January 2016

Essays on University Competition

Zachary George Davis
Purdue University

Graduate School Form
30 Updated 12/26/2015

PURDUE UNIVERSITY
GRADUATE SCHOOL
Thesis/Dissertation Acceptance

This is to certify that the thesis/dissertation prepared

By Zachary George Davis

Entitled

Essays on University Competition

For the degree of Doctor of Philosophy

Is approved by the final examining committee:

Kevin J. Mumford
Co-chair

John M. Barron
Co-chair

Justin L. Tobias

Brian Roberson

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Approved by Major Professor(s): Kevin J. Mumford and John M. Barron

Approved by: Justin L. Tobias 7/27/2016

Head of the Departmental Graduate Program Date

ESSAYS ON UNIVERSITY COMPETITION

A Dissertation

Submitted to the Faculty

of

Purdue University

by

Zachary G. Davis

In Partial Fulfillment of the

Requirements for the Degree

of

Doctor of Philosophy

August 2016

Purdue University

West Lafayette, Indiana

ACKNOWLEDGMENTS

I'd like to thank my co-chairs, Kevin Mumford and Jack Barron. My work greatly benefited from their guidance. I'd also like to thank my other committee members, Justin Tobias and Brian Roberson, who provided invaluable advice. I also would like to thank Xiaoxiao Li, Hajime Shimao, and Evan Totty for many valuable discussions.

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ABSTRACT

Davis, Zachary G. PhD, Purdue University, August 2016. Essays on University Competition. Major Professors: Kevin J. Mumford and John M. Barron.

The dissertation is comprised of two independent chapters on competition between universities and how government policy changes the nature of the competition. The first chapter looks at how in-state tuition effects competition between public and private four year universities. The second chapter looks at how federal aid effects the behavior of individual for-profit universities, and estimates the effect of a rule change on the amount of federal aid revenue collected by for-profit universities.

In the first chapter, I note that universities use institutional aid to discriminate between students of differing abilities. I estimate that public universities provide $107 of aid per ACT point on average, while private universities provide $238 of aid per ACT point on average. In public sector universities, in-state and out-of-state students are offered similar amounts of institutional aid per ACT point. However, private universities use institutional aid to discriminate between in-state and out-of-state students, providing in-state students approximately twice as much institutional aid per ACT point than out-of-state students. Since students pay the same tuition at private universities regardless of their home state, this location based discrimination is surprising. I develop a general equilibrium model populated with heterogeneous educational institutions to explain why private universities price discriminate in favor of in-state students. The model shows that a low in-state tuition and student preferences for staying in their home state supports private, but not public, universities offering lower net prices to in-state students as an equilibrium. I then illustrate how the model can be used to evaluate public policy changes, such as changes in public tuition policies and changes in state subsidies to public universities. The model pre-

dicts that decreasing a public university's in-state tuition causes the private university in the same state to decrease enrollment which increases the average ability of their student body. The overall effect of the tuition decrease causes the share of low ability students attending a university to increase.

In the second chapter, I investigate the effect of the Higher Education Opportunity Act (HEOA), passed in 2008, which reauthorizes the Higher Education Act of 1965. The HEOA relaxed the 90/10 rule, which requires for-profit institutions to receive at least ten percent of their revenue from non-federal sources, on for-profit institutions by revoking federal aid eligibility after two years of violating the rule instead of one year, which went into effect in 2010. When submitting regulatory compliance reports, postsecondary institutions are allowed to bundle together different campuses. I study the effect disallowing bundling would have on the number of for-profit campuses, and the effect of the rule change on for-profit institution bundling behavior and the amount of federal aid revenue received by for-profit institutions. I find that students at for-profit institutions more federal aid after the rule change, even after accounting for demographic changes. I create a theory comparing for-profit institution bundling behavior under the two different violation rules. I find that for-profit institutions increase the size of the bundles under the two year violation rule, which I also observe in the data. I find that unbundling the campuses approximately doubles the number of one year violations though the number of two year violations remains roughly the same. Before the rule change in 2010, the majority of one year rule violators where bundled with other campuses. I also estimate the amount of federal aid revenue for-profit institutions receive with and without the rule change. I find that for-profit institutions receive almost one billion dollars more federal aid revenue under the two year violation rule, which is about 4.5 percent more than they would have received under the one year violation rule.

1. DISCRIMINATION BY LOCATION: UNIVERSITY PRICING BEHAVIOR AND IN-STATE TUITION

1.1 Introduction

The nature of competition between universities remains elusive. Universities value revenue and their students' average academic ability, and tuition generates much of their revenue. The supply of academically exceptional students is finite, unfortunately, so universities must compete for the best and the brightest. To attract the best and the brightest, universities offer a discount from their posted tuition called institutional aid. The tradeoff between student ability and revenue may depend on whether the university is publicly or privately owned. Universities also have access to each student's family's financial records, allowing universities to price discriminate by income. While price discrimination by ability and income are both well known and well studied features of the higher education market, universities also price discriminate by a student's state of origin.

On average, I estimate that public universities provide \$107 of institutional aid per point on the ACT[1]. Private universities provide \$238 of aid per point on the ACT. Allowing aid per ACT point to vary by a student's location, public universities still provide about \$107 of aid per ACT point to both in-state and out-of-state students. Private universities favor in-state students, providing them \$295 of aid per point as opposed to only \$166 of aid point to out-of-state students.

Both public and private universities discriminate by location. Though public universities do not use institutional aid to discriminate by location, they explicitly post a lower tuition for in-state students. The lower in-state tuition is set by the

[1]Throughout this paper, I use the ACT instead of the SAT. Universities accept both, though some prefer one to the other. In recent years, the same number of students are taking the ACT and the SAT.

state, which funds public universities using state tax revenue. On the other hand, private universities have no apparent incentive to discriminate by location, yet they provide more institutional aid per ACT point to in-state students. In my paper, I use the National Postsecondary Student Aid Study to provide robust empirical evidence that private universities price discriminate by location using institutional aid. I then develop a general equilibrium model to explain why private universities discriminate by location.

General equilibrium models of the higher education market have recently become popular. Both Epple et al. (2013) and Fu (2014) develop general equilibrium models to study the effects of different public policies on the competition between universities for students. As in Epple et al. and Fu, my model includes both public and private universities competing for students across states. My model differs from Epple et al. (2013) by allowing public universities to set out-of-state tuition and to provide institutional aid to students. Fu (2014) does not allow universities to choose institutional aid, since she is more interested in studying the students university choice. Since I am interested in university price setting behavior, I allow public and private universities to choose the amount of aid provided to each type of student. In my model, universities choose institutional aid amounts, which vary by ability and are allowed to differ between in-state and out-of-state students. Public universities post the tuition for out-of-state students, but state governments exogenously set the in-state tuition. Private universities post one tuition that applies to all students, regardless of where they live. There is no explicit incentive for a private university to favor one student over any other based solely on the student's home state.

The universities I study are all non-profit institutions. Presumably, non-profit institutions do not maximize profits, so it is unclear what to include in a university[2] objective function. Horwitz and Nichols (2007) identifies four categories of non-profit firm objectives, which are firm output maximization, market output maximization,

[2]The literature on non-profit institutions focuses mostly on the healthcare industry, but the models are general enough in most cases that they can be applied to the higher education industry.

profit maximization [3], and a combination of firm output and profit maximization. Firm output and market output objectives generally are constrained to make zero profit, and maximize some combination of quantity and quality of output. Profit maximizing non-profit institutions maximize profit, though profit accrues to the administration of the non-profit firm as increased salaries, nicer offices, and other perks. Epple et al. (2013) specifies universities as firm output maximizers, with each university maximizing the quality of the student body. Fu (2014) specifies universities as maximizing both firm output and profit. I follow Fu (2014)'s lead, and universities in my model maximize both the student body quality and profit.

Student preferences explain why private universities discriminate in favor of in-state students. Applying to universities involves more than just a financial cost. Fu (2014) estimates that applying to the first university costs about $1,900 while applying to the second costs about $900.[4] My model assumes that students apply only to two universities to account for application costs. The students decide to which two universities to apply based on their preferences. Some students want to stay near home, so they only apply to universities in their home state. Some students want small class sizes and engaged professors. These students apply only to private universities, since private universities are generally much smaller than publics. Some students want access to the resources provided by a large state school. These students apply only to public universities.

With these three groups, in-state applicants to a private university are a mix between students who want to stay near home and students who want small class sizes. Out-of-state applicants to a private university just prefer smaller class sizes. Due to state governments setting a low in-state tuition, some of the in-state applicants are willing to attend a significantly lower priced option. The out-of-state applicants alternative options are not as cheap as in-state applicants, since private universities are generally more expensive. To compete for the in-state students, the private university

[3] Horwitz and Nichols (2007) call this the "for-profit in disguise" theory.

[4] She finds the marginal cost of applying decreases in the number of applications sent, suggesting economies of scale.

offers in-state applicants a lower price. A lower price could be set by offering in-state students the same lump sum discount, but universities value high ability students; so private universities use institutional aid to compete with public universities for in-state students.

In section 1.2, I provide robust empirical evidence that private university discriminate by location using institutional aid. I then develop a theoretical model in section 1.3 that uses in-state tuition and student preferences to explain location discrimination in private universities. Apart from explaining location based discrimination in private universities, my model includes an exogenously set in-state tuition at public universities. In recent years, state governments have decreased the funding at public universities, allowing those universities to increase in-state tuition. Figure 1.1 shows the average in-state tuition in states with Big Ten universities from 1995 to 2009. The pricing hierarchy remained relatively constant until the early 2000's, when states began allowing universities to increase their in-state tuition. For example, Minnesota and Illinois used to have some of the least expensive in-state public universities. Now they are among the most expensive. The general equilibrium effects of changing in-state tuition are not well understood, and I address this question in section 1.4.

There, I provide general equilibrium comparative static results for a decrease in one state's in-state tuition. My model predicts that an decrease in tuition increases the share of low ability students attending a university and decreases the share of middle and high ability students attending a university. The public university in which the tuition decrease occurs also decreases the amount of institutional aid per ability it awards students, causing an increase in their share of in-state students but a decrease in the average ability of their student body. The private university in the state that decreased public in-state tuition responds to their competitor's tuition decrease by increasing their sticker price tuition and the amount of institutional aid per ability awarded to its students. Their share of in-state and out-of-state students decreases, but the average ability of their student body increases. The tuition decrease also directly impacts the other state's public university, causing it to increase their out-of-state tuition and increase the amount of institutional aid per ability awarded to its out-of-state students. Their share of out-of-state students decreases, but the average ability of the out-of-state students increases. I also provide comparative static results for a decrease in one state's subsidy per in-state student subsidy, and an increase in demand for higher education. Section 1.5 provides concluding remarks and extensions.

1.2 Empirical Findings

My paper focuses on the private university's pricing response to public in-state tuition, but my model must also explain other aspects of the higher education market. Students in the model choose which university to attend. Universities in the model choose tuition as well as institutional aid. Other researchers have already investigated related topics.

Long (2004) studies how in-state tuition effects a student's choice of university. She finds that with in-state tuition, 71 percent of four year students attend the public university. Without state support, only 56 percent of four year students would attend the public university and enrollment would increase at two year colleges. She also finds evidence that decreasing in-state tuition incentivizes students to attend the cheaper public university, even if the private option offers more educational resources. Her paper provides evidence that state educational policy effects a student's choice of university, though she does not investigate how universities might respond if states cease controlling in-state tuition.

Other papers study how state or federal financial aid effects a student's desire to attend a university.[5] They find that merit based financial aid programs, such as the Georgia HOPE scholarships, tend to increase enrollment and need based aid programs, such as Pell grants, have little to no effect on enrollment. These studies do not address the role institutional aid plays in the student's decision process, though

[5]See Angrist (1993), Angrist and Chen (2011), Kane (1995), Dynarski (2003), Dynarski (2002), Dynarski (2000), Singell et al. (2006) and Monks (2009) for further discussion.

they do suggest that offering merit aid is a more effective recruitment strategy than offering need based aid. My theory accounts for the role of institutional aid by allowing institutional aid to depend on a student's ability, but not their income.

Hurwitz (2012) estimates that an additional \$1000 of institutional aid increases the probability the student will attend that university by 1.66 percentage points. The elasticity he estimates varies by income. The probability low income students (<\$50,000) attend a university increases by 3 percentage points in response to an additional \$1000 of institutional aid, while the probability high income students (≥\$250,000) attend increases by about 1 percentage point. Curs (2008) conducts a similar study on the effect of merit based aid at the University of Oregon. He finds that a \$1000 increase in merit aid increases an in-state student's enrollment probability by 6.8 percentage points. The same increase in merit aid increases an out-of-state student's enrollment probability by only 2.5 percentage points. He also finds that need based grants have little effect on enrollment probability. Hurwitz and Curs's results demonstrate that students respond to institutional aid offers.

The model I create must also explain tuition. Rizzo and Ehrenberg (2004) study the causes of tuition and enrollment fluctuations at public universities. They identify state demographics/institutional characteristics, sources of institutional aid, sources of student financial aid, enrollment pressure, and school quality/competitive position as possible sources of tuition and enrollment fluctuations. Using institutional and state level data, they regress state need-based grant aid, in-state tuition, out-of-state tuition, and the nonresident share of students on their list of sources. They find evidence that public universities use out-of-state students to increase the student body quality rather than supplement revenues. Curs and Dar (2010) ask whether pricing strategies respond to changes in state financial aid policies. Using panel data, they estimate how state level grants effect public tuition, private tuition and institutional grant aid, controlling for federal grants, different measures of institutional revenue, enrollment, and demographic variables. They find that federal grants tend to increase both tuition and institutional aid amount. State appropriations decrease tuition and institutional aid, and university investment income increases tuition and institutional aid. The empirical research on tuition setting behavior focuses on pricing responses to state and federal aid, but not public sector in-state tuition.

Understanding tuition setting behavior requires state or institutional level data, at a minimum. Institutional level data from the Integrated Postsecondary Education Data System (IPEDS) is free, publicly available, and widely used. Student level data, however, is necessary to understand how institutional aid varies between students. Epple et al. (2003), Doyle et al. (2009), and Doyle (2010) all use the National Postsecondary Student Aid Study (NPSAS), containing data on individual students and their financial aid awards. Epple et al. (2003) regress institutional aid on SAT score, GPA, income, and state and race variables. They interact each with a dummy variable for private universities, and a dummy for low ranked universities. They find that institutional aid is unresponsive to SAT at top ranked schools, but top ranked schools do respond to GPA by increasing institutional aid by about $690 per GPA point. Doyle et al. (2009) study how institutional aid responds to Pell Grants and state grants, as well as income and ability, in public four year universities. They find institutional aid increases with ability and decreases with income, and that public universities tend to complement state aid policies. Doyle (2010) estimates a similar equation as Doyle et al. (2009), using a series of NPSAS releases[6]. Estimating the equation separately for each year, he finds a shift towards rewarding merit and away from funding need. My theory considers only student ability, not income, and Doyle's observation that universities are shifting toward merit aid supports that choice.

1.2.1 Data

I conduct my analysis using the National Postsecondary Student Aid Study (NPSAS) and the Integrated Postsecondary Education Data System (IPEDS). The NPSAS contains demographic and financial information on individual students enrolled in a

[6]He uses the 1992-1993, 1995-1996, 1999-2000, and 2003-2004 NPSAS releases

university, including financial aid awards. I use the 2003-2004, 2007-2008, and 2011-2012 NPSAS releases to estimate my model. Epple et al. (2003), Doyle et al. (2009), and Doyle (2010) all use earlier waves of the NPSAS from the 1990's. Only Doyle (2010) uses the 2003-2004 NPSAS, which is the most recent data he uses but the earliest data I use. I use the IPEDS to calculate mean tuition of the different types of universities.

In the NPSAS, I restrict my sample to public and private non-profit four year universities that are selective. There are three measures of selectivity: minimally selective, moderately selective, and very selective. Selectivity is calculated using a combination of the 25th and 75th SAT and/or ACT percentiles and the university admittance rate.[7] I estimate my model for each different selectivity category, since very selective universities may have a different aid policy than minimally selective universities.

My dependent variable is a student's institutional aid. I am interested in how universities differ in their aid packages to in-state versus out-of-state students, so I include both merit and need based aid, as well as work-study and athletic aid in my measure of institutional aid. I do not include loans made by the institution, since those must be paid back by the student.

Table 2.2 shows the summary statistics. Comparing the percent of students with aid between in-state and out-of-state students in private universities, the discrimination favoring in-state students is already apparent. A higher percentage of in-state students get aid in private universities. It isn't surprising to see public universities providing more aid to out-of-state students, but it is surprising to see private universities favoring in-state students.

My main independent variable is the student's ACT score. The 2008 and 2012 NPSAS contain a derived ACT score. The derived score is the actual ACT score, if the student took the ACT, or it is the ACT equivalent if the student took the SAT. The 2004 NPSAS does not contain a derived ACT score, but it does contain the

[7]The selectivity measure was developed for the IPEDS.

actual ACT and SAT scores for students who took those tests. I impute the ACT score in 2004 by regressing the ACT score on the SAT verbal and math scores. I use the coefficients from that regression to impute the 2004 ACT scores for students who only have SAT scores. Dropping the 2004 NPSAS from the regression does not effect the qualitative results. I drop all students without an ACT score from the regressions (Jones, 1996).

The NPSAS contains data on whether the student pays in-state or out-of-state tuition at public universities. I consider every student that pays in-state tuition as being an in-state student, even if they are not from the same state as their university. For private universities, I consider a student to be in-state if their university is in the student's home state. Previous studies have accounted for lump sum differences in aid between in-state and out-of-state students. I interact the student's in-state status with the sector of their university as well as their ACT score, which allows me to observe differences between how public and private universities reward ability between in-state and out-of-state students.

When applying to a university, potential students submit their ACT score, high school GPA, a writing sample, and letters of recommendation. In addition, students filing a Free Application for Federal Student Aid (FAFSA) let universities know their financial situation. In all specifications, I've included most of the demographic characteristics universities use in determining the institutional aid award, but I have excluded the university's own tuition and the students high school GPA. I exclude tuition from the controls, since universities choose tuition and institutional aid simultaneously in my theoretical model. Including tuition does not change the result. Unlike the ACT score, high school GPA is difficult to compare across students from different high schools. Also, high school GPA signals dependability as well as ability. Including high school GPA as a control complicates the interpretation of the ACT score's marginal effect by distributing the effect of academic ability on institutional aid across multiple variables.

1.2.2 Methodology

I regress institutional aid on student ACT scores interacted with their university's sector and whether they they are in-state or out-of-state. My specification is:

$$\begin{aligned} Aid_{ij} &= \beta_0 + \beta_1 ACT_{ij} \cdot PubIn_{ij} + \beta_2 ACT_{ij} \cdot PubOut_{ij} \\ &+ \beta_3 ACT_{ij} \cdot PrivIn_{ij} + \beta_4 ACT_{ij} \cdot PrivOut_{ij} \\ &+ \beta_5 PubOut_{ij} + \beta_6 PrivIn_{ij} + \beta_7 PrivOut_{ij} + Controls_{ij} + \varepsilon_{ij} \end{aligned} \quad (1.1)$$

Here, Aid_{ij} is the amount of institutional aid provided to student i at school j, ACT_{ij} is student i's derived ACT score and $PubIn$, $PrivIn$, $PubOut$, and $PrivOut$ are indicators for public in-state students, private in-state students, public out-of-state students, and private out-of-state students, respectively. Gender, race, income, dependency status, expected family contribution (EFC), school selectivity, year, and total enrollments are included as controls.

In equation 1.1, I am interested in how a student's ability effects a university's institutional aid award decision but many students do not receive any institutional aid. I cannot exclude those students receiving no institutional aid, though, because that will bias my estimates. In the model, we assume Aid_{ij} has a randomly distributed component, ε_{ij}. Suppose the only difference between two students with a relatively low ACT score is that one student received institutional aid, while the other did not. For students with relatively low ACT scores, including only the ones who have received aid will bias our estimates downward. If students with high ACT scores generally receive some aid, their error terms will be independently and identically distributed since none would be excluded. Students with low ACT scores do not receive aid as often as high ACT score students, so only including those receiving some aid excludes students in the lower tail of the error term's distribution. Models observing only large shocks for observations on one part of the sample decrease the slope of the line if the slope is positive, as it is in this case, and negatively biases the OLS estimator.

Also, in the case of some students, the university might be willing to admit low ACT students if those students paid a price higher than the posted tuition. Offering a negative amount of institutional aid would accomplish this goal, but a university's advertised tuition is the highest price they are able to charge. Since negative institutional aid may be desirable but impossible and the OLS estimator is likely negatively biased by students not receiving any institutional aid, I follow Epple et al. (2003), Doyle et al. (2009), and Doyle (2010) in treating institutional aid as censored data, and interpret Aid_{ij} as a function of the latent variable Aid^*_{ij}:

$$Aid_{ij} = \begin{cases} Aid^*_{ij} & \text{if} \quad Aid^*_{ij} \geq 0 \\ 0 & \text{if} \quad Aid^*_{ij} < 0 \end{cases} \tag{1.2}$$

Aid^*_{ij} can be interpreted as the institutional aid amount a university would like to award a student if they were able to charge more than the advertised tuition. I estimate equation 1.1 using a Tobit model to account for the censored data.

Tobit model estimates can be reported three different ways: the partial effects of the ACT interaction terms on $E(Aid^*_{ij}|controls_{ij})$, the effect on the latent variable, $E(Aid_{ij}|Aid_{ij} > 0, controls_{ij})$, the effect on the conditional expectation, and $E(Aid_{ij}|controls_{ij})$, the effect on the unconditional expectation.

I interpret the Tobit estimates using the conditional expectation. Since universities cannot award negative institutional aid, interpreting the effect on the latent variable is meaningless. Furthermore, I am only interested in how the ACT effects university institutional aid award decisions. Using the unconditional expectation to interpret the partial effects gives weight to students who did not receive any aid from the university. The appropriate measure of the ACT score's marginal effect on institutional aid is the conditional expectation.

In my theoretical model, the university chooses the posted tuition and institutional aid. Choosing the institutional aid is equivalent to choosing the marginal effect of the ACT score. In my model, I do not allow any portion of the ACT distribution to receive zero aid, and the conditional marginal effect captures this aspect of my model best.

1.2.3 Empirical Results

Table 1.2 reports the OLS estimates as well as the latent and conditional Tobit estimates. Tables 1.3, and 1.4 report only the conditional Tobit estimates. The marginal effects of the ACT score on institutional aid without considering location are reported in columns 1, 2, and 3 in table 1.2. The OLS estimates public universities offer $128.4 of aid per ACT point on average, while private universities offer $345.6 per point. The latent variable Tobit estimates that publics provide $439.8 per ACT point and privates provide $434.3 per point. Conditional on the student receiving some aid, I find that public universities offer $107.3 of aid per ACT point and private universities offer $237.6 of aid per point.

Both the OLS and the latent variable Tobit marginal effects are larger than conditional marginal effects, which is true for all specifications. The latent variable assumptions in the Tobit model allow the university to offer negative aid, increasing the slope estimates as discussed above. For this reason, I prefer the conditional marginal effects calculated using the latent Tobit estimates. Since the Tobit is nonlinear, calculating the marginal effects requires the other independent variables to be fixed at some value. The conditional marginal effects in tables 1.2, 1.3, and 1.4 are calculated at the means of the other independent variables. The OLS estimates are closer to the conditional marginal effects than the latent variable Tobit estimates, but are still larger because I calculate the conditional marginal effects at the means of the other independent variables.

The marginal effects of the ACT score on institutional aid allowing universities to discriminate by location are in columns 4, 5, and 6 in table 1.2. Conditional on a student receiving some aid, public universities provide $105.5 of aid per ACT point to in-state students and provide $102.7 of aid per point to out-of-state students. Private universities provide $294.5 per ACT point to in-state students and $166 of aid per ACT point to out-of-state students. The difference between in-state and out-of-state marginal effect of the ACT score are found in the Difference row. The

\$128.5 difference between in-state and out-of-state aid offers at private universities is evidence that they favor in-state students, and is statistically different from zero and economically large.

Columns 4, 5, and 6 in table 1.2 include all selective universities, but selectivity varies across institutions. Table 1.3 estimates equation 1.1 for each selectivity separately as well as for the subsample of dependent students.[8] Though the magnitude of the marginal effects change across specifications, it is always the case that private universities provide more aid to in-state students. Very selective universities favor in-state students the most, providing them \$125.3 more than out-of-state students per point on the ACT. Moderately selective universities favor in-state students the least, providing them \$65.04 of aid per ACT point. Restricting the sample to only the dependent students, private universities provide in-state students \$146.9 more than out-of-state students per ACT point. The difference between aid offers to in- and out-of-state students at private universities is not only large, but statistically significant. The difference in aid offers at public universities is relatively small, changes sign across specifications, and is not statistically significant.

The conditional marginal effects are calculated at the means of the control variables, but it could be that private universities aid offers to in- and out-of-state students could vary depending on the student's level of income or their ACT score percentile. Figures 1.2 and 1.3 graph the ACT score's marginal effect on aid as the ACT percentile varies and as the student's income varies, with 95 percent confidence intervals for each estimate. In both figures, the ACT score's marginal effect on aid for in-state students at private universities is larger than for out-of-state students. Figure 1.2 shows that as the ACT percentile increases, so does the marginal effect of the ACT score on institutional aid. Figure 1.3 shows that as the student's income percentile increases, the ACT's marginal effect slightly decreases.

Table 1.4 contains conditional marginal effects of the ACT score on aid for the four census regions. Public universities in each of the regions have no consistent pattern

[8]Dependent students are still claimed as dependent by their parents when filing taxes.

as to whether they favor in-state or out-of-state students with aid per point on the ACT. In the west, public universities provide $59.23 more to in-state students per ACT point while public universities in the northeast provide out-of-state students with $50.19 more in aid per ACT point than in-state students. Across regions in the private universities, the only statistically significant difference between in-state and out-of-state aid per ACT point is in the northeast. Northeastern private schools provide $235.2 more in aid per ACT point to in-state students. Discrimination in favor of in-state students is still large in the south, as southern private universities provide about $63.52 more to in-state students than out-of-state students, though the difference is not statistically significant. The result that private universities favor in-state students is driven mostly by universities in the northeast. The majority of all private universities are on the eastern seaboard, mostly in the northeast, so this result is not surprising. The difference between the point estimates in private universities are consistently negative across regions, while public universities show no pattern.

The empirical evidence showing private universities offering more aid to in-state students is robust to alternative specifications. I now develop a theoretical model to explain this phenomenon and address comparative static questions.

1.3 Theory

While the higher education market is subject to regulations and receives subsidies from both the state and federal governments, the market also includes a rigorous application process with multiple decisions on both the student's and the university's parts. Fu (2014) notes a complete model would endogenize tuition, applications, admission, enrollment, and financial aid but such a model would complicate the empirical analysis to the point of intractability. In her model, both private and public universities endogenously set tuition but institutional aid is exogenously determined. Tuition is determined by a university's relative preference for student ability over profit and by students expected utility for that particular university.

Epple, Romano, and Sieg have developed a model of the higher education market[9] endogenize financial aid by letting universities perfectly price discriminate.[10] But these papers leave applications exogenous and do not differentiate between private and public universities. Their 2008 paper is similar to their previous work, except they investigate racial diversity in higher education by allowing universities to distinguish between two types of students in their objective function. Epple et al. (2013) builds on the previous versions of their model by differentiating between public and private universities and and setting them in multiple states. In the 2013 model, public universities choose a minimum ability threshold for admissions but their tuition is set exogenously, and private universities choose tuition subject to an exogenous upper limit.

Another aspect of the Epple, Romano, and Sieg model is that students include both tuition and quality of the university in their utility function, where quality of the student body and expenditure per student determine the overall quality of the university. Fu (2014)'s approach differs in that student utility from attending a university is stochastic. In Fu's approach, the mean of the distribution can be interpreted to include the student's perception of the university's quality. Fu's approach allows more flexibility interpreting how students value each university, and my model will follow her lead in this respect.

My primary goal is to investigate the effects of state level tuition policies on institutional aid choices at public and private schools. My approach is similar to the approach of Epple et al. (2013), though I allow public universities to set out-of-state tuition. In my model, universities choose their student population by pricing undesirable students out of their institution. I also abstract away from the application process by assuming that if a student applies, they will be admitted, and applying is

[9]See Epple et al. (2002), Epple et al. (2003), and Epple et al. (2006).

[10]Epple and Romano published papers in 1998 and 2002 modeling the secondary education market, investigating the effects of educational vouchers. The model based on their 1998 paper is significantly different than their higher education market model. Besides the differences in public policy at the secondary and post-secondary educational levels, their 1998 model has private high schools maximizing profit, instead of quality.

costly. States provide subsidies to public universities for each in-state student that enrolls. Since I am focusing on effects of state level tuition policy, state and federal student aid does not play a significant role in my analysis. I include only institutional aid in my model. Both Turner (2012) and Turner (2014a) provide empirical evidence that universities respond to federal student aid by decreasing institutional aid, and Epple et al. (2013) develop a theoretical framework in which universities capture federal student aid by increasing tuition. Additionally, I do not include the state as an actor in my model, aside from exogenously setting in-state tuition. Groen and White (2004), Fethke (2005), and Fethke (2006) all include preferences of a state government in their analyses of university price setting, focusing on the strategic interaction between the two institutions in setting a public universities price.

1.3.1 Environment

My model exists in a world containing two states, denoted by $s \in \mathscr{S} = \{1, 2\}$. Each state has two universities, one of which is public, q, and the other private, r, and has a population of potential students. These populations are of equal size, and the students have a nonattendance option, n. The set of universities (and the nonattendance option) in state s is $J_s = \{q_s, r_s, n_s\}$, and an element of J_s is denoted j_s.

1.3.2 Students

The student population has unit mass in each state. Students have three different levels of ability in each state, so that $\alpha^s_\ell \in A^s = \{\alpha^s_1, \alpha^s_2, \dots, \alpha^s_m\}$ is a student's ability. The set A^s is ordered so that $\alpha^s_{i+1} > \alpha_\ell$. Ability can be interpreted a few different ways. It could be a composite score of how desirable a student is to a university, or just a single measurement of ability such as a student's ACT score or their GPA.

To maintain a consistent interpretation with my empirical results and to follow Fu (2014)[11], I interpret α_ℓ^s as tertiles of student's ACT scores.

Each student has five possible choices. While a student in state s can go to any university in either state, they can only choose the nonattendance option in their home state. Since submitting an application is costly, each student applies only to two universities. There are three types of student preferences that determine to which universities they apply.

Some students want to stay close to home so they apply to universities in their home state. The proportion of the home state only set, $S_s = \{n_s, q_s, r_s\}$, is denoted by $\tau_S^{\alpha_\ell^s}$. I allow the proportion to vary by state and ability level, so the subscript indicates the student preference while the superscript indicates the state and ability of the student.

Other students only want to attend a private university, so they apply to the two private options. I denote set of students applying only to private universities as $R_s = \{n_s, r_s, r_{s'}\}$ where $s \neq s'$. The proportion of private university only students is $\tau_R^{\alpha_\ell^s}$.

The final group only want to attend a public university, so they apply to two public options with a choice set of $Q_s = \{n_s, q_s, q_{s'}\}$ where $s \neq s'$. The proportion of public university only student$\tau_Q^{\alpha_\ell^s}$.

The set of student's university choice sets for each state is:

$$K_s = \{S_s, R_s, Q_s\} \tag{1.3}$$

An element of $k_s \in K_s$ is one of the three student preference sets. A specific university in a students choice set is denoted as $j_s \in k_s$. Figure 1.4 illustrates the application sets for the different types of students in each state. The encircled options denote the set of university to which that particular student set of students applies. Each student set also has the outside option, but since the outside option doesn't require an application, it is not included in figure 1.4.

[11]In her paper, Fu (2014) uses three different ability levels. I follow her example here.

In defining the student preferences, I have excluded preferences like an out-of-state only group in which students from state s would apply only to universities in state s'. While there is undoubtedly a set of students with these preferences, the model's primary goal is to explain the differential institutional aid offers between in-state and out-of-state students at private universities. If I included an out-of-state only group, both in-state and out-of-state students are applying to both of the public and private universities in the same state. I argue that because in-state students are apply to both public and private universities, the private university competes for these students by offering them a lower net price using higher institutional aid. If I include the out-of-state only group, I would observe the same pricing behavior in the private university. Since in-state students receive a relatively and significantly larger tuition reduction at the public university compared to the private university, the institutional aid gap between in-state and out-of-state students would still exist, though the magnitude might be smaller. Since the out-of-state only group would not change the private university pricing behavior, and would only serve to complicate an already complex model, I exclude the out-of-state only group from the model.

I also exclude preferences in which students apply to more than two schools. I exclude these preference sets for the same reason I exclude the out-of-state only group; it would complicate an already complex model. Another way to think about excluding certain preferences is that I am assuming the proportion of students holding those preferences equals zero. In my numerical solution to the model, I assume that 62 percent of students have in-state only preferences, and that 19 percent of students have either public or private university only preferences. I choose these proportions to mirror the fact that about 80 percent of students choose to study in their home state, and my analyses are not sensitive to small changes in these proportions. In the proportions I have chosen, there is a large quantity of students for whom the public and private universities are directly competing. If there were few students applying to both the public and private universities in their home state, private universities would not need to provide in-state students a discount since those student's other option is an equally high priced private university. I want to emphasize that competing for in-state students drives the institutional aid difference between in- and out-of-state student in private universities, so I assume that the only preferences in my model are those in equation 1.3.

Each university has an associated price, $P_{j_s}(\alpha_\ell^v)$ where $s \in \mathscr{S}$ is the university's state and $s' \in \mathscr{S}$ is the student's state, and an associated utility, $u_{j_s}(\alpha_\ell^{s'})$. Both the price and the utility a student faces at each option varies along two different dimensions, their home state and their ability. Students from different states with the same ability may face a different set of prices or derive different amounts of utility depending on the location of the university. This feature allows me to capture in-state pricing effects and student geographic preferences. Similarly, students of differing abilities from the same state may face different prices and also may value attending those universities differently.

The student i's utility for option $j_s \in k_s$ is:

$$U_{j_s}(\alpha_\ell^s) = \delta_{k_s} \ln \left(u_{j_s}(\alpha_\ell^s) - P_{j_s}(\alpha_\ell^s)\right) + \epsilon_{i,j_s} \tag{1.4}$$

where ϵ_{i,j_s} is a student's idiosyncratic preference for attending university j or nonattendance, and δ_{k_s} is a student preference specific scaling parameter. The price of nonattendance is normalized to zero. The student's maximization problem is

$$\max_{j_s \in k_s \in K_s} \quad U_{j_s}(\alpha_\ell^s) \tag{1.5}$$

I assume that ϵ_{i,j_s} are independently and identically distributed according to the Type 1 Extreme Value distribution.[12] Solving the student's maximization problem yields the probability that a student i chooses option $j_s \in k_s$ is:

$$\gamma_{j_s,k_s}^{\alpha_\ell^s} = \begin{cases} 1 & \text{if} \quad \frac{(u_{j_s}(\alpha_\ell^s) - P_{j_s}(\alpha_\ell^s))^{\delta_{k_s}}}{\sum_{j_s \in k_s} (u_{j_s}(\alpha_\ell^s) - P_{j_s}(\alpha_\ell^s))^{\delta_{k_s}}} > 1 \\ \frac{(u_{j_s}(\alpha_\ell^s) - P_{j_s}(\alpha_\ell^s))^{\delta_{k_s}}}{\sum_{j_s \in k_s} (u_{j_s}(\alpha_\ell^s) - P_{j_s}(\alpha_\ell^s))^{\delta_{k_s}}} & \text{if} \quad \frac{(u_{j_s}(\alpha_\ell^s) - P_{j_s}(\alpha_\ell^s))^{\delta_{k_s}}}{\sum_{j_s \in k_s} (u_{j_s}(\alpha_\ell^s) - P_{j_s}(\alpha_\ell^s))^{\delta_{k_s}}} \in [0,1] \\ 0 & \text{if} \quad \frac{(u_{j_s}(\alpha_\ell^s) - P_{j_s}(\alpha_\ell^s))^{\delta_{k_s}}}{\sum_{j_s \in k_s} (u_{j_s}(\alpha_\ell^s) - P_{j_s}(\alpha_\ell^s))^{\delta_{k_s}}} < 0 \end{cases} \tag{1.6}$$

[12]Epple et al. (2013) assume student's idiosyncratic preference shocks take the Type 1 Extreme Value distribution. The distributional choice is convenient because it implies smooth demand functions in a multivariate choice problem.

Equation 1.6 can also be thought of as the demand function for university j_s from students in preference group k_s.

1.3.3 Universities

There is no consensus about how to specify a university's objective function. The majority of universities are non-profit organizations,[13] and there are many theories about the form a non-profit firm's objective function may take in the literature.[14] The most common choice of objective function has the university maximizing educational quality. Epple et al. (2006), Epple et al. (2003), Epple et al. (2013), and Chade et al. (2013) all use some measure of educational quality while Epple and Romano (1998) uses a standard profit function to characterize private secondary schools. Groen and White (2004) use both educational quality and revenue, but investigate each separately. Fu (2014) includes both profit and educational quality in her objective function, and my model follows her lead.

The price universities charge students has two components, the tuition and the institutional aid. I assume the price a student pays, $P_{j_s}(\alpha_\ell^v)$, takes the functional form

$$P_{j_s}(\alpha_\ell^{s'}) = t_{j_s}^{s'} - b_{j_s}^{s'}\alpha_\ell^{s'} \tag{1.7}$$

where $t_{j_s}^{s'}$ is the tuition set by the university, and $b_{j_s}^{s'}\alpha_\ell^{s'}$ is the total institutional aid the university grants to student with ability α_ℓ^v living in state 1. Both public and private universities choose separate $b_{j_s}^{s'}$ parameters depending on whether $s = s'$ or not. Allowing different $b_{j_s}^{s'}$ parameters enables universities to discriminate between in- and out-of-state students. Public universities are able to choose out-of-state tuition, $t_{j_s}^{s'}$ when $s \neq s'$, but the state government sets the in-state tuition, $t_{j_s}^{s'}$ when $s = s'$.

[13] Deming et al. (2012) documents the recent increase in the share of enrollments at for-profit schools. From 2000 to 2009 the share of enrollments increased from about 4% to nearly 11%. While the share is increasing, it is still relatively small. It is unlikely that the for-profit universities are competing with the more selective four year universities for students.

[14] See Horwitz and Nichols (2007) and Malani et al. (2003) for summaries of the theories. Though most reference the healthcare industry, they also apply to universities

Though nothing prevents private universities from setting different tuitions for in-state and out-of-state students, they generally set one price for everyone.[15] Private universities set the same tuition for in-state and out-of-state students, or $t^{s'}_{j_s}|_{s=s'} = t^{s'}_{j_s}|_{s\neq s'}$.

The theory is designed to model the long run equilibrium. Universities choose the tuition and institutional aid variables simultaneously, and the model is static. Other theories of the education market incorporate the application-admission-matriculation sequence. Since I am only interested in state policy effects on long run university pricing decisions, the form of state educational policy has not changed[16] and the pricing decisions I observe span eight years,[17] it is unnecessary to model the yearly matching process.

The university welfare function in my model is:

$$\begin{aligned}\Pi_{j_s} = &\sum_{\alpha^{s'}_\ell|s=s'} (\theta^{\alpha^{s'}_\ell}_{j_s} \cdot \alpha^{s'}_\ell + P_{j_s}(\alpha^{s'}_\ell) - c_{j_s} + \rho^{s'}_{j_s})(\tau^{\alpha^{s'}_\ell}_{\mathscr{S}} \gamma^{\alpha^{s'}_\ell}_{j_s,\mathscr{S}_s} + \tau^{\alpha^{s'}_\ell}_{X_s} \gamma^{\alpha^{s'}_\ell}_{j_s,X_s}) \\ &+ \sum_{\alpha^{s'}_\ell|s\neq s'} (\theta^{\alpha^{s'}_\ell}_{j_s} \cdot \alpha^{s'}_\ell + P_{j_s}(\alpha^{s'}_\ell) - c_{j_s} + \rho^{s'}_{j_s})(\tau^{\alpha^{s'}_\ell}_{X_s} \gamma^{\alpha^{s'}_\ell}_{j_s,X_s}) - F_{j_s} \qquad (1.8)\end{aligned}$$

where c_{j_s} is the university specific cost parameter, F_{j_s} is a university specific fixed cost, $\theta^{\alpha^{s'}_\ell}_{j_s}$ are parameters on the university's preference for ability, $\rho^{s'}_{j_s}$ is the per student state subsidy for a student, and $X_s \in \{Q_s, R_s\}$. Since private universities do not receive state subsidies directly, $\rho^{s'}_{j_s} = 0$ in private universities ($j_s = r_s$). Public universities only receive state subsidies for in-state students, so $\rho^{s'}_{j_s} > 0$ only when $s = s'$. The ability parameters, $\theta^{\alpha^{s'}_\ell}_{j_s}$, allow different marginal benefits of increasing the university's share of each different ability level. Since universities have both fixed costs and endowments, F_{j_s} can be negative or positive. I normalize $F_{j_s} = 0$ since I am interested in university pricing decisions, not entry and exit decisions. The objective function incorporates a nonlinear preference for student ability as well as profit. Fu

[15]It could be the case that private universities give a lump sum discount that favors either in-state or out-of-state students.

[16]The form of state support has not changed drastically over the years I observe though the level of state support may have, especially between 2008 and 2012.

[17]I observe data in 2004, 2008, and 2012.

uses nonlinear preferences for ability, and my functional form is similar to hers. She also includes a nonlinear preference for profit, which I do not include.

An important feature of the university welfare function, Π_{j_s}, is that it takes the same form for universities in both sectors. This differs from Epple et al. (2013) since public university tuition and institutional aid is set exogenously in their model, while private universities have an exogenous tuition cap and choose institutional aid. While the parameter values in my model may differ between the sectors and universities, the functional form cannot by itself explain why private universities favor in-state students when awarding institutional aid. The difference emerges from student preferences for universities. University j_s competes with a different set of universities, depending on whether the student is in-state or out-of-state. For example, take the private university in state 1, university r_1. For in-state students, university r_1 believes some portion of those students want to stay in state 1. The in-state student's choice set is either $\{n_1, q_1, r_1\}$ or $\{n_1, r_1, r_2\}$, and if a large enough portion of students want to stay in their home state, r_1's main competitor is the in-state public university q_1. For out-of-state students, university r_1 believes those students prefer to attend a private university. The choice set for those students is $\{n_2, r_1, r_2\}$, with r_2 competing directly with r_1 for those students. Since university r_1 has a different set of competitors depending on the student's home state, they may offer different prices to in-state and out-of-state students. Since in-state tuition is substantially lower than tuition at private universities, in-state tuition drives this difference.

The public university's maximization problem is:

$$\max_{\{t_{j_s}^{s'}, b_{j_s}^{s'} | s \neq s'\}, \{b_{j_s}^{s'} | s = s'\}} \Pi_{q_s} \tag{1.9}$$

and the private university's maximization problem is:

$$\max_{\{b_{j_s}^{s'} | s \neq s'\}, \{b_{jk} | s(i,j)=1\}, t_{j_s}^{s'}|_{s \neq s'} = t_{j_s}^{s'}|_{s=s'}} \Pi_{r_s} \tag{1.10}$$

Now, I will define and discuss the equilibrium.

1.3.4 Equilibrium

The exogenous components of my model are:

1. The number of students, and the proportion of students holding preferences for home, private or public universities
2. The set of universities, $J_s = \{q_s, r_s\} \forall s \in \mathscr{S}$
3. The set of student utility for each university, $\{u_{n_s}(\alpha_\ell^{\alpha_\ell^s}), u_{j_s}(\alpha_\ell^s)\} \forall j_s \in k_s \in K_s$
4. The distribution of ϵ_{i,j_s} for $j_s \in k_s \in K_s$, and the distribution of α_ℓ^s
5. The forms of the student utility function and the university welfare function,
6. The parameters $\theta_{j_s}^{\alpha_\ell^{s'}}$, ρ_{j_s}, c_{j_s}, and $t_{q_s}^{s'}|_{s=s'} = T_{q_s}^s$, the in-state tuition.

An equilibrium is defined as a set of tuition and institutional aid parameters $\{t_{j_s}^{s'}, b_{j_s}^{s'} | s = s' \cup s \neq s'\} \forall j_s \in J_s$ and student choice probabilities, $\gamma_{j_s,k_s}^{\alpha_\ell^s}$, that maximizes public university's welfare subject to the constraint $t_{q_s}^{s'}|_{s=s'} = T_{q_s}^s \forall s \in \mathscr{S}$, maximizes private university's welfare subject to the constraint $t_{j_s}^{s'}|_{s \neq s'} = t_{j_s}^{s'}|_{s=s'} \forall s \in \mathscr{S}$, and maximizes student's utility.

The first order condition (FOC) with respect to $t_{j_s}^{s'}$ when $s \neq s'$ for a public university is:

$$\frac{\partial \Pi_{j_s}}{\partial t_{j_s}^{s'}} = \sum_{\alpha_\ell^{s'} | s \neq s'} \tau_{Q_s}^{\alpha_\ell^{s'}} \gamma_{j_s,Q_s}^{\alpha_\ell^{s'}} + (\theta_{j_s}^{\alpha_\ell^{s'}} \cdot \alpha_\ell^{s'} + P_{j_s}(\alpha_\ell^{s'}) - c_{j_s} + \rho_{j_s}^{s'}) \tau_{Q_s}^{\alpha_\ell^{s'}} \frac{\partial \gamma_{j_s,Q_s}^{\alpha_\ell^{s'}}}{\partial t_{j_s}^{s'}} = 0 \quad (1.11)$$

Public universities do not have an in-state tuition FOC, since it is set by the state. Private universities choose one tuition variable for both in- and out-of-state students, so the private tuition FOC is summed over $\alpha_\ell^{s'}$ when $s = s'$ and when $s \neq s'$. I have included the state subsidy, $\rho_{j_s}^{s'}$, in equation 1.11 even though the state subsidy is nonzero only for in-state public university students, whose tuition is set exogenously.

The FOC for a public university when $s \neq s'$ with respect to $b_{j_s}^{s'}$ is:

$$\frac{\partial \Pi_{j_s}}{\partial b_{j_s}^{s'}} = \sum_{\alpha_\ell^{s'} | s \neq s'} -\alpha_\ell^{s'} \cdot \tau_{Q_s}^{\alpha_\ell^{s'}} \gamma_{j_s,Q_s}^{\alpha_\ell^{s'}} + (\theta_{j_s}^{\alpha_\ell^{s'}} \cdot \alpha_\ell^{s'} + P_{j_s}(\alpha_\ell^{s'}) + \rho_{j_s} - c_{j_s}) \frac{\partial \gamma_{j_s,Q_s}^{\alpha_\ell^{s'}}}{\partial b_{j_s}^{s'}} = 0 \quad (1.12)$$

While equation 1.12 is the FOC for out-of-state students, the FOC for in-state students is similar except that there are two summed proportion and demand terms, $\tau \cdot \gamma$. Private universities have an FOC with respect to $b_{j_s}^{s'}$ as in equation 1.12, except that R_s is substituted for Q_s. The state subsidy, ρ_{j_s}, is nonzero only in the public in-state university's FOC with respect to $b_{j_s}^{s'}$, though I have included it in equation 1.12 for completeness. It is useful to note that $\frac{\partial \gamma_{j_s,Q_s}^{\alpha_\ell^{s'}}}{\partial t_{j_s}^{s'}}$ and $\frac{\partial \gamma_{j_s,Q_s}^{\alpha_\ell^{s'}}}{\partial b_{jk}}$ are both functions of utility values and prices.

Due to the nonlinearity of $\gamma_{j_s,X_s}^{\alpha_\ell^{s'}}$, a closed form solution for the twelve choice variables does not exist. Also, there are multiple equilibria depending on the relationship between the parameters. Using the NPSAS and the IPEDS, I have data on the tuition, institutional aid variables, cost per student, and state subsidies per student, as well as ACT score data. I treat these as known, and use three student ability levels. The parameters $\{u_{j_s}(\alpha_\ell^s)\}$ and $\theta_{j_s}^{\alpha_\ell^{s'}}$ are unknown. I construct a reasonable set of parameters that support the observed price variables as an equilibrium. Tables 1.5 and 1.6 contains the parameters I use to calibrate my model.

First, I calculate student utility parameters. In the model, each student chooses between three options. For simplicity, I will call these options $\{u_0, u_1, u_2\}$ with associated prices $\{p_1, p_2\}$ and $p_0 = 0$. The prices are known. I treat the share of students, $\{s_0, s_1, s_2\}$, in each school as known and used the NPSAS to calculate the shares. The shares differ across the three preference types of students, and I've set them to be symmetric across states. Shares can be seen in table 1.5. I also treat u_0, the utility of the outside option, as known.[18] When calculating the share of students in each group choosing the outside option, I use the number of students attending a two year public college and interpret the outside option as students attending a two year college. I have set the value of the outside option to be the same for each student regardless of their type or ability.

[18]The utility of the outside option can also be viewed as the average surplus a student receives from choosing the outside option.

Table 1.5 shows what percentage of students of each type choose the three possible options. I calculate these percentages for three ability levels using the NPSAS. The ability levels are the average ACT score for the bottom, middle, and top third of students in the ACT distribution, so each ability level includes the same number of students. For each of the three types, the percentage choosing the outside option decreases as ability increases. For in-state only students and public only students, more students choose the in-state public university than their other option. A larger percentage of the private only students choose to attend their out-of-state university option, as opposed to attending their in-state option.

To calculate utility, I set the probability that a student chooses option 1, which follows from equation 1.6, to the share of students in that sector, s_0. That is:

$$\frac{(u_1 - p_1)^\delta}{u_0^\delta + (u_1 - p_1)^\delta + (u_2 - p_2)^\delta} = s_1 \tag{1.13}$$

I omit the ability variable for the student and any variability in the scaling parameter, δ, to simplify notation. The probabilities that the student chooses options 0 or 2 are similar, and the denominator is the same for each probability. I solve for u_1 and u_2 by taking the ratios s_1/s_0 and s_2/s_0. The solution, in terms of the shares, u_0, and prices, for u_1 is:

$$u_1 = \left(\frac{s_1 \cdot u_0^\delta}{s_0}\right)^{\frac{1}{\delta}} + p_1 \tag{1.14}$$

and the solution for u_2 is similar. Since the terms on the right side of equation 1.14 are all known and equation 1.14 applies to all levels of student ability, utility is calculated separately for every option and for every student ability level. The surplus of choosing option 1 in equation 1.14 is:

$$u_1 - p_1 = \left(\frac{s_1 \cdot u_0^\delta}{s_0}\right)^{\frac{1}{\delta}}$$

Holding p_1 constant, students will be less elastic with respect to net price changes as u_0 increases, as δ decreases, or as the ratio $\frac{s_1}{s_0}$ increases. In table 1.5, I calculate the share of students choosing each option by ability level for each of the three types of students. Regardless of the type of student, the ratio $\frac{s_1}{s_0}$ is increasing in ability.

All else equal, the increasing ratio $\frac{s_1}{s_0}$ means that low ability students will be more responsive to price changes than high ability students, and I find that low ability students are more price sensitive in my theoretical results.

Using the utilities computed from equation 1.14 and the prices, I am able to calculate $\frac{\partial \gamma_{j_s,X_s}^{\alpha_\ell^{s'}}}{\partial t_{j_s}^{s'}}$ and $\frac{\partial \gamma_{j_s,X_s}^{\alpha_\ell^{s'}}}{\partial b_{j_s}^{s'}}$ from equations 1.11 and 1.12. The only unknown quantities left in the FOCs now are the parameters on ability, $\theta_{j_s}^{\alpha_\ell^{s'}}$. Since I am using three ability levels to calibrate the model, there are three ability parameters. Each university now has three FOCs and the three unknown parameters are linearly related, so a solution exists that satisfies the FOCs.

Finally, it is necessary to check the second order conditions. Since there are no longer any unknown parameters, it is simple to compute the Hessian matrices for each university, all of which are negative definite. My model supports an equilibrium in which private universities price discriminate in favor of in-state students when calibrated to reasonable parameters.

1.4 Theoretical Applications and Comparative Statics

My model can compute the ability value parameters, $\theta_{j_s}^{\alpha_\ell^{s'}}$, by sector. The equilibrium prices used to compute the parameters are in table 1.6. I have set the initial prices to be symmetric for public and private universities across states $\{1, 2\}$.

The higher education industry has been going through considerable changes. Figure 1.1 shows the average in-state tuition in Big Ten university states from 1995 to 2009. Around 2003, in-state tuition began an upward trend. Some states, like Indiana, Iowa, and Wisconsin, stopped this upward trend, while other states, like Minnesota and Illinois, let it continue. Knowing how students and other competing universities respond to changes in public in-state tuition is of great interest to state legislatures as well as universities. Similarly, many states have been decreasing the amount of support they provide to universities. Wisconsin made especially deep cuts in state support to the University of Wisconsin in 2015.

Focusing on Indiana and Illinois, while Illinois has allowed there in-state tuition to increase, Indiana has not. From 2006 to 2013, the percentage of people in Indiana between ages 17 and 25 attending a public university rose from about 41.5 percent[19] to about 44.1 percent. Over the same time frame, the percentage of people in Illinois attending a public university rose from 40.9 percent to just 41.9 percent. Illinois' in-state tuition increased relative to Indiana's, and Indiana saw a larger increase in students attending public universities. In both state, people attending private universities has remained relatively constant.

The State Higher Education Finance Report by Pernsteiner and Blake (2016) documents that state appropriations per student in public institutions have fallen over the years. From 2006 to 2013, state appropriation per student fell from $7,899 to $6,260. From 2008 to 2015, state appropriations per student in Illinois rose by 38.2 percent while they fell in Indiana by 8 percent. Appropriations by student fell by 15.3 percent on average from 2008 to 2015. Though neither the American Community Survey nor the State Higher Education Finance Report directly address whether a student is in-state or out-of-state, the differences by state in the higher education landscape in tuition and state level appropriations change over time and my theory is able to address those changes.

While not much is known about the effect of cuts in subsidies to universities, there are many studies on tuition elasticity. Curs and Singell (2002) find that in-state students are less responsive to net price changes than out-of-state students at the University of Oregon. They also find that the elasticity depends on when you begin observing the student in the application-admission-enrollment process. Students are much more elastic if you account for the entire process since students are less committed to a university during the application phase. Curs and Singell control for competitor's price in their estimates using the average price of all universities across the country. Hemelt and Marcotte (2011) find tuition elasticities of about -0.1

[19] I calculate these numbers using the American Community Survey (ACS) from the Census. I use 2006 and 2013 as benchmark years because the ACS sampling changed between 2005 and 2006 and 2013 is the latest currently available year.

and use averages of community college tuition and private university tuition to control for competitor's prices.[20] Tuition elasticities at private universities are less well understood than at public universities.

My theoretical model provides a general equilibrium framework which predicts how prices, student shares, and the average ability of each university's student body change across different states and sectors in response to changes in tuition, state subsidies, and demand. Using the parameters calculated in the previous section, I examine the effects of \$1,000 decrease in state 1's public in-state tuition, a \$1,000 decrease in state 1's per in-state student subsidy to their public university, and a 5 percent increase in demand.[21]

1.4.1 Net Price Changes by Ability Level

In some of the comparative static results I present, the tuition, $t_{j_s}^{s'}$, and the institutional aid parameter, $b_{j_s}^{s'}$, move in the same direction. Because there is more than one ability level, the direction of the net price change for each ability level is not immediately obvious when both price parameters move in the same direction. If both price parameters move in the opposite direction, the direction of the net price change for students of all ability levels is immediately obvious. Since universities use these two price parameters to determine the ability composition of their student body, the two parameters rarely move in the opposite directions.[22] I derive the direction the net price changes for all possible changes in the price parameters.

[20] Identifying the relevant set of competitor's tuitions has generally been ignored, and is an area for future research.

[21] I calculate a 5 percent increase in demand by decreasing the value of the outside option by 5 percent.

[22] In fact, the two parameters never move in opposite directions in the examples I discuss.

The change in the net price for a student when tuition and aid change in the same direction is given by:

$$\Delta P(\alpha) = P_2(\alpha) - P_1(\alpha) = (t_2 - b_2\alpha) - (t_1 - b_1\alpha) = \Delta t - \Delta b\alpha \tag{1.15}$$

where a subscript 1 denotes the initial values, and a subscript 2 denotes the values after the exogenous shock. I omit subscripts indicating the type of university and student to avoid notational clutter and because equation 1.15 applies to all universities. If $\Delta t > 0$ and $\Delta b > 0$, the direction of the change is given by:

$$\Delta P(\alpha) \geq (<) \ \ 0 \quad \text{if} \quad \tfrac{\Delta t}{\Delta b} \geq (<) \ \ \alpha \tag{1.16}$$

and if $\Delta t < 0$ and $\Delta b < 0$, the direction of the change is given by:

$$\Delta P(\alpha) \geq (<) \ \ 0 \quad \text{if} \quad \tfrac{\Delta t}{\Delta b} \leq (>) \ \ \alpha \tag{1.17}$$

If $\Delta b = 0$, the direction of the net price change is given by the sign of Δt. If $\Delta t = 0$, the direction of the net price change is given by the sign of $-\Delta b$.

Equation 1.16 shows that when both price parameters are increasing, students with an ability below $\frac{\Delta t}{\Delta b}$ face a net price increase. In other words, when both tuition and institutional aid are increasing, low ability students will face a net price increase. Equation 1.17 shows that when both price parameters are decreasing, students with an ability greater than $\frac{\Delta t}{\Delta b}$ will face a net price increase. Universities choose their student body composition changes by deciding the direction and magnitude of both Δt and Δb.

1.4.2 Decreasing Public In-State Tuition

An exogenous decrease in state 1's public in-state tuition affects all the universities in my model. In table 1.7, I calculate the percent change in both price parameters, the share of students at each ability level along with the total change in the share of students, the change in the average ability of the student body, and the change in university welfare[23] in response to a $1,000 decrease in state 1's in-state tuition.

[23]University welfare is calculated using equation 1.8

Effect on Individual Universities

The $1,000 decrease in state 1's in-state tuition causes state 1's public university to decrease their in-state institutional aid parameter, b_j by 46.5 percent or by $48.83. Using equation 1.17, in-state students with an ability level greater than $\frac{\Delta t_j}{\Delta b_j} = \frac{\$1{,}000}{\$47.90} = 20.48$ will see an increase in their net price and students with an ability lower than 20.48 see a decrease in net price. In fact, we see that an increase in the share of students with ability level $\alpha_\ell = 17$ and decreases in the shares of student with ability levels $\alpha_\ell = 22$ and $\alpha_\ell = 27$. Out-of-state tuition increased by $14 and out-of-state aid increased by $0.515. Using equation 1.16, out-of-state students with an ability level less than $\frac{\Delta t_j}{\Delta b_j} = \frac{\$14}{\$0.515} = 27.18$ see a net price increase. Since all students in my model have an ability level less than 27.18, all out-of-state students see a price increase and the share of out-of-state students decreases. State 1's public university increases their share of low ability in-state students and decreases their share of high ability in-state students by their endogenous response of changing their in-state institutional aid parameter. The average ability of their students decreases, but the university's welfare increases by a small amount due to the large increase in the share of low ability students.

State 1's private university competes for students directly with state 1's public university. The private university responds to the decreased public in-state tuition by increasing their tuition, t_j, and both in-state and out-of-state institutional aid parameters, b_j. The out-of-state aid parameter increases by more than the in-state aid parameter, meaning that out-of-state students with an ability level less than 21 see a net price increase while in-state students with an ability level less than 22.8 see a net price increase. Both in-state and out-of-state low ability student shares decrease, while middle and high ability student shares increase. The average ability of students at state 1's private university increases, as does the university's welfare. Note that even though in-state middle ability students see a net price increase, the share of middle ability in-state students actually increases. In-state students are composed of students that apply only to the in-state universities and students that apply only to the private universities. State 1's middle ability students see price increases in all of their options, other than the outside option. Since the net price increases are different magnitudes, some middle ability students will choose a different university after the decrease in the tuition. In my parameterization of the model, a larger share of state 1's middle ability students choose their home state's private university.

State 2's public university also competes for students directly with state 1's public university. State 2's public university responds to the decrease in their competitor's in-state tuition by increasing both their tuition, t_j, and their institutional aid parameter, b_j, for out-of-state students. The increases in their out-of-state tuition and institutional aid parameter means that out-of-state students will see a net price increase if there ability level is less than 21.8. State 2's share of low ability out-of-state students decreases, while their share of middle and high ability out-of-state students increases. The in-state institutional aid parameter increases. Since in-state universities cannot change in-state tuition, the institutional aid parameter increase causes net price to fall for in-state students of all abilities. Even though the net price is falling for all in-state students, state 2's public university sees decreases in the shares of low and middle ability students. State 2's private university is also decreasing low and middle ability student's net price, and the public universities price decrease is not large enough to compete for the students at the margin. State 2's public university sees a decrease in its total share of students, but the average ability of its student body increases.

State 2's private university does not directly compete with state 1's public university for students, so the decrease in state 1's public in-state tuition does not directly effect their prices. State 2's private university does compete directly with both state 1's private university and state 2's public university, both of whom change their prices. The direct responses by state 2's public university and state 1's private university dampen the reaction of the private university in state 2. The tuition and institutional aid parameters for state 2's private university are decreasing for both in-and out-of-state students. All out-of-state students see a net price increase, though only in-state students with abilities greater than 23.5 see a net price increase. Low and middle ability shares increase, while high ability shares decrease at state 2's private university. Their total share of students increases, though the average ability of their student body decreases.

Effects on States

Whether decreasing in-state tuition is a net positive or net negative change depends upon the objective of the state. Suppose the state cares about increasing the human capital productivity in their state. Decreasing the in-state tuition causes more students to attend a four year university, but those are all low ability students. My model predicts that decreasing in-state tuition increases the number of middle and high ability students attending a four year university. Whether the productivity of the human capital stock increases or decreases in response to the in-state tuition decrease is beyond the scope of this paper, but if you believe the gains to education depends on a student's ability, my model suggests that decreasing in-state tuition has a non-zero effect on the stock of human capital productivity.

My model also shows that a state unilaterally decreasing their in-state tuition also decreases the share of students attending a university in their neighboring state. While I only model university competition here, the interstate effects of my model suggest that state governments should also be acting strategically when setting tuition policies. Groen and White (2004) study the different objectives between public universities and state governments, but they do not consider if states set tuition policies to compete with each other. My model can be extended to study competition for human capital stock between states.

From the university's perspective, the public and private universities in state 1 both see a welfare gain as a result of state 1 decreasing in-state tuition, with the public university gaining the most. State 2's universities both experience a welfare decrease. If the state legislature cares about their state's universities welfare, then my model suggests that decreasing in-state tuition increases their state's universities welfare at the expense of their neighboring state's universities welfare.

A Symmetric vs Asymmetric Decrease in In-state Tuition

So far in section 1.4.2 I have focused on an asymmetric decrease in in-state tuition in which only state 1's public university decreases their in-state tuition. Table 1.8 shows how the public and private universities in both states respond if both state governments decide to decrease their public in-state tuitions by $1,000. In the asymmetric case shown in table 1.7, state 2's private university makes only small adjustments to their prices. In the symmetric case, state 2's private university adjusts their prices in a similar magnitude and direction to state 1's private university in the asymmetric case.

In general, the results for both state's public and private universities in the symmetric case is very similar to state 1's public and private university results in the asymmetric case. The largest divergence is that in the symmetric case, state 1's public university adjusts its out-of-state tuition at a much larger magnitude than it does in the asymmetric case. In the symmetric case, the both state's public universities adjust their out-of-state student prices in a similar direction and magnitude as state 2's public university in the asymmetric case. In the asymmetric case, the state 1's public university is only competing with state 2's public university for out-of-state students. Since state 2's public university makes only small adjustments to their in-state prices, state 1's public university has no incentive to make large changes in their out-of-state net tuition in the asymmetric case. In the symmetric case, both public universities make large net tuition changes for their in-state students, causing both public universities to adjust their out-of-state net tuition to remain competitive.

1.4.3 Decreasing the State Subsidy

States also provide subsidies to public universities in my model. Recently, states have been reducing the amount of those subsidies to universities. In table 1.9, I calculate the percent change in both price parameters, the share of students at each ability level along with the total change in the share of students, the change in the average ability of the student body, and the change in university welfare in response to a $1,000 decrease in the state subsidy per in-state student.

Effect on Individual Universities

State 1's public university is directly effected when the state subsidy per in-state student decreases by $1,000. The decrease in the subsidy is a loss of revenue to the university. To compensate for the loss in revenue, the university decreases the in-state institutional aid parameter to increase net price for all in-state students. In-state student shares all decrease as a result of the net price increase. The university also decreases the out-of-state tuition and institutional aid parameters, decreasing net price for students of all ability levels. These decreases are relatively small compared to the change in in-state net price, and the resulting increase in out-of-state student shares of all ability are also relatively small. Overall, the total share of students in state 1's public university decreases. The average ability at the university increases, though, since low ability students are the most responsive to the net price increase.

Due to the decrease in the state 1's subsidies to the public university, state 1's private university decreases their tuition, t_j, and both in- and out-of-state institutional aid parameters, b_j, to compete for in-state students. The price parameter changes cause net prices to rise for in-state students with an ability greater than 24.4 and prices to rise for out-of-state students with an ability greater than 20.9. In other words, state 1's private university is raising net prices for high ability in-state students, and middle and high ability out-of-state students. In-state student shares of all ability levels are increasing, even though high ability students are being charged a higher price. Low ability shares of out-of-state students are increasing, while both middle and high ability student shares are decreasing. The private university gains in total share of students, but sees a decrease in the student body's average ability.

State 2's public university also directly competes for students with state 1's public university, and responds to state 1's reaction to the decrease in subsidies by increasing the net price for all of its in-state students, and decreasing the tuition and institutional aid parameters for out-of-state students. The reduction in tuition and aid parameters causes increases in net prices for students with an ability greater than 23.2. Their share of out-of-state students increase for all ability levels, even though high ability out-of-state students see a net price increase. They also gain in low and middle ability in-state student shares, but see a decrease in their high in-state student ability share. Their total share of students increases, due mostly to a gain in out-of-state students. The average ability of their student body decreases.

State 2's private university does not directly compete for students with state 1's public university. However, since they compete for students with both state 1's private university and state 2's public university, state 2's private university responds to those universities' changing prices. State 2's private university increase tuition and both in- and out-of-state institutional aid parameters. These increases results in net price increases for in-state students with an ability less than 23.5 and out-of-state students with an ability less than 14. In other words, low and middle ability in-state students see a net price increase, while out-of-state students all see a net price decrease. Both in- and out-of-state low and middle ability student shares both decrease, even though the out-of-state students see net price decreases. The total share of students at state 2's private university is decreasing and the average ability of the student body is increasing.

Effects on States

Comparing the welfare impact on the universities, state 1's public university suffers a relatively large welfare loss. All other universities in my model see a small welfare increase. If state legislatures care about the welfare of the universities, my model predicts that decreasing state subsidies is detrimental to public universities and that the welfare loss at the public university is not compensated for by welfare increases at other universities.

My model also predicts that the share of students not attending a four year university increases. The increase in nonattendance is especially prevalent among low ability students. The average ability of students not attending is increasing. If state legislatures believe that attending a four year university increases the productivity of their workforce, then decreasing the share of students attending a four year university by decreasing the state subsidy is not in their interest.

1.4.4 Increasing Demand for Higher Education

In the previous two examples, changes in state policy shock the public university in state 1 and those shocks spread throughout the higher education system. Using the American Community Survey, I find that in 2000 nearly 52 percent of 18 to 22 year olds were not enrolled in any sort of educational institution. In 2013, only 40 percent of 18 to 22 year olds were not enrolled in an educational institution. By decreasing the value of the outside option, I use my model to examine the effects of an increase in demand for higher education. I decrease the outside option by 5 percent for students in both state 1 and state 2, so demand increase affects the two states symmetrically. These results may be found in table 1.10.

Effect on Individual Universities

In response to the demand increase, the public universities decrease the in-state institutional aid parameter b_j, increasing the net price for all in-state students. They also decrease the out-of-state tuition and institutional aid parameters so that high ability out-of-state students see a net price increase, while low and middle ability out-of-state students see a net price decrease. In-state student shares all decrease due to the net price increase. Low and middle ability out-of-state student shares increase, while high ability student shares decrease. Their total share of in-state students decreases while their share of out-of-state students increases. The average ability of in-state students increases while out-of-state student average ability decreases.

Private universities respond to the increase in demand by decreasing tuition, t_j, and decreasing both in- and out-of-state institutional aid parameters, b_j. All in-state students see a decrease in net price while all out-of-state students see an increase in net price. Consequently, private universities increase their share of in-state students and decrease their share of out-of-state students. The average ability of in-state students decreases while the average ability of out-of-state students increases.

Effects on States

Due to the increase in demand, there are fewer students not attending a four year university. The decrease in nonattendance is smaller than the demand increase since net prices are generally increasing, though some out-of-state public university students do see net price decreases. Low ability students entering four year universities drive the decrease in nonattendance, since some of both middle and high ability students are actually choosing not to attend due to net price increases.

1.5 Conclusion

Private universities offer $295 per ACT point to in-state students but just $166 per point to out-of-state students. Since private universities have no incentive to discriminate between in- and out-of-state students, I create a general equilibrium model to explain why private universities use institutional aid to favor in-state students. In-state tuition and student preferences for a university's sector or location drives private universities to set prices favorable to in-state students.

If private universities did not compete with public universities for students, then the aid gap between in- and out-of-state students at private universities would not exist. As long as in-state applicants include students who prefer to stay in their home state, and do not apply out of state, a private university knows their only competition for that set of students comes from the public university. Since state governments set public in-state tuition below the market rate and the pool of in- and out-of-state applicants differ, private universities respond by decreasing the net price paid by in-state students and increasing prices paid by out-of-state students. Since they advertise the same tuition regardless of a student's home state, private universities decrease the net price by offering more institutional aid to in-state students.

I use the model to study a decrease in one state's public in-state tuition, a decrease in one state's subsidies to its public university, and an increase in demand for higher education. My model predicts that decreasing in-state tuition affects not just the public university in which the decrease occurs, but also the universities that compete directly and indirectly with that public university. Decreasing in-state tuition in one state increases students enrolled in four year universities in both states in my model. Decreasing subsidies to a public university also affects universities and students across state lines, decreasing the number of students in both states enrolled in a public university.

My model currently takes state policy decisions as exogenous. Though it is beyond the scope of this paper, I can extend the model to endogenize policy decisions and analyze the strategic interaction between governments under different state government objective functions. My model also predicts private university price responses to increases in public universities' tuition. I plan on testing these hypotheses in future papers.

Table 1.1.: Summary Statistics

	Public		Private	
	In-State	Out-of-State	In-State	Out-of-State
Institutional Aid	3,577 (3,769)	7,593 (7,017)	10,730 (7,050)	12,873 (8,728)
% with Aid	28.6	35.3	76.7	67.4
ACT Score	22.4 (4.36)	23.1 (4.56)	23.1 (4.69)	24.8 (5.06)
EFC	11,490 (15,536)	16,739 (19,103)	12,680 (17,259)	18,559 (21,469)
Income	71,316 (64,610)	95,046 (78,558)	78,227 (71,492)	104,436 (89,011)
% Dependent	80.7	89.6	85.8	92.3
% Nonwhite	31.3	29.8	28.6	28.4
% Female	53.4	49.7	58.2	53.5
Number of Obs	44,250	5,320	18,120	10,370
Tuition:				
Very Selective	6,844 (3,267)	18,618 (8,227)	27,997 (11,056)	
Mod. Selective	5,768 (2,624)	14,205 (7,416)	21,556 (8,711)	
Min. Selective	4,786 (2,353)	9,838 (5,344)	20,035 (10,381)	
Enrollments:				
Very Selective	25,989 (13,733)		11,412 (10,232)	
Mod. Selective	19,204 (11,643)		4,822 (4,740)	
Min. Selective	11,114 (7,238)		3,202 (3,059)	

Standard deviations in parentheses. All dollar values are in 2012 dollars.

Table 1.2.: Comparing marginal effects of the ACT score on institutional aid between the OLS and Tobit models

Dependent Var: Institutional Aid	OLS	Tobit		OLS	Tobit	
		Latent	Conditional		Latent	Conditional
	(1)	(2)	(3)	(4)	(5)	(6)
IS Public ACT	128.4***	439.8***	107.3***	121.8***	442.5***	105.5***
	(9.081)	(22.67)	(5.822)	(8.447)	(22.59)	(5.663)
OS Public ACT				141.8***	349.6***	102.7***
				(24.88)	(47.97)	(14.36)
Difference				**19.94**	**-92.82****	**-2.81**
				(23.15)	**(46.11)**	**(13.55)**
IS Private ACT	345.6***	434.3***	237.6***	419.4***	531.3***	294.5***
	(23.24)	(30.78)	(18.45)	(20.80)	(27.86)	(16.97)
OS Private ACT				240.1***	304.7***	166.0***
				(34.55)	(46.58)	(26.00)
Difference				**-179.4*****	**-226.7*****	**-128.5*****
				(31.52)	**(42.48)**	**(22.97)**
Observations	78,030	78,030	78,030	78,030	78,030	78,030

IS = In-State. OS = Out-of-State. Standard errors in parentheses, clustered by unitid and year. Other variables controlled for include: gender, race, income, expected family contribution (used in federal financial aid calculations), dependency status, selectivity of university, year, state of university, and enrollment size of university. *** p<0.01, ** p<0.05, * p<0.1

Table 1.3.: Conditional Tobit model estimates of ACT effects on institutional aid for different samples

Dependent variable: Institutional Aid:	All	Very Selective	Moderately Selective	Minimally Selective	Dependents
	(1)	(2)	(3)	(4)	(5)
IS Public ACT	105.5***	110.5***	93.55***	94.02***	122.9***
	(5.663)	(12.65)	(6.143)	(10.16)	(6.400)
OS Public ACT	102.7***	121.1***	104.0***	45.40	120.4***
	(14.36)	(30.01)	(18.26)	(34.96)	(15.87)
Difference	**-2.81**	**10.56**	**10.43**	**-48.62**	**-2.54**
	(13.55)	**(28.2)**	**(17.51)**	**(34.56)**	**(15.03)**
IS Private ACT	294.5***	273.0***	326.5***	196.1***	314.6***
	(16.97)	(38.58)	(17.36)	(26.85)	(19.64)
OS Private ACT	166.0***	147.7***	261.4***	101.9*	167.7***
	(26.00)	(39.81)	(26.84)	(53.26)	(28.28)
Difference	**-128.5*** **	**-125.3*** **	**-65.04** **	**-94.15* **	**-146.9*** **
	(22.97)	**(40.58)**	**(26.41)**	**(56.62)**	**(24.74)**
Observations	78,030	23,700	45,010	9,320	65,560

IS = In-State. OS = Out-of-State. Standard errors in parentheses, clustered by unitid and year. Other variables controlled for include: gender, race, income, expected family contribution (used in federal financial aid calculations), dependency status, selectivity of university, year, state of university, and enrollment size of university. *** p<0.01, ** p<0.05, * p<0.1

Table 1.4.: Conditional Tobit model estimates by region

	South	West	Northeast	Midwest
	(1)	(2)	(3)	(4)
Public:				
In-State ACT	103.2***	62.19***	111.3***	116.9***
	(7.059)	(10.14)	(15.98)	(12.77)
Out-of-state ACT	111.6***	3.474	161.2***	95.35***
	(24.33)	(27.95)	(29.07)	(25.71)
Difference	**8.42**	**-59.23****	**50.19***	**-21.44**
	(23.27)	**(27.16)**	**(27.71)**	**(23.41)**
Private:				
In-state ACT	358.8***	203.8***	271.9***	311.3***
	(31.83)	(34.60)	(34.60)	(21.60)
Out-of-state ACT	294.8***	188.5***	36.69	301.9***
	(43.03)	(38.49)	(40.46)	(48.84)
Difference	**-63.52**	**-14.44**	**-235.2*****	**-7.79**
	(49.4)	**(45.56)**	**(34.99)**	**(45.4)**
Observations	26,630	12,750	18,430	19,690

IS = In-State. OS = Out-of-State. Standard errors in parentheses, clustered by unitid and year. Other variables controlled for include: gender, race, income, expected family contribution (used in federal financial aid calculations), dependency status, selectivity of university, year, state of university, and enrollment size of university. *** p<0.01, ** p<0.05, * p<0.1

Table 1.5.: Values used to calibrate and numerically solve the theoretical model for students

Students:			
	Student Options		
In-State Only Percentages:			
	Outside	Public IS	Private IS
$\alpha_\ell = 17$	49	38	13
$\alpha_\ell = 22$	28	53	19
$\alpha_\ell = 27$	17	56	27
$\delta = 0.7$, $\tau = 0.62$			
Public Only Percentages:			
	Outside	Public IS	Public OS
$\alpha_\ell = 17$	46	34	20
$\alpha_\ell = 22$	25	47	28
$\alpha_\ell = 27$	14	48	38
$\delta = 0.8$, $\tau = 0.19$			
Private Only Percentages:			
	Outside	Private IS	Private OS
$\alpha_\ell = 17$	55	14	31
$\alpha_\ell = 22$	30	20	50
$\alpha_\ell = 27$	11	17	72
$\delta = 0.8$, $\tau = 0.19$			

IS stands for in-state. OS stands for out-of-state. There is mass $\frac{1}{3}$ of each ability level. The δ is the scaling parameter, and the τ is the proportion of students of that type. The utility of the outside option is 1,000.

Table 1.6.: Values used to calibrate and numerically solve the theoretical model for universities

Universities:		
	Public	Private
IS Tuition (t_j)	\$6,000	\$20,000
OS Tuition (t_j)	\$14,000	
IS Aid (b_j)	\$105	\$295
OS Aid (b_j)	\$103	\$166
Cost (c_j)	\$40,000	\$50,000
Subsidy (ρ_j)	\$12,000	

IS stands for in-state. OS stands for out-of-state. There is mass $\frac{1}{3}$ of each ability level. The δ is the scaling parameter, and the τ is the proportion of students of that type. The utility of the outside option is 1,000.

Table 1.7.: The effect of a $1,000 decrease in state 1's in-state tuition on tuition, enrollment, and the average ability of students.

	Public 1		Private 1		Public 2		Private 2		Not Attend	
	IS	OS	IS	OS	IS	OS	IS	OS	1	2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
% Δ Tuition (t_j)	-16.67	0.001	0.37	0.37	0	2.02	-0.036	-0.036		
% Δ Aid (b_j)	-46.5	0.005	1.1	2.12	0.007	12.6	-0.104	-0.276		
% Δ Uni. Welfare	6.18	6.18	1.9	1.9	-1.19	-1.19	-0.28	-0.28		
% Δ in share of students by ability ($\gamma_j(\alpha_\ell)$):										
$\alpha_\ell = 17$	12.4	-0.011	-10.9	-1.78	-0.065	-17.6	1.06	1.12	-0.81	-0.58
$\alpha_\ell = 22$	-1.15	-0.003	0.44	0.054	-0.003	1.39	0.013	0.007	0.18	0.1
$\alpha_\ell = 27$	-2.53	-0.001	2.1	0.053	0.008	3.67	-0.067	-0.12	0.19	0.13
% Δ Total Share	1.85	-0.004	-1.59	-0.32	-0.015	-2.01	0.23	0.17	-0.19	-0.15
% Δ Avg Ability	-0.96	0.001	0.84	0.101	0.005	1.36	-0.07	-0.07	0.08	0.06

All values are percent changes. Tuition and aid are the parameters in the price function, $P_j(\alpha_\ell) = t_j - b_j\alpha_\ell$ for university j and ability level α_ℓ. The percent change in the share of students enrolled is separated by ability, α_ℓ, and the three ability levels, 17, 22, and 27, are comparable to the lower, middle, and top terciles of the ACT score distribution. University welfare is calculated using equation 1.8 and the total share of students is calculated by summing the shares of the three different ability levels.

Table 1.8.: The effect of a $1,000 decrease in state 1 and state 2's in-state tuition on tuition, enrollment, and the average ability of students.

	Public 1		Private 1		Public 2		Private 2		Not Attend	
	IS	OS	IS	OS	IS	OS	IS	OS	1	2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
% Δ Tuition (t_j)	-16.67	2.03	0.34	0.34	-16.67	2.03	0.34	0.34		
% Δ Aid (b_j)	-46.5	12.59	1.01	1.86	-46.5	12.59	1.01	1.86		
% Δ Uni. Welfare	5.0	5.0	1.61	1.61	5.0	5.0	1.61	1.61		
% Δ in share of students by ability ($\gamma_j(\alpha_\ell)$):										
$\alpha_\ell = 17$	12.3	-17.58	-9.89	-0.68	12.3	-17.58	-9.89	-0.68	-0.76	-0.76
$\alpha_\ell = 22$	-1.15	1.39	0.45	0.06	-1.15	1.39	0.45	0.06	0.17	0.17
$\alpha_\ell = 27$	-2.52	3.67	2.03	-0.07	-2.52	3.67	2.03	-0.07	0.19	0.19
% Δ Total Share	1.84	-2.02	-1.37	-0.15	1.84	-2.02	-1.37	-0.15	-0.17	-0.17
% Δ Avg Ability	-0.95	1.36	0.77	0.03	-0.95	1.36	0.77	0.03	0.08	0.08

All values are percent changes. Tuition and aid are the parameters in the price function, $P_j(\alpha_\ell) = t_j - b_j\alpha_\ell$ for university j and ability level α_ℓ. The percent change in the share of students enrolled is separated by ability, α_ℓ, and the three ability levels, 17, 22, and 27, are comparable to the lower, middle, and top terciles of the ACT score distribution. University welfare is calculated using equation 1.8 and the total share of students is calculated by summing the shares of the three different ability levels.

Table 1.9.: The effect of $1,000 decrease in per student subsidies to state 1's public university on tuition, enrollment, and the average ability of students.

	Public 1		Private 1		Public 2		Private 2		Not Attend	
	IS	OS	IS	OS	IS	OS	IS	OS	1	2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
% Δ Tuition (t_j)	0	-0.001	-0.27	-0.27	0	-1.43	0.026	0.026		
% Δ Aid (b_j)	-10.9	-0.004	-0.75	-1.55	-0.006	-8.37	0.075	0.223		
% Δ Uni. Welfare	-38.9	-38.9	0.61	0.61	0.25	0.25	0.32	0.32		
% Δ in share of students by ability ($\gamma_j(\alpha_\ell)$):										
$\alpha_\ell = 17$	-16.3	0.009	11.8	1.29	0.048	18.7	-0.78	-0.899	1.33	0.93
$\alpha_\ell = 22$	-4.27	0.003	2.95	-0.038	0.003	5.13	-0.014	-0.092	0.54	0.34
$\alpha_\ell = 27$	-2.03	0.001	1.46	-0.038	-0.006	2.17	0.048	0.051	0.23	0.14
% Δ Total Share	-6.55	0.003	4.45	0.23	0.01	6.98	-0.17	-0.19	0.75	0.5
% Δ Avg Ability	1.004	-0.001	-0.63	-0.073	-0.004	-0.98	0.052	0.055	0.08	-0.06

All values are percent changes. Tuition and aid are the parameters in the price function, $P_j(\alpha_\ell) = t_j - b_j\alpha_\ell$ for university j and ability level α_ℓ. The percent change in the share of students enrolled is separated by ability, α_ℓ, and the three ability levels, 17, 22, and 27, are comparable to the lower, middle, and top terciles of the ACT score distribution. University welfare is calculated using equation 1.8 and the total share of students is calculated by summing the shares of the three different ability levels.

Table 1.10.: The effect of a 5 percent increase in demand on tuition, enrollment, and the average ability of students.

	Public 1		Private 1		Public 2		Private 2		Not Attend	
	IS	OS	IS	OS	IS	OS	IS	OS	1	2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
% Δ Tuition (t_j)	0	-0.37	-0.09	-0.09	0	-0.37	-0.09	-0.09		
% Δ Aid (b_j)	-0.39	-2.14	-0.19	-0.75	-0.39	-2.14	-0.19	-0.75		
% Δ Uni. Welfare	2.12	2.12	-1.34	-1.34	2.12	2.12	-1.34	-1.34		
% Δ in share of students by ability ($\gamma_j(\alpha_\ell)$):										
$\alpha_\ell = 17$	-1.01	2.87	3.37	-0.86	-1.01	2.87	3.37	-0.86	-0.09	-0.09
$\alpha_\ell = 22$	-0.24	0.32	0.69	-0.34	-0.24	0.32	0.69	-0.34	0.009	0.009
$\alpha_\ell = 27$	-0.07	-0.02	0.15	-0.05	-0.07	-0.02	0.15	-0.05	0.01	0.01
% Δ Total Share	-0.37	0.76	1.11	-0.31	-0.37	0.76	1.11	-0.31	-0.03	-0.03
% Δ Avg Ability	0.06	-0.18	-0.2	0.05	0.06	-0.18	-0.2	0.05	0.008	0.008

All values are percent changes. A 5 percent increase in demand is calculated by decreasing the surplus of the outside option by 5 percent. Tuition and aid are the parameters in the price function, $P_j(\alpha_\ell) = t_j - b_j\alpha_\ell$ for university j and ability level α_ℓ. The percent change in the share of students enrolled is separated by ability, α_ℓ, and the three ability levels, 17, 22, and 27, are comparable to the lower, middle, and top terciles of the ACT score distribution. University welfare is calculated using equation 1.8 and the total share of students is calculated by summing the shares of the three different ability levels.

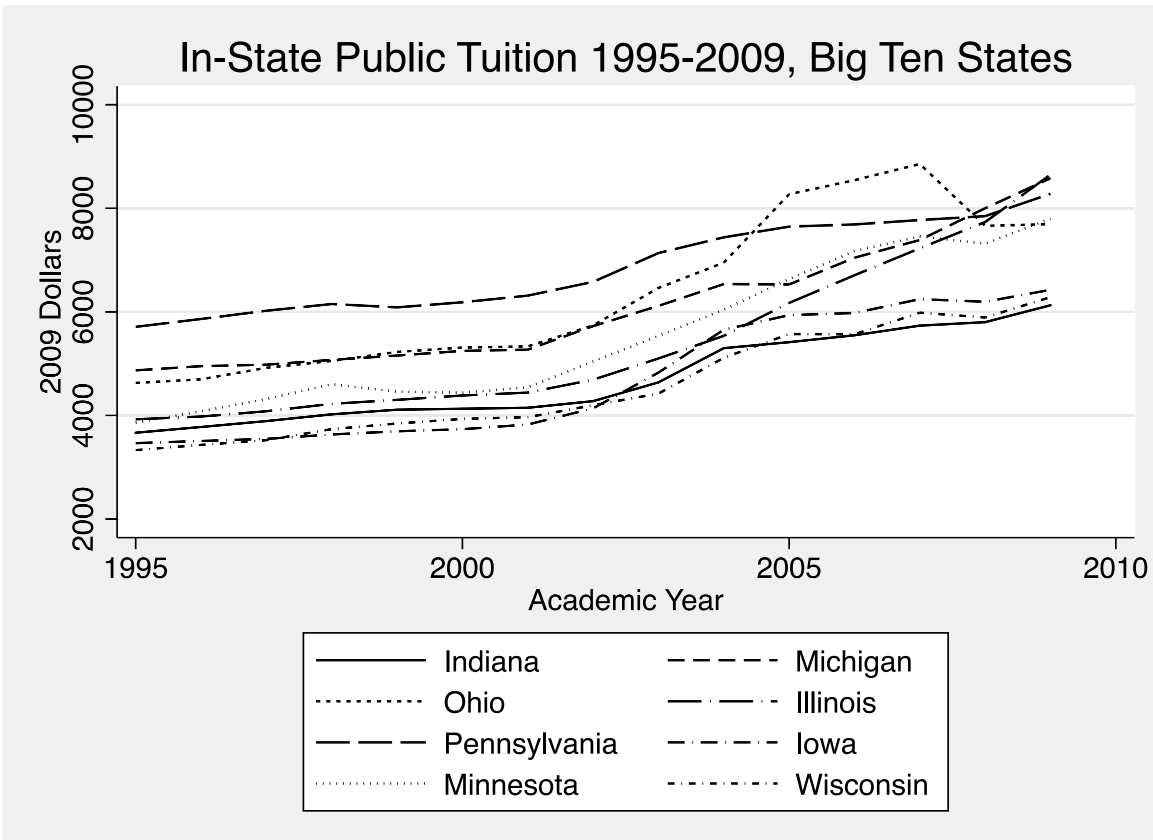

Fig. 1.1.: Comparison of in-state public university in Big Ten states

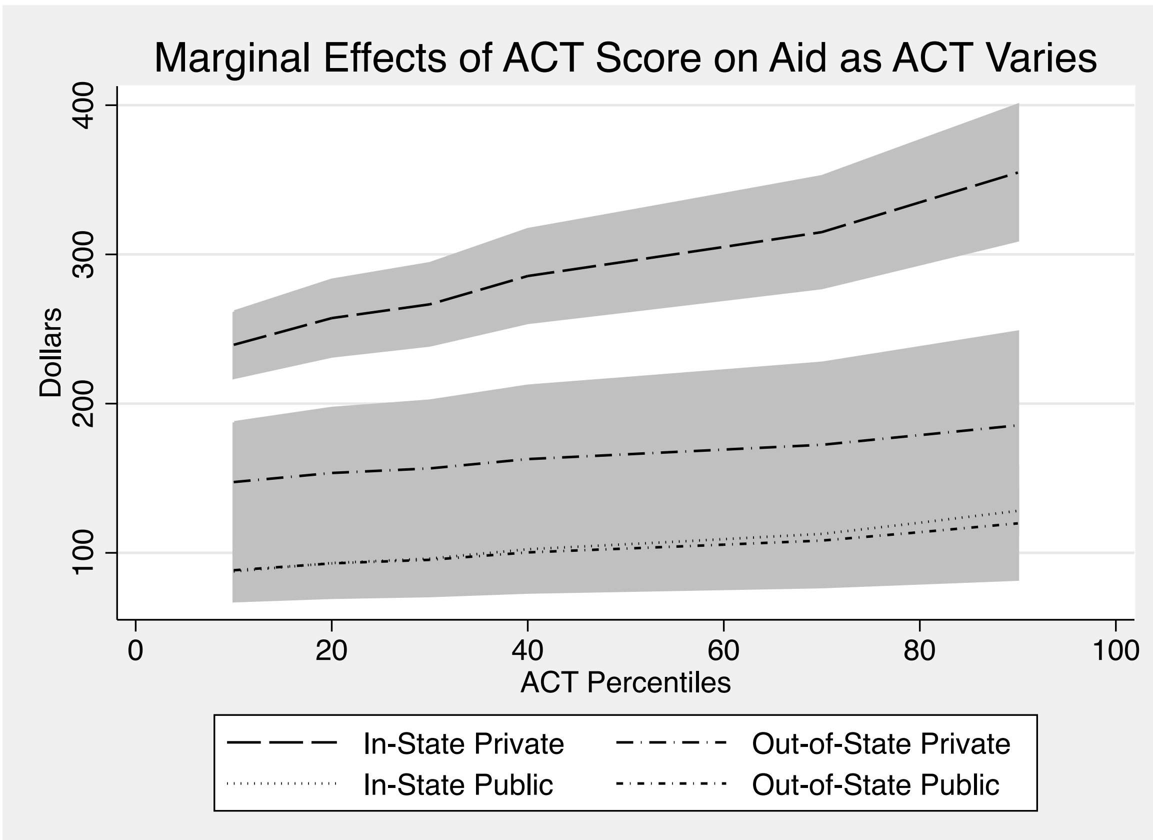

Fig. 1.2.: Marginal effects of the ACT score on aid as the ACT varies

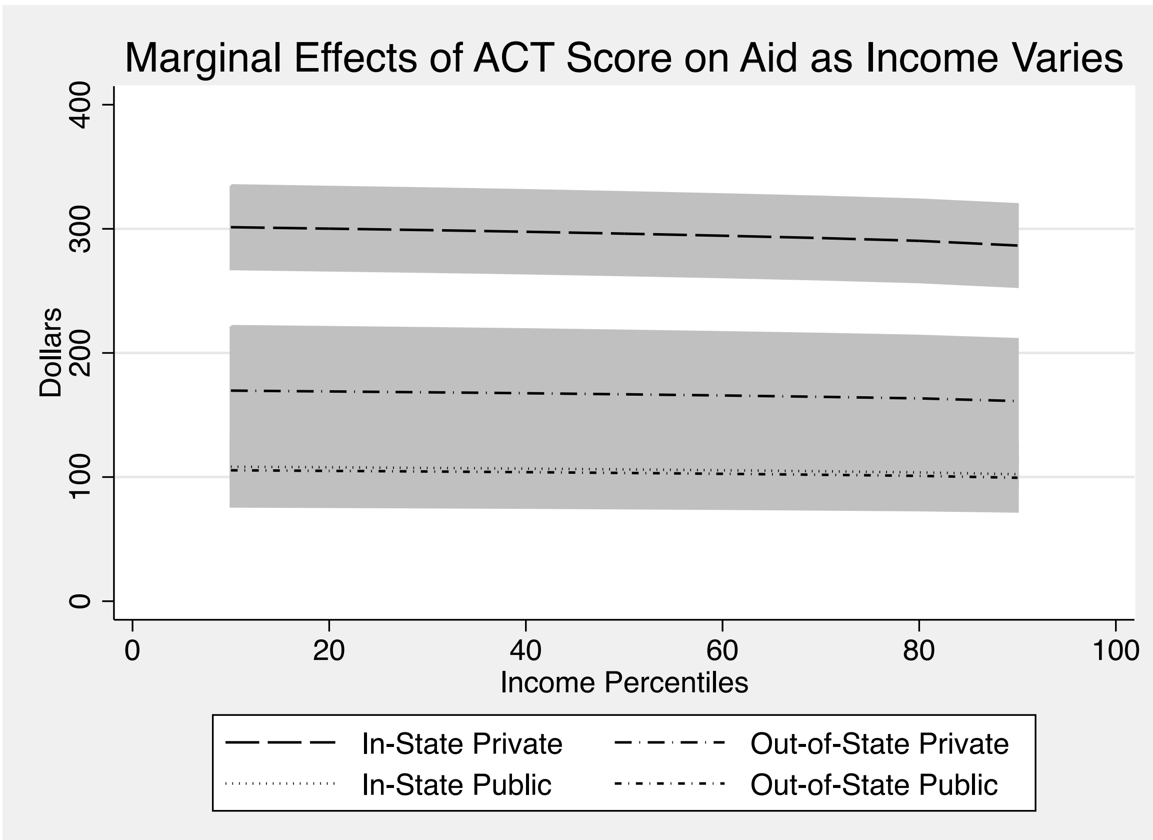

Fig. 1.3.: Marginal effects of the ACT score on aid as income varies

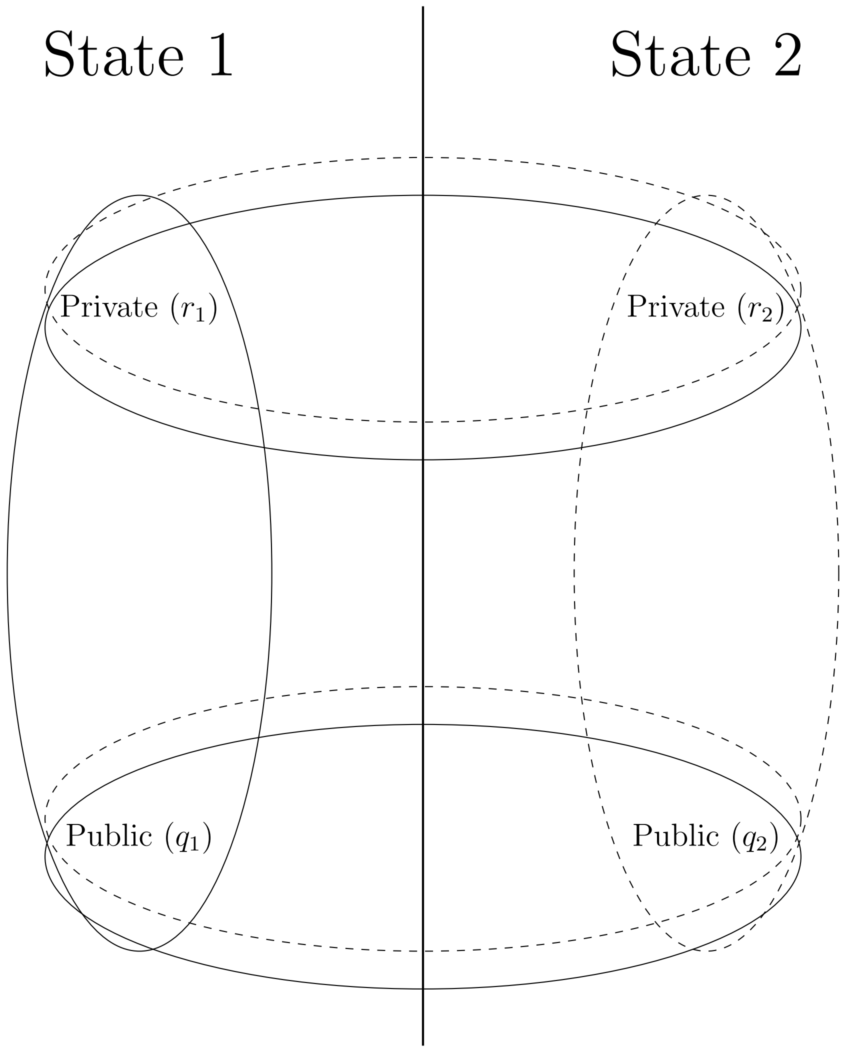

Fig. 1.4.: Illustration of the three student preference types across the two states.

Solid ellipses are groups of state 1 students. Dashed ellipses are groups of state 2 students. Private means the private university and public means the public university in each respective state. Private is also denoted by r and public is denoted by q. All students also have an outside option, which is not shown above, as well as the two universities in each choice set that are shown above.

2. UNBUNDLING FOR-PROFIT HIGHER EDUCATION: RELAXING THE 90/10 REVENUE CONSTRAINT

2.1 Introduction

For-profit postsecondary institutions have become a large player in higher education in the past decade. Deming et al. (2012) and Gilpin et al. (2015) document and explains the large growth in the for-profit sector. Along with the growth in the for-profit sector, there has also been growth in scrutiny and regulation of the for-profit sector. One regulation, the 90/10 rule, has applied to for-profit postsecondary institutions in some form since 1992. Under the 90/10 rule, a for-profit school cannot receive more than 90 percent of their revenue from Title IV funds. Title IV funds are federal aid dollars disbursed by the Department of Education based on a student's financial need.

For-profit institutions are able to bundle separate campuses together as one entity in order to comply with the 90/10 rule. In 2008, congress passed a reauthorization of the Higher Education Act that relaxes the 90/10 violation policy on for-profit institutions. The policy change allows schools to violate the rule two years in row instead of one year before losing eligibility for Federal Title IV aid. Executives at for-profit corporations actively considered bundling campuses when deciding on 90/10 rule compliance strategies. According to a 2012 Senate report, an executive at Herzing University[1] wrote in an email in 2009:

> My initial thought is to match Toledo with Omaha because they are smaller enterprises and that way we can reserve Minneapolis for Akron if necessary. Right now the Toledo/Omaha rate would be . . . 72.6% . . .

[1]Herzing University converted to non-profit status in 2015, likely to avoid new and proposed "gainful employment" regulations on for-profit universities.

> Right now Akron/Minneapolis would be . . . 78.5%. This group could in theory go up to the $20,000,000.00 mark in combined revenue, with the current cash and still be under the 90% threshold.

The Herzing executive cares both about the combined rate of the campuses, as well as the amount of revenue the campuses receive individually and combined.

I examine the impact of relaxing the 90/10 rule violation policy on the behavior of for-profit institutions and estimate the impact of the rule change on the amount of federal student aid received by for-profit institutions. Using individual student level data from the Department of Education, I find for-profit students have increased their reliance on Title IV aid after the rule change. The increase in Title IV aid usage cannot be explained by demographic changes or a decrease in reliance on non Title IV aid. I develop a theoretical model in which universities consider both the size of the universities and the Title IV revenue percentages when making campus bundling decisions. I show that relaxing the violation policy increases the size of campus bundles and revenue in for-profit institutions, which is supported by the data. I also estimate that relaxing the 90/10 rule violation policy causes an extra 900 million dollars in Federal aid to go to for-profit institutions.

The for-profit education sector is increasingly important to understand as they become a larger player in postsecondary education. For-profit postsecondary growth is driven by a number of factors. In one of the earlier papers studying for-profit institution growth, Cellini (2009) finds that two year for-profit institutions are a substitute for non-profit community colleges. She found that local communities in California voting to fund a public community college decreased the number of for-profit institutions in the market, as well as private college enrollment, while increasing public college enrollment. In her 2010 paper, Cellini finds that increases in the Pell and Cal grant programs increase[2] the number of public and for-profit institutions, though the increase in for-profit institutions is larger. Gilpin et al. (2015) find that

[2]It is worth noting that Kane (1995) shows that means tested aid, like Pell grants, may not increase enrollments

occupation growth in the fields for-profit institutions offer explains some of the growth in for-profit sector. No matter the causes of the for-profit sector growth, a larger number of for-profit institutions means more Title IV aid is directed to the for-profit sector, and any Title IV eligibility change will have a larger impact.

Understanding the regulations on the higher education industry is crucial to understanding how these regulations affect the for-profit sector. These regulations include the different types of Title IV aid and the eligibility requirements to receive this aid. Eligibility requirements differ between for-profit institutions and non-profit schools. The 90/10 rule is an eligibility requirement only applied to for-profit institutions. It is meant to ensure that at least some students value the education at the for-profit institution enough to be willing to pay for it out of pocket. Also, universities are allowed to bundle together campuses when submitting compliance reports to the Department of Education. Non-profit universities do not have any incentive to bundle campuses together. Because of the 90/10 rule, for-profit institutions have a strong incentive to bundle campuses together when submitting compliance reports. In section 2.1.1, I discuss the regulations on the higher education industry in more detail along with the policy changes passed by congress in 2008.

2.1.1 Regulations on the Higher Education Industry

Title IV Aid

The Higher Education Act of 1965, under Title IV, created a number of student aid programs administered by the Department of Education. There are three different kinds of Title IV aid, grants, loans, and work study. Students are not required to repay grants, but they are required to repay loans, with interest.

Title IV grants include Pell grants, Federal Supplemental Education Opportunity grants (FSEOG), Teacher Education Assistance for College and Higher Education (TEACH) grants, and the Iraq/Afghan Service grant[3]. Pell grants are the most

[3]This grant was created in the 2010-2011 academic year

common and are need based. The amount depends on whether the student attends part time or full time, and if they are taking classes for the full year or less. FSEOGs are similar to Pell grants in that they are also need based. They are different in that instead of being disbursed directly to the student, each school receives a certain amount of FSEOG money and students must apply to the school instead of the Department of Education, and may not receive the aid if the FSEOG funds have already been allocated. Title IV aid distributed by the college is called campus based aid. TEACH grants go to students in eligible education programs. TEACH grants are not need based, have service requirements, and are based on the subject the student is preparing to teach. If the service requirements are not met, the TEACH grant is converted to a Direct Unsubsidized loan.

Title IV loans included Direct Subsidized and Unsubsidized loans, Stafford Subsidized and Unsubsidized loans, Direct PLUS loans to parents or graduate students, and Federal Perkins loans. Direct loans are made directly from the Department of Education. Stafford loans are funded by private banks and the transaction is facilitated by the Department of Education. Subsidized loans are need based. The government pays the interest during for nonpayment periods[4]. Unsubsidized loans are available to everyone, regardless of need. The Perkins loan is for students with exceptional need. The interest rate is set at 5 percent and the student borrows directly from the school. Perkins loans are another form of campus based aid, and not all schools participate in this program.

Title IV work study programs are also campus based aid, and are funded the same way as FSEOGs and Perkins loans. Funds are to be used to help pay for the students education, though the school must pay the student directly unless otherwise requested by the student.

Student need is determined when they fill out the Free Application for Federal Student Aid (FAFSA). A complex, nonlinear formula is used to determine the Expected Family Contribution (EFC). The formula is based on the student's income and

[4]After leaving school, loan repayment is deferred for six months

wealth, the parent's income and wealth, how many siblings the student has attending a postsecondary institution, and the cost of attendance at their chosen schools, among other things. Need based Title IV aid is effected by the student's EFC. The higher the EFC is, the less need based aid is available.

Schools must be eligible to receive Title IV aid. A for-profit institution is eligible if it provides a program that prepares students for gainful employment, is accredited by a recognized regional or nationally recognized accrediting agency, and has been in existence for at least two years. A for-profit institution is also subject to the 90/10 constraint. For-profit institutions can choose whether or not to apply for Title IV eligibility. Cellini and Goldin (2012) estimates that tuition at Title IV eligible for-profit institutions is about 75 percent higher than tuition at comparable non Title IV eligible institutions. Cellini and Goldin note that while the tuition gap between Title IV and non Title IV for-profit institutions could be caused by those institutions increasing tuition to get more aid, the tuition may be higher to compensate for the cost of obtaining and maintaining Title IV eligibility.

Turner (2014b) estimates the economic incidence of a specific Title IV program, namely Pell grants. She finds that students receiving more Pell grant aid receive less institutional aid. Non-profit universities decrease institutional aid by approximately 78 cents for every Pell grant dollar received by a student. For-profit institutions, on the other, decrease aid only by about 6 cents for every Pell grant dollar, though this may be because for-profit institutions do not offer much institutional aid in the first place and use the tuition to capture Pell grant dollars. Cellini and Goldin (2012) suggests that tuition rather than institutional aid may be more sensitive to increases in Title IV aid.

The 90/10 Rule

In 1992, the 85/15 rule was implemented in the Higher Education Amendments to restrict the amount of federal funds for-profit postsecondary institutions could receive.

The rule applied only to for-profit institutions, and restricts them from earning more than 85 percent of their revenue from federal Title IV student aid. The rule is similar to a rule implemented by the Department of Veterans Affairs, which states that not more than 85 percent of a program's students may receive benefits from the VA. The VA's rule was also implemented in 1992, though the 1952 Korean Conflict GI Bill includes similar language. While these two rules are similar, the 85/15 rule in the Higher Education Amendment of 1992 applies to revenue while the other applies to the number of students in a program. The 85/15 rule was implemented to ensure federal dollars were going to a quality program. Legislators thought that if at least fifteen percent of students were willing to pay out of pocket[5], then the program is valued enough to support with federal aid.

The Higher Education Amendment of 1998 was more lenient to for-profit institutions, changing the 85/15 rule to the 90/10 rule. The 90/10 rule still applies only to for-profit institutions and restricts them from receiving more than 90 percent of their revenue from Title IV federal student aid. If the school violates the 90/10 rule for one year, becomes provisionally certified. If the school is caught violating the 90/10 rule for two years in a row, the school loses Title IV eligibility. To regain eligibility, the school has to meet licensing, accreditation, and financial responsibility requirements for two years.

Calculating the 90/10 revenue percentage is rather complex. In general, aid disbursed by the Department of Education is considered Title IV aid, though there are exceptions. The Department of Education disburses both subsidized and unsubsidized loans, but only subsidized loans and some portion of unsubsidized loans count as Title IV aid. Also, federal aid to veterans and active military are not Title IV aid, and do not count towards Title IV revenue. For-profit institutions have an incentive to recruit students eligible for veteran and military benefits to reduce their reliance on Title IV aid.

[5]Or each student is willing to pay fifteen percent of the tuition out of pocket.

The 2012 Senate report discusses that for-profit institutions use many strategies to comply with the 90/10 rule. As one Herzing University executive wrote, "90/10 is a multi-front battle, like cancer - we won't find one single solution other than abolition." For-profit institutions can change the way their campuses are bundled, stop disbursing Title IV funds to a bundle of campuses, require students to pay up front in cash, increase tuition, make it difficult for students to receive living expense stipends, pursue military benefits, and convert to non-profit status if the situation becomes dire[6]. I focus on how the rule changes in the 2008 Higher Education Opportunity Act affects the campus bundling behavior at for-profit institutions.

For-profit "Bundling"

Bundling describes how a for-profit institution with many campuses combines different subsets of those institutions with each subset submitting their own financial statements that determine their 90/10 revenue percentage. The Office of Postsecondary Education (OPE) within the Department of Education issues a single numeric ID for each entity that receives Title IV funds, called an OPEID. At non-profit institutions, each separate campus is associated with a specific OPEID, so the OPEID is tied to a unique geographic location. At for-profit institutions, separate campuses from across the country can be associated with one OPEID. Institutions can also change which campuses are associated with an OPEID. According to a Senate Congressional report in 2012, changing the campuses covered by an OPEID requires the Department of Education, the college's accrediting agency, and State regulators to approve the change.

In my data, for example, ITT Tech had 43 different campuses across the US in 2008. These 43 different campuses were split into 22 different bundles. Each of these bundles is associated with just one 90/10 revenue percentage. These bundles are

[6]There was also a period from 2008 to 2012 during which 50 percent of the value of institutional loans counted as non Title IV revenue that were made during that fiscal year, instead of only the cash repayments made during that fiscal year counted as non Title IV revenue.

determined by the company that owns the ITT Tech, and are apparently unrelated to the proximity of the campuses. For example, one bundle includes campuses located in Washington, Kansas, and North Carolina. Another includes campuses in California, Missouri, and Georgia. In the quote at the beginning of the paper, Herzing University was considering pairings that included Toledo with Omaha and Akron with Minneapolis, even though pairing Toledo with Akron would make more sense if geography mattered.

Bundling campuses across states occurs relatively frequently in my data, and the universities most frequently engaging in this type of bundling tend to be well known, publicly traded names such as ITT Tech, Everest College, and Brown Mackie College. Other for-profit institutions like the University of Phoenix, Bryant and Stratton College, and National American University bundle all their campuses together instead of dividing them into subsets. Since the 90/10 revenue percentage associated with a particular bundle of campuses cannot be tied to a specific geographic region, it is impossible to account for local economic and demographic conditions and changes without first unbundling the revenue percentages. I provide a process that unbundles for-profit institution's revenue percentages.

The Higher Education Opportunity Act of 2008

President Bush signed the Higher Education Opportunity Act of 2008 (HEOA) on August 14th. It reauthorized the Higher Education Act of 1965, which must be renewed every four to six years. The HEOA expired in 2013, though the changes it made remain in place until congress passes a reauthorization bill. As section 2.1.1 mentioned, the government began imposing accountability measures on for-profit institutions in 1992. The HEOA changed some of those accountability measures, as well as adding new ones.

I focus on the change in the enforcement of the 90/10 rule, which affects for-profit institutions' eligibility for Title IV aid. The HEOA moved the 90/10 rule language into the program participation agreement, instead of leaving it in the eligibility requirements. As an eligibility requirement, violating the 90/10 rule results in a loss of eligibility in the university's next fiscal year. Moving the rule into the program participation agreement gives for-profit institution a second year to come back into compliance with the 90/10 rule. Moving the language was effective on the date of signing in 2008, but the Code of Federal Regulations (CFR) was not updated until July 1st, 2010. I consider the rule change effective in 2010, though for-profit institutions undoubtedly anticipated the change.

The HEOA also contains changes to the calculation of the 90/10 revenue percentage. Before 2008, loan repayments counted as non Title IV revenue, but not the net present value of the loans. Between 2008 and 2012, the net present value of loans made by the for-profit institutions count as non Title IV revenue. Since the change in 90/10 percentage calculation occurs during most of the years in my data, I need to consider its effect on for-profit institutions' behavior. The calculation change increases the amount of non Title IV revenue a for-profit institutions receives, which decreases the revenue percentage if the institution doesn't change its behavior. The institution can accept more Title IV aid, but without a change in the 90/10 violation policy the institution has no incentive to exceed their revenue percentage before the calculation change by increasing their Title IV revenue. Since the calculation change starts at the beginning of my data and expires near the end, it does not complicate my analysis of the violation rule change that occurs in the middle of my data.

Recently, the Department of Education has been working on requiring for-profit institutions to prove their students are gainfully employed to maintain Title IV eligibility. These regulations are called gainful employment requirements. While the term gainful employment has existed in the Higher Education Act since 1965, schools haven't been required to provide proof that their alumni are gainfully employed. The Department of Education has been working of defining gainful employment using metrics like debt-to-income ratios, loan repayment rates, and completion and job placement rates.

While the Department of Education's metrics are untested when it comes to predicting success in for-profit students, Cellini and Chaudhry (2013), Lang and Weinstein (2013), and Deming et al. (2014) all estimate the gains to attending a for-profit institution. Cellini and Chaudhry (2013) estimate that for-profit students earn about 10 percent more relative to high school graduates without a college degree, which translates to about a 4 percent return per year of education in a for-profit institution. Compared to estimates of returns in other sectors, 4 percent is slightly lower. Lang and Weinstein (2013) finds no statistically significant difference between the return to certificates and associates degrees from for-profit institutions or non-profit institutions. Lang and Weinstein's point estimates suggest that for-profit certificates have a lower return and for-profit associates degrees have a higher return. On the other hand, Deming et al. (2014) investigates how employers view degrees from for-profit institutions. Their results vary by the type of job, but they generally found that candidates with a for-profit degree were never *more* likely to be called back. Estimating the costs and benefits of attending different types of postsecondary institutions to students and taxpayers, Cellini finds that for-profit students needs an earnings increase of 8.5 percent per year to cover the cost, while a community college student requires a gain of 5.3 percent per year.

The gainful employment rule was originally introduced in 2011, but a federal judge put a hold on it. For-profit higher education industry groups and the Department of Education are currently fighting over gainful employment requirements in court. Since gainful employment requirements have not been enforced throughout my sample, I do not consider their effect on for-profit institutions' behavior.

2.2 Students at For-Profit Institutions

Students attending for-profit institutions differ from those attending non-profit institutions. Deming et al. (2012) find that for-profit institutions attract more female and minority students on average, using the Beginning Postsecondary Student Longitudinal Study from 2004 to 2009 (BPS 2004/2009). The BPS 2004/2009 is restricted student level data that is not able to observe changes in student composition over time. Since demographic changes at for-profit institutions may affect their bundling behavior, I use the 2008 and 2012 National Postsecondary Student Aid Study (NPSAS[7]) to calculate and compare changes in student's federal aid and demographics at for-profit and non-profit institutions. Since the HEOA changes I study took place in 2010, the 2008 and 2012 NPSAS provide a before and after picture of students in for-profit and non-profit institutions.

Table 2.4 provides demographic summary statistics of for-profit and non-profit students in 2008 and 2012. As Deming et al. (2012) found, women and minorities attend for-profit institutions at higher rates than non-profit institutions. Between 2008 and 2012, the share of both women and minorities attending for-profit institutions has decreased even though both still comprise a majority of the for-profit student body. Non-profit institutions also have a majority share of women that has decreased between 2008 and 2012, though their share of minorities has increased. While most students at all institutions are not married and the percentage of unmarried students is increasing over time, there are more married students at for-profit institutions than at non-profit institutions. For-profit students are older on average than non-profit students, though students in both sector have gotten younger between 2008 and 2012.

Most important for federal aid receipt, and thus for bundling decisions, are income and tax dependency status. A much higher percentage of non-profit students are dependents than for-profit students, though the dependency rate has increased over time in both sectors. Family income is higher for both dependent and independent non-profit students, though average income has fallen between 2008 and 2012. Lower income allows students to qualify for more Title IV aid. If for-profit students are qualifying for more Title IV aid, the 90/10 constraint is more likely to bind at each campus.

[7]The 2004 NPSAS is the base study from which the participants in the BPS 2004/2009 are drawn.

Table 2.5 displays the percentage of students with different types of aid, as well as the amount of aid they received conditional on the student receiving a positive amount of that aid. The percentage of students in both sectors receiving Pell grants has grown significantly from 2008 to 2012, though a much higher percentage of for-profit students receive Pell grants than non-profit students. Over three quarters of for-profit students also take out Federal loans to pay for their education, compared to about forty percent of non-profit students. The percentage of for-profit students receiving Federal loans has increased from 2008 to 2012, too, while there has been no growth in the percentage of non-profit students Federal loan usage.

Table 2.6 shows that, conditional on receiving a nonzero aid amount, for-profit students are relying more on Title IV aid in 2012 and less on non-Title IV aid than in 2008 while non-profit student Title IV usage remains stagnant. For-profit institutions also saw a growth in the percentage of students receiving aid from the Department of Veterans Affairs, and the amount those veteran students receive at for-profit institutions nearly doubled, as well. Veteran student growth at non-profit institutions is stagnant between 2008 and 2012, and the amount non-profit veteran students receive grew by much less than at for-profit institutions. When the 90/10 constraint was relaxed from the one year violation rule to the two year violation rule, for-profit institutions became able to rely more on Title IV aid and used techniques, like rearranging campus bundles or recruiting veterans, to allow their students to receive more Title IV aid.

Tables 2.5 and 2.6 do not condition on student demographic, aid, or institution characteristics. While for-profit students rely more of Title IV aid in 2012, they also have lower incomes in 2012. If the increase in for-profit students reliance on Title IV aid is driven solely by demographics, then it's possible for-profit institutions are responding to demographic changes only and not the changes in the 90/10 constraint violation rules. I estimate the equation

$$Aid_{ij} = \beta_0 + \beta_1 \mathbb{I}[year = 2012] + \Gamma_{1i} D_i + \Gamma_{2i} A_i + \Gamma_j S_j + \vartheta_{ij} \tag{2.1}$$

where Aid_{ij} is the amount or percentage of the student's aid, $\mathbb{I}[year = 2012]$ is one if the year is 2012 and zero in 2008, D_i is a vector of student demographic characteristics including immigration status, income, dependency status, race, a quadratic in age, sex, marital status, and ACT score, A_i is a vector of student aid characteristics including all non-Title IV Federal aid, all state and local grants, and all state, local, and private loans, and S_j is a vector of institution level characteristics including tuition and campus fixed effects. Campus fixed effects are included to capture location specific changes that are not captured by student characteristics. I estimate equation 2.1 using only students at for-profit institutions, and I use the estimated equation 2.1 to calculate the average amount of Aid students receive in 2008 and 2012. Tables 2.7 and 2.8 contains average aid amounts conditional on student and institution characteristics calculated from equation 2.1.

After controlling for demographic, aid, and institutional variables, the nearly $2,000 increase from 2008 to 2012 in Title IV aid reliance decreases to a little over a $1,000 increase. Demographic, non Title IV aid usage, and campus specific policies explain a little less than half of the increase in Title IV aid usage. The Title IV aid usage increase is due to an increase in the use of Pell Grants, as opposed to an increase in subsidized loans. The Pell Grant maximum award increased from $4,310 in 2008 to $5,550 in 2012[8]. The increase in the maximum award caused students to receive a large Pell grant award, thus driving up the amount of Title IV aid each student received. Not all students receive the maximum Pell Grant award. Between 2008 and 2012, the students received on average about 7 percentage points more of the maximum Pell Grant Award in 2012 as well as receiving a larger total dollar Pell Grant award in 2012. The increase in Pell Grants is caused both by an increase in the maximum award amount as well as an increase in the percentage of the maximum Pell Grant awarded.

While for-profit students are relying more on Pell Grants, they are relying less on subsidized loans. Without controlling for demographic, aid, or institution char-

[8]$5,550 in 2012 is $5,304.54 in 2008 dollars

acteristics, students use of subsidized loans did not change between 2008 and 2012. After controlling for those characteristics, usage of subsidized loans fell by about $240 from 2008 to 2012. Reliance on unsubsidized loans has increased, though, by about $900 whether conditioning on student and institution characteristics or not. Moving away from subsidized loans and toward Pell grants reduces for-profit student debt for low income students, though that decrease in reliance on debt disappears when unsubsidized loans are considered.

Since the increase in Title IV aid is not explained by demographic, aid, or campus location characteristics, the change in for-profit campus bundling behavior around 2010 is at least partially explained by the HEOA.

2.3 Theory

For-profit postsecondary education just recently came to the attention of economists. Until now, no one has modeled the bundling behavior of for-profit institutions. My model consists of for-profit institutions that have the option of opening some number of campuses. Each campus has some Title IV revenue and some non Title IV revenue. Since I focus on the bundling behavior of for-profit institutions, I abstract away from 90/10 compliance strategies that rely on changing the 90/10 ratio within an individual campus by assuming that the non Title IV revenue is drawn from a known distribution and is not a random variable. Title IV revenue has a known component but also has a random component, so each institution does not know exactly how much Title IV revenue each campus earns.

In deciding how to bundle their campuses, for-profit institutions care about about the amount of Title IV and non Title IV revenue each campus receives and the resulting 90/10 percentage of the possible pairings. For-profit universities can also choose to open or close some campuses. In a 2010 email about acquiring new campuses, a Herzing University executive wrote, ”We are only interested in schools with low 90/10 ratios, which are healthy, and $1M+ in revenue.“ In my model, for-profit institutions have the option of opening a set number of campuses, though they do not have to open all of the possible campuses. The option of not opening all campuses simulates for-profit institutions' option of opening or closing campuses after the 90/10 violation rule changes.

The model consists of two periods, so I can compare a two year violation rule to a one year violation rule. I assume the bundles of campuses are chosen before the first period, and the bundle composition is permanent. In reality, universities can change their bundle composition with the approval of the Department of Education, the college's accrediting agency, and state regulators. While these three entities normally approve of the changes, the process is costly and takes time. I construct the model to compare a one year violation regime to a two year violation regime, so I abstract away from any dynamic choices for-profit universities might encounter, which includes changing bundle composition between periods.

2.3.1 The Model

Assume there is one for-profit institution with n campuses. All campuses are the same size and generate the same revenue. They only differ in the percentage of revenue derived from Title IV aid. There are two time periods, $t = \{1, 2\}$. Before the start of these two periods, the institution chooses its set of bundles. During these periods, the institution cannot change the configuration of the bundle set.

Each campus, i, has an associated average Title IV revenue percentage, $\rho_{i,t}$. The revenue percentage, $\rho_{i,t}$, is determined by three components: Title IV revenue, which has a fixed and a random component, and non-Title IV revenue.

Title IV revenue has a known, time invariant, component, μ_i, and an unknown, time varying, random component, $\epsilon_{i,t}$, so that $TIV_{i,t} = \mu_i + \epsilon_{i,t}$, where $TIV_{i,t}$ is Title IV revenue at campus i in time t. The unknown component follows a mean zero bivariate normal distribution with covariance matrix Σ. Non-Title IV revenue is a known, campus specific, time invariant constant, η_i. The revenue percentage takes the form:

$$\rho_{i,t} = \frac{\mu_i + \epsilon_{i,t}}{\eta_i + \mu_i + \epsilon_{i,t}} \tag{2.2}$$

Note that the revenue percentage can be rearranged so that:

$$\frac{\rho_i}{1-\rho_i} = \frac{\mu_i + \epsilon_{i,t}}{\eta_i} \tag{2.3}$$

The revenue percentage must be below a certain percentage, δ, otherwise the campus violates the δ rule and must shut down. Two possible versions of the rule exist. Under the one year rule, the institution must keep every campus below the δ revenue percentage *each* period. Under the two year rule, the institution must keep every campus below the δ revenue percentage *for at least one* period.

Under the one year rule, the institution is interested in the probability that a particular campus does not violate the δ rule in both periods:

$$\begin{aligned} Pr(\rho_{i,1} < \delta \cap \rho_{i,2} < \delta) &= Pr\left(\frac{\mu_i + \epsilon_{i,t}}{\eta_i + \mu_i + \epsilon_{i,t}} < \delta \cap \frac{\mu_i + \epsilon_{i,t}}{\eta_i + \mu_i + \epsilon_{i,t}} < \delta\right) \\ &= Pr\left(\epsilon_{i,1} < \frac{\delta\eta_i}{1-\delta} - \mu_i \cap \epsilon_{i,2} < \frac{\delta\eta_i}{1-\delta} - \mu_i\right) \\ &= \int_{-\infty}^{\frac{\delta\eta_i}{1-\delta}-\mu_i} \int_{-\infty}^{\frac{\delta\eta_i}{1-\delta}-\mu_i} \phi_i(\epsilon_{i,1}, \epsilon_{i,2}) d\epsilon_{i,1} d\epsilon_{i,2} \end{aligned} \tag{2.4}$$

Here, $\phi_i(\cdot)$ is the bivariate normal probability density function for campus i. Under the two year rule, the institution is interested in the probability that a particular campus does not violate the δ rule in at least one of the periods:

$$\begin{aligned} Pr(\rho_{i,1} < \delta \cup \rho_{i,2} < \delta) &= Pr\left(\frac{\mu_i + \epsilon_{i,t}}{\eta_i + \mu_i + \epsilon_{i,t}} < \delta \cup \frac{\mu_i + \epsilon_{i,t}}{\eta_i + \mu_i + \epsilon_{i,t}} < \delta\right) \\ &= Pr\left(\epsilon_{i,1} < \frac{\delta\eta_i}{1-\delta} - \mu_i \cup \epsilon_{i,2} < \frac{\delta\eta_i}{1-\delta} - \mu_i\right) \\ &= \int_{-\infty}^{\frac{\delta\eta_i}{1-\delta}-\mu_i} \int_{-\infty}^{\frac{\delta\eta_i}{1-\delta}-\mu_i} \phi_i(\epsilon_{i,1}, \epsilon_{i,2}) d\epsilon_{i,1} d\epsilon_{i,2} \\ &\quad + 2\int_{\frac{\delta\eta_i}{1-\delta}-\mu_i}^{\infty} \int_{-\infty}^{\frac{\delta\eta_i}{1-\delta}-\mu_i} \phi_i(\epsilon_{i,1}, \epsilon_{i,2}) d\epsilon_{i,1} d\epsilon_{i,2} \end{aligned} \tag{2.5}$$

Figure 2.1 shows the different regions the integrals in equations 2.4 and 2.5 cover. Since these regions do not depend on the distribution, the random Title IV time shocks do not need to be independent and I can allow for correlation over time, though I do not to simplify the simulation. The one year rule covers only region A in figure 2.1. The two year rule expands the coverage to region $A + B + D$. Since the area under the $\phi_i(\epsilon_{i,1}, \epsilon_{i,2})$ expands, campusese have a higher probability of satisfying the revenue constraint under the two year rule than the one year rule.

Suppose the institution combines the campuses into bundles with N being the set of all bundles and $|N| \leq n$. There are a number of ways to aggregate campuses. I sum the Title IV and non-Title IV revenues separately to account for size differences across campuses. Consider a bundle $J \subseteq N$ that has $|J| > 1$. Using equation 2.3, note that:

$$\frac{\rho_J}{1-\rho_J} = \frac{\sum_{\forall j \in J}(\mu_j + \epsilon_j)}{\sum_{\forall j \in J}\eta_j}$$

$$= \frac{\sum_{\forall j \in J}\mu_j}{\sum_{\forall j \in J}\eta_j} + \frac{\sum_{\forall j \in J}\epsilon_j}{\sum_{\forall j \in J}\eta_j}$$

and that

$$\sigma_J = \frac{\sum_{\forall j \in J}\sigma_j^2}{(\sum_{\forall j \in J}\eta_j)^2}$$

which assumes ϵ_j are independent $\forall j$. Therefore, we get:

$$\epsilon_J \sim N(0, \sigma_J)$$

Also note that $\sigma_J^2 \leq \sigma_j^2$ for all $j \in J$ so

$$1 - \Phi_J\left(\frac{\delta\eta_J}{1-\delta} - \mu_J\right) \leq 1 - \Phi_j\left(\frac{\delta\eta_J}{1-\delta} - \mu_J\right) \quad \forall j \in J$$

An institution decreases their probability of violating the revenue percentage rule by bundling their campuses together.

Assuming that ϵ_j are independent $\forall j$ simplifies calculating the variance of a bundle's revenue percentage. It is also a reasonable assumption to make. Bundles can, and do, include campuses from many different states. While shocks to the national economy may affect revenue percentages of all campuses, regional shocks may differ because the universities are located hundreds or thousands of miles apart. If regional shocks are relatively uncorrelated, my model doesn't lose anything by assuming independence across shocks to different campuses.

Every campus in the institution earns a revenue of $\mu_i + \epsilon_i + \eta_i$ and incurs a cost of c_i while it is operating. The realized profit for each campus is $\pi_i = \mu_i + \epsilon_i + \eta_i - c_i$. If an institution violates the rule, the institution does not earn any profit. The expected profit of a single campus is $\Pi_i = \Phi_i(\frac{\delta \eta_i}{1-\delta} - \mu_i)(\mu_i + \eta_i - c_i)$. The expected profit of a bundle, J, is $\Pi_J = \Phi_J(\frac{\delta \eta_J}{1-\delta} - \mu_J) \sum_{j=1}^{|J|} (\mu_j + \eta_j - c_j)$ where j denotes an individual campus in the bundle. The expected profit for the institution is the sum of the expected profits of each bundle, or

$$\Pi = \sum_{J=1}^{|N|} \Pi_J = \sum_{J=1}^{|N|} \Phi_J(\frac{\delta \eta_J}{1-\delta} - \mu_J)\left(\sum_{j=1}^{|J|} (\mu_j + \eta_j - c_j) - C_{|J|} \right)$$

Here, I use $C_{|J|}$ to denote the administrative cost to operating $|J|$ number of bundles.

The institution's problem is:

$$\max_N \sum_{J=1}^{|N|} \Pi_J \tag{2.6}$$

Each university must:

1. Choose how many campuses to open
2. Choose the set of bundles, conditioning on which campuses it decides to open

when maximizing profits.

If the institution bundles all their campuses together, their probability of violating the revenue percentage is minimized. But if they do violate the revenue percentage, the entire institution is shut down and they lose their entire profit. On the other hand, if they do not bundle, each campus has higher chance of violating the rule but only that campus loses its profit if it violates the rule.

2.3.2 Simulation

There is no clear analytical solution to equation 2.6. I report the distribution of choices from simulated universities. To fix ideas on how the simulation works, consider a university that has the option of opening two campuses. The possible sets of campuses the university can open are:

$$
\begin{aligned}
&1 : \{\varnothing\} \\
&2 : \{1\} && 3 : \{2\} \\
&4 : \{1\}, \{2\} && 5 : \{1, 2\}
\end{aligned}
$$

Even though the university can open two campuses, it may choose not to if the expected profit for that combination is less than zero. If the university does choose to open two campuses, it then needs to choose whether it should open the campuses as two separate bundles or to bundle the two campuses together. Depending on the expected average Title IV revenue percentage is for each campus, different universities will choose different sets of bundles even if they are opening the same number of campuses.

To illustrate the effect of the rule change,I simulate 100,000 universities. While there are not 100,000 for-profit universities, simulating many universities approximates the true distribution of university entry and bundling decisions for the chosen parameters. Each university has the option of opening four campuses, which means there are 52 possible sets of bundles, including the empty set (non-entry in the market). The campus parameters are:

$$
\begin{aligned}
&\delta = \{0.85, 0.9\} \\
&\mu_i \sim N(120,000, 30,000^2) \\
&\eta_i \sim N(16,000, 4,000^2) \\
&\sigma_i^2 = 100,000 \\
&c_i = \mu_i + \eta_i + \zeta_i \\
&\zeta_i \sim N(-1,000, 1,000^2)
\end{aligned}
$$

These parameters are chosen to illustrate the effect of the rule change and are not calibrated to the data. Under these parameters, the average Title IV revenue percentage using these values is about 88.2. Figure 2.2 shows the simulated distribution of expected Title IV revenue percentages for one campus at each university. The true distribution in figure 2.2 is not known. The average revenue percentage in figure 2.2 is higher than the average revenue percentage in the data because the revenue percentages in the data are observed after for-profit institutions have worked to comply with the revenue constraint. I assume the true campus revenue percentage distribution is higher than observed, since otherwise there would be no need to bundle to comply with the revenue constraint. The simulation illustrates one possible mechanism to explain the observed change in for-profit institution's bundling behavior.

The cost parameter, c_i, determines entry into the market. If the cost is set sufficiently low by giving ζ_i a low mean, every university will choose to open all four campuses. The administrative cost, $C_{|J|}$, is a multiplicative combination of the costs of each campus in the bundle. For example, if there are three campuses with costs c_1, c_2, and c_3 and each campus is its own bundle, then $C_{|J|} = c1 \cdot c2 + c1 \cdot c3 + c2 \cdot c3 + c1 \cdot c2 \cdot c3$. If campuses 1 and 2 are bundled together and campus 3 is its own bundle, then $C_{|J|} = (c1 + c2) \cdot c3$. If all three campuses are bundled together, then $C_{|J|} = 0$ since I assume there is no extra administrative cost to running only one bundle.

Violating the revenue constraint at a campus causes the university to lose the campus, and the profit associated with that campus. Suppose a university has two campuses, campus 1 and campus 2. Suppose campus 1 has a revenue percentage of 92 percent the first year and 88 percent the second year, and campus 2 has a revenue percentage of 88 both years. Under both the one year rule and the two year rule, campus 2 is below the 90 percent constraint and the university earns all profits associated with campus 2. On the other hand, campus 1 violates the constraint in the first year. Under the one year rule, campus 1 shuts down and the university only profits from campus 2. On the other hand, campus 1 does not violate the constraint in the second year. Under the two year rule, the university profits from campus 1 and campus 2.

2.3.3 Results

In table 2.1, I report the results of the simulation in four different regulatory environments and compare them to the analog in the data. The first environment is a one year violation rule versus a two year violation rule. The second environment is a 90 percent upper limit for Title IV revenue versus an 85 percent upper limit for Title IV revenue. Columns one and two show the results under the 85/15 rule for the one and two year violation rules. Columns three and four show the results under the 90/10 rule for the one and two year violation rules. I use the same set of simulated campuses for all regulatory environments. Columns five and six show the analog in the data to the 90/10 regulatory environment in columns three and four. In columns five and six, I calculate bundle size and revenue percentages using the Integrated Postsecondary Education Data System and revenue percentage estimates described in section 2.4. The pre 2010 data corresponds to the one year violation rule while the post 2010 data corresponds to a two year violation rule.

I report the average size of a bundle, the average revenue percentage, and the average university profit in table 2.1. Under both the 90/10 constraint and the 85/15 constraint, the average bundle size increases under the two year violation rule due to a lower probability of violating the rule and a lower administrative cost. The observed average bundle size increases after 2010, which mirrors the simulation. The simulation also shows that the average revenue percentage is higher under the two year violation rule regardless of whether universities are constrained by the 85/15 rule or the 90/10 rule. The estimated average campus revenue percentage increases after 2010, which mirrors the simulation. When I exclude bundles consisting of only one campus, the simulation produces numbers similar to the data. Though the simulation is an example and not a calibration, it more closely matches the data when single campus institutions are excluded.

Comparing the bundle size and average revenue percentages between the 90/10 simulation and the 85/15 simulation, universities under the 85/15 rule are more cautious. They do not open as many high revenue percentage campuses as they would under the 90/10 constraint, which decreases the size of the average bundle.

I also calculate average university profit in table 2.1, but only for the simulations. I do not have data on, and cannot calculate, profit at for-profit institutions. In the simulations, I find that universities are more profitable under the 90/10 constraint than the 85/15 constraint. I also find that, under both constraints, universities are more profitable under the two year violation rule than the one year violation rule.

Since the HEOA occurs while the 90/10 rule is in effect, I focus on the results under the 90/10 rule. For the 90/10 rule, expected profits and bundle sizes are both higher under the two year violation rule. My model and simulation suggest that after switching to the two year rule, I should observe larger bundle sizes and each institution should have fewer bundles. The model takes the amount of revenue each campus earns as exogenous. If this is not the case, for-profit universities may manipulate their admissions or advertising to change their average revenue percentage. Since the probability of violating the rule is smaller under the two year rule, universities have an incentive to increase the μ_i or σ_i^2 of their campuses which are both exogenous in my model.

2.4 Methodology and Data

To test the predictions implied by my theory, I need data on revenue percentages for every for-profit campus before and after the rule change in 2010. Since campus specific data on Title IV revenue applied only to tuition and education related expenses does not exist, unbundling requires constructing an alternative measure of the 90/10 revenue percentage. I use the Integrated Postsecondary Education Data

System (IPEDS) to create both campus specific and bundle specific proxy revenue percentages, along with the actual revenue percentage data downloaded from studentaid.ed.gov.

The IPEDS includes all postsecondary schools accept Title IV aid and is reported for each separate campus within an institution. Cellini and Goldin (2012) estimate that the number of for-profit institutions is twice as large as the official count and number of students is one-quarter to one-third larger. These schools are not included in my data, and would make a poor control group since they are not required to submit compliance reports to the Department of Education. Gilpin et al. (2015) note that the current for-profit higher education literature focuses on two year schools that mainly grant associates degrees. Since the 90/10 rule applies to all for-profit institutions, I include four year, two year, and less than two year schools in my analysis. Some for-profit institutions include different types of schools in the same bundle, so excluding any type of for-profit institution could bias my results. Though I observe each campus' revenues, expenditures, and enrollments, I do not observe to which institution each campus belongs. Ownership of for-profit campuses matters because my theory predicts a for-profit institution will open fewer campuses and increase the size of the bundle. Since I do not observe ownership, I can only test whether bundle size increases.

The reported revenue percentage is taken from the EZ-Audit system through which universities report their financial data to the Office of Postsecondary Education to ensure regulatory compliance. The Institute for Education Sciences (IES), which is the institute that collects the IPEDS, is an entirely separate from the Office of Postsecondary Education (OPE) within the Department of Education, though they collect similar data. The OPE has released the 90/10 revenue percentages on the studentaid.ed.gov site from the 2007-2008 academic year to the 2012 to 2013 academic year. The OPE only reports revenue percentages for each bundle, not each campus within the bundle. So to estimate a revenue percentage for each campus, I merge the IPEDS data with the revenue percentage data.

2.4.1 Unbundling the 90/10 Revenue Percentage

Ideally, I would take the total amount of Title IV aid each for-profit campus receives and divide it by its tuition and fee revenue. The IPEDS does not include the each campuses total Title IV revenue, but it does contains components of Title IV revenue such as total Pell grants. I use Pell grant revenue as a proxy because it is the largest Title IV grant program and is positively correlated with the total amount of Title IV funds an institution receives. The IPEDS does not contain data on total Title IV aid revenue or even Title IV subsidized government loans.

In the IPEDS, there are unique identifiers for both campuses and bundles. Using the campus level data, I construct my revenue percentage proxy, $\widetilde{revpct}$, at both the campus level and the bundle level. Since Pell grants are only a portion of the Title IV revenue a institution receives, $\widetilde{revpct}$ is generally much lower than the observed 90/10 revenue percentages, and so it is not directly comparable to the actual revenue percentage. Understanding the effect of unbundling for-profit institutions requires a measure of an unbundled 90/10 percentage that is directly comparable to the bundled revenue percentage.

To unbundle the revenue percentage to the campus level, I estimate a revenue percentage, $\widehat{revpct}_{t,i}$ for each campus, i, using $\widetilde{revpct}_{t,i}$. To do this, I first estimate the equation:

$$revpct_j = \alpha_0 + \sum_{l=1}^{4} \alpha_l \widetilde{revpct}^{\,l}_{t,j} + \gamma_{1,j} + \gamma_{2,j} \cdot I(year \geq 2010) + \varphi_{t,j} \qquad (2.7)$$

where $\gamma_{1,j}$ and $\gamma_{2,j}$ are bundle fixed effects for before 2010 and after 2010, respectively. The indicator function $I(year \geq 2010)$ is one when the year is 2010 or later and zero otherwise. Equation 2.7 is estimated at the bundle level. Here, $revpct_j$ is the observed revenue percentage for each bundle and $\widetilde{revpct}_{t,j}$ is the 90/10 percentage proxy calculated for each bundle. I fit equation 2.7 using a quartic in $\widetilde{revpct}_b$ to capture any possible nonlinearities in the relationship between the proxy and the actual value. I predict $\widehat{revpct}_{t,i}$ using the equation:

$$\widehat{revpct}_{t,i} = \hat{\alpha}_0 + \sum_{l=1}^{4} \hat{\alpha}_l \widetilde{revpct}_{t,i}^{\,l} + \hat{\gamma}_{1,j} + \hat{\gamma}_{2,j} \cdot I(year \geq 2010) \tag{2.8}$$

Equation 2.8 predicts revenue percentages for each campus allowing the bundle composition to change with the rule change. The predicted campus revenue percentages are deviations from that campus's bundles' average revenue percentage. The direction of the deviation is determined by the magnitude of the proxy, $\widetilde{revpct}_{t,i}$.

I check equation 2.7's fit by predicting bundle level revenue percentages using the equation:

$$\widehat{revpct}_{t,j} = \hat{\alpha}_0 + \sum_{l=1}^{4} \hat{\alpha}_l \widetilde{revpct}_{t,j}^{\,l} + \hat{\gamma}_{1,j} + \hat{\gamma}_{2,j} \cdot I(year \geq 2010) \tag{2.9}$$

Note that equation 2.8 is calculated using the campus level proxy while equation 2.9 is calculated using the bundle level proxy. The distributions the actual revenue percentages and the two predicted revenue percentages from equations 2.8 and 2.9 are shown in figure 2.5 along with the distribution of true revenue percentages. The predicted revenue percentages for the bundles follows the actual revenue percentages pretty closely. Equation 2.7's R^2 is 0.85, so much of the variation in the actual revenue percentages is explained. The main difference is that at revenue percentages above 60, the predicted percentages are shifted away from the actual percentages. Overall, the model fits the data well.

2.5 Results

Tables 2.2 and 2.3 shows the summary statistics and number of rule violations for campuses and bundles after I unbundle the revenue percentages. In general, the number of for-profit campuses are increasing over the six years in my sample. The average revenue percentage is also increasing. Since my sample occurs during the 2007-2009 recession, and there is evidence that skill acquisition occurs during depressed labor markets [9], students would rely more on Title IV assistance during recessions. In section 2.2, I find that for-profit students are more likely to be nonwhite, female, receive more federal loans and Pell grants per student than students in non-profit colleges, and have a lower family income than students in non-profits. Due in part to students in for-profit institutions being more likely to be using Title IV aid and the sluggish labor market recovery, the average revenue percentages have been increasing from 2008 to 2013, though these factors cannot explain all of the increase. Also, figure 2.4 shows the distribution of actual revenue percentages by year, which is shifting towards right and bunching near the 90 percent cutoff.

The predicted revenue percentages does not entirely reflect the increase in revenue percentages over this time period. I predict an increase in revenue percentages, going from about 65.6 percent in 2008 to about 69.7 percent in 2013, as seen in column 6 of table 2.2. From 2010 to 2013, I predict a decrease in the average revenue percentage. In equation 2.7, the pseudo revenue percentage, $\widetilde{revpct}$, and the indicator function interacted with $\gamma_{2,j}$ are the only time varying components in the model. The time varying components in my model are not meant to capture the observed shift towards the 90/10 cutoff, because I am interested in isolating the HEOA's effect on revenue percentages. Since the HEOA policy changes effect all Title IV accepting for-profit institutions, my estimates cannot entirely rule out effects of the recession and sluggish labor market recovery on for-profit bundling behavior, though the predicted decrease in average revenue percentages implies that I'm capturing policy effects and not labor market trends.

2.5.1 Bundle Size

My theoretical model predicts that switching from a one year to a two year 90/10 violation rule will discourage for-profit institutions from unbundling their campuses, especially bundles comprised of high percentage campuses. Column 4 of table 2.2

[9]See DeJong and Ingram (2001), Sakellaris and Spilimbergo (2000), Dellas and Koubi (2003)

shows the average bundle size of for-profit campuses that were included in a bundle from 2008 to 2013. During the six years in my sample, the average bundle size has monotonically increased from 3.57 in 2008 to 4.86 in 2013. The increase in average bundle size is consistent with the model's simulations.

While the increase in bundle size has been relatively steady throughout my sample as opposed to one large increase in 2010, the increase still provides support for my theory. Since the violation rule change in the HEOA was effective the day it was signed in August of 2008, for-profit institutions were anticipating the rules change in the CFR in 2010. The two year lag between the date of the signing the reauthorization to the CFR update allowed for-profit institutions time to adjust to the policy change. So I observe a steady increase in bundle size as opposed to one large increase.

2.5.2 Rule Violations

Table 2.3 shows the predicted number of campuses and bundles violating the 90/10 rule. The rise in revenue percentages causes an increase in the number of potential 90/10 rule violations. Using the estimated revenue percentages for the bundles, I find that the number of one year violations at the bundle level increased after 2010 in column 1 of table 2.3, reflecting an increase in the revenue percentages. Two year violations shown in column 2 of table 2.3 increased in 2011, since it takes an extra year after the policy change to violate this rule.

Columns 3 and 4 in table 2.3 show the number of campuses violating the one and two year 90/10 rules. Unbundling the campuses approximately double the number of one year violators after 2010, though the number of two year violators remains roughly the same. Before 2010 under the one year rule, I predict many more campuses violating the one year rule than after 2010. Column 5 in table 2.3 shows that most of these violations occur in campuses that are bundled with other campuses. For two year rule violators, before 2010 most of the violations were at campuses that were bundled. Afterwords, bundled campuses were less likely to violate the two year rule.

By allowing for-profit institutions to bundle campuses together when submitting regulatory compliance reports, the Department of Education is decreasing the effectiveness of the 90/10 rule. More campuses would lose eligibility if for-profit institutions were forced to unbundle.

2.6 The Effect of the HEOA Rule Change

Though my theoretical model does not address the change in Title IV revenue for-profit institutions accept, the change in the 90/10 violation rules does offer an incentive to for-profit institutions to increase Title IV revenue. I estimate the effect of the rule change in the HEOA on the amount of Title IV funds directed to for-profit institutions. After estimating equation 2.7 and predicting revenue percentages for each campus in equation 2.8, I predict revenue percentages holding bundle fixed effects constant before 2010 using the equation:

$$\widehat{revpct}'_{t,i} = \hat{\alpha}_0 + \sum_{l=1}^{4} \hat{\alpha}_l \widetilde{revpct}^{l}_{t,i} + \hat{\gamma}_{1,j} \tag{2.10}$$

The difference between equation 2.8 and equation 2.10 is that I force $I(year \geq 2010)$ equal to zero for the entire sample in equation 2.10. The predicted revenue percentages from equation 2.10 are the campus revenue percentages we would have observed if the rule had not changed. This requires that I assume $\hat{\gamma}_{2,j}$ captures only the effect of the change from a one year to a two year rule violation. The HEOA also changed the way for-profit institutions calculate their 90/10 revenue percentages, allowing for-profit institutions to count additional revenues as non-Title IV. These changes were also implemented in 2010 and would cause revenue percentages to decrease if universities do not change in response. If universities respond to the revenue percentage calculation change, they would have no incentive to increase revenue percentages above what they were under the one year violation rule.

Figure 2.7 shows the distribution of the predicted campus revenue percentages with the rule change, $\widehat{revpct}_{t,i}$, versus the distribution of the predicted campus revenue percentage without the rule change, $\widehat{revpct}'_{t,i}$. With the rule change, campus revenue percentages tend to cluster just below the 90 percent cutoff, which mirrors the actual revenue percentage distribution. Without the rule change, the revenue percentage distribution shifted away from the 90 percent cutoff. The switch to the a two year violation rule allows for-profit institutions to accept more Title IV revenue than they previously had, incentivizing campuses to increase their revenue percentages or universities to open new campuses in areas that are accessible to lower income students.

I calculate the estimated amount of Title IV revenue at each campus by multiplying the estimated revenue percentage and the total tuition and fee revenue. I then sum the estimated Title IV revenue across for-profit campuses for each year. Figure 2.8 shows the estimated Title IV revenue for-profit institutions accept with the rule change and without the rule change. I only include campuses that are in my sample for all six years when calculating the estimated revenue percentages. I find that the rule change can account for roughly 0.9 billion extra dollars in Title IV aid going to for-profit institutions each year. Considering that the for-profit institutions in my sample are generally receiving between 20 to 23 billion dollars in Title IV aid between 2010 and 2013, and extra 0.9 billion dollars is about 4.5 percent more Title IV aid than they would have otherwise received.

2.7 Conclusion

Congress passed the Higher Education Opportunity Act in 2008, which relaxed the Title IV aid eligibility requirements on for-profit institutions. Beginning in 2010, for-profit institutions lose eligibility by violating the 90/10 rule for two consecutive years instead of losing eligibility after violating it once. The 90/10 rule requires for-profit institutions to receive at least ten percent of their revenue from non-Title IV sources. Relaxing the 90/10 constraint allowed for-profit institutions to collect more Title IV revenue from their students, and I find that students at for-profit institutions use nearly $1,000 more Title IV aid after the rule change. After predicting a revenue percentage for each campus, I find that the number of one year 90/10 rule violations would double if the Department of Education counted every campus as an individual entity when submitting regulatory compliance reports, instead of allowing for-profit institutions to bundle campuses together.

Further research is needed to understand the impact on students attending for-profits that violate the 90/10 rule. If a for-profit institution closes, it is required to find a suitable alternative for its students, but there may not be any suitable alternatives in the area. To understand the impact of an unbundling policy on the students, defining and quantifying the number of suitable alternatives in the vicinity of for-profit institutions that violate the 90/10 rule is necessary.

I also find that relaxing the 90/10 violation rule caused for-profit institutions to include more campuses in a bundle and to accept more Title IV aid revenue. The average bundle size increased from about 3.5 to 4.8 among campuses that are bundled. I estimate that for-profit institutions in my sample receive about $900 million, 4.5 percent, more Title IV aid revenue under the two year rule than they would under the one year rule. Further research is needed to understand the characteristics of for-profit institutions that benefit from having the 90/10 violation rule relaxed.

2.8 Figures and Tables

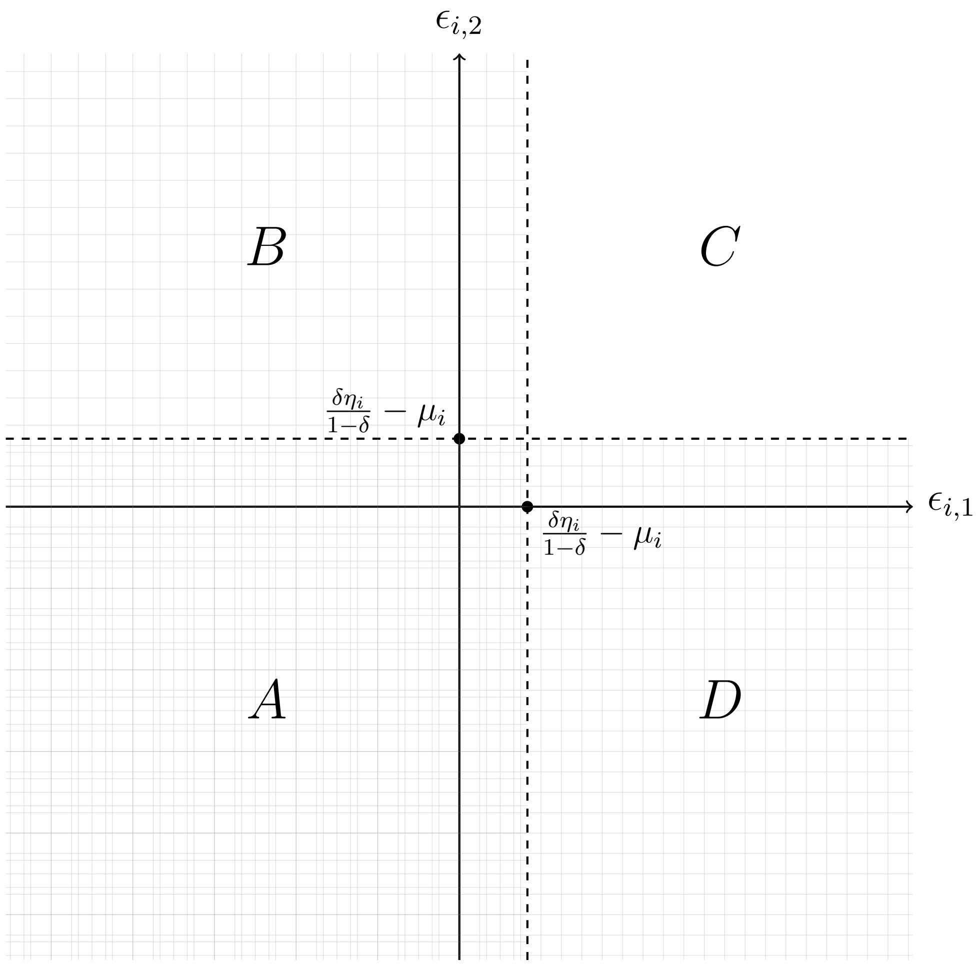

Fig. 2.1.: Probability areas for the distribution of $\epsilon_{t_1}, \epsilon_{t_2}$.

Under the one year violation rule, the institution must get draws of ϵ_{t_1} and ϵ_{t_2} from area A. Under the one year violation rule, the institution can get draws of ϵ_{t_1} and ϵ_{t_2} from areas A, B, and D. Two draws from area C

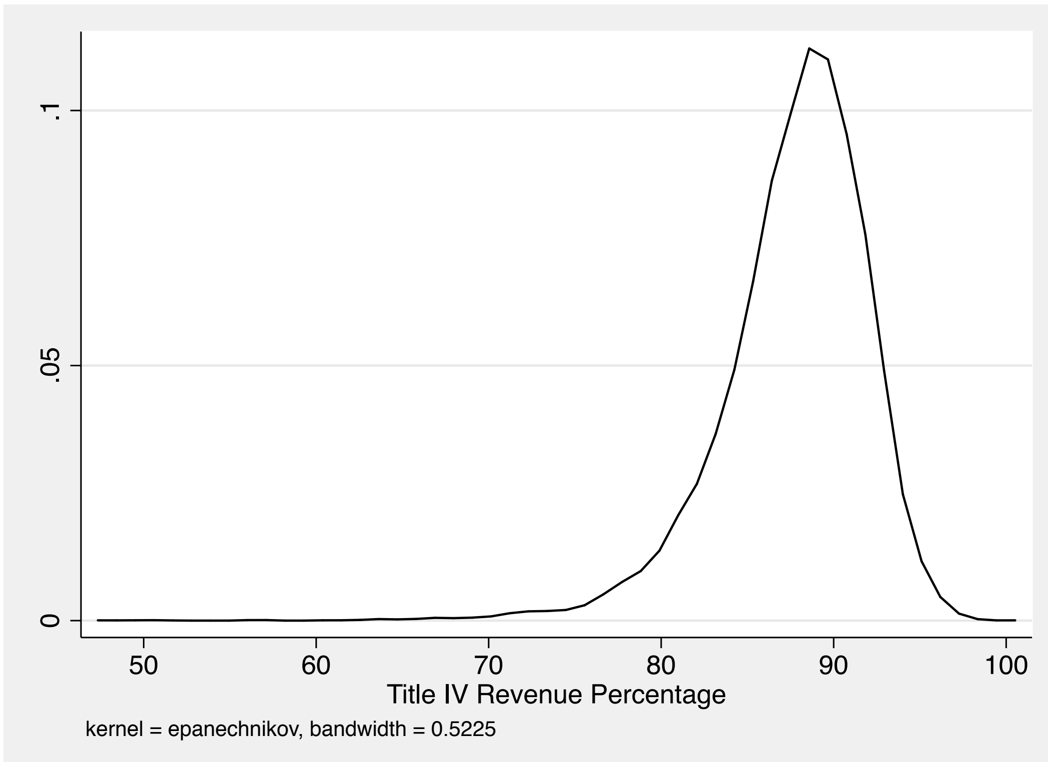

Fig. 2.2.: Simulated Title IV revenue percentages for 100,000 campuses.

The distribution above is for one campus from each university. There are 400,000 possible campuses. The revenue percentage distribution is the same for the other campuses in each university.

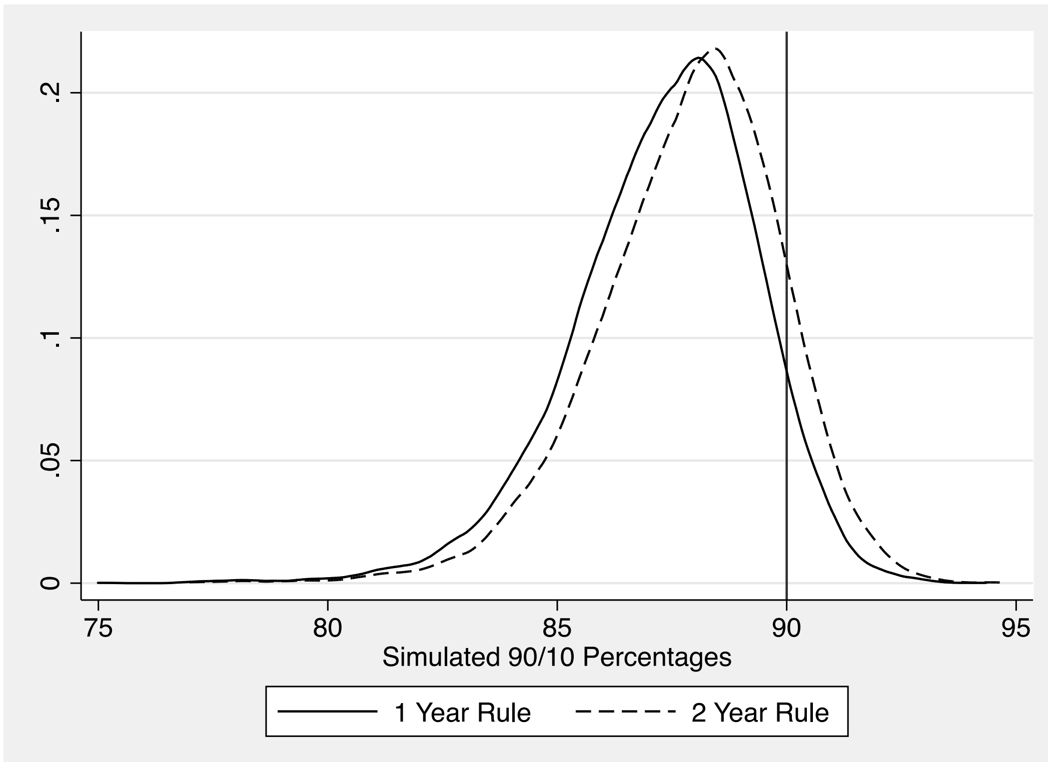

Fig. 2.3.: Comparison of simulated 90/10 revenue percentages under the one year and two year violation rule.

The distributions above are the simulated 90/10 revenue percentages for each bundle under the two different rules. The revenue percentage distribution is the same for the other campuses in each university.

Table 2.1.: Comparison of theoretical and empirical results

	Theoretical Results				Empirical Results	
	85/15 Rule		90/10 Rule		90/10 Rule	
	1 Yr	2 Yr	1 Yr	2 Yr	<2010	$\geq$2010
	(1)	(2)	(3)	(4)	(5)	(6)
All Bundles						
Avg Bundle Size	2.41	2.91	3.21	3.38	1.35	1.47
					(0.04)	(0.02)
Δ Avg Bundle Size	0.5		0.17		0.12	
					(0.05)	
Avg Revenue Percentage	86.4	87.3	87.3	87.9	65.2	71.1
					(0.29)	(0.2)
Δ Avg Revenue Percentage	0.9		0.6		5.84	
					(0.36)	
Bundles with at least two campuses						
Avg Bundle Size	2.43	2.91	3.22	3.38	3.63	4.33
					(0.27)	(0.18)
Δ Avg Bundle Size	0.48		0.16		0.7	
					(0.33)	
Avg Revenue Percentage	86.4	87.3	87.3	87.9	73.6	78.7
					(0.55)	(0.38)
Δ Avg Revenue Percentage	0.9		0.6		5.1	
					(0.67)	
Avg University Profit	1,286	4,659	4,246	7,535		
Δ Avg University Profit	3,373		3,289			

Though the theoretical results are not directly comparable to the empirical results, the theoretical and empirical results move in the same direction. Standard errors are included for the empirical results in the parentheses. I include the average expected university profits in the theoretical results, but I do not have data on university profits.

Table 2.2.: Campus and bundle summary statistics and predicted revenue percentages

Year	Campuses	Bundles	Size≥2	Avg Size	Avg $revpct_j$	Avg $\widehat{revpct_j}$
	(1)	(2)	(3)	(4)	(5)	(6)
2008	2645	1969	263	3.57	63.0	65.6
2009	2731	2013	268	3.68	67.5	65.9
2010	2952	2094	274	4.13	70.6	72.1
2011	3131	2136	316	4.15	70.3	71.2
2012	3191	2149	326	4.20	71.9	70.6
2013	3160	2059	285	4.86	71.4	69.7

Columns 1, 2, and 3 show the total number of campuses, bundles of campuses, and bundles with a size greater than one campus. Column 4 show the average size of a bundle if that bundle contains at least 2 campuses. Columns 5 and 6 compare the average revenue percentage observed in the data and the average predicted revenue percentage across bundles.

Table 2.3.: Campus and bundle 90/10 rule violations

	Bundled		Unbundled		In a Bundle	
	1 Year	2 Year	1 Year	2 Year	1 Year	2 Year
	≥90	≥90	≥90	≥90	≥90	≥90
	(1)	(2)	(3)	(4)	(5)	(6)
2008	11		86		76	
2009	17	3	67	32	51	31
2010	32	5	81	42	52	38
2011	33	16	50	17	21	3
2012	28	15	35	16	8	2
2013	19	8	21	8	3	0

I use predicted revenue percentages for all violation calculations. Columns 1 and 2 show the total number of bundles violating the 90/10 rule. Columns 3 and 4 show the total number of campuses violating the 90/10 rule. Columns 5 and 6 show the total number of the unbundled campuses that violate the 90/10 rule and are also bundled with at least one other campus.

Table 2.4.: Demographic summary statistics of students at for-profit and non-profit institutions in 2008 and 2012

	For-profit students		Non-profit students	
	2008	2012	2008	2012
	(1)	(2)	(3)	(4)
% Female	66.1	57.5	56.7	54.9
% Minority	59.9	54	35.3	40.1
% Not Married	76.8	78.9	82.8	86.7
% Dependent	31.2	35.6	58.7	62.5
% Foreign born	6.3	5	5.2	5.6
Dependent's Income ($)	47,457	40,833	75,267	71,688
	(45,761)	(41,197)	(61,132)	(69,766)
Independent's Income ($)	23,984	18,469	32,417	23,507
	(25,510)	(23,146)	(32,581)	(27,597)
Age	27.3	26.4	25	23.8
	(8.7)	(9.2)	(8.4)	(8.5)
ACT score	17.9	19.7	21.7	21.5
	(4.2)	(4.8)	(4.8)	(4.9)
Observations	14,420	30,720	79,990	51,310

All dollar amounts are in 2008 dollars. Standard deviations in parentheses.

Table 2.5.: Grant and loan summary statistics (percentages) of students at for-profit and non-profit institutions in 2008 and 2012

	For-profit students		Non-profit students	
	2008	2012	2008	2012
	(1)	(2)	(3)	(4)
% with Pell Grants	63.8	75.7	35.7	47.9
% with Fed. Loans	75.9	82.8	41.7	41.9
% with Non-Fed. Loans	43.1	14.6	15.1	5.7
% with Veteran Aid	2.4	5.8	2.4	2.6

All dollar amounts are in 2008 dollars, and are conditional on the student receiving a non zero amount of that type of aid. Standard deviations in parentheses.

Table 2.6.: Grant and loan summary statistics (amounts) of students at for-profit and non-profit institutions in 2008 and 2012

	For-profit students		Non-profit students	
	2008	2012	2008	2012
	(1)	(2)	(3)	(4)
Percent of Max. Pell Amount	41	48.9	22.8	30.6
	(39.4)	(38.5)	(35.9)	(38.4)
Non Title IV Federal Aid ($)	6,675	3,305	2,174	2,432
	(4,119)	(2,996)	(2,551)	(2,381)
Non Federal Grant Aid ($)	3,310	3,794	5,659	6,478
	(3,365)	(5,098)	(6,304)	(8,897)
Non Federal Loans ($)	6,407	5,362	6,819	5,687
	(5,070)	(4,662)	(5,691)	(5,939)
Federal Loans ($)	6,057	6,561	5,553	5,719
	(2,644)	(2,888)	(2,634)	(2,635)
Title IV Aid ($)	8,274	10,199	7,465	7,364
	(4,759)	(6,093)	(5,280)	(5,843)
Pell Grants ($)	2,770	3,365	2,753	3,321
	(1,324)	(1,601)	(1,363)	(1,607)
Subsidized Fed. Loans ($)	3,285	2,863	3,911	3,262
	(1,298)	(1,148)	(1,463)	(1,190)
Unsubsidized Fed. Loans ($)	3,427	3,852	3,773	3,412
	(1,530)	(1,995)	(1,818)	(2,098)
Veteran's Aid ($)	6,908	11,244	5,978	6,820
	(4,563)	(10,025)	(4,962)	(8,134)
Observations	14,420	30,720	79,990	51,310

All dollar amounts are in 2008 dollars, and are conditional on the student receiving a non zero amount of that type of aid. Standard deviations in parentheses.

Table 2.7.: Average total Title IV aid and Pell Grants received by students at for-profit institutions.

	(1)	(2)	(3)	(4)	(5)
Dep Var: Total TIV Aid					
2008	7,228***	7,315***	7,472***	7,560***	7,861***
	(156.0)	(170.4)	(171.9)	(176.5)	(179.5)
2012	9,212***	9,171***	9,097***	9,056***	8,915***
	(176.0)	(134.5)	(123.2)	(82.82)	(84.25)
Difference	1,984***	1,857***	1,625***	1,496***	1,054***
	[218.0]	[209.5]	[196.0]	[259.3]	[263.8]
Dep Var: Pell Grant Percentage					
2008	0.410***	0.427***	0.426***	0.388***	0.416***
	(0.0130)	(0.00721)	(0.0152)	(0.0114)	(0.00972)
2012	0.489***	0.481***	0.482***	0.500***	0.486***
	(0.00726)	(0.00524)	(0.00855)	(0.00533)	(0.00456)
Difference	0.0790***	0.0544***	0.0556***	0.112***	0.0697***
	[0.0143]	[0.00862]	[0.0172]	[0.0167]	[0.0143]
Sets of control variables					
Student Demographics		X			X
Student Aid			X		X
Tuition, Campus F.E.				X	X
Observations	45,140	45,140	45,140	45,140	45,140

*** p<0.01, ** p<0.05, * p<0.1 Standard errors in parentheses. Clustered standard errors in brackets. Clusters are at the campus level. Observations rounded to the nearest tenth. All amounts are in 2008 dollars, except Pell Grant percentages. The maximum Pell Grant amount in 2008 was $4,310 and the maximum amount in 2012 was $5,304.54 in 2008 dollars (or $5,550 in 2012 dollars). Student demographic controls include immigration status, income, dependency status, race, age and age square, sex, marital status, and ACT score. Student aid controls include all other federal aid (including veterans benefits), all other non federal grants and loans. F.E. = fixed effects

Table 2.8.: Average Title IV subsidized and unsubsidized loans received by students at for-profit institutions.

	(1)	(2)	(3)	(4)	(5)
Dep Var: Subsidized Loans					
2008	2,376***	2,368***	2,370***	2,527***	2,493***
	(69.39)	(71.51)	(64.31)	(51.01)	(45.29)
2012	2,309***	2,313***	2,312***	2,238***	2,254***
	(28.14)	(25.93)	(30.21)	(23.94)	(21.26)
Difference	-67.38	-55.24	-57.45	-288.7***	-238.3***
	[72.41]	[75.28]	[66.88]	[74.95]	[66.55]
Dep Var: Unsubsidized Loans					
2008	2,166***	2,102***	2,175***	2,289***	2,167***
	(73.32)	(69.21)	(79.86)	(52.02)	(63.75)
2012	3,069***	3,099***	3,064***	3,011***	3,068***
	(41.53)	(46.17)	(47.38)	(24.41)	(29.92)
Difference	903.1***	997.0***	889.6***	722.1***	901.7***
	[78.51]	[78.81]	[83.03]	[76.43]	[93.68]
Sets of control variables					
Student Demographics		X			X
Student Aid			X		X
Institution Characteristics				X	X
Observations	45,140	45,140	45,140	45,140	45,140

*** p<0.01, ** p<0.05, * p<0.1 Standard errors in parentheses. Clustered standard errors in brackets. Clusters are at the campus level. Observations rounded to the nearest tenth. All amounts are in 2008 dollars. Student demographic controls include immigration status, income, dependency status, race, age and age square, sex, marital status, and ACT score. Student aid controls include all other federal aid (including veterans benefits), all other non federal grants, and all other non federal loans. Institution characteristics include tuition and campus level fixed effects.

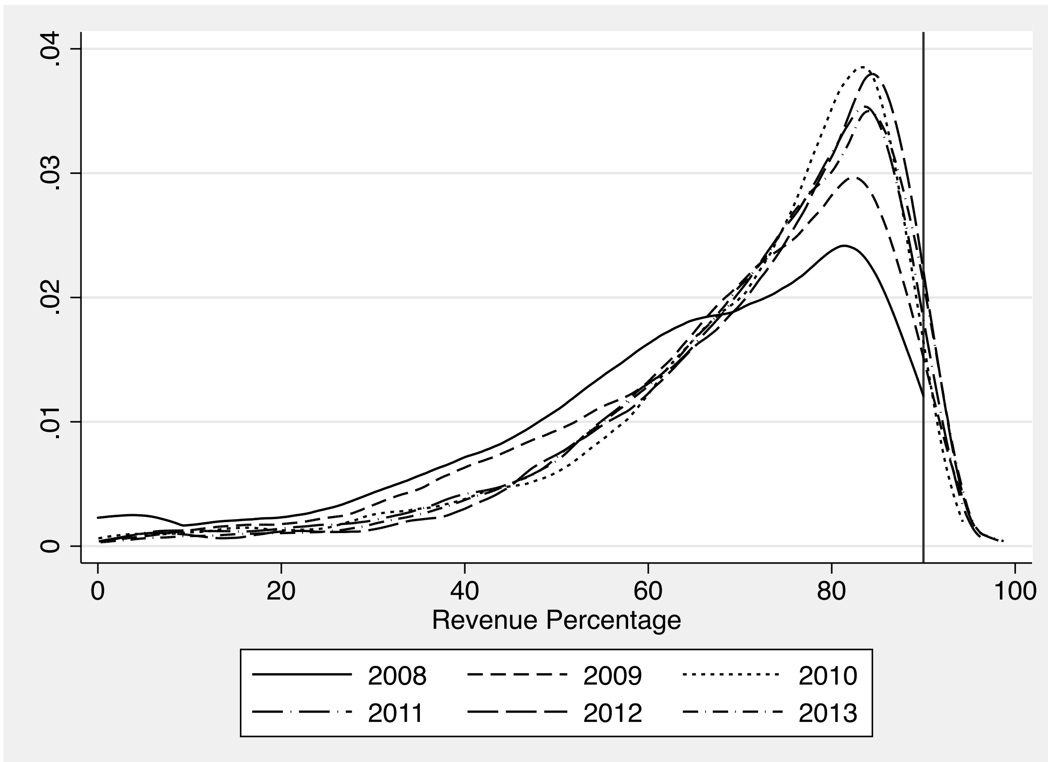

Fig. 2.4.: Actual 90/10 revenue percentage distributions in for-profit universities by year.

The vertical line is at the 90 percent cutoff.

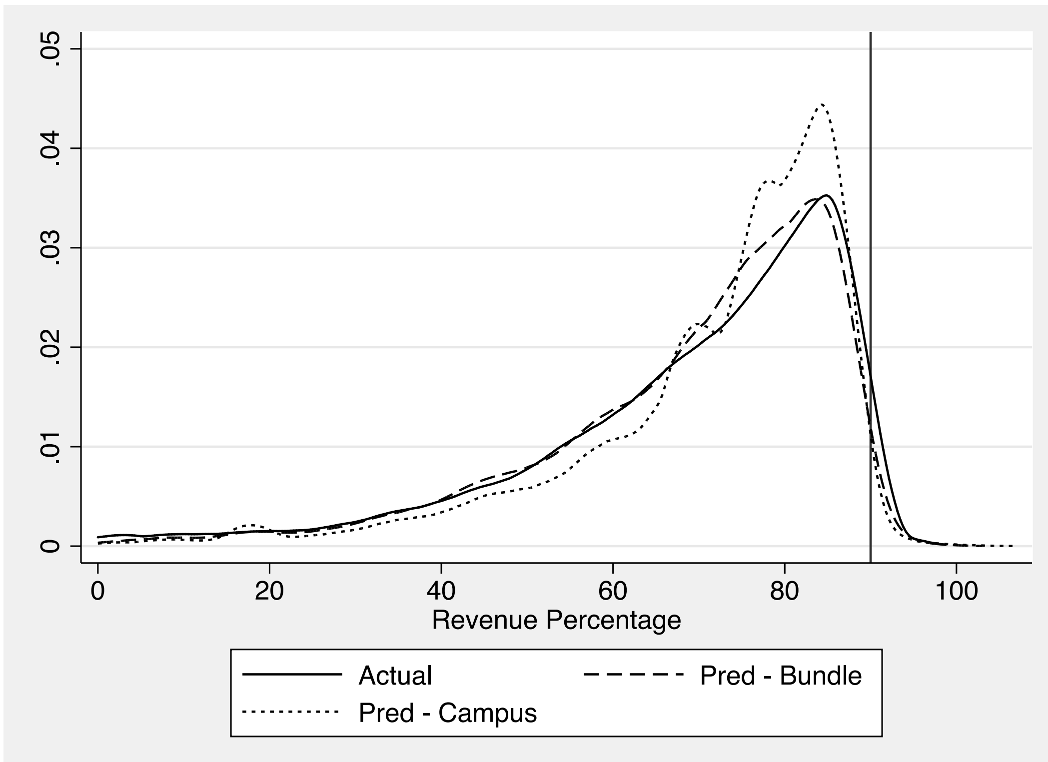

Fig. 2.5.: Estimated and actual 90/10 revenue percentage distributions in for-profit universities.

The vertical line is at the 90 percent cutoff.

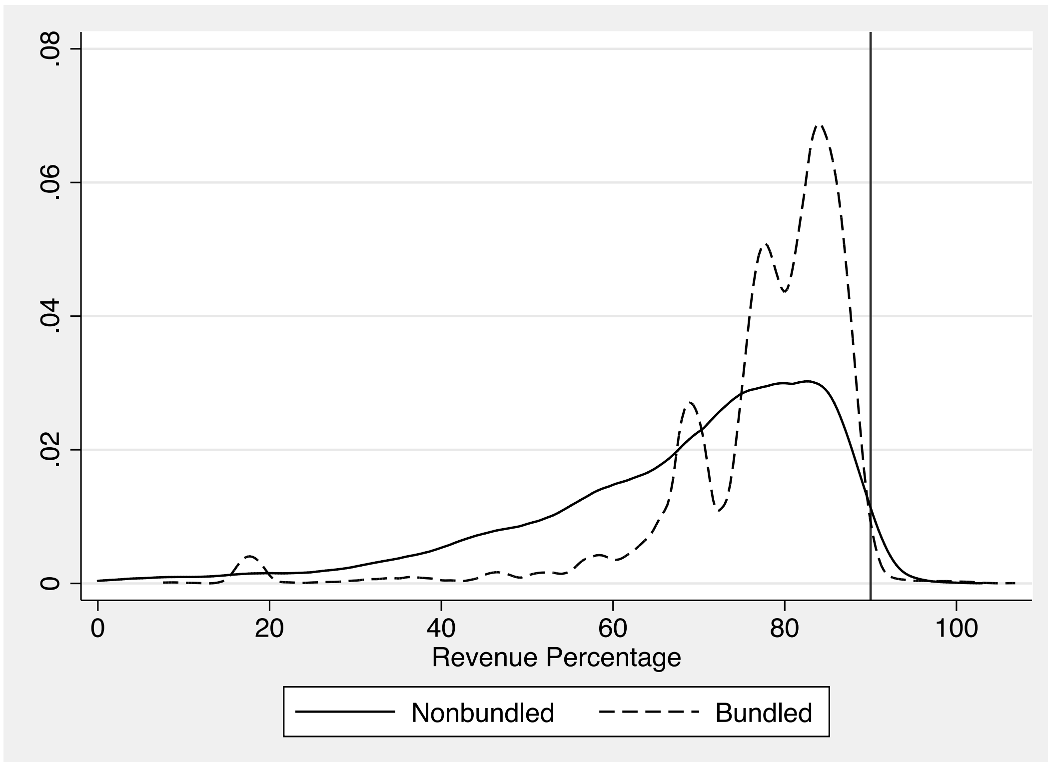

Fig. 2.6.: Estimated 90/10 revenue percentage distributions: Bundled campuses versus non-bundled campuses.

The vertical line is at the 90 percent cutoff.

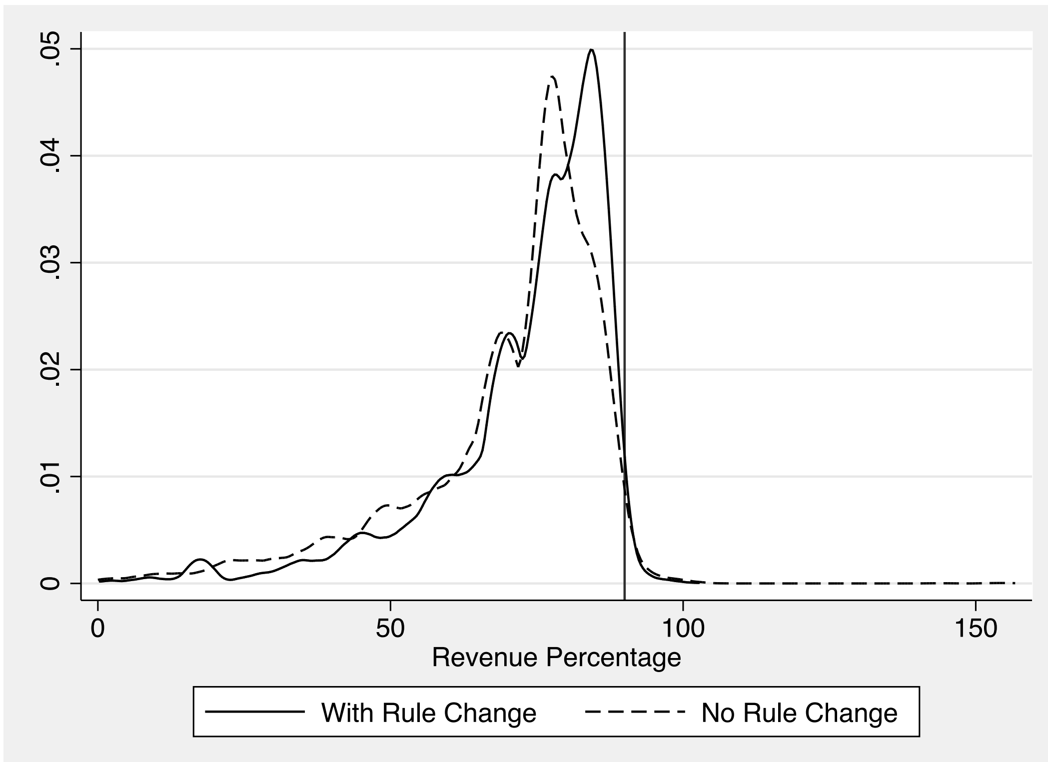

Fig. 2.7.: Estimated 90/10 revenue percentage distributions in for-profit universities after 2010.

The vertical line is at the 90 percent cutoff.

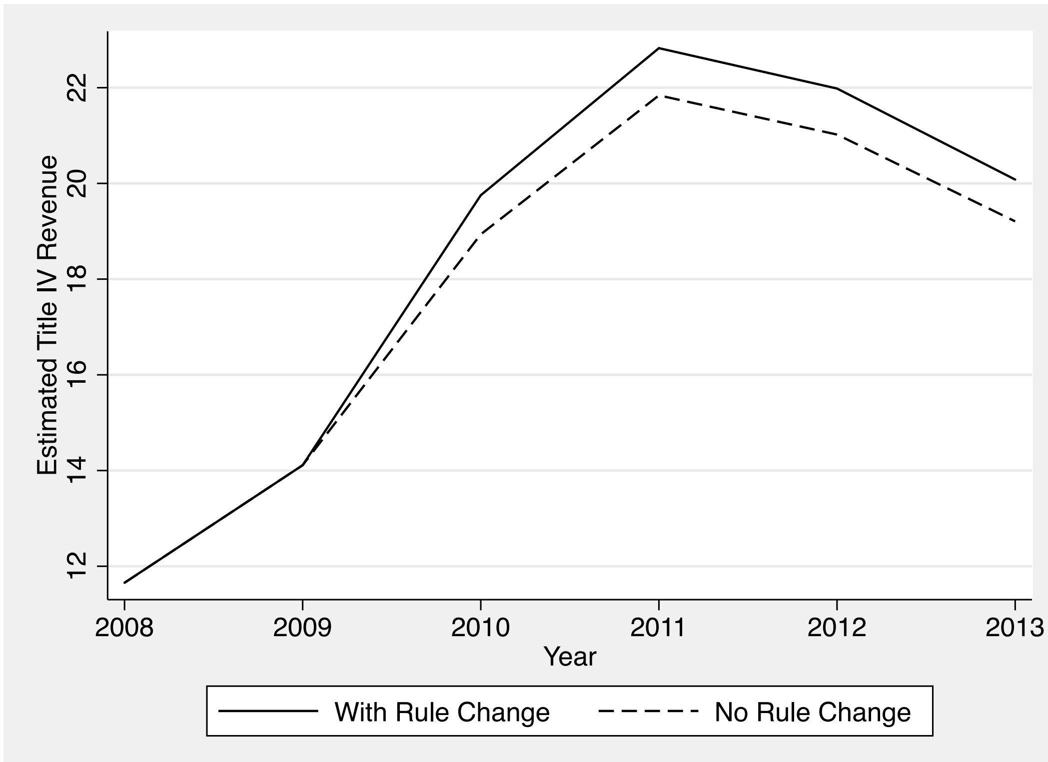

Fig. 2.8.: Estimated Title IV revenue for-profit universities accept with and without the rule change. I estimate for-profit universities receive about 4.5 percent more Title IV aid in revenue due to the rule change.

The solid line is the observed estimated Title IV revenue. The dashed line is the estimated Title IV revenue without the switch to the two year violation rule. The difference between the solid and dashed lines is roughly 0.9 billion dollars.

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VITA

VITA

Zachary G. Davis

EDUCATION

Ph.D. in Economics, Purdue University — August 2016

Dissertation: *"Essays on University Competition"*

Advisors: Kevin Mumford (co-chair), Jack Barron (co-chair), Justin Tobias, Brian Roberson

M.S. in Economics, Purdue University — 2013

B.S. in Economics and Mathematics, Miami University — 2010

FIELDS OF INTEREST

Labor, Industrial Organization, Education, Econometrics

RESEARCH

"In-State Tuition and University Price Discrimination" (Job Market Paper)

"Unbundling For-Profit Higher Education: Relaxing the 90/10 Constraint"

PRESENTATIONS

Miami University — November 14, 2014

"In-State Tuition and University Price Discrimination"

AWARDS AND GRANTS

Robert W. Johnson Award for Distinguished Research Proposal	2013
Purdue Research Foundation Grant	2013
Distinguished Teaching	Summer 2013
Outstanding Teaching	Fall 2012
Outstanding Recitation Teaching	Fall 2010
Snider Prize, Outstanding Undergraduate Student Award	Spring 2010

TEACHING EXPERIENCE

Principles of Macroeconomics, Instructor	Summer 2013
Principles of Macroeconomics, Instructor	Fall 2012
Principles of Macroeconomics, Instructor	Summer 2012
Principles of Economics, Recitation Leader	Fall 2010

OTHER EXPERIENCE

Research Assistant, Purdue University

Mohitosh Kejriwal	Spring 2012
Kevin Mumford	Fall 2012

Teaching Assistant, Purdue University

Kevin Mumford, Online Masters Econometrics	Fall 2013, 2014, 2015
Justin Tobias, Online Masters Econometrics	Summer 2014
Yong Bao, Online Masters Econometrics	Spring 2013
Kelly Blanchard, Principles of Economics	Fall 2012
Kelly Blanchard, Principles of Economics	Spring 2011