}\right)\right]=0. \tag{18}$$

Using equation (15) and (17) in (18) yields:

$$\frac{Eh_z(\cdot)}{\lambda}+x(a,g)\left(t_z+\frac{q_{\overline{a}}}{q_I}a+s-I-c_p'(N)-\frac{q_{\overline{a}}}{q_I}\overline{a}\right)=0.$$

Rearranging terms, we obtain the admission equation for the marginal student in group z, with ability $a=a_{min}^{p,z}$:

$$\frac{Eh_z(q_p,a_{min}^{p,z})}{\lambda}+x_p(a_{min}^{p,z})\left[t_{p,z}(a_{min}^{p,z})+s\right]=x_p(a_{min}^{p,z})\left[I_p+c_p'(N_p)\right]+x_p(a_{min}^{p,z})\frac{\partial q_p/\partial\overline{a}_p}{\partial q_p/\partial I_p}(\overline{a}_p-a_{min}^{p,z}). \tag{19}$$

The left-hand side of the equation is the marginal benefit of admitting the student with $a=a_{min}^{p,z}$, which includes the monetary value of the student's contribution to the aggregate achievement at the public university ($Eh_z(q_p,a_{min}^{p,z})/\lambda$) and the student's contribution to the university revenue (tuition net of institutional aid plus per student subsidy), adjusted for the expected time spent in college by the marginal agent, $x_p(a_{min}^{p,z})$.

The right-hand side of the equation denotes the effective marginal cost of the student, as in Epple et al. (2017). This cost is the sum of the direct marginal resource cost and the marginal peer cost, both of which are adjusted for the student's expected duration of enrollment. The marginal peer cost is calculated by multiplying the negative of the student's impact on the peer measure, represented as $(\overline{a}_p-a_{min}^{p,z})/N_p$, by the resource cost required to maintain quality, which is equal to $\frac{\partial q_p/\partial\overline{a}_p}{\partial q_p/\partial I_p}N_p$.

D.3 Identity constraints in the optimization problem of a for-profit college:

$$N_j=\sum_g\pi_g\int\int p_j(a,y,g;T,Q)x_j(a,g)f_g(a,y)dady, \tag{20}$$

$$\overline{a}_j=\frac{1}{N_j}\sum_g\pi_g\int\int ap_j(a,y,g;T,Q)x_j(a,g)f_g(a,y)dady. \tag{21}$$

N_j is the enrollment and $\overline{a}_j$ the average ability of student body.