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

Abstract

The growth of for-profit colleges has been historically aided by online instruction, and budget crunches at public institutions, circumstances which have resurfaced during the COVID-19 pandemic. We set up and calibrate a general equilibrium model of competition between public and for-profit institutions in the U.S. four-year college market. Our predicted levels of tuition, instructional spending and average student body ability match data counterparts well. In policy experiments, we vary the generosity of public support for higher education and we consider the effects of "gainful employment" legislation that would link access to federal funding for universities to their graduates' debt-to-earnings ratios. We find that Pell Grant cap increases would benefit for-profit colleges, which flexibly decrease tuition and instructional spending to attract a higher number of low-income beneficiaries. Our simulations indicate for-profit colleges prefer to comply with gainful employment standards, but do so by lowering tuition and instructional quality.

JEL-Codes: D400, D580, I280.

Keywords: college choice, funding policies, non-traditional students, general equilibrium.

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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 accounts 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the growth of the for-profit sector stalled after the Great Recession,[3] but in 2019 the U.S. Department of Education repealed regulations that held for-profit colleges accountable to "gainful employment" legislation in order to maintain access to financial aid. Preliminary data for 2020 indicate that for-profit four-year enrollment was relatively unaffected by the pandemic (-0.1 percent down compared to Fall 2019), while public and nonprofit institutions saw declines of two percentage points in undergraduate enrollment.[4] As such, for-profit colleges are likely to increase their market share in the pandemic online instruction environment, and will continue to compete for federal funding, and to educate a large share of low-income, first-generation college students.

We analyze competition between for-profit, public and nonprofit higher education providers by setting up and calibrating a general equilibrium model, building on the work of Epple and Romano (1998), Epple, Romano, and Sieg (2006) and Epple et al. (2018). Our model introduces for-profit colleges as profit-maximizing 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]

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

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

[3] A U.S. Senate (2012) investigaton was triggered by the poor labor market outcomes experienced by veterans benefitting 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] Fall 2020 Enrollment (As of Oct 22) National Student Clearinghouse Research Center's Monthly Update on Higher Education Enrollment, Nov 12, 2020. https://nscresearchcenter.org/stay-informed/

[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 not-for-profit institutions generally place a higher weight on academic quality, through selective admission policies and higher instructional spending.

The goal of our paper is to provide a general equilibrium framework capable of assessing the response of the for-profit sector to changes in the generosity of public support for higher education.

We focus on 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 per cent in 2000, it had reached 12 per cent by Fall 2010.[6]

Our model features two types of students: *traditional* and *nontraditional*. 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 percent market share. In the market for nontraditional students, for-profit colleges compete mainly with public colleges, which had a 48 percent market share in 2011, and to a lesser extent with not-for-profit 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 developments in more detail in Section 2.

In our model, four-year for-profit colleges choose their level of tuition and instructional spending. These institutions respond to the tuition and instructional spending observed at nonprofit colleges and in the public sector. 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 student achievement.

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

We evaluate a quantitative version of the model, which delivers predictions about levels of instructional spending, equilibrium student body ability and earnings premia in the labor market by type of college. Pricing at for-profit colleges also emerges as an equilibrium outcome of the model. The model matches enrollment market shares, ability rankings across types of students and universities, and observed levels of student borrowing, federal and institutional financial aid.

Our first set of counterfactual analyses considers state budget crunches as a result of decreasing tax revenue, a likely development in the context of the COVID-19 recessionary environment. In the first scenario, public universities face decreasing levels of subsidies but are allowed to raise tuition to compensate for the revenue loss. In the second scenario, we impose a tuition freeze along with a subsidy cut. We observe the effects of these policies on for-profit market shares, instructional spending and average student ability. Another set of counterfactual analyses considers potential increases in subsidies at state schools and increases in the maximal Pell Grant cap. Such policies are highly likely, given the Biden administration pledge to increase college affordability. We vary the generosity of the maximal cap on Pell Grants, and study the effects on overall enrollment and student allocation across different sectors. 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 students with higher eligibility for Pell grants. Our simulations further indicate that lower-tuition (mostly online) 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 indicates that a doubling of the Pell Grant maximal cap (a Biden campaign promise) leads to lower welfare gains than more modest increases in the award cap.

In our gainful employment policy experiment, we find that for-profit colleges prefer to comply with the debt-to-earnings ratios that would allow them continued access to federal funding, but do so by lowering tuition and instructional spending. While counterfactual loan default rates decrease, the policy scenario indicates immediate negative welfare effects because of the deterioration in instructional quality.

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 et al. (2017, 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 traditional from nontraditional students, whose average abilities, incomes, outside options and financial aid packages vary considerably. 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 et al. (2017) lead to increased attendance among low income and middle- and high-ability students, and increases in instructional spending at private non-profit institutions.

In response to the findings from our Pell Grant experiments, we quantify the response of for-profit institutions to gainful employment policies. Such legislation has been passed under the Obama administration partly in response to rising default rates among graduates of for-profit universities. Repealed under the Trump administration, gainful employment policies will be likely reactived in the near future.

The paper also contributes to the broader literature analyzing the effects of higher education policies in quantitative models. Caucutt and Kumar (2003), Akyol and Athreya (2005), Ionescu and Chatterjee (2012), and Johnson (2013) analyze the effects of tuition subsidies. Ionescu (2009), Lochner and Monge-Naranjo (2011), Ionescu and Chatterjee (2012), Ionescu and Simpson (2016) examine the impact of student loan policies in the context of borrowing constraints. Abbott et. al (2019) compare the effects of ability-tested grants and expansion of student loans in a model of intergenerational 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. Deming, Goldin and Katz (2012, 2013) summarize some of early findings in this literature, pointing out the lower returns to schooling experienced by for-profit students, which suggest "for-profit institutions are not offering students as good a return on their investment as do other types of colleges." Hoxby (2017) provides return on investment calculations that show the earnings of students engaged in online college education rarely cover their private costs, and almost never the social cost of their education. Armona, Chakrabaarti and Lovenheim (2018) use an instrumental variable aproach 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 very 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. Goodman and Henriques Volz find that for-profit college attendance increases about 2 percent for a 10 percent cut in state appropriations. Our counterfactual estimates indicate a 1.88 percent increase in for-profit overall enrollment for a 10 percent decrease in subsidies.

The analysis proceeds 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 in Section 4. We report the results of our counterfactual analyses in Section 5, and conclude in Section 6.

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

The growth of the for-profit sector has been associated with a series of developments in the U.S. higher education market: the rise in nontraditional student enrollment, the decrease in state subsidies for public schools, and the increasing availability of federal financial aid and student loans.

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 five percent in 2001 to 31 percent in 2011. One explanation for the fast rise in market share is that for-profit colleges may be offering learning environments more suitable for older, nontraditional students, who may have work and family responsibilities. For example, for-profit colleges are more likely to offer online courses, and have lower admission requirements. 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).

While for-profit colleges were capturing a larger share of the nontraditional student market, public schools were facing a significant shift in their funding structure. Figure 1, panel D shows that the share of net tuition revenue in the operating revenues of public universities has increased, while the share of public subsidies has been declining. The higher reliance on net tuition revenue, which translated into increases in net tuition, drove the price of public universities closer to the sticker price charged by for-profit colleges. Goodman and Henriques Volz (2020) estimate that for-profit college attendance increases about 2 percent for a 10 percent cut in state appropriations. Deming and Walters (2018) explore the joint effect of state budget cuts coupled with tuition increase caps or tuition freezes. Using an event study design, they find that enrollment and graduation rates at public universities decrease following state policies that limit both subsidies and the capacity of public schools to raise tuition. Several authors have pointed out that capacity constraints at public schools have allowed for-profit schools to capture rising demand. Sarah 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. Stephanie 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. Federal expenditure on Pell Grants 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.[7] When the for-profit market share peaked, in 2007-2008, over 40 percent of students attending for-profit colleges were financing their studies with private loans, compared to 25 percent of students in nonprofit colleges and 14 percent of students in public schools.[8]

The rapid adoption of distance and online education also facilitated the growth of the for-profit sector. While both for-profit and public colleges enrolled less than seven percent of students in distance education in 2000, by 2012, 57.5 percent of students at for-profit colleges were taking exclusively distance education courses, compared to 5.5 percent of students in the public sector.[9] While the increasing availability of broadband Internet after 2000 spurred the adoption of online education, for-profit colleges received further incentives after the "50 percent rule" was repealed. 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

[7] College Board, Federal Aid per Recipient by Program over Time in Current and Constant Dollars.

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

[9] Data from from 1999-2000 National Postsecondary Student Aid Study indicate that 3.8 percent of for-profit students were enrolled in distance education, compared to 6.9 percent 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.

financial aid. In our model, we don't explicitly model the online educational component at for-profit colleges, but we acknowledge that nontraditional students may have different preferences for attending for-profit colleges compared to traditional "brick and mortar" public and nonprofit colleges. We also take into account that online delivery may involve lower non-tuition costs (room and board, transportation).

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 loan defaults experienced by graduates of for-profit colleges.[10] 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, 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.

[10]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.

3 The Model

The potential student population, normalized to 1, consists of two groups of agents: traditional (denoted t) and nontraditional (denoted nt), whose levels of ability, income, and financial aid differ. Let π_t and π_{nt} indicate the proportions of traditional and respectively nontraditional agents in the total population. Potential students are heterogeneous in after-tax income y and ability a (pre-college preparation). Let $f_t(a, y)$ and $f_{nt}(a, y)$ denote the joint densities of (a, y) for traditional and nontraditional agents, respectively.

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. The number of alternatives is given by $J = P + R + M$, where P is the number of public colleges, R the number of for-profit colleges and M is the number of not-for-profit institutions. We model one public university, so $P = 1$.

An agent enrolled in college j with quality q_j acquires human capital equal to $h_j = q_j a^{\beta}$, where $\beta > 0$. This specification captures the fact that more able students will accumulate more skills for the same level of educational quality. The achievement of an agent that does not pursue higher education is $h_0 = Ba^{\beta_0}$, where $B, \beta_0 > 0$.

3.1 Agents' preferences and choices

An agent is characterized by (a, y, g), where g is an indicator denoting the group the agents belongs to (t or nt). The agents derive utility from consumption and academic achievement. We assume the utility of the student (a, y, g) enrolling in college j is given by:

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

where $u_j(a, y, g)$ is the systematic component of the utility and and ϵ_j is an idiosyncratic component which has a Type I Extreme Value Distribution with location parameter equal to zero and scale parameter equal to one.

The systematic component is given by $u_j(a, y, g) = \alpha_{j,g} \ln(c_j h_j)$, where $\alpha_{j,g}$ is a weighting parameter that can vary among the traditional and non-traditional agents, $c_j(a, y, g)$ and

$h_j(a, y, g)$ denote consumption and achievement. The systematic component from the outside option is $u_0(a, y, g) = \alpha_0 \ln(yh_0)$.

For each college choice, potential students can choose between enrolling full time or part time. We assume part time students pay half the corresponding tuition, and receive half the financial aid and achievement relative to a full time student with the same characteristics.

Students pay different prices for a college education, depending on their ability, income and traditional/nontraditional status. Denote by $t_j(a, y, g)$ the price paid by a full time student of type (a, y, g) at college j. This price is net of institutional and non-institutional financial aid. Students also pay non-tuition costs, denoted by NC_j. Thus, the budget constraint of the full time student of type (a, y, g) enrolling at university j is:

$$c_j(a, y, g) + t_j(a, y, g) + NC_j = y. \tag{2}$$

If the student enrolls part time, she pays half the tuition and the non-tuition costs. Denote by $V_{j,ft}(a, y, g, \epsilon_j)$ and $V_{j,pt}(a, y, g, \epsilon_j)$ the systematic component of indirect utilities from enrolling full time and part time, respectively, at college j. Assuming feasibility of the budget constraints, we substitute consumption into the expression of utility and write the indirect utilities of agent (a, y, g) corresponding to full time or part time enrollment in college j:

$$V_{j,ft}(a, y, g, \epsilon_j) = \alpha_{j,g} \ln[y - t_j(a, y, g) - NC_j] + \alpha_{j,g} \ln[h_j(a, y, g)] \tag{3}$$

$$V_{j,pt}(a, y, g, \epsilon_j) = \alpha_{j,g} \ln[y - 0.5t_j(a, y, g) - 0.5NC_j] + \alpha_{j,g} \ln[0.5h_j(a, y, g)]. \tag{4}$$

Consequently, the utility derived from enrolling in college j is

$$U_j(a, y, g, \epsilon_j) = max[V_{j,ft}(a, y, g), V_{j,pt}(a, y, g)] + \epsilon_j. \tag{5}$$

Let $d_j(a, y, g) = 1$ if the agent chooses to enroll full time ($V_{j,ft}(a, y, g, \epsilon_j) \geq V_{j,pt}(a, y, g)$) and 0 otherwise. Given tuition levels, quality of colleges, and institutional and non-institutional financial aid, agents choose among the options available in order to maximize their utility. Denote by $D(a, y, g, d(a, y, g), \epsilon)$ the optimal decision rule. Integrating out the taste shocks, we obtain the conditional choice probabilities for college j, for each agent group g. We denote the conditional probabilities as $p_j(a, y, g; T(a, y, g); Q)$, 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.

3.2 The Higher Education Sector

The quality of college j is given by:

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

where $\overline{a}_j$ is the average pre-college human capital 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.

Denote by $t_j^f(a, y, g)$ the full time tuition schedule at university j for the student of type (a, y, g). We model federal and institutional financial aid as functions of student ability and income. Thus,

$$t_j^f(a, y, g) = T_j - FedAid_j(a, y, g) - InstAid_j(a, y, g), \tag{6}$$

where T_j is the sticker price at university j. The part-time students pay half of $t_j^f(a, y, g)$. Consequently, the tuition schedule $t_j(a, y, g)$ at university j is

$$t_j(a, y, g, d_j) = [d_j(a, y, g) + 0.5(1 - d_j(a, y, g))]t_j^f(a, y, g). \tag{7}$$

The public sector. The public university maximizes the aggregate achievement of its students subject to a balanced budget, similar to Epple et al. (2019). The university chooses the full time equivalent (FTE) enrollment N_p, instructional spending I_p, per FTE student and the admission functions $\delta_p(a, y, g) \in [0, 1]$, which are the shares of type (a, y) students that are admitted from group g. The public university charges a sticker price T_p and receives a subsidy s per FTE 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. As the agents' income is net of taxes, we do not model the tax income that funds the subsidy or the student financial aid. However, in the policy experiments we model a balanced government budget that pins down the necessary increase in taxes when the university subsidies or the student financial aid are increased.

Using the notation for conditional probabilities introduced above, $p_p(a, y, g; T, Q)$ is the fraction of type (a, y, g) students that attend the public university if admitted. Also, $t_p(a, y, g, d_p)$ is the tuition net of financial aid paid by agent (a, y, g), where d_p indicates whether the agent pays full or part time tuition. $\delta_p(a, y, g)$ is the fraction of type (a, y, g) agents that are admitted by the public university. We write the budget constraint of the university as

$$N_p s + \sum_g \pi_g \int \int t_p(a, y, g, d_p)\delta_p(a, y, g)p_p(a, y, g; T, Q)f_g(a, y)dady = N_p I_p + C_p(N_p), \quad (8)$$

where $N_p s$ is the total amount of subsidies received by the university. The second term on the left hand side of the equation represents total tuition revenue, where π_g is the proportion of group g in the total potential student population. On the right hand side of the budget constraint, $N_p I_p$ are the instructional costs, and $C_p(N_p)$ captures other costs that are not related to instruction ("custodial costs"). Let $h(q_p, a, d_p) = [d_p(a, y, g) + 0.5(1 - d_p(a, y, g))]q_p a^\beta$ represent the achievement of agent (a, y, g) if enrolled at the public institution. The problem of the public university can be written as:

$$\max_{\delta_p(a,y,g), I_p, N_p} \sum_g \pi_g \int \int h(q_p, a, d_p)\delta_p(a, y, g)p_p(a, y, g; T, Q)f_g(a, y)dady, \quad (9)$$

subject to the budget constraint (8), the tuition schedules, the feasibility constraints $\delta_p(a, y, g) \in [0, 1]$, for all student types, and the following identity constraints:

$$N_p = \sum_g \pi_g \int \int [d_p(a, y, g) + 0.5(1 - d_p(a, y, g))]\delta_p(a, y, g)p_p(a, y, g; T, Q)f_g(a, y)dady, \quad (10)$$

$$\overline{a}_p = \frac{1}{n_p} \sum_g \pi_g \int \int a\delta_p(a, y, g)p_p(a, y, g; T, Q)f_g(a, y)dady, \quad (11)$$

where N_p is the FTE enrollment, $\overline{a}_p$ the average ability, and n_p the size of the student body at the public school, given by:

$$n_p = \sum_g \pi_g \int\int \delta_p(a,y,g) p_p(a,y,g;T,Q) f_g(a,y) da dy. \tag{12}$$

The optimization problem of the public university yields an endogenous admission threshold a^p_{min}, such that for the marginal student with $a = a^p_{min}$, the effective marginal cost of the student equates the marginal benefit of admission. As in Epple et al. (2017), the effective marginal cost of the student is given by the direct marginal cost of instruction and the marginal peer cost (negative for students with ability below the school's average, positive otherwise). The marginal benefit of admitting the student equates the tuition paid and the per student subsidy received by the university, plus the monetary value of the student's contribution to the aggregate achievement at the public university.

For-profit sector. For-profit colleges choose the sticker price and instructional spending per student in order to maximize expected profit. They are non-selective, admitting all students that would like to enroll. Students enrolling in the for-profit sector can receive federal financial aid and may pay a net price lower than the tuition charged by the college.

Denote by $T_{r,i}$ and $I_{r,i}$ the tuition and spending at for-profit college i, where $i = \overline{1,R}$. The tuition schedule for student (a,y,g) at college i is $t_{r,i}(a,y,g,d_{r,i})$, where $d_{r,i} = 1$ if the student enrolls full-time, and zero otherwise. Also, $p_{r,i}(a,y,g;T,Q)$ is the corresponding choice probability of attending the for-profit college. The problem of a for-profit university is (for brevity, we drop the subscript i):

$$\max_{T_r,I_r} \Pi_r = \sum_g \pi_g \int\int t_r(a,y,g,d_{r,i}) p_r(a,y,g;T,Q) f_g(a,y) da dy - N_r(T_r,I_r) I_r - C_r(N_r), \tag{13}$$

subject to identity constraints

$$N_r = \sum_g \pi_g \int\int [d_r(a,y,g) + 0.5(1 - d_r(a,y,g))] p_r(a,y,g;T,Q) f_g(a,y) da dy, \tag{14}$$

$$\overline{a}_r = \frac{1}{n_r} \sum_g \pi_g \int\int a p_r(a,y,g;T,Q) f_g(a,y) da dy, \tag{15}$$

where N_r is the FTE enrollment, $\overline{a}_r$ the average ability, and n_r the size of the student body at the for-profit, given by:

$$n_r = \sum_g \pi_g \int \int p_r(a, y, g; T, Q) f_g(a, y) da dy. \tag{16}$$

Not-for-profit sector. As we focus on the interaction between the public and for-profit institutions, we do not explicitly model the behavior of nonprofit colleges. Thus, the sticker prices and per student spending, denoted $T_{e,z}$ and $I_{e,z}$ for college $z = \overline{1, M}$, are exogenous and based on observed values. However, we model price discrimination in college tuition, which is an important feature of the nonprofit sector (see Epple et al., 2017, 2019). To this end, we estimate different institutional aid functions by ability, income and student group (traditional and non-traditional) for different groups of colleges (see Table A5). Thus, in equilibrium, students enrolled in not-for-profit 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. Consequently, the average ability of the student body, enrollment and resulting quality in the not-for-profit sector are endogenous, determined in equilibrium by student sorting across institutions.

3.3 Equilibrium

The exogenous elements of the model are the relative sizes of the two groups of potential students, π_t and π_{nt}, the joint distributions of ability and income, $f_y(a, b)$, $f_{nt}(a, b)$, the distribution of the preference shocks ϵ_j, the state subsidy s, the tuitions of the public university $\{T_p\}$ and not-for-profit colleges $\{T_{e,z}\}_{z=1}^{M}$, as well as the federal and institutional financial aid functions, $FedAid_j(a, y, g)$ and $InstAid_j(a, y, g)$.

Denote by $J(a, y, g)$ the set of colleges that admit the type (a, y, g) in equilibrium and provide positive utility to the student. Then the conditional choice probability for type (a, y, g) for college j is given by:

$$p_j(a, y, g) = \frac{\exp[u_j(a, y, g)]}{\exp[u_0(a, y, g)] + \sum_{k \in J(a,y,g)} \exp[u_k(a, y, g)]}.$$

Definition 1. *Given the exogenous elements, the equilibrium is a vector of university qualities* $\{q_j\}$*, the tuitions of profit colleges* $\{T_{r,i}\}_{i=1}^{R}$*, enrollments* $\{N_j\}$ *, per student spending* $\{I_j\}$ *, average ability of student body* $\{\overline{a}_j\}$ *, admission functions at public university* $\{\delta_r(a,y,g)\}$ *, and student decisions* $\{d(a,y,g), D(a,y,g,d(a,y,g),\epsilon)\}$ *for all types* (a,y,g)*, corresponding to the conditional probabilities* $p_j(a,y,g)$*, such that, for all* $j \in J$*:*

1) students make the optimal choice, taking as given the university quality and price vectors, the admission thresholds at public and elite not-for-profit schools, and the public policies;

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

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

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

4 Data and Estimation

We calibrate/estimate the parameters of the model in order to reproduce key features of the U.S. higher education sector and student outcomes. Our analysis focuses on 2012-2014, a period when for-profit colleges experienced a relatively steady market share. We model one representative public university, two not-for-profit and two for-profit colleges. Tables 1 and 2 present a summary of the data moments used in calibration, and provide sources.

4.1 Parameters taken directly form the data

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 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.[11] To assess the size of the nontraditional potential student

[11] 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.

population, we consider individuals aged 25-45, who do not hold a college degree and have attained at least ninth grade.[12] We find $\pi_t = 0.35$ 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).[13] Observing the AFQT scores of potential traditional and nontraditional students (individuals over the age of 24, not holding a college degree) 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. A visual representation of the distribution fit is shown in Appendix Figure 1.

Income distributions. To determine the income distributions for traditional and nontraditional students, we take into account the fact that traditional students are "dependent". As such, universities and the federal government consider their parental income when determining financial aid. For the purposes of applying for Federal Student Aid (FAFSA), nontraditional students are considered "independent", and their relevant income is their own (and their spouse's, if married). We therefore use a measure of parental income for traditional students: the family income reported by the head of the household in households with a seventeen year old present. We use data from the 2012-2014 American Community Survey, and adjust for taxes.[14] 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 2).

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

[12] 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

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

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

nontraditional students.[15]

Tuition and instructional spending groups. We use IPEDS data for the 2013 academic year to distinguish between two groups of nonprofit institutions, high and low tuition. We use the median tuition level as the threshold between higher and lower priced colleges, and proceed to find the corresponding average instructional spending in each group. We use the same procedure to create lower/higher tuition groups among for-profit colleges. The lower tuition group is largely comprised of institutions which offer almost exclusively online instruction. For the public institution, we use College Board data on average instructional spending and tuition, distinguishing between the in-state and out-of-state sticker price.

Subsidies. General institutional subsidies from states and local authorities represent a large share of the revenues of public colleges, as illustrated in Figure 1, panel D. Using data from the IPEDS Delta Cost Project, we find the per capita average state, endowment and local appropriations for public four-year colleges.

Non-tuition costs. To quantify non-tuition costs, we use data from the College Board Annual Survey of Colleges, which separately identifies room and board, books and supplies, transportation and other expenses. 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 among students enrolled in exclusively online education. Based on the College Board figures, we also acknowledge the slightly higher non-tuition costs at not-for-profit colleges.

Custodial costs. The cost function for a university with enrollment n_j and instructional costs I_j is:

$$C(n_j, I_j) = F + v_1 n_j + v_2 {n_j}^2 + n_j I_j,$$

where $v_1 n_j + v_2 {n_j}^2 + F$ is a custodial cost function, which captures the fixed costs F (e.g. maintenance of plant) and variable costs that depend on student enrollment, $v_1 n_j + v_2 {n_j}^2$.

To approximate the custodial cost function, we use the IPEDS Delta Cost Project dataset, which provides detailed information on categories of costs for a rich panel of universities. We

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

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 Appendix Table 1.

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.[16] We expect universities differ greatly in cost structures, and we attempt to deal with the underlying heterogeneity by estimating a fixed effects regression, capturing within-university variation in the effect of enrollment on custodial costs.[17] In practice, we estimate

$$C_{tj} = \alpha_j + \gamma_t + c_1 k_{tj} + c_2 k_{tj}^2,$$

where C_{tj} are custodial costs per capita in period t at institution j, α_j is a university fixed effect, γ_t an academic year fixed effect, and k represents university j's market share.

In calibration, we translate these coefficients into the aggregate cost function $C(n_j, I_j)$, with $v_1 = c_1$ and $v_2 = c_2 \sum_{i=1}^{J} k^2$. As other analysts, (Epple et al., 2018; Gordon and Hedlund, 2019), we find it necessary to set $c_1 = 0$ to approximate an increasing cost function. Fixed costs obtained from IPEDS as expenditures for the operation and maintenance of plant category are scaled to be consistent with the university market shares. Coefficients are shown in Table 1.

Federal grants. The Federal 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 (room and board, textbooks) 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, using data from

[16] 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.

[17] Other analysts (Gordon and Hedlund, 2019) have followed a similar fixed effects regression approach. Epple et al. (2006) address cost heterogeneity for not-for-profit colleges by using university endowments as instrumental variables.

the National Postsecondary Student Aid Study: 2012 Undergraduates survey (NPSAS2012), and take into account the cap on the maximum amount of federal financial aid, which stood at 5,500 dollars in 2013. The EFC approximation is shown in Appendix Table 2.

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 3.

State financial aid. We impute the average amount of state financial aid based on NPSAS:2012 for different parental or own income categories for traditional and respectively nontraditional students. Figures are shown in 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). Figures are presented in 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 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.[18]

[18] We run these predictions separately by type of institutional control to capture the fact that some higher education providers, in particular for-profit colleges, have institutional arrangements in place to facilitate stu-

4.2 Jointly determined parameters

The remaining parameters to be calibrated are the parameters of the quality functions $(A_j, \gamma_j, \omega_j)$ for each university type, the parameter β in the achievement function for college graduates, the parameters in the achievement function (B, β_0) for the outside option, the utility weighting parameter α and and the preference parameters $\alpha_{j,g}$.

We normalize the productivity of for-profit colleges in group I ($A_r^I = 1$) and calibrate the productivities of the other types of universities (A_p, A_e^I, A_e^{II}, and A_r^{II}). We also assume that the public and nonprofit institutions have the same achievement function, and set $\gamma_p = \gamma_e$ and $\omega_p = \omega_e$. We allow the quality functions to be different for both groups of for-profit institutions. Thus, we estimate γ_r^I, γ_r^{II} and $\omega_r^I, \omega_r^{II}$.

The preference parameters $\alpha_{j,g}$ are equal across schools for traditional students. We denote them by α_t. Nontraditional students have the same preference parameter $\alpha_{r,nt} = \alpha_t$ when enrolling in for-profit schools, but an additional utility cost of attending public and nonprofit institutions, which predominantly cater to traditional (age 18-24) students. Consequently, $\alpha_{p,nt} = \theta\alpha_{r,nt}$ where $\theta < 1$.

In order to capture 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 independence and diversity associated with going to a different state for the college experience. In equilibrium, a fraction of agents enrolling in the public sector will choose the out-of-state option. As Epple et al. (2018) 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 match better the behavior of the public sector.

We additionally calibrate an admission threshold parameter a^e_{min}, which reflects the minimal ability threshold for admission to Group I nonprofit institutions, which tend to be high tuition, highly selective institutions.

dent access to private loans, and disproportionately serve students who use veteran benefits to finance their education.

Summing up, there are 17 parameters to be calibrated, shown in Table 3. We determine these parameters by minimizing the distance between the target moments in the data and the simulated moments implied by the model. 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 listed in Table 2.

We target the following moments in the data: market shares of different sectors in total enrollment; college market shares within their respective sector (for-profit or nonprofit); enrollment rates of traditional and nontraditional students in different sectors; levels of instructional spending in different sectors; tuition charged by for-profit colleges; the ratio of mean student ability in different sectors and the ratio of predicted achievement of college graduates relative to non-graduates.

We use the following data sources for the 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. Within each sector (nonprofit, for-profit) we calculate Group I market shares as the fraction of full-time equivalent enrollment in Group I relative to the sector overall full-time equivalent enrollment.

Instructional spending and tuition. Per capita instructional expenditure and average tuition by type of institutional control is collected from the Delta Cost Project as an average for the period 2012-2014. The cut-off between low and high tuition groups in the not-for-profit and for-profit sectors is the median level of (sticker price) tuition.

Ability ratios. To proxy the ability ratio of nonprofit and for-profit students, we use the ratio of raw AFQT scores from the NLSY79. To proxy the ability ratio between Group I nonprofit students and public students, we turn to NPSAS:12 (which allows us to identify students attending Group I tuition institutions), and take the average of composite SAT scores for U.S. citizen undergraduates enrolled in four-year bachelor's programs.

College vs. outside option achievement ratio. We calculate the college achievement relative to the outside option as the ratio of the average achievement of all traditional students enrolled in college to the average achievement of those that decide not to enroll. We use the college wage premium at age 30 (in NLSY97 data) as a proxy for this ratio.

5 Results

Table 3 shows the jointly determined parameters. The elasticity of spending per student is lowest in the second (lower tuition) group of for-profit schools, and highest at public and not-for-profit schools.[19] This pattern could reflect fundamental differences in the skills production function across sectors. For example, a larger share of students at for-profit institutions are taking classes exclusively online. The literature suggests that a quality-equivalent online course requires higher per student spending than an on-ground course (Smith and Mitry, 2008). The share of students taking online courses increases as we go down the ranking of for-profit schools. The lower calibrated value of the per student spending effect in for-profit group II institutions, (ω_r^{II}), is in line with the higher share of exclusively online enrollment in these institutions. Another fundamental difference in skills production across sectors comes from instructor training. For-profit colleges employ fewer Ph.D. holding instructors, and are more reliant on part-time and temporary staff. This pattern suggests that increases in instructional spending may not lead to fundamental changes in the quality of instruction at for-profit colleges.

The sensitivity of educational quality to the average ability of students at public schools, γ_p, is similar to that at for-profit institutions in Group I. The parameter is much larger at Group II for-profit universities. The average ability of the student body is significantly smaller at Group II, mostly online, for-profit institutions. The larger peer effect elasticity at Group II institutions suggests that a small increase in the quality of peers can have large effects on program quality.

[19] The value of the spending elasticity parameter for public and not-for-profit schools, 0.194, is close to the value found by Epple et al. (2018), .155.

The estimated values of productivity parameters follow the expected pattern given by the instructional spending ranking. These TFP 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 instructional spending and average student body ability, we expect the TFP ranking to follow the ranking of these two dimensions. Indeed, we find that Group I not-for-profit institutions exhibits the highest productivity, followed by the public sector and the second not-for-profit group. Group II in the for-profit sector exhibits the smallest productivity.

The calibrated elasticity of own ability in the achievement function is larger at the college level than for the outside option ($\beta > \beta_0$). The outside option is largely determined by pre-college education, where other dimensions of human capital formation, such as the human capital of teachers or parents, play a relatively more important role.

Table 4 illustrates model predictions about the 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 the for-profit market shares (targeted moments) as well as the allocation of independent students across sectors (targeted for the for-profit sector). 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 by SAT score. We split the sample into six groups, based on standard deviations of the SAT score. We compare allocations between universities across these groups to allocations among standard deviations of our ability measure. Keeping in mind the differences between the two samples and the two proxies for ability,[20]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, the model captures the fact that high ability students are more likely to enroll in private nonprofit

[20]Our calibration aims to match moments for the entire U.S. population, not just the NPSAS:2012 sample. While SAT scores are highly correlated with the AFQT (the basis for our measure of ability), we do not expect the two distributions to overlap in the overall population, since SAT-taking students are likely positively selected.

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.

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 is again likely a reflection of the complex nature of the admissions process at nonprofit institutions.

5.1 Policy Experiments

Subsidy cut and tuition increase in the public sector

Our first counterfactual analysis considers 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 (d), and are likely to continue in the context of recessionary pressures on state budgets. In the first scenario, we implement a 10 percent subsidy cut at public schools (a per capita cut of 1,030 dollars), coupled with a tuition increase in the same amount. The results are presented in Table 5. The cost increase at public schools leads to a decrease of 0.9 percentage points in the enrollment of traditional students. At the same time, the public school market share for traditional students drops from 59.3 percent to 55.7 percent. The level of instructional spending in the public sector decreases sligthly, from 12 to 11.9 thousand. The public university responds by enrolling a higher share of students paying the higher, out-of-state tuition (an increase from 17.2 to 20.6 percent). The higher tuition tag at public schools does not lead to significant changes in instructional spending or tuition charged by for-profit colleges. However, for-profit colleges capture part of the public market share decrease. In the traditional student market they grow from 4.6 to 5.1 percent, and in the nontraditional market from 25.4 to 27 percent.

The magnitude of the effect of state subsidy cuts on for-profit enrollment is similar to findings by Goodman and Henriques Volz (2020), who estimate that enrollment in the for-profit sector increases about 2 percent for a 10 percent cut in state appropriations. We find a 1.88 percent increase in for-profit overall enrollment for a 10 percent decrease in subsidies.[21]

Subsidy cut and tuition cap in the public sector

In the second counterfactual scenario, illustrated in Table 5, we consider a 10 percent subsidy cut at public institutions, accompanied by a tuition freeze. Not allowing public universities to compensate the subsidy cut by raising tuition leads to a drop in their market share to 55.4 percent.

Public schools respond by significantly decreasing the level of instructional spending, from 12 to 10.7 thousand, and slightly raising out-of-state enrollment — out of state tuition is also capped in this scenario — to 17.3 percent. Group I nonprofit institutions capture a larger share of the market, attracting students who respond to the drop in instructional spending at the public institution. For-profit colleges see notable increases in market share but also raise their tuition and levels of instructional spending, as they are now in a better position to compete with the resource-deprived public school.

Subsidy increase and tuition decrease in the public sector

We consider a policy that supplements subsidies per capita for the public institution by 10 percent (1,030 dollars), allowing it to reduce tuition by an equal amount. This scenario is the reverse of our first counterfactual policy. The increase in overall enrollment is 1.9 percentage points. The market share of the public institution increases from 59.3 to 62.8 percent. Out-of-state enrollment adjusts downward to 14.2%. The subsidy is financed through a 0.52% income tax, and the resulting increase in overall enrollment leads to additional tax revenue needs for Pell Grant beneficiaries, financed through a 0.06% percent direct tax on income.

[21] We reach this figure by dividing the change in for-profit enrollment (Counterfactual I in Table 5) by the change in overall enrollment (traditional+nontraditional), calculated using relative group sizes of 0.35 for traditional and 0.65 for nontraditional.

Pell Grant increases

Increasing Pell Grants has been one of the campaign promises of the Joe Biden administration. Under his plan, the Pell Grant award cap would double. The fourth scenario in Table 5 considers a more modest increase in the Pell Grant cap, from 5.5 to 7.5 thousand dollars, while the fifth scenario shows the effects of a doubling of the Pell Grant maximal award, from 5.5 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 (scenario IV), families with incomes above 70,000 dollars would not benefit from the Pell Grant increase. Under an increase of the maximal cap to 11, families with incomes above 80,000 would remain ineligible. As such, the Pell Grant scenarios have a strong redistributive component, supporting college access mostly for lower income students.

Both counterfactual scenarios result in considerable increases in overall enrollment for traditional as well as nontraditional students. Under a doubling of the Pell Grant cap, enrollment of traditional students increases to as much as 52.4 percent of the cohort.[22] For-profit colleges capture a large share of this increase. The share of traditional students enrolled in for-profit schools increases from under four percent to 8.9 percent under the most generous Pell increase scenario. For-profit colleges see remarkable market share gains in the nontraditional student market, where they grow to 67.2 percent under the Pell doubling scenario. Lower tuition (Group II) for-profit colleges are particularly apt at capturing the Pell Grant surplus, increasing market share by significantly reducing tuition and instructional spending. Their market share increase is largely achieved through higher enrollment of lower-ability students, as indicated by the ability ratio between nonprofit and for-profit student bodies, which increases to 1.17 from 1.09 under counterfactual V, and the college/non-college achievment ratio, which drops from 1.11 to 1.03 under a doubling of the Pell Grant.

Under the more modest Pell Grant increase (counterfactual IV), Group I (higher tuition)

[22] To put this relatively high figure into context, 2013 NCES data indicates that 65.9 percent of recent high school completers enrolled in college in 2013, 42.1 percent in four-year colleges, while 23.8 in two-year colleges. Increased generosity of Pell Grants may lead to higher persistence of entering cohorts, as well as a likely switch from two-year college enrollment (which we model as part of the "outside option" in this paper) to four-year college enrollment.

institutions maintain a relatively high level of tuition and instructional spending, but end up accounting for only 7 percent of the for-profit market. In turn, Group II institutions decrease tuition to only 4.3, attracting more Pell Grant recipients, to whom they provide a very low level of instructional spending, 490 dollars per capita. This 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.

Under counterfactual scenario V, the doubling of the Pell Grant cap, Group I (higher tuition) for-profits emulate the strategy of Group II institutions and implement drastic cuts in tuition to attract Pell Grant beneficiaries. Group I institutions consequently reduce instructional spending per capita to 800 dollars, while Group II institutions spend 700 dollars per capita, but monetize the fact that their students incur lower non-tuition costs on account of the online delivery of instruction, and charge 6.1 thousand in tuition. Under the double Pell cap scenario, lower tuition nonprofit institutions also increase market share in the nonprofit sector, relative to more expensive institutions. Finally, we quantify the supplementary financial effort for a doubling of Pell Grants as a 1.32 percent direct income tax financing public subsidies, in order to account for the increased enrollment at public schools, and a 1.8 percent direct income tax which pays for the Pell Grant increase.

Gainful Employment policy experiment

Our final counterfactual implements a policy that ties access to federal funding to students' debt-to-earnings ratios post-graduation. Our model delivers predictions for loan balances accumulated after one period of enrollment for each student. We forecast loan repayments under a typical 10-year Stafford loan schedule, using a 4 percent interest rate.[23] Wages are forecast as the product of human capital h and shocks ϵ, where $h = q_j a^\beta$, q_j is the institutional quality of for-profit college j and a is the individual ability. We assume $\ln(\epsilon)$ is normally distributed,

[23]This figure corresponds to an average of the Stafford subsidized fixed interest rate, which stood at 3.4 percent in 2012-2013, 3.86 percent in 2013-2014, and 4.66 percent in 2014-2015.

with mean μ and standard deviation σ. We choose μ and σ such that to match the mean and standard deviation of the wages of college graduates in the American Community Survey 2013 (44,360 and 35,493 dollars, respectively). First, we calculate the mean achievement of enrolled students in the baseline model, denoted $\overline{h}$. Thus, we can calculate the mean and standard deviation of the ϵ shocks: μ_ϵ=44.36/$\overline{h}$ and σ_ϵ=35.49/$\overline{h}$. Next, we calculate the mean μ and standard deviation σ for $\ln(\epsilon)$. Given predicted wages and loan repayment schedules, we calculate the debt-to-earnings ratio for one period of enrollment.

The policy scenario we consider is the loss of Pell Grant funding for colleges whose graduates exceed a debt-to-earnings ratio of three percent for the loans accumulated during one year of enrollment.[24] Results are shown in Table 6. In panel A, we illustrate the debt-to-earnings ratios by type of institution. In the baseline simulation, public and nonprofit institutions have ratios below the threshold, while rates at for-profit colleges exceed three percent. Under the gainful employment policy, both for-profit institutions prefer to operate at the cut-off. They reach this level by lowering their tuition considerably, from 17.5 to 6.4 for Group I and from 10.1 to 5 for Group II institutions. At the same time, for-profit colleges also lower instructional spending. Group I for-profit institutions remain profitable at this level, while Group II institutions register a loss, suggesting that, in the long run, these institutions might exit the market under a gainful employment policy. In the short run, however, the effect of the policy is to slightly increase overall enrollment, as more students are attracted to for-profit institutions, whose strategic response to the policy is to lower tuition. While the policy achieves its goal of lowering debt-to-earnings ratios, given that for-profit institutions lower tuition charges, its short run impact on educational quality is negative. For-profit institutions attract lower ability students — as shown by the nonprofit/for-profit ability ratio, which increases to 1.12 from 1.09— to whom they deliver lower levels of instructional spending. In the long run, this negative effect may however be muted by the exit of Group II institutions.

Under the gainful employment scenario, public and nonprofit institutions continue to have debt-to-earnings ratios well below the threshold, although nonprofit Group II institutions are

[24]Gainful employment policies under the Obama administration considered annual debt-to-earnings rates greater than 12% as *failing* rates. Since our analysis considers the loans accumulated during one period of enrollment, we divide 12% by an estimate of four years of full-time enrollment.

at the lower end of the warning "zone" under the Obama administration policy.[25] Interestingly, the gainful employment policy leads to an increase in the debt-to-earnings ratios at public and nonprofit institutions, as students who previously attended for-profit institutions switch sectors, as a result of the decrease in instructional spending and average student body ability at for-profit institutions.

5.2 Welfare Analysis

In Table 6, we compare the aggregate utility of traditional and nontraditional agents across our policy experiments. As some of our counterfactual policies fundamentally aim to reduce societal inequalities and improve outcomes for lower income individuals, we also highlight how the average utility in the lower income group varies across experiments as a fraction of the average utility. Our analysis does not, however, take into account externalities from college attendance, which are likely to be positive (Lochner and Monge-Naranjo, 2011).

Subsidy cuts coupled with tuition increases lead to modest welfare gains compared to baseline. Faced with lower instructional quality and higher prices at public colleges, students reorient towards nonprofit and for-profit colleges, or choose not to enroll. As a result, the average student ability increases at nonprofit colleges and at the public university. The instructional quality decreases slightly at the public and for-profit colleges, but increases in the nonprofit sector. Thus, the welfare gains in the subsidy cut/tuition increase scenario reflect the net peer effect externalities in our model, as students reorienting to nonprofit colleges benefit from higher instructional quality. In conjunction with tuition caps, subsidy cuts have a negative overall effect on the welfare of traditional students. This is likely due to the cuts in instructional spending at public universities, which educate the majority of traditional students. Lower income and nontraditional students however continue to see welfare gains, suggesting that, in their case, the welfare gains from peer effect externalities outweigh losses resulting from lower instructional quality at public institutions.

Subsidy increases coupled with tuition cuts result in across the board small losses in wel-

[25] Debt to earnings rates less than or equal to 8% were considered passing rates, while rates greater than 8% but less than or equal to 12% were deemed "zone" rates. See "Gainful Employment Information", https://studentaid.gov/data-center/school/ge [accessed Jan 4, 2020]

fare. The quality of the public university declines as the spending per student decreases. In addition, the tax increase that finances this policy induces a negative effect on welfare.

Increases in the maximal Pell cap however lead to overall welfare gains, despite a similar tax increase implemented to finance such a policy. These gains are particularly notable for lower income individuals, whose overall welfare increases considerably relatively to the average. This result suggests that Pell Grants may be reaching high ability but income constrained individuals. The Pell Grant experiment however has 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. The increase in enrollment is occurring mostly in low selectivity, low instructional quality institutions. The negative impact on instructional quality translates into lower aggregate welfare in the scenario where the cap on Pell Grants is doubled. Despite much higher levels of college enrollment, the overall welfare increase is smaller than for a Pell Grant cap increase of two thousand dollars (scenario IV). Aggregate welfare is also lowered by the higher level of direct income taxes needed to finance the doubling of Pell Grants. The redistributive effects of a doubling of Pell Grants remain, as expected, particularly strong, and the welfare gains for lower income individuals dominate an increase in the Pell cap of only two thousand dollars. In Table 8, we illustrate aggregate welfare for different categories of students under gradual Pell Grant increase scenarios, from 5.5 to 11 thousand dollars. For traditional students, maximal welfare is reached for an increase to 6.5 thousand, while the welfare of nontraditional students is highest for an increase to 8.5 thousand. Lower income traditional students see the highest gains under a doubling of the Pell Grant, while welfare is highest for a 10.5 increase in the case of lower income nontraditional students.

The Gainful Employment policy leads to lower overall welfare levels relative to the baseline, particularly for lower income individuals, because of the strategic response of for-profit colleges, which reduce instructional spending along with per capita tuition. However, these welfare effects do not account for any welfare gains resulting from lower future loan default rates, which are ultimately the main goal of Gainful Employment policies.

6 Conclusion

The model set up in this paper 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 cost and elasticity parameters for mostly online for-profit institutions indicate their ability to rapidly increase enrollment in response to changing market circumstances.

Our policy experiments consider pressures on state appropriations for public universities, and policy changes to Pell Grant caps and gainful employment requirements. Our counterfactual analyses indicate that further subsidy cuts at public schools are likely to increase the for-profit market share. If these subsidies are implemented in conjunction with tuition increases, our analysis indicates that public colleges are likely to respond by significantly increasing the fraction of students attending out-of-state. In turn, a policy that caps tuition while decreasing subsidies has the similar effect of raising the for-profit market share, but public colleges respond by decreasing instructional spending.

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. However, we find the welfare gains from a doubling of the cap are smaller than those from more modest increases in the Pell Grant cap.

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, for-profit colleges attempt to reach the threshold by lowering average instructional spending, and lower tuition institutions register financial losses, suggesting exits in the long run, which are likely to generate negative shocks to their students. These findings suggest that gainful employment policies should be accompanied by minimal instructional quality standards and contingency plans for students attending bankrupt institutions.

Our model delivers predictions about market share changes for lower tuition not-for-profit institutions, which to some extent compete with for-profit institutions. Further research is needed to investigate the responsiveness of the not-for-profit sector to changes in for-profit levels of tuition. We also hope to extend this model in future work to highlight the role that advertising and online delivery of instruction play in allowing lower-cost for-profit colleges great flexibility in responding to market dynamics.

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Table 1: Model parameters and data sources

Description	Parameter	Value	Source
Relative group sizes			
Traditional	π_t	0.35	ACS
Nontraditional	π_{nt}	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		$ln(y_{nt} + 10.22) \sim N(3.49, 0.71)$	ACS
Income-ability correlations	ρ	0.3	NLSY97
Tuition at public school	T_p	8.9 (in-state) ; 22.2 (out-of-state)	College Board[a]
Public school subsidy per capita	s	10.3	IPEDS
Tuition at nonprofit schools	$T_{e1}; T_{e2}$	$35.4; 14.57$	College Board
Instructional spending, nonprofit	$I_{e1}; I_{e2}$	$18.6; 5.78$	College Board
Nontuition costs[b]	NC	10.25;11.25;7.25	College Board, NPSAS:12
Custodial cost function -public			
	F_p	0.4	IPEDS, estimated
	$c_{1,p}$	0	
	$c_{2,p}$	42	
Custodial cost function -private for-profit Group I	F_r	0.02	IPEDS, estimated
	$c_{1,r}$	0	
	$c_{2,r}$	62.38	
Custodial cost function			IPEDS, estimated
-private for-profit Group II	F_r	0.05	
	$c_{1,r}$	0	
	$c_{2,r}$	8.44	
Federal grants		see Table A2	NPSAS: 12
Federal loans		see table A3	NPSAS: 12
State grants		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.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 for-profit Group II, as we adjust the average non-tuition College Board cost 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).

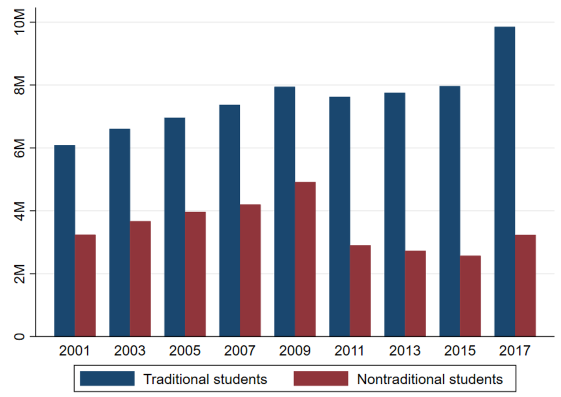
Table 2: Target moments

Target moment	Data	Model
Percentage of traditional students enrolled[a]	28.8	31.06
Market shares		
For-profit, total	10.08	9.53
Public, traditional	69.25	59.3
For-profit, traditional	3.77	4.6
For-profit, nontraditional	28	25.36
Instructional spending, public institutions[b]	10.24	11.98
Ability ratio, nonprofit/for-profit (traditional)[c]	1.1	1.09
Ability ratio, nonprofit Group I/public (tradititional)[d]	1.09	1.13
Relative achievement ratio college/non-college [e]	1.3	1.11
Tuition at for-profit colleges, Group I [f]	18.4	17.45
Tuition at for-profit colleges, Group II	10.9	10.11
Instructional spending, for-profit Group I	5.5	4.98
Instructional spending, for-profit Group II	2.7	2.9
% enrolled in Group I out of total for-profit enrollment[g]	25	23
% enrolled in Group I out of total nonprofit enrollment	70	61.04
% of public students attending out-of-state[h]	15	17.17

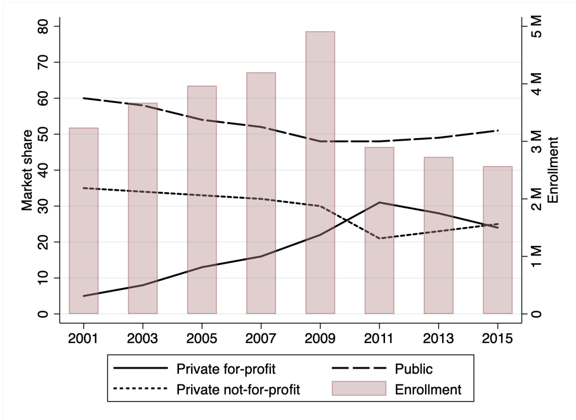
Notes: a. Enrollment market shares by type of student and type of institution are based on NCES Digest of Education Statistics, Tables $dt15\_302.60$ and $dt15\_303.50$. b. Instructional spending values are obtained from the Delta Cost Project as the average for 2012-2014. c. NLSY97 data, based on AFQT scores of students enrolled in four-year colleges. d. To proxy the ability of students enrolled in group I nonprofit institutions, we use 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. e. The achievement ratio is proxied using NLSY97 data on the wage gap at age 30 between college degree holders and non-degree holders. e. Delta Cost project, average tuition for the 2012-2014 period. f. 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 2013. g. NPSAS:12

Table 3: Model parameters

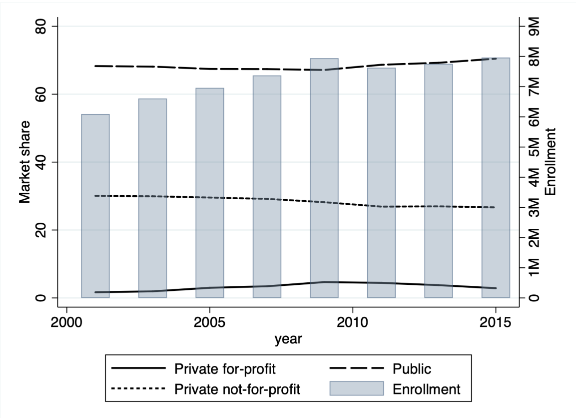
Quality function public school		
Productivity	A_p	1.096
Peer effect elasticity	γ_p	0.209
Spending elasticity	ω_p	0.194
Quality function nonprofit school		
Productivity, Group I	A_e^I	1.167
Productivity, Group II	A_e^{II}	1.008
Quality function for-profit schools		
Peer effect elasticity, Group I	γ_r^I	0.282
Spending elasticity, Group I	ω_r^I	0.058
Peer effect elasticity, Group II	γ_r^{II}	0.765
Spending elasticity, Group II	ω_r^{II}	0.059
Productivity, Group II	A_{pr}^{II}	0.628
Individual ability elasticity (college)	β	0.488
Individual ability elasticity (outside option)	β_0	0.340
Productivity parameter (outside option)	B	2.465
Utility weighting parameter	α	7.110
Utility cost (nontraditional students)	θ	0.964
Out-of-state preference parameter	ν	1.018
Admission threshold, non-profit Group I	a_{min}^e	2.708



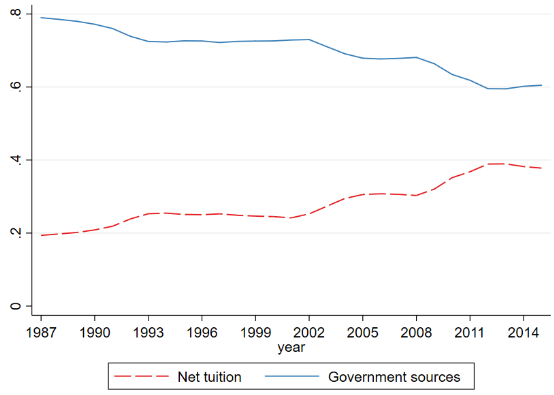
(a) Traditional and nontraditional student enrollment



(b) Market share, nontraditional students



(c) Market share, traditional students



(d) Public university revenue sources over time

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 1: Trends in the four-year college market

Table 4: Model fit- market shares by ability and income

	Data			Model		
	Public	Private nonprofit	Private for-profit	Public	Private nonprofit	Private for-profit
A.Enrollment						
Dependent	69.2	27.0	3.8	59.3	36.1	4.6
Independent	50.0	22.1	27.9	56.8	17.9	25.4
B. SAT/Ability distribution[a]						
Dependent						
<-1	69.7	23.8	6.5	78.3	15.4	6.2
[-1,0)	73.6	23.7	2.7	73.0	21.1	5.9
[0,1)	71.2	27.7	1.1	52.7	38.3	4.3
[1,2)	63.2	36.1	0.7	48.1	48.5	3.3
>2	42.5	57.3	0.2	47.6	49.5	2.9
Independent						
<-1	57.0	14.6	28.3	64.6	6.2	29.2
[-1,0)	62.7	17.6	19.7	64.3	7.1	28.6
[0,1)	69.5	17.2	13.4	56.0	19.0	25.0
[1,2)	61.0	23.7	15.2	50.9	26.4	22.7
>2	78.1	14.9	7.0	49.3	28.6	22.1
C. Income distribution						
Dependent						
$0-30$	70.8	23.9	5.3	71.6	24.5	4.0
$30-50$	67.6	28.9	3.5	71.3	23.9	4.8
$50-70$	70.4	27.2	2.4	63.8	31.1	5.1
$70-100$	69.9	28.7	1.4	55.4	39.5	5.1
>100	67.1	32.0	0.9	47.7	48	4.3
Independent						
$0-30$	56.4	17.8	25.8	60.4	3.4	36.2
$30-50$	49.4	17.8	32.8	65.5	7.4	27.1
>50	46.4	27.7	25.9	53.6	23.2	23.3

Notes: *a*. Panel B compares the distribution of standardized SAT scores by institutional control, obtained from NPSAS:2012, with the model predictions on the distribution of 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 analyses

Moment	Baseline	Counterfactuals[a]				
		I	II	III	IV	V
		Subsidy cut & Tuition increase	Subsidy cut & Tuition cap	Subsidy increase & Tuition decrease	Pell Cap increase	Pell Cap doubled
Enrollment, traditional (%)	31.1	29.2	29.4	33.0	38.2	52.4
Enrollment, nontraditional (%)	5.2	4.9	4.8	5.4	10.9	18.2
Market shares						
For-profit, total enrollment	9.5	10.3	10.3	8.8	26.1	31.8
Public, traditional students	59.3	55.7	55.4	62.8	57.9	56.9
For-profit, traditional students	4.6	5.1	5.0	4.2	7.9	8.9
For-profit, nontraditional students	25.4	27.0	27.5	24.1	60.4	67.2
Instructional spending, public	12.0	11.9	10.7	12.0	11.7	10.6
Achievement ratio, college/non-college	1.1103	1.1129	1.1011	1.1063	1.0682	1.0263
Ability ratio, NFP/FP (traditional)	1.0945	1.0947	1.0942	1.0942	1.1925	1.1734
Ability ratio, NFP Group 1/ Public	1.1335	1.1300	1.1333	1.1373	1.1459	1.1748
Tuition, for-profit I	17.47	17.37	17.57	17.50	15.50	4.76
Tuition, for-profit II	10.12	10.04	10.24	10.16	4.28	6.10
Instructional spending, FP I	4.98	4.95	5.01	4.99	4.38	0.79
Instructional spending, FP II	2.91	2.88	2.94	2.92	0.49	0.70
FP1 share of total for-profit enrollment	23.0	22.9	23.1	23.0	7.0	17.0
NFP1 share of total nonprofit enrollment	61.2	60.8	61.3	61.5	56.0	47.4
Out-of-state enrollment, public	17.2	20.6	17.3	14.2	14.0	8.5
Tax financing additional subsidies (%)	-	-	-	0.52	0.44	1.32
Tax financing Pell Grant increase (%)	-	-	-	0.06	0.39	1.80

Notes: a. Counterfactual I 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 II, a 2,000 subsidy cut at public institutions is coupled with a tuition freeze. Counterfactual III implements a 2,000 subsidy increase, along with a tuition decrease in the same amount. Counterfactual IV is a 2,000 dollar increase in the upper Pell Grant limit, from 5,500 to 7,500. Counterfactual V is a doubling of the Pell Grant cap to 11,000 dollars.

Table 6: Counterfactual analysis — Gainful employment

	Baseline	Gainful Employment
A. Simulated debt-to-earnings ratios		
Public	0.0173	0.0184
Nonprofit, Group I	0.0098	0.0159
Nonprofit, Group II	0.0183	0.0206
For-profit, Group I	0.0365	0.03
For-profit, Group II	0.0328	0.03
B. Main moments		
Enrollment, traditional (%)	31.1	32.7
Enrollment, nontraditional (%)	5.2	6.6
Market shares		
For-profit, total	9.5	19.1
Public, total	59.3	55.4
For-profit, traditional	4.6	10.7
For-profit, nontraditional	25.4	41.6
Instructional spending, public	12.0	12.0
Achievement ratio, college/non-college	1.11	1.08
Ability ratio, NFP/FP (traditional)	1.09	1.12
Tuition, for-profit I	17.5	6.4
Tuition, for-profit II	10.1	5.0
Instructional spending, FP I	5	2.6
Instructional spending, FP II	2.9	3.0
Enrollment share, for-profit I	23	23.3
Enrollment share, nonprofit I	61.2	61.4
Out-of-state enrollment, public	17.2	17.4

Notes: a. Counterfactual I involves a 2 ,000 dollar decrease in per capita subsidies at public universities coupled with an equal increase in public school tuition per capita. Counterfactual II concerns a 3,000 dollar increase in the upper Pell Grant limit, from 5,500 to 8,500. Counterfactual III is a 3,000 dollar decrease in per capita subsidies.

Table 7: Welfare analysis

	Baseline	Subsidy cut, tuition increase	Subsidy cut, tuition cap	Subsidy increase, tuition cut	Pell cap increase 8.5k	Pell cap doubled	Gainful employment
All							
Traditional	100	100.0067	99.9732	99.8813	101.1943	101.0279	99.8425
Nontraditional	100	100.0201	100.0210	99.8379	106.0915	105.9052	99.8371
Lower income, 0-30							
Traditional	100	100.0815	100.0268	99.9365	105.2945	106.3943	99.6601
Nontraditional	100	100.0208	100.0131	99.9706	113.7257	114.5007	99.7665
Ratio low income to overall welfare							
Traditional	76.31	76.37	76.35	76.35	79.40	80.36	76.17
Nontraditional	78.61	78.61	78.61	78.61	84.27	84.99	78.56

Notes: Values for overall welfare are normalized to 100 for the baseline scenario. The ratio of low income to overall welfare represents the ratio of average welfare of lower income agents (0-30,000 dollars) to overall average welfare. The counterfactual scenarios are illustrated in tables 5 and 6.

Table 8: Pell Grant increase scenarios, aggregate welfare changes

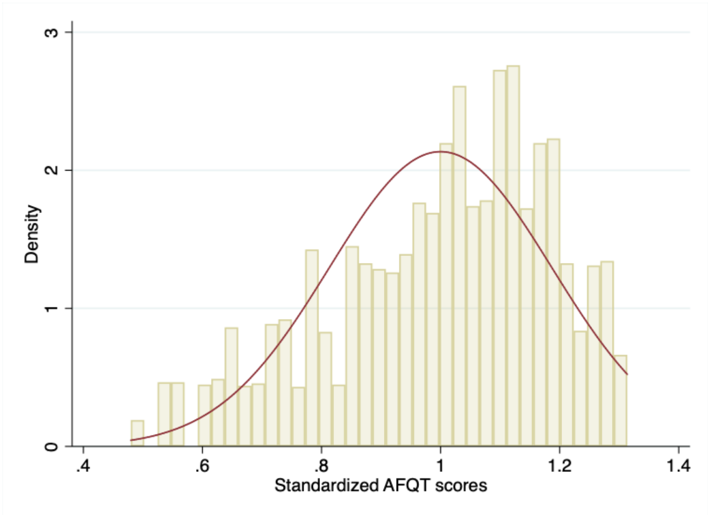
Pell Grant	All		Lower income[a]	
Cap	Traditional	Nontraditional	Traditional	Nontraditional
5.5 (baseline)	100	100	100	100
6.5	**101.27**	105.97	105.21	113.23
7.5	101.19	106.09	105.29	113.73
8.5	101.12	**106.13**	105.46	114.10
9.5	101.07	106.11	105.73	114.37
10.5	101.06	106.04	106.22	**114.59**
11	101.03	105.91	**106.39**	114.50

Notes: a. Lower income defined as 0-30 thousand dollars.

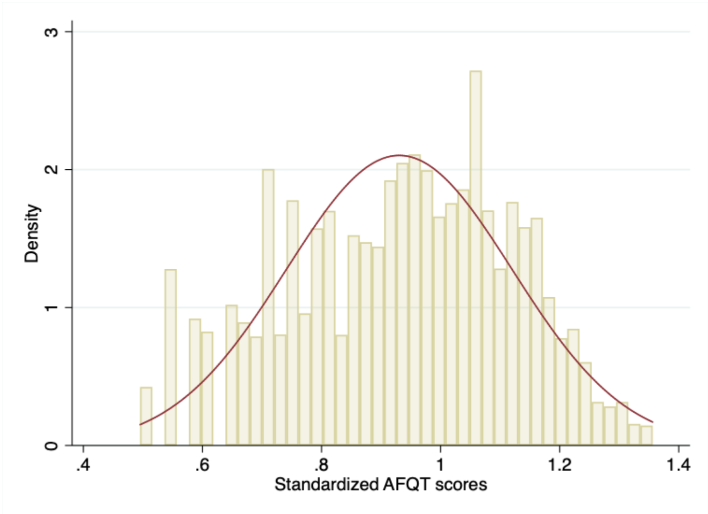
Appendix

A Additional tables and figures

A. Traditional students



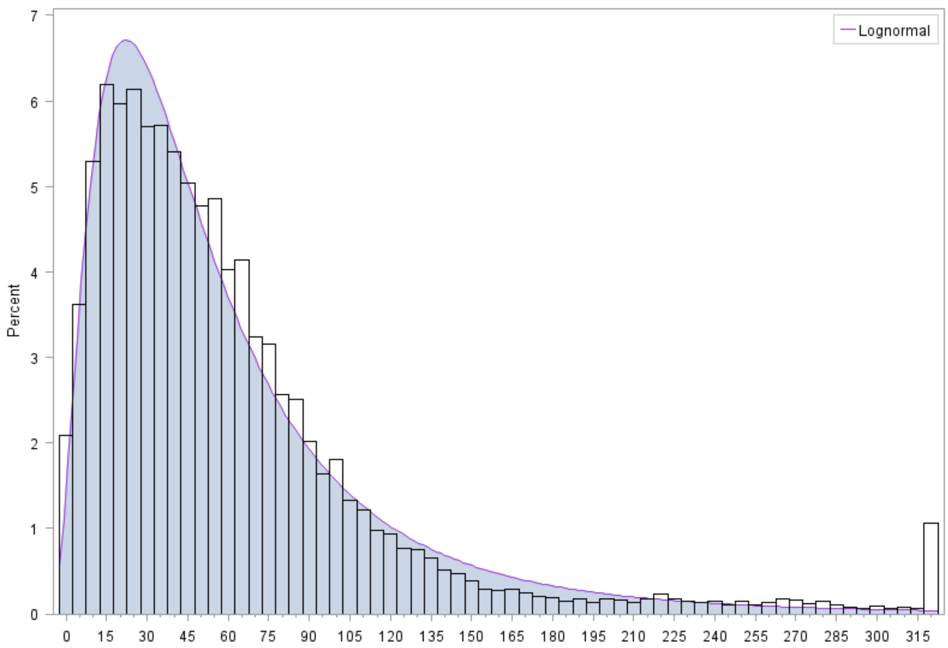
B.Nontraditional students



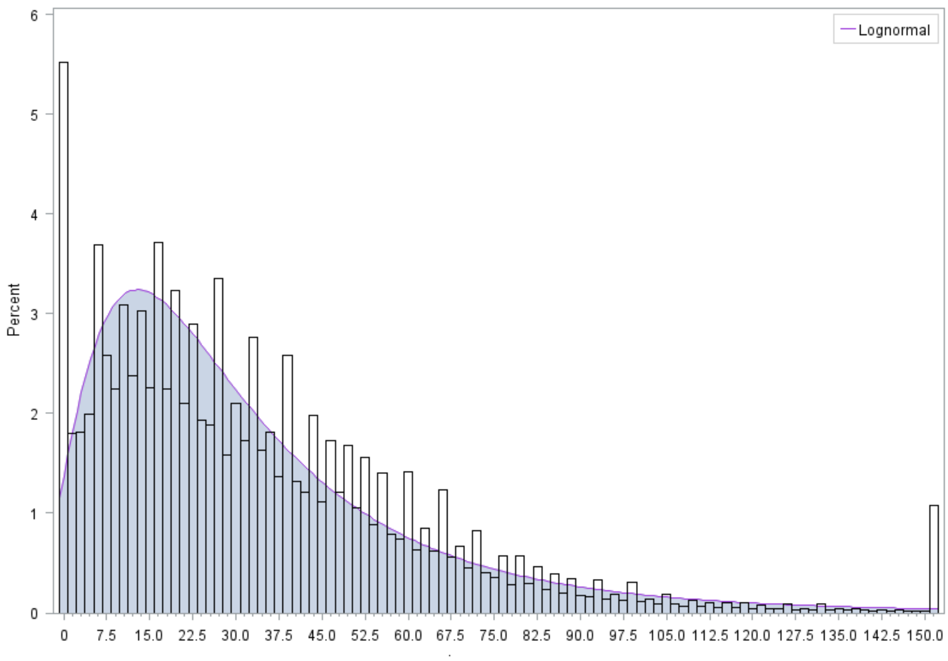
Notes: National Longitudinal Survey of Youth 1997, Armed Force Qualifications Test (AFTQ) data standardized to mean 1. Normal distribution fit. .

Figure A1: Ability prediction

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 A2: Income prediction

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

Source: IPEDS, balanced panel of institutions 1996-2002, Carnegie Classification 31-33.

Table A2: EFC prediction

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 predictions

	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

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 prediction, nonprofit schools

	Group I, High tuition		Group II, Lower tuition	
	Intercept	Income coefficient	Intercept	Income coefficient
(type of student/ ability group)				
Traditional, <-1	14.70	-0.037	4.868	-0.002
	(2.41)	(0.02)	(0.71)	(0.007)
Traditional, [-1,0)	14.69	-0.021	5.923	-0.001
	(0.69)	(0.005)	(0.622)	(0.006)
Traditional, [0,1)	14.67	-0.018	6.043	-0.0002
	(0.56)	(0.003)	(0.59)	(0.007)
Traditional, [1,2)	17.57	-0.028	9.136	-0.018
	(0.96)	(0.005)	(2.46)	(0.0158)
Traditional, >2	21.94	-0.056	8.966	-0.022
	(2.97)	(0.016)	(4.1)	(0.02)
Nontraditional, <-1	8.637	-0.035	2.998	-0.067
	(1.96)	(0.0437)	(0.939)	(0.037)
Nontraditional, [-1,0)	8.866	-0.054	2.967	-0.042
	(2.056)	(0.169)	(0.654)	(0.0152)
Nontraditional, [0,1)	8.301	-0.087	2.807	-0.033
	(2.690)	(0.141)	(0.873)	(0.016)
Nontraditional, [>1)	12.880	-0.111	2.523	-0.046
	(5.08)	(0.35)	(1.327)	(0.038)

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, 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, predictions

	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.

B Computation of equilibrium

1. Pick starting values for the enrollment and mean ability of the student body at all institutions (five in total), instructional spending at the public 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 utilities for all colleges. Given the net costs, we check whether the student affords to attend. For each college j, we compare the utilities from enrolling full time and part time and choose the largest of the two. In the case of the public university, we check whether the student is admitted or not.

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

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

5. Calculate the utility levels 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.