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The Out-of-State Tuition Distortion

IHELG Monograph

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The Out-of-State Tuition Distortion*

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Abstract

Public universities in the United States typically charge much higher tuition to non-residents. Perhaps due, at least in part, to these differences in tuition, roughly 75 percent of students nationwide attend in-state institutions. While distinguishing between residents and non-residents is consistent with welfare maximization by state governments, it may lead to economic inefficiencies from a national perspective, with potential welfare gains associated with reducing the gap between in-state and out-of-state tuition. We first formalize this idea in a simple model. While a social planner maximizing national welfare does not distinguish between residents and non-residents, state governments set higher tuition for non-residents. The welfare gains from reducing this tuition gap can be characterized by a sufficient statistic relating out-of-state enrollment to the tuition gap. We then estimate this sufficient statistic via a border discontinuity design using data on the geographic distribution of student residences by institution.

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1 Introduction

This research examines economic distortions associated with differences between resident and non-resident tuition at public universities in the United States. It is well-known that public institutions charge much higher tuition to non-residents, with the University of California System, for example, charging $12,294 in tuition and fees for California residents and $38,976 for non-residents during the 2016-2017 academic year.[1] Perhaps due, at least in part, to these differences in tuition, roughly 75 percent of students nationwide attend in-state institutions (NCES, 2012).

While distinguishing between residents and non-residents is consistent with state welfare maximization, it may lead to economic inefficiencies from a national perspective, with potential welfare gains associated with reducing the gap between in-state and out-of-state tuition. To see this, consider a hypothetical example of two students, one living in Illinois and one in Wisconsin. Suppose that both have competitive application profiles so that neither is constrained by admissions processes. In addition, assume that the student from Illinois finds the University of Wisconsin-Madison to be a better fit and that the student from Wisconsin finds the University of Illinois to be a better fit. Given this, in the absence of tuition differences, both would attend out-of-state institutions. But, suppose that, due to much higher out-of-state tuition, both students choose to attend the home-state institution. Then, both students would be better off, with universities receiving identical tuition revenue, if they could pay in-state tuition rates at the out-of-state institution. As should be clear, there are two crucial ingredients underlying this inefficiency. First, students must have heterogeneous preferences over institutions, with rankings, absent tuition differences, differing across students. Second, in choosing institutions, students must be responsive to tuition differences.

While this example is extreme, it illustrates a more general point. Distinguishing between residents and non-residents when setting tuition may lead to inefficiencies from a national perspective, with students attending institutions that may not be the best fit for them. In this research, we first formalize this idea in the context of a simple model in which students, taking tuition as given, choose between in-state and out-of-state institutions. We begin by showing that a social planner maximizing national welfare does not distinguish between residents and non-residents for tuition purposes. We then consider how state governments, accounting for enrollment responses, set tuition policies, under the assumption that they maximize the welfare of their residents. We show that, by ignoring the welfare of non-residents, state governments cross-subsidize in-state students by charging higher tuition for out-of-state students. Finally, following the literature on sufficient statistics for welfare analysis, we show that narrowing the gap between resident and non-resident tuition leads to a welfare gain, and this gain can be characterized by a sufficient statistic relating

[1] See http://admission.universityofcalifornia.edu/paying-for-uc/tuition-and-cost/ (accessed October 21, 2016).

out-of-state enrollment patterns to non-resident tuition.[2]

In estimating this sufficient statistic, a key identification problem that we face involves separating these distortionary effects of tuition policies from geography. That is, students may disproportionately attend in-state institutions due to either discounted tuition for in-state students or due to a preference for attending institutions close to home. To isolate the distortionary effects of this out-of-state tuition markup, we use a border discontinuity design, comparing attendance at institutions for students living close to state borders.[3] That is, by comparing in-state students and out-of-state students living near each other, we can remove the effects of geography and isolate the effects of tuition.

To implement this border discontinuity design, our baseline analysis uses data on the geographic distribution of students by institution. The key data source is the Freshman Survey, administered by the Higher Education Research Institute (HERI). The survey includes a question on zip code of permanent residence, allowing us to measure the geographic distribution of enrollment at institutions. Using these data from 1997 to 2011, we find large discontinuities, with a sharp jump in enrollment when moving from the out-of-state side of the border to the in-state side of the border.

Complementing these baseline findings, we present four additional pieces of evidence. First, we address two alternative explanations for our documented border discontinuities, one based upon differential admissions standards and another based upon endogenous sorting around the border. Second, using information on tuition, we document larger discontinuities along borders with larger differences between out-of-state and in-state tuition. Along these lines, we also show that enrollment discontinuities are smaller along borders with reciprocity agreements that offer tuition discounts to non-residents. Third, using separate survey data on student choice sets, we find that, conditional on being admitted and geography, students are more likely to select in-state institutions from their choice sets and especially so when there are large tuition discounts for residents. Fourth, we document smaller border discontinuities for private institutions, which do not provide tuition discounts to residents.

Finally, we use our estimates of enrollment responses to tuition in order to conduct a welfare analysis. In particular, we consider a marginal reduction in out-of-state tuition, offset by a budget balancing increase in resident tuition. We show that the welfare gains from this policy change are substantial, implying significant distortions associated with the existing gap between in-state and

[2]The sufficient statistics approach involves using well-identified estimates of behavioral responses in order to the quantify the welfare implications of policy changes. Representative studies include Chetty et al. (2008) on unemployment insurance, Finkelstein et al. (2015) on Medicaid, and Saez (2001) on income taxation. Chetty (2008) provides an overview of this literature.

[3]For an analysis of how housing prices differ along school district attendance zones borders, using similar variation, see Black (1999).

out-of-state tuition.

The paper proceeds as follows. First, we summarize the related literature and describe our contribution. Second, we develop a theoretical model in which we formally derive our sufficient statistic approach. In the context of this model, we then describe possible corrective policies. Next, we describe the data and our empirical results. Relating this back to the theory, we then use our estimates to compute the welfare gains associated with reducing the tuition gap. Finally, the conclusion outlines some future directions for the research and summarizes.

2 Literature Review

This is, of course, not the first study examining the gap between out-of-state tuition and in-state tuition in the U.S.[4][5] Cohodes and Goodman (2014) analyze a program in Massachusetts that provided academically strong students with tuition waivers at in-state public colleges and find that eligible students disproportionately attended in-state institutions and had lower college completion rates. Kane (2007) evaluates a program offering residents of the D.C. up to $10,000 per year to cover tuition at select out-of-state institutions. He finds increases in the number of first-time federal financial aid applicants, the number of first-year college students receiving Pell Grants, and college attendance. Likewise, Abraham and Clark (2006) document that the program increased the likelihood that students applied to eligible institutions and also increased college enrollment rates. Other studies on out-of-state tuition include Groat (1964), Morgan (1983), and Noorbakhsh and Culp (2002). Relative to existing studies, our paper is the first in this literature to attempt to estimate the role of non-resident tuition on enrollment via a border discontinuity design, and, more importantly, to use these estimates to calculate any welfare gains associated with reducing the gap between non-resident and resident tuition.

This research is also related to a literature on interstate migration. Studies in this literature include Blanchard et al. (1992), who study migration responses to state labor market shocks. DePasquale and Stange (2015) examine the role of state licensing requirements for nurses in interstate migration and other labor market outcomes. Moretti (2012) documents that highly educated individuals in the U.S. are more mobile, and our results suggest that this difference could be even larger were the gap between out-of-state and in-state tuition to be lowered. Moretti (2012) also

[4]There is also a literature examining student enrollment patterns within and across countries in Europe. Dwenger et al. (2012) examine enrollment responses to the introduction of tuition in some German states. Mechtenberg and Strausz (2008) analyze the Bologna process, which harmonized higher education within the European Union in the hopes of increasing student mobility.

[5]More broadly, this paper contributes to a literature on the role of tuition and financial aid in college attendance. Representative studies in this literature include Avery and Hoxby (2004), Dynarski (2003), and Hoxby and Bulman (2016). While this literature is often focused on the decision of whether or not to attend college, our study focuses on the choice between in-state and out-of-state institutions, conditional on attending college.

argues that mobility is inefficiently low and makes the case for relocation vouchers. A related literature examines the likelihood that students remain in the state when transitioning from college to the workforce. State governments often justify higher tuition for non-residents based upon the argument that out-of-state students tend to return to their state of residence and thus neither contribute to the future tax base nor generate human capital externalities for state residents. In a recent contribution, Kennan (2015) estimates a dynamic migration model in which students decide where to go to college, accounting for, among other factors, differences between resident and non-resident tuition. He finds that reductions in tuition lead to increases in college enrollment and the subsequent stock of college educated workers. This is in contrast to Bound et al. (2004), who find little relationship between the production of college graduates and the subsequent stock of college educated workers.

This paper also contributes to a literature on federalism. A key issue in the design of federations involves the vertical delegation of authorities between different levels of government (i.e. national, state, and local governments). A common argument against decentralization is that, in setting policy, localities maximize the welfare of residents and thus may fail to internalize cross-jurisdiction externalities that either benefit or harm non-residents. Among others, see Oates (1972), Oates (1999), Inman and Rubinfeld (1997), Besley and Coate (2003), and Knight (2013). Like this work, the welfare loss in our model is generated by the assumption that local policymakers only value resident welfare. Our paper contributes to this literature by examining differential pricing for accessing public services between resident and non-residents, a novel mechanism through which decentralization creates welfare losses.

3 Theoretical Model

This section develops a simple theoretical model in which students, accounting for tuition policies and geography, choose between colleges.[6] We first develop expressions for welfare and then consider how a social planner maximizing national welfare would set policies. We then consider a positive model in which state governments set in-state and out-of-state tuition. After linking our expressions for welfare to a literature on sufficient statistics, we consider two extensions of the model.

[6]This model is related to Epple et al. (2013), who consider resident and non-resident tuition but also private public universities. While their model takes tuition rates as given, public universities face incentives to admit out-of-state students for both financial and non-financial reasons. One key finding of their analysis is that increases in tuition at public institutions leads to a reduction in college attendance, with little switching to private universities.

3.1 Setup

Consider two states (s), East ($s = E$) and West ($s = W$), each with population normalized to one.[7] Each state has a public college (c), and each college sets two variables: resident (in-state) tuition (r_c) and non-resident (out-of-state) tuition (n_c). Student i receives the following monetary payoff from attending college c:

$$u_{ic} = \alpha q_c - t_{ic} - \delta_{ic} + (1/\rho)\varepsilon_{ic}$$

where q_c represents (exogenous) quality of college c, δ_{ic} represent travel costs, and ε_{ic} is assumed to be distributed type-1 extreme value. Tuition for student i attending college c is represented by t_{ic}, and this equals r_c for in-state students and n_c for out-of-state students. The parameter $\rho > 0$ represents the precision of unobserved preferences (i.e. $\rho = 1/\sigma$). When there is a significant degree of heterogeneity in preferences, then ρ will be small, and students will be relatively unresponsive to tuition. Conversely, with a small degree of heterogeneity, then ρ will be large, and students will be relatively responsive to tuition. Finally, assume that out-of-state students face higher travel costs, relative to in-state students. In particular, we normalize travel costs for in-state students to zero ($\delta_{ic} = 0$ for in-state colleges) and assume uniform travel costs ($\delta_{ic} = \delta > 0$) for students attending out-of-state colleges.

Then, let P_s denote the probability that a student from s attends the in-state institution. For students from state W and E, these probabilities are given by:

$$P_W = \frac{\exp(\alpha\rho q_W - \rho r_W)}{\exp(\alpha\rho q_W - \rho r_W) + \exp(\alpha\rho q_E - \rho n_E - \rho\delta)}$$

$$P_E = \frac{\exp(\alpha\rho q_E - \rho r_E)}{\exp(\alpha\rho q_E - \rho r_E) + \exp(\alpha\rho q_W - \rho n_W - \rho\delta)}$$

Otherwise, students attend out-of-state institutions, with probabilities $1 - P_W$ and $1 - P_E$.

We next consider the budget constraint facing colleges. Let f_c denote the fraction of in-state students attending college c. For state W, this is equal to $f_W = P_W/[P_W + (1 - P_E)]$. Assume that educating a student requires a constant expenditure, or marginal cost, equal to m.[8] Then, college W faces the following budget constraint:

$$f_W r_W + (1 - f_W) n_W = m$$

That is, the weighted average of resident and non-resident tuition must equal the unit cost of educating a student.

[7] We later consider an extension to more than two states.

[8] We later consider an extension to fixed costs.

3.2 Welfare

We begin by developing expressions for welfare and the associated responses to changes in tuition policy. Utilitarian welfare, averaged across states, equals $0.5(V_E + V_W)$, where V_W and V_E are the inclusive values for a representative student, after scaling by ρ so that welfare is money metric:

$$V_W(r_W, n_E) = (1/\rho)\ln[\exp(\alpha\rho q_W - \rho r_W) + \exp(\alpha\rho q_E - \rho n_E - \rho\delta)]$$

$$V_E(r_E, n_W) = (1/\rho)\ln[\exp(\alpha\rho q_E - \rho r_E) + \exp(\alpha\rho q_W - \rho n_W - \rho\delta)]$$

Then, consider changes in non-resident tuition equal to Δn_W and Δn_E, offset by budget-balancing changes in resident tuition. In this case, the change in welfare equals:

$$0.5\left[\frac{\partial V_W}{\partial n_W}\Delta n_W + \frac{\partial V_E}{\partial n_W}\Delta n_W + \frac{\partial V_E}{\partial n_E}\Delta n_E + \frac{\partial V_W}{\partial n_E}\Delta n_E\right]$$

Using the envelope condition, this can be re-written as:

$$0.5\left[\{-P_W\frac{\partial r_W}{\partial n_W} - (1-P_E) - P_E\frac{\partial r_E}{\partial n_W}\}\Delta n_W + \{-P_E\frac{\partial r_E}{\partial n_E} - (1-P_W) - P_W\frac{\partial r_W}{\partial n_E}\}\Delta n_E\right]$$

Thus, evaluating changes in welfare requires information on the change in resident tuition associated with an increase in non-resident tuition at both colleges.

In the case of equal increases in non-resident tuition in both states, we have that $\Delta n_W = \Delta n_E = \Delta n$. Further, let $\frac{\partial r_W}{\partial n} = \frac{\partial r_W}{\partial n_W} + \frac{\partial r_W}{\partial n_E}$ represent the combined change in required resident tuition at W and likewise for $\frac{\partial r_E}{\partial n}$. Then, the change in welfare is given by:

$$0.5\Delta n\left[-P_W\frac{\partial r_W}{\partial n} - (1-P_E) - P_E\frac{\partial r_E}{\partial n} - (1-P_W)\right]$$

Thus, the change in welfare depends upon the changes in resident tuition in both states associated with this uniform increase in non-resident tuition. In the Appendix, we show that, using the institution budget constraints, these required changes in resident tuition can be characterized by the following two equations:

$$\left(\frac{\partial P_W}{\partial r_W}(\frac{\partial r_W}{\partial n} - 1)\right)[r_W - m] + P_W\frac{\partial r_W}{\partial n} - \frac{\partial P_E}{\partial r_E}(\frac{\partial r_E}{\partial n} - 1)[n_W - m] + (1-P_E) = 0$$

$$\left(\frac{\partial P_E}{\partial r_E}(\frac{\partial r_E}{\partial n}-1)\right)[r_E-m]+P_E\frac{\partial r_E}{\partial n}-\frac{\partial P_W}{\partial r_W}(\frac{\partial r_W}{\partial n}-1)[n_E-m]+(1-P_W)=0$$

In order to build intuition, we next note several special cases. First, if tuition is at non-discriminatory levels (i.e. $r_W = n_W = m$ and $r_E = n_E = m$), then we have that $\frac{\partial r_W}{\partial n} = \frac{-(1-P_E)}{P_W}$ and $\frac{\partial r_E}{\partial n} = \frac{-(1-P_W)}{P_E}$. Inserting these into the welfare expression, we have that the change in welfare equals zero. This is consistent with non-discriminatory tuition being socially optimal, as will be shown more formally below. Second, we consider the case of no behavioral responses (i.e. $\frac{\partial P_E}{\partial r_E} = \frac{\partial P_W}{\partial r_W} = 0$). In this case, we again have that $\frac{\partial r_W}{\partial n} = \frac{-(1-P_E)}{P_W}$ and $\frac{\partial r_E}{\partial n} = \frac{-(1-P_W)}{P_E}$. Then, following standard logic in public economics, there is no welfare loss in the absence of behavioral responses. Thus, any prospects for increasing welfare when reducing the gap between non-resident and resident tuition will require a behavioral response.

Third, in the symmetric case ($q_W = q_E$, $r_E = r_W = r$, and $n_E = n_W = n$), attendance probabilities are also symmetric ($P_E = P_W = P$), and the required change in resident tuition can be written more compactly as:

$$\frac{\partial r}{\partial n} = \frac{-(1-P)-\frac{\partial P}{\partial r}(n-r)}{P-\frac{\partial P}{\partial r}(n-r)}$$

Based upon this expression, Figure 1 plots the relationship between resident and non-resident tuition. In the absence of a behavioral response ($\frac{\partial P}{\partial r} = 0$), this relationship is linear, with a slope equal to $-(1-P)/P$. That is, resident tuition can be reduced by an amount equal to $(1-P)/P$ when increasing non-resident tuition by one dollar. This simply reflects the mechanical effect through which, by increasing non-resident tuition by one dollar, the institution raises a per-student amount equal to $1-P$, which is then re-distributed to the resident students, which comprise a fraction P. Also, note that it is always feasible for colleges to set non-discriminatory tuition such that $r = n = m$. With a behavioral response, the relationship is no longer linear. At the point of non-discriminatory tuition ($r = n = m$), the slope again equals $-(1-P)/P$, regardless of the size of the behavioral response. Behavioral responses play no role in this case since residents and non-residents pay equal tuition. As non-resident tuition increases beyond m, the relationship flattens and the ability to cross-subsidize resident students is weakened. This is due to the financial loss associated with losing non-resident students, who cross-subsidize resident students. Eventually, "profits" from non-residents are maximized at $n = m + (1/\rho)$ and additional increases in non-resident tuition require increases in resident tuition.[9] That is, beyond $n = m + (1/\rho)$, there is no additional scope for reducing in-state tuition. This is due to the fact that, beyond this minimum

[9] This can be derived by setting the numerator of $\frac{\partial r}{\partial n}$ equal to zero (i.e., $-(1-P) = \frac{\partial P}{\partial r}(n-r)$) and noting both that $\frac{\partial P}{\partial r} = -\rho P(1-P)$ and that the institutional budget constraint can be written as $P(n-r) = (n-m)$.

feasible resident tuition, the behavioral response by non-resident students, which leads to a reduction in total tuition revenue collected from non-residents, more than offsets the mechanical effect associated with increasing non-resident tuition, which leads to an increase in total tuition revenue collected from non-residents.

Further, in the symmetric case, the change in welfare can be written more compactly as:

$$\Delta n\left[-P\frac{\partial r}{\partial n}-(1-P)\right]$$

This simple expression reflects the envelope condition for the discrete choice case. In particular, a fraction $1-P$ of students attending out-of-state institutions are directly affected by the change in non-resident tuition. Likewise, a fraction P of students attending in-state institutions are directly affected by the change in resident tuition according to $\frac{\partial r}{\partial n}$. While some students do switch institutions in the event of a change in tuition, they were indifferent between institutions and thus their utility is not directly affected by marginal changes in tuition policies.

Using the above expression for $\frac{\partial r}{\partial n}$, we then have the following change in welfare in the symmetric case:

$$\Delta n\left[-P\left(\frac{-(1-P)-\frac{\partial P}{\partial r}(n-r)}{P-\frac{\partial P}{\partial r}(n-r)}\right)-(1-P)\right]$$

Since $\frac{\partial r}{\partial n}>\frac{-(1-P)}{P}$ when $n>r$, we have that welfare is reduced when non-resident tuition is further increased. Equivalently, we can say that welfare will increase when reducing existing gaps between non-resident and resident tuition. This is consistent with the initial idea that gaps between non-resident and resident tuition may lead to economic inefficiencies and that reducing these gaps may lead to welfare gains.

Finally, from an empirical perspective, the change in welfare can be characterized by a sufficient statistic relating in-state enrollment to resident tuition ($\frac{\partial P}{\partial r}$). That is, to measure the change in welfare, one does not need to separately estimate the underlying parameters (ρ,δ,q_W,q_E). Instead, the response of enrollment to tuition is a sufficient statistic for the change in welfare and, given this, the key objective of our empirical analysis will involve estimating this sufficient statistic via a border discontinuity design.

3.3 Socially optimal policies

Returning to the more general case, in which we allow for non-symmetric quality, we have that the social planner chooses the set of policies (r_W,n_W,r_E,n_E) in order to maximize national social welfare, subject to the two institutional budget constraints. As above, we consider changes in non-resident tuition, offset by changes in resident tuition. Building upon intuition from the prior section, marginal changes in non-resident tuition do not induce distortions in the absence of preexisting differences between resident and non-resident tuition. Thus, non-discriminatory tuition is optimal. This result is summarized in the following Proposition, and the Proof is provided in the Appendix.

Proposition 1: Socially optimal tuition policies are non-discriminatory in nature. That is, optimal policies are given by $n_W = r_W = m$ **and** $n_E = r_E = m$**.**

3.4 Policies under decentralization

For comparison purposes with policies set by a national planner, we next consider how states set tuition policies under decentralization. From a positive perspective, this analysis also sheds light on why states distinguish between residents and non-residents when setting tuition.

To begin, we assume that states choose policies to maximize the welfare of their residents and do not account for the welfare of non-residents.[10] In this case, taking the policies of E as given, the first-order-condition for state W is given by:

$$\frac{\partial V_W}{\partial r_W}\frac{\partial r_W}{\partial n_W} = 0$$

Thus, states set out-of-state tuition in order to minimize in-state tuition ($\frac{\partial r_W}{\partial n_W} = 0$). Using the state budget constraint, and taking the derivative with respect to non-resident tuition, holding fixed tuition in state E, one can show that:

$$\frac{\partial P_W}{\partial r_W}\frac{\partial r_W}{\partial n_W}[r_W - m] + P_W\frac{\partial r_W}{\partial n_W} + (1 - P_E) - \frac{\partial P_E}{\partial n_W}[n_W - m] = 0$$

Since $\frac{\partial r_W}{\partial n_W} = 0$ in equilibrium, we have that non-resident tuition can be characterized by:

$$n_W = m + \frac{(1 - P_E)}{\partial P_E/\partial n_W}$$

Thus, since $\partial P_E/\partial n_W$ is positive, we have that states set higher tuition for non-residents ($n_W > m > r_W$) in equilibrium. These results, along with additional results in the symmetric case, are summarized in the following Proposition, with a proof in the Appendix.

Proposition 2: In equilibrium, states set higher tuition for non-residents ($n_W > m > r_W$ and $n_E > m > r_E$**). In the symmetric case (**$q_W = q_E$**), there is a unique equilibrium. In this equilibrium, increases in the response of enrollment to tuition, as captured by the parameter** ρ**, lead to reductions in non-resident tuition. That is,** $\frac{\partial n}{\partial \rho} < 0$.

[10] In assuming that policymakers maximize resident welfare, we thus abstract from the possibility that state governments and state universities may have different objectives. For example, it is possible that state governments maximize resident welfare and that state universities maximize revenue. See Groen and White (2004).

The intuition for this comparative static is that, when students are responsive to tuition, $\frac{\partial P}{\partial n}$ is large, and there is stiff competition for students. Due to this competition, states lower non-resident tuition. When students are unresponsive to tuition, by contrast, $\frac{\partial P}{\partial n}$ is small, the demand curve is steep, and there is sufficient variation in student preferences that states can extract some of the rents earned by non-resident students.

Moreover, one can show that this decentralized problem is equivalent to states maximizing "profits" on out-of-state students, defined by $(n_W - m)(1 - P_E)$, and using the proceeds to cross-subsidize in-state students. Again, profits are maximized by setting out-of-state tuition such that in-state tuition is minimized.

As a summary of these theoretical results, Figure 2 provides a graphical overview of how welfare changes as a function of non-resident tuition in state W. For the purposes of this Figure, we focus on the symmetric case and assume that policies in E are fixed at Nash equilibrium levels, with resident tuition below non-resident tuition, and then consider changes in policies in state W. The x-axis depicts non-resident tuition in state W (n_W), with resident tuition adjusting such that the budget remains balanced. The Figure depicts the welfare of residents (V_W), the welfare of non-residents (V_E), and combined welfare ($V_W + V_E$). At Nash equilibrium non-resident tuition ($n_W = n^*$), we have that, by definition, the welfare of residents (V_W) is maximized. Decreases in non-resident tuition from this point generate first-order welfare gains for residents of E but only second-order welfare losses for residents of W. Thus, reductions in non-resident tuition generate national welfare gains, as exhibited by the curve for national welfare (V_W+V_E). Further reductions in non-resident welfare generate national welfare gains until the point at which policies are non-discriminatory ($n_W = r_W = m$). As shown, national welfare is maximized at this point, and thus non-discriminatory tuition in an individual state maximizes national welfare even when other states set discriminatory tuition.

3.5 Extensions

In the Appendix, we consider two extensions of the model, one involving fixed costs and another involving more than two states. First, while the baseline model focuses on a simple cost structure with only marginal costs, we consider the case in which institutions also face fixed costs. Given that these costs must be paid by institutions regardless of student enrollment patterns, the key welfare calculations are unchanged in this case. That is, it remains the case that equating resident and non-resident tuition is socially optimal. Moreover, the welfare gains associated with reducing out-of-state tuition can be characterized by the same sufficient statistic relating enrollment to tuition policies. We also consider decentralization with fixed costs. It remains the case that universities attempt to maximize variable profits from non-residents and charge non-resident tuition in excess of m. Moreover, so long as fixed costs are sufficiently small, institutions charge higher tuition to non-residents, when compared to resident tuition. To summarize, the introduction of fixed costs does not change the welfare analysis, and the tuition gap remains in equilibrium so long as these fixed costs are sufficiently small.

Second, we examine the case of more than two states. The key difference here is that students have a greater degree of choice among out-of-state institutions, potentially yielding increased competition between institutions for non-resident students. From a normative perspective, we find that the key welfare lesson is again unchanged: equating resident and non-resident tuition remains socially optimal. Moreover, the welfare gains associated with reducing out-of-state tuition can be characterized by the same sufficient statistic relating enrollment to tuition policies, under the interpretation that $1-P$ reflects out-of-state attendance aggregated over all out-of-state institutions. Turning to decentralization, we show, in a calibrated version of the model, that an increase in the number of states leads to a reduction in non-resident tuition due to competition for non-resident students. This decrease is small, however, and resident tuition falls more quickly, reflecting the financial windfall to institutions associated with a mechanical increase in out-of-state attendance due to the increased choice set. Moreover, non-resident tuition is bounded from below, above m, even as the number of states grows large. This reflects the fact that universities retain market power due to product differentiation. To summarize, an increase in the number of states beyond two does not change the welfare analysis, and the tuition gap remains in the decentralized equilibrium even with a large number of states.

4 Corrective Policies

This section considers three possible solutions to the distortion associated with higher non-resident tuition under decentralization. We first discuss interventions by the federal government followed by reciprocity agreements between state governments. Finally, we consider residence-based tuition vouchers.

Given that the federal government internalizes the welfare of both residents and non-residents of a given institution, it is natural that higher-level governments may be able to solve this problem. The judicial branch is one possible forum for this debate, and non-resident students have indeed challenged the constitutionality of state universities discriminating against non-residents when setting tuition. Federal courts, however, have generally ruled in favor of states and against non-resident students due to the fact that non-residents do not pay taxes in the state supporting the public institution. In addition, federal courts have given states significant leeway in defining residency for tuition purposes, allowing, for example, one-year residency requirements (Palley (1976)). Importantly, attending the university does not typically count towards the residency requirement, and students thus do not qualify for in-state tuition following their first year of study. Given this, another possibility involves new federal law requiring state institutions to charge the same tuition to non-residents coupled with a plan that would involve a series of payments between states.[11]

In the absence of federal intervention, and given the hypothesized welfare losses associated with this non-resident tuition distortion, it is natural that state governments may attempt to reduce barriers via reciprocity agreements under which students can pay in-state tuition rates at out-of-state institutions. Four regional exchanges provide discounts to non-resident students from member states: the Western Undergraduate Exchange, the Midwest Student Exchange Program, the Academic Common Market, and Tuition Break (New England). A vast majority of states (44 out of 50) participate in at least one of these exchanges (Marsicano, 2015).[12] There are several limitations of these agreements in practice. First, participation is selective, with not all public institutions in these states participating. Second, slots are not guaranteed and tend to be made available to students only when excess space is available. Third, these exchanges may only be available to students whose major field of study is not offered in their home state. Finally, students receive only discounts from the non-resident rate and pay more than residents.[13] Despite these limitations, we provide some

[11] There are two key details that need to be addressed when designing such a plan. First, while states set symmetric in-state rates in the theoretical model, tuition rates differ across states in the U.S. depending upon the level of subsidies from the state government and other factors. Given this, one limitation of eliminating non-resident tuition involves a free-rider problem. In particular, the incentives for states to subsidize public colleges and universities with tax revenue collected from residents would be diminished. Given this, any transfer plan may need to involve payments from states that have relatively small subsidies to states that have relatively large subsidies. Second, while the baseline model assumed that states are of equal population, state sizes differ in the United States and smaller states will tend to experience net inflows of students in these programs. Given this, and in the presence of state subsidies for higher education, any transfer plan may also need to involve payments from states that are net exporters of students, typically large population states, to states that are net importers of students, typically small population states. For further information on a possible federal interstate payment plan, see Palley (1976).

[12] In addition, specific state universities sometimes provide discounts to students living in nearby border areas. The University of Massachusetts-Dartmouth, for example, while participating in Tuition Break, also offers the Ocean State Proximity Plan, which offers discounts to residents of Rhode Island. See http://www.umassd.edu/undergraduate/tuition/ (accessed October 16, 2015). Also, the most comprehensive reciprocity agreement is between Minnesota and three of their neighbors, Wisconsin, North Dakota, and South Dakota. This program is designed to completely remove tuition and admissions barriers and has been in existence since the 1960s. During the fall of 2013, over 40,000 students participated in this program. Given that institutions charge different in-state tuition rates, this reciprocity program involves students paying the maximum of the tuition in the home state and in the state in which the institution is located. Also, given heterogeneity in population and that these states subsidize their institutions, there are typically payments from large states to small states. For example, North Dakota receives a net inflow of students from Minnesota and, as compensation, the state of Minnesota makes an interstate payment to the state of North Dakota. For more information, see http://archive.leg.state.mn.us/docs/2015/mandated/150402.pdf (accessed October 16, 2015).

[13] In some cases, these discounts are substantial and participating students pay tuition that is close to resident rates, while in other cases participating students receive relatively small discounts.For example, students participating in Tuition Break during the 2015-16 academic year and attending the University of Maine pay $12,570 in tuition, substantially less than the $26,640 paid by non-residents not participating and closer to the resident rate of $8,370. At the University of New Hampshire, by contrast, participants pay $24,588, closer to the non-resident rate of $27,320

evidence below that these reciprocity agreements are efficiency-enhancing.

Another natural solution would be for states to provide their residents with tuition vouchers. In the context of the model, state E, for example, could provide vouchers in an amount equal to $n_W - r_E$ that could be used at the out-of-state college W. This would equalize tuition at in-state and out-of-state institutions as residents of E would pay tuition equal to r_E regardless of institution.[14] One potential problem with these vouchers involves economic incidence. In particular, since residents of state E would no longer internalize out-of-state tuition, state W, given their objective to maximize total tuition revenue from non-residents, would have an incentive to further increase out-of-state tuition by an amount equal to the voucher ($n_W - r_E$). This would increase non-resident gross tuition from n_W to $2n_W - r_E$, and net tuition paid by students would remain equal to n_W. Thus, the benefits of tuition vouchers may be captured by the out-of-state institution, rather than by the state resident, with no change in the allocation of students across institutions.

5 Data

To estimate the sufficient statistic identified in the model, we use a border discontinuity design, as detailed below, in which we examine institutional enrollment patterns for students living close to state borders. To measure this distribution, we use the restricted access version of the HERI Freshman Survey, covering the years 1997-2011. In this survey, incoming freshman at select institutions are asked a battery of questions involving their demographics, high school experience, and, importantly for our analysis, the zip code of their permanent residence.[15] In addition, we can distinguish between public and private institutions, and the restricted access version also includes a measure of the state in which the institution is located. Further, our restricted access version also includes measures of in-state and out-of-state tuition and fees for each institution included in the analysis.[16] To summarize, our analysis uses information on student permanent residence (zip code and state), institution state, institutional status (public or private), and tuition and fees, separately for residents and non-residents.

Given the survey design, note that this is a sample of institutions, not a sample of students. Hence, our unit of analysis to follow involves institutions, rather than students. Further, this is

than to the resident rate of $11,128. These figures are taken from http://www.nebhe.org/info/pdf/tuitionbreak/2015-16_RSP_TuitionBreak_TuitionRates.pdf (accessed October 16, 2015).

[14] The closest such system is the program discussed above, under which residents of Washington D.C. receive up to $10,000 to attend out-of-state institutions. One important difference, however, is that this system is funded by the federal government, rather than by the District itself.

[15] We exclude institutions that had fewer than 100 respondents to the survey in a given year. In addition, to focus on a consistent set of institutions, we exclude two-year institutions.

[16] These tuition measures are taken from the Integrated Postsecondary Education Data System (IPEDS) at the National Center for Education Statistics (NCES).

not necessarily a representative sample of institutions as colleges choose to participate in the survey in order to gather information about their incoming students. Nonetheless, participation is widespread, with over 1,000 institutions participating at least once during our sample period.[17]

To implement the border discontinuity design, we use zip code maps to first calculate the distance from each zip code centroid to every state border.[18] For each zip code, we then focus on the closest state border. More formally, let δ_z be the distance from zip code z to the closet border. Then, we code distance as negative ($d_{zc} = -\delta_z$) for students attending institutions in the closest border state and code distance as positive ($d_{zc} = \delta_z$) for students attending in-state colleges. We focus on bandwidths of 20km, and, as a robustness check, we also present results for bandwidths of 10km and 30km.

Using this sample, we then collapse zip codes into larger geographic units, which we refer to as distance bins. In our baseline analysis, we create two distance bins for each border, one representing the out-of-state side of the border and one representing the in-state side of the border. Each of these border sides includes students living within the bandwidth of 20 kilometers of the border. We also refer to these 20km border bins as border sides. Second, we create two-kilometer distance bins. That is, for the baseline bandwidth of 20 kilometers on either side of the border, there are 20 distance bins for each border, the first between 18 and 20 kilometers outside of the border, the second between 16 and 18 kilometers outside of the border, etc.

We complement this analysis of HERI data with two additional datasets. First, we analyze information on student payments from the restricted access version of the National Postsecondary Student Aid Study (NPSAS), collected by the NCES. [19] These data have information on both official tuition and fees, separately for residents and non-residents, and as well as actual payments made by students surveyed. While our baseline HERI data include the former measure, they do not include the latter measure. In the analysis to follow, we use two measures of payments, one being tuition and fees paid and the second being net tuition and fees, which subtracts out any grants received by the student.

Second, as a further complement to our analysis of the baseline HERI data, we examine the Educational Longitudinal Study (ELS 2002-2006). These data consist of a nationally representative longitudinal study of 10th graders in 2002 and 12th graders in 2004. In addition to measures of the zip code of permanent residence, these data include information on the set of colleges to which students applied and the set of colleges to which they were accepted.[20] We then infer the

[17] This is an unbalanced panel of institutions as few participate in all 15 years of the sample.

[18] We use 2000 Census zip code maps for the 1997-2000 HERI data and 2010 Census zip code maps for the 2001-2011 HERI data.

[19] We analyze data from the following waves: 1999-2000, 2003-2004, 2007-2008, and 2011-2012.

[20] These choice sets are based upon retrospective survey questions during the third wave, conducted in 2006, during which students were attending college.

choice from this set of acceptances based upon the school that they chose to attend. Using these data, we then examine both admissions decisions by institutions and student enrollment decisions given these choice sets.

6 Methods

As described above, the goal of the empirical analysis involves estimating the responsiveness of out-of-state enrollment to out-of-state tuition (i.e. $\frac{\partial P}{\partial n}$). We begin by describing a simple border discontinuity (BD) design, which compares enrollment between residents and non-residents, both living close to the border. While the border discontinuity design does not use any information on tuition, we also develop a tuition discontinuity design (TD). This design also compares enrollment between residents and non-residents, both living close to the border, but also uses information on the drop in tuition when crossing the border. Finally, we discuss a hybrid design, which compares the border discontinuity in enrollment between institutions with large and small differences between resident and non-resident tuition.

A key identification challenge involves separately measuring the effects of distance and the effects of the tuition gap. In particular, to separate distance and responses to the tuition gap, we estimate the responsiveness of non-resident enrollment to the tuition gap via the following border discontinuity (BD) design:

$$\ln(N_{bct}) = g(d_{bct}) + \rho^{BD} 1[d_{bct} > 0] + \theta_{ct} + \theta_{bt}$$

where N_{bct} is the number of students from distance bin b attending college c in year t, and d_{bct} represents the distance from b to the border associated with c. The function g is smooth in distance, which, as described above, is negative (positive) for out-of-state (in-state) students. Finally, θ_{ct} represents college-by-year fixed effects, and θ_{bt} represents bin-by-year fixed effects. Thus, the comparison is both within institutions and within geographic areas.

By focusing on students living close to state borders, we can separate the role of tuition from the role of geography. In particular, ρ^{BD} is the percent change in enrollment when crossing the border:

$$\rho^{BD} = \lim_{d_{bct} \to 0} [\ln(N_{bct})|in-state) - \ln(N_{bct})|out-of-state)]$$

Using the theoretical model outlined above, we have that, considering college c, this key border discontinuity parameter can be written as:

$$\rho^{BD} \quad = \quad \rho(n_c - r_c)$$

Thus, the key coefficient from this border discontinuity design identifies the product of ρ, the responsiveness of enrollment to tuition, and $(n_c - r_c)$, the tuition gap between residents and non-residents. That is, any border discontinuity reflects both an underlying difference in tuition and student responses to this difference in tuition.

In order to separate these two channels, tuition differences and enrollment responses to these differences, behind any border discontinuity, we next discuss the tuition discontinuity design, which incorporates information on tuition for residents and non-residents. In particular, we estimate the following tuition discontinuity design regression:

$$\ln(N_{bct}) = f(d_{bct}) - \rho^{TD} t_{bct} + \theta_{ct} + \theta_{bt}$$

where t_{bct} represents tuition for students attending institution c from distance bin b at time t. This equals in-state tuition for residents and out-of-state tuition for non-residents. More formally, $t_{bct} = n_{ct} 1[d_{bct} < 0] + r_{ct} 1[d_{bct} > 0]$. Thus, this tuition discontinuity design is identified by measuring the change in enrollment associated with the discontinuous drop in tuition when crossing the border from neighboring states into the institution state.

As before, the key measured discontinuity can be interpreted as follows.

$$\rho^{TD}(n_c - r_c) = \lim_{d_{bct} \to 0} [E(\ln(N_{bct})|in-state) - E(\ln(N_{bct})|out-of-state)]$$

Given the results above, in the context of the border discontinuity design, we have that:

$$\rho^{TD} \quad = \quad \rho$$

Thus, by incorporating measures of resident and non-resident tuition, the tuition discontinuity design allows us to identify the key theoretical parameter measuring the responsiveness of enrollment to tuition.

Finally, we investigate whether any measured effects in our tuition discontinuity design are driven by tuition differences or other reasons that students may attend in-state institutions (in addition to geography). For example, if public institutions primarily recruit in-state students, then our tuition discontinuity design will attribute this recruiting to lower in-state tuition. To separate these other reasons why students may attend in-state institutions from both tuition and geography, we also estimate the following hybrid discontinuity design that includes both distance and tuition:

$$\ln(N_{bct}) = f(d_{bct}) - \rho^{TD} t_{bct} + \rho^{RD} 1[d_{bct} > 0] + \theta_{ct} + \theta_{bt}$$

As shown, this hybrid design is identified both by border discontinuities and by differences in the tuition gap across institutions. In particular, this design now compares the enrollment discontinuity between institutions with large and small tuition gaps. The parameter from the border discontinuity design (ρ^{RD}) captures all non-tuition factors, such as recruiting, contributing to the border discontinuity, and the parameter from the tuition discontinuity design (ρ^{TD}) isolates the role of tuition.

7 Results

Before estimating the border discontinuity models developed above, we provide evidence on differences in tuition between residents and non-residents using information on both posted tuition prices and actual payments by students. Having established that non-residents pay more than residents, we then describe the results from our border discontinuity design. We then address two alternative explanations for our border discontinuity, one involving differential admissions standards and another involving endogenous sorting. We then present results from the tuition discontinuity design and the hybrid discontinuity design. We also investigate whether reciprocity agreements reduce border discontinuities. We then conduct a similar analysis using a separate dataset on student choice sets. Finally, our results are compared for those for private institutions.

7.1 Differences in Tuition Payments

As a starting point, we document differences in posted tuition and fees, which we also refer to as sticker prices since they are not adjusted for any discounts in the form of grants. Table 1 provides average tuition and fees (2011 dollars), separately by year and for residents and non-residents, in the sample of institutions included in the HERI data. As shown, in-state tuition rose from just over \$5,000 in 1997 to just over \$8,000 in 2011. For non-residents, by contrast, tuition rose from roughly \$13,500 in 1997 to over \$19,000 in 2011. As shown in the final column, tuition rose more rapidly for non-residents, as the gap rose from just over \$8,000 in 1997 to just over \$11,000 in 2011. Averaged across all years, and as shown in the final row, resident tuition is roughly \$6,000 and non-resident tuition is roughly \$15,000, implying an average gap of \$9,000 during our sample period.

Of course, student payments are often well below these posted tuition prices due to grants and other forms of financial aid. To examine student payments, we turn to evidence from the NPSAS, which, as described above, includes information on both tuition payments and payments net of grants. We begin by analyzing payments by students to public institutions in Table 2. As shown in the first column, in-state students pay around \$7,200 less than out-of-state students, and this difference is statistically significant at conventional levels. This gap is similar in magnitude to, but a bit lower than, the \$9,000 average gap across the HERI sample years, as documented in

Table 1. We next regress payments on the sticker price adjusted for whether or not the student is a resident or a non-resident. If payments are perfectly correlated with sticker prices, then we expect a coefficient of one. If payments are uncorrelated with sticker prices, by contrast, then we expect a coefficient of zero. As shown in column 2, we find that there is a correlation, with an increase in the sticker price of one dollar associated with an increase in student tuition payments of 76 cents. Column 3 controls for both this sticker price and a simple indicator for whether or not the student is in-state. As shown, even after controlling for residency status, sticker prices matter. Said differently, the difference in tuition payments between residents and non-residents is larger at institutions with larger differences between resident and non-resident tuition. Columns 4-6 provide results from analogous specifications in which the dependent variable is net tuition and fees, which adjust for all grants received by the student. As shown, resident pay about $6,400 less than non-residents on net. Likewise, sticker prices also matter, with an increase in the sticker price of one dollar associated with a 70 cent increase in student net payments. Finally, as in column 3, the difference in net tuition payments between residents and non-residents is also larger when the difference in sticker prices is larger.

7.2 Border Discontinuity Design

Having established that residents pay less than non-residents at public institutions, we next provide results from our border discontinuity design. We begin with graphical evidence. Figure 3 plots the number of students in the HERI data attending a given institution in a given year from a given 2km distance bin. The x-axis depicts distance, in kilometers, from the border, where negative distance represents out-of-state bins and positive distance represents in-state bins. Naturally, as distance on the x-axis crosses zero, bins change from being non-resident to resident. Each bar represents the average enrollment in that distance bin across all public institutions. For example, on average across public institutions and years 1997-2011, there are roughly 4 students in bins between 0 and 2 kilometers inside the border.[21]

As shown, there is a striking discontinuity in enrollment, jumping from below one on the out-of-state side of the border to around 6 on the in-state side of the border. Also, there is no discernible slope in enrollment on either side of the border, with fewer than one out-of-state student on average and roughly 6 in-state students, regardless of distance to the border. As the HERI data combine large and small institutions, we next present results in which the number of students in a given bin attending a given institution is scaled by the total number of students attending that institution and within 20 kilometers of the border. As shown, we see a similar discontinuity, with an increase

[21] Note that there are fewer students living very close to the border (within two kilometers). This is due to the fact that there are few zip codes with centroids within two kilometers of the state border. Note that all regressions include bin fixed effects, which control for this pattern.

of 8 percentage points, from roughly one percent of enrollment in each two-kilometer bin on the non-resident side of the border to roughly 9 percent of enrollment in a given bin on the in-state side of the border.

Table 3 presents regression versions of these figures, based upon two border sides, which, as noted above, aggregate the ten 2km distance bins into a single geographic unit of observation. Also, as noted above, these specifications all include institution-year fixed effects and border side-year fixed effects. As shown, using a baseline bandwidth of 20km, there is an increase of roughly 60 students when crossing the border. Column 2 presents results using the percentage of students in each border side (i.e., dividing enrollment in each border side by the total enrollment around the border). As shown, there is an increase in enrollment of 81 percentage points when crossing the border. Finally, in order to measure the percent change in enrollment when crossing the border, column 3 presents results using $\ln(N_{bct}+1)$ as the dependent variable.[22] As shown, we again have that enrollment increases substantially when crossing from the out-of-state side of the border to the in-state side.

We next consider three robustness checks. First, Tables 4 and 5 present results using our baseline larger geographic unit, border sides, but for alternative bandwidths. As shown in Table 4, when considering all zip codes within a smaller bandwidth, 10 kilometers around the border, the change in the enrollment is smaller. This is due largely to the mechanical effect of having fewer potential enrollees when considering a smaller bandwidth. The results in columns 2 and 3, which do account for differences in the number of potential enrollees, are a bit smaller in magnitude when compared to the baseline results in Table 3 but remain positive and statistically significant at conventional levels. Likewise, when considering all zip codes within a larger bandwidth (30 kilometers around the border) in Table 5 , the results in columns 2 and 3 are a bit larger in magnitude when compared to the baseline results in Table 3. These larger effects for larger bandwidths may reflect the fact that the analysis now includes students further away from the border, and travel costs may make the out-of-state students less comparable to the corresponding in-state students. Taken together, these results are robust to alternative bandwidth measures.

As a second robustness check, we next examine results using our baseline bandwidth of 20km but using 2km distance bins, our smaller geographic unit. These specifications allow for us to separately control for distance to the border, which, as noted above, is negative on the out-of-state side of the border and positive on the in-state side. The results are presented in Table 6. As shown in column 1, we have an increase of roughly 8 students when comparing the distance bin between the border and 2km inside the border to the distance bin between the border and 2km outside of the border. Likewise, in column 2, we have an increase in enrollment of 7.5 percentage points, relative

[22]Note that we use $\ln(N_{bct}+1)$ rather than $\ln(N_{bct})$ since some border sides have zero enrollment. Results dropping these bins and using $\ln(N_{bct})$ yield similar results.

to the total enrollment within 20km of the border. Finally, in column 3, we again have a substantial increase in enrollment when crossing the border.

As a third robustness check, we drop institutions that are close to state borders since the non-resident side of the border may no longer be comparable to the resident side of the border. For example, differences in travel times could be substantial for an institution located 10 kilometers inside the border. To do so, we drop institutions within 30 kilometers of the border, and, as shown in Table 7, the results are robust to dropping these institutions.

Taken together, the graphical and regression estimates point towards a strong and robust border discontinuity, with large increases in enrollment at public institutions when crossing the border. This suggests that there may be substantial welfare gains associated with reducing the gap between resident and non-resident tuition.

7.3 Alternative Explanations

We next consider two alternative explanations, beyond geography, for our border discontinuity. The first alternative explanation involves differential admissions thresholds. While our theoretical model does not include an admissions margin, state universities maximizing resident welfare may, in addition to setting differential tuition, have an incentive to set lower admissions standards for residents, relative to non-residents. Indeed, an analysis of self-reported student acceptance decisions, as detailed in Section 7.5 below, documents that in-state applicants are more likely to be accepted by colleges, and especially so at public institutions.[23] Given this, our border discontinuity in enrollment could be explained by a difference in student composition when crossing the border, with high ability students on both sides of the border but only low ability students on the in-state side of the border.

We address this alternative explanation in three ways. First, we restrict the sample to high ability students, defined as students with SAT/ACT test scores that are above the institutional median, defined separately for each year in our data. Presumably these students were unconstrained, or at least less constrained, by the admissions process at the institution. As shown in Table 8, our results remain economically and statistically significant when focusing on this sub-population. Based upon this border discontinuity for the high ability sample, we conclude that our baseline border discontinuity cannot be explained solely by a sharp change in student ability when crossing the state border.

Second, we next include all students but restrict our sample to less selective institutions, those with median test scores below the corresponding median across all institutions in our sample. At these non-selective institutions, admissions processes are less salient, and thresholds should thus

[23] See also Groen and White (2004)

be less binding for non-residents. As shown in Table 9, however, our results for these less selective institutions are similar to those in the baseline specification. This again suggests that our baseline results are not driven by differences in admissions criteria for residents and non-residents.

Third, as detailed in Section 7.5 below, we use information on student applications and admissions to construct choice sets. Then, conditional on being accepted, we find that students are more likely to attend in-state institutions and especially so when there is a large difference between resident and non-resident tuition. This is also suggests that our baseline results are not driven by admissions advantages for residents.

A second alternative explanation involves endogenous sorting around state borders. That is, students (or parents) with a strong preference for a specific institution may choose to live inside the state border in order to access in-state tuition. For two reasons, we feel that this is unlikely to explain our large estimated border discontinuities. First, students apply for college admissions during their senior year of high school, and accessing in-state tuition requires one year of residency prior to enrolling at the university. Thus, in order to access in-state tuition for the first year of college, parents would need to change their residence in advance of the college applications process. Second, we see neither any bunching of students just inside of the state border nor a corresponding drop in students just outside of the state border, a pattern that would naturally be expected under endogenous sorting.

7.4 Variation in Tuition Policies

To further explore the role of tuition, we next present results exploiting variation in tuition policies. In this case, we measure the change in enrollment associated with the decrease in tuition when crossing from the out-of-state side to the in-state side of the border. Following that, we also present results from the hybrid discontinuity design, in which we combine the border discontinuity design and the tuition discontinuity design. Finally, we compare discontinuities along borders with and without reciprocity agreements, which, as described in Section 4, reduce the gap between resident and non-resident tuition.

These tuition discontinuity design results are presented in Table 10, in which tuition is measured as tuition and fees (in thousands of 2011 dollars). As described above, tuition equals the non-resident rate for the out-of-state side of the border and the resident rate for the in-state side of the border. As shown in column 1, an increase in tuition of \$1,000 is associated with an decrease of roughly 6 students. Thus, achieving the baseline border discontinuity of 60 students in column 1 of Table 3 requires a tuition gap of roughly \$10,000. As shown in column 2, which uses the percent of enrollment as the dependent variable, an increase in tuition of \$1,000 is associated with an decrease of 8 percentage points, when compared to the total border population. Finally, column

3 documents that an increase in tuition of $1,000 is associated with an decrease in enrollment of roughly 19 percent.

We next present results in Table 11 from our hybrid discontinuity design, in which we control for both the simple border discontinuity and the tuition discontinuity. This specification compares enrollment discontinuities along borders with large tuition gaps to borders with smaller tuition gaps. As shown, the coefficient on the simple in-state indicator remains positive, suggesting that there is a discontinuity even in the absence of a gap between non-resident and resident tuition. After controlling for the in-state indicator, the coefficient on tuition does fall in magnitude, relative to those in Table 10. Nonetheless, the coefficient remains negative and statistically significant in all three specifications. Thus, while the hybrid design does suggest a somewhat smaller role for tuition, when compared to the tuition discontinuity design, the coefficients on tuition remain negative and statistically significant.

Finally, we return to our border discontinuity design but compare reciprocity borders to non-reciprocity borders. Reciprocity borders are those in which the two states participate in the same exchange, defined as one of the four regional exchanges described in Section 4.2. Likewise, non-reciprocity borders are defined as those in which the two states do not participate in the same exchange, even if one or both do participate in an exchange. We hypothesize that, due to tuition discounts, border discontinuities should be smaller along reciprocity borders. In order to classify borders, we compiled a list of state entry years for each exchange from the exchange websites and state government publications and then categorized every border, in every year, as reciprocity or non-reciprocity.[24] As shown in Table 12, discontinuities are indeed smaller along reciprocity borders, when compared to non-reciprocity borders, although this difference is only statistically significant in the first column.

7.5 Analysis of Admissions and Choice Sets

As a complement to our analysis of HERI data, we next analyze data from the Educational Longitudinal Study (ELS 2002-2006), as described above. Unlike our baseline HERI survey, these ELS data have information on student applications and acceptances. We use these data to first analyze the role of residency status in admissions decisions. Then, using these measures of admissions to create choice sets, we can identify the role of tuition in student choices via revealed preference (Avery et al. (2013)). As described above, these analyses shed further light on the admissions margin in our baseline enrollment discontinuities.

We begin by analyzing whether admissions standards differ between residents and non-residents.

[24]The exchange websites are http://msep.mhec.org (MSEP), http://www.nebhe.org/programs-overview/rsp-tuition-break/overview/ (NEBHE), http://www.sreb.org (SREB), and http://www.wiche.edu/wue (WUE). Also helpful was Abbott's history of the WUE Abbott (2004).

In particular, Table 13 provides the results from our analysis of institution acceptance decisions. In this analysis, we treat student-application pairs as the unit of observation and then estimate a linear probability model for whether or not the student is accepted at a given institution. Key independent variables include an in-state indicator and SAT and GPA scores. In addition, all specifications include institution fixed effects, which control for selectivity.[25] Column 1 provides an analysis of public institutions. As shown, SAT and GPA scores are, not surprisingly, positively related to admissions decisions. Conditional on these measures, we find that in-state applicants are 4 percentage points more likely to be admitted to public institutions, when compared to out-of-state applicants, and these differences are statistically significant at conventional levels. Column 2 includes student fixed effects, and identification in this case comes from students who applied to both in-state and out-of-state institutions. As shown, the results are even stronger in this case, with admissions rates for residents 7 percent points higher than admissions rates for non-residents.

Next, using the set of schools to which students were admitted, we construct student choice sets and then estimate alternative-specific conditional logit models of student enrollment decisions. These models include institution fixed effects, and identification thus comes from institutions that are both chosen by at least one accepted student and not chosen by at least one accepted student.[26] Note that these data do not include enough student respondents to conduct a border discontinuity design. Instead, we control for the distance, in thousands of kilometers, between the student, based upon the zip code of the permanent residence, and the institution. Analogously to our border discontinuity design, column 1 of Table 14 reports results from a specification including an indicator for in-state institutions and a quadratic measure of distance. As shown, conditional on distance, students are more likely to attend in-state institutions than out-of-state institutions, and this difference is statistically significant. Analogously to our tuition discontinuity design, column 2 reports results from a specification including tuition, in thousands of dollars and adjusted for whether the student is in-state or out-of-state. As shown, conditional on distance, students are more likely to attend institutions with tuition discounts for residents. Finally, in analogue to our hybrid discontinuity design, column 3 reports results from a specification controlling for both an in-state indicator and tuition. As shown, the coefficient on in-state falls and becomes statistically insignificant, and the coefficient on tuition is relatively stable and remains statistically significant at conventional levels. In all three specifications, it is clear that distance enters non-linearly, with distance becoming a positive factor in student decisions at roughly 2,500 kilometers. Given this limitation of the quadratic specification, we next estimate specifications controlling for the natural log of distance,

[25] We restrict attention to students reporting both GPA and SAT/ACT scores, and the sample of institutions consists of four-year institutions with at least 10 appearances in student application sets.

[26] We restrict attention to students reporting a choice set of at least two and attending a single institution. The sample of institutions consists of four-year institutions and, due to computational considerations, at least 10 appearances in student choice sets.

which guarantees a monotonic relationship. As shown in column 4-6, the results are similar in this alternative specification, with students more likely to attend in-state institutions and especially those with large discounts for residents. To summarize, this analysis of choice sets using a separate data set corroborates our baseline results, with students more likely to choose in-state institutions from their choice sets and especially so when large discounts are offered to residents.

7.6 Private Institutions

Returning to the HERI data, we next consider private institutions, where tuition does not discriminate between residents and non-residents. Figures 5 and 6 present border discontinuity results, again using a bandwidth of 20km. As shown, we still find a discontinuity for private institutions, with enrollment increasing from roughly 0.5 students on average per bin on the out-of-state side of the border to roughly 1.5 students on the in-state side of the border. While this increase of 1 student is less than the increase of roughly 5 students for public institutions (Figure 3), these are not directly comparable given that private institutions tend to be smaller than public institutions. To address this issue, Figure 6 presents results based upon enrollment as a percent of the total border enrollment at a given institution. As shown, the fraction of students attending a given institution increases by roughly 4 percentage points, from 3 percent to 7 percent. This is smaller than the jump, as documented in Figure 4, of roughly 9 percentage points for public institutions. Table 15 presents regression versions of these figures, in which we estimate border discontinuity regressions for private universities. As shown in columns 1, we find an increase of roughly 9 students when crossing the border. This represents a roughly 50 percentage point increase in enrollment, as shown in column 2. Finally, in column 3, we find an increase in enrollment of 74 percent when crossing the border. These are again smaller than the corresponding regression results for public institutions.

This finding of border discontinuities for private institutions is surprising given that these institutions do not distinguish between residents and non-residents for tuition purposes. In the Appendix, we explore two potential explanations for this border discontinuity for private institutions. First, in parallel to Section 7.1 and using NPSAS payments data, we show that residents pay less on net than non-residents even at private institutions. This difference is largely due to higher state aid for residents and is consistent with several state aid programs that provide grants to state residents attending private institutions within the state. Second, in parallel to Section 7.5 and using ELS data on self-reported student acceptance decisions, we show that in-state applicants are more likely to be accepted by private institutions. Thus, the border discontinuity for private institutions may reflect both financial differences and differences in admissions standards between residents and non-residents. Finally, we note that the financial and admissions advantages for residents are smaller at private institutions than at public institutions.

To summarize, we find evidence of border discontinuities for private institutions. These are smaller than the border discontinuities for public institutions and can be explained by both financial and admissions advantages for residents.

8 Welfare Consequences

We next use our parameter estimates from the tuition and hybrid discontinuity designs as inputs into measures of welfare changes associated with reducing the tuition gap between non-residents and residents. Recall from the theoretical model that the change in welfare associated with a one dollar *decrease* in non-resident tuition ($\Delta n = -1$) in the symmetric case can be written as:

$$P\left(\frac{-(1-P)-\frac{\partial P}{\partial r}(n-r)}{P-\frac{\partial P}{\partial r}(n-r)}\right)+(1-P)$$

Note further that $\frac{\partial P}{\partial r} = -\rho P(1-P)$. Plugging this in and re-arranging, we have that the welfare change is given by:

$$P\left(\frac{-(1-P)+\rho(n-r)P(1-P)}{P+\rho(n-r)P(1-P)}\right)+(1-P)$$

Thus, the parameter ρ is a sufficient statistic for the change in resident tuition given a change in non-resident tuition, and this is itself a sufficient statistic for the change in welfare.

To measure these key parameters, we use the estimate of the parameter ρ from both the tuition design in Table 10 and the hybrid designs in Table 11. Also, we assume an in-state fraction of 75 percent, which is similar to the national fraction of students attending in-state institutions. Finally, the researcher must also specify a tuition gap, and we use a gap of \$6,416, as reported using data on net payments for residents and non-residents at public institutions in Table 2.

As shown in the second panel of Table 16, there is a mechanical benefit for non-residents, whose welfare rises by 25 cents, reflecting the fraction attending out-of-state institutions, when reducing non-resident tuition by one dollar. In the absence of a behavioral responses, resident tuition must rise by 33 cents, leading to a welfare reduction for residents equal to 25 cents (third panel). Thus, in the absence of a behavioral response, there is no aggregate change in welfare. With a behavioral response, by contrast, resident tuition needs to be increased by only 3 cents (column 1), leading to a welfare decline for residents equal to 2 cents, as shown in the bottom panel. Thus, aggregate welfare rises by 23 cents. Note that this large increase in welfare is driven by the fact that resident tuition needs to increased only slightly following a reduction in non-resident tuition. This is in turn driven by the large behavioral response, an increase in out-of-state enrollment and a reduction in in-state enrollment, and the associated financial windfall received by institutions. Given that the estimated tuition discontinuity may include factors other than tuition, we next use a more conservative estimate of -0.0610 from the hybrid discontinuity design (column 3 of Table 11). As shown, the welfare gain is somewhat smaller, equal to 9 cents in aggregate, as resident tuition must increase by 21 cents in this case.

9 Conclusion

We view this paper as a first step in the development of measures of welfare losses associated with higher non-resident tuition. Future work could extend this in several directions. First, while reducing the tuition gap may improve efficiency, it may be detrimental from an equity perspective. This would be the case, for example, if low-income students tend to attend in-state institutions due to the low tuition and higher income students tend to disproportionately attend out-of-state institutions. In this case, when reducing the gap between non-resident and resident tuition, high income students would experience a reduction in tuition, at the expense of low-income students. Thus, there may be a standard trade-off between equity and efficiency when setting tuition for residents and non-residents. Second, our welfare estimates are local in nature, and we thus cannot calculate the welfare consequences of large policy changes, such as interventions designed to completely eliminate differences between resident and non-resident tuition. Consideration of these larger policy changes would require estimates of the full set of structural parameters (Chetty (2008)).

To summarize, we show that, in the context of a simple discrete choice model, state governments inefficiently distinguish between residents and non-residents when setting tuition policy. The welfare gain from reducing the tuition gap can be estimated as a sufficient statistic measuring the responsiveness of out-of-state attendance to out-of-state tuition. We estimate this sufficient statistic using a border discontinuity design. Both graphical and regression analysis document a substantial enrollment discontinuity. We also find evidence of discontinuities as tuition decreases when crossing the border, and these results are robust to a hybrid discontinuity design, in which we compares discontinuities along borders with large and small declines in tuition for residents, relative to non-residents. We also find smaller enrollment discontinuities along reciprocity borders. These results are corroborated using a separate dataset that includes information on student choice sets. Finally, back-of-the envelope calculations suggest substantial welfare gains from reducing the tuition gap.

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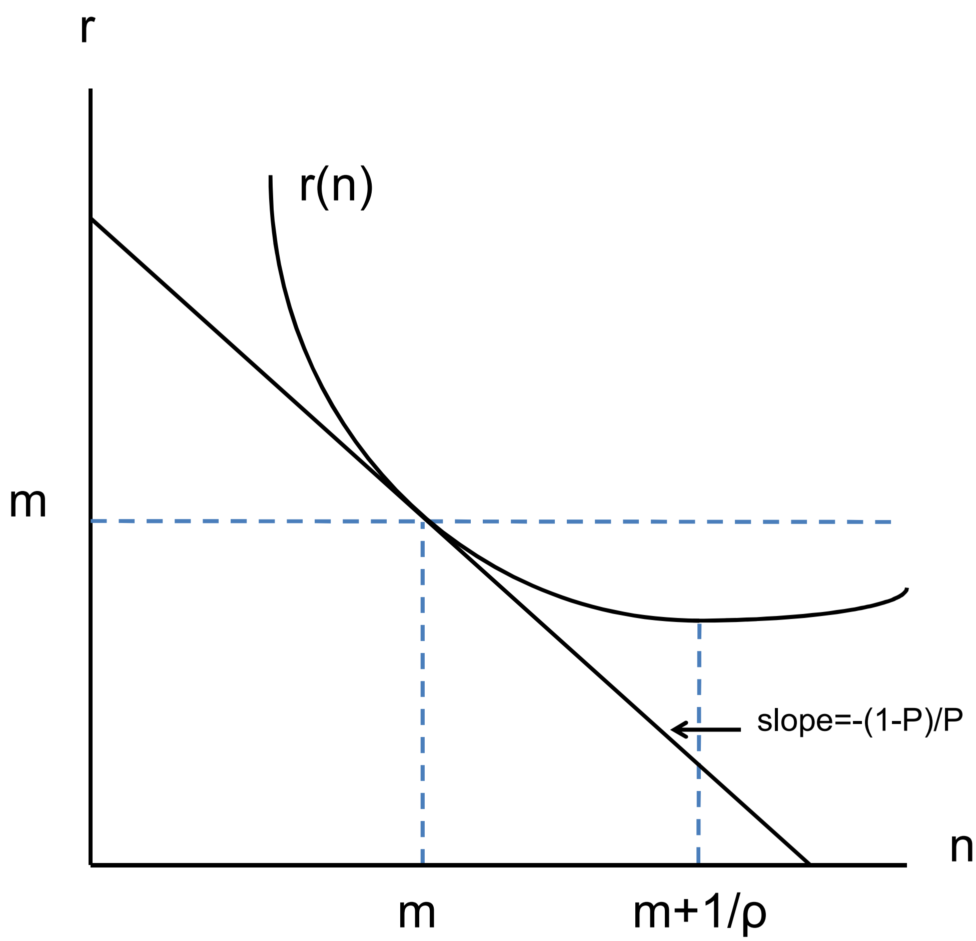

Figure 1: Resident and Non-Resident Tuition

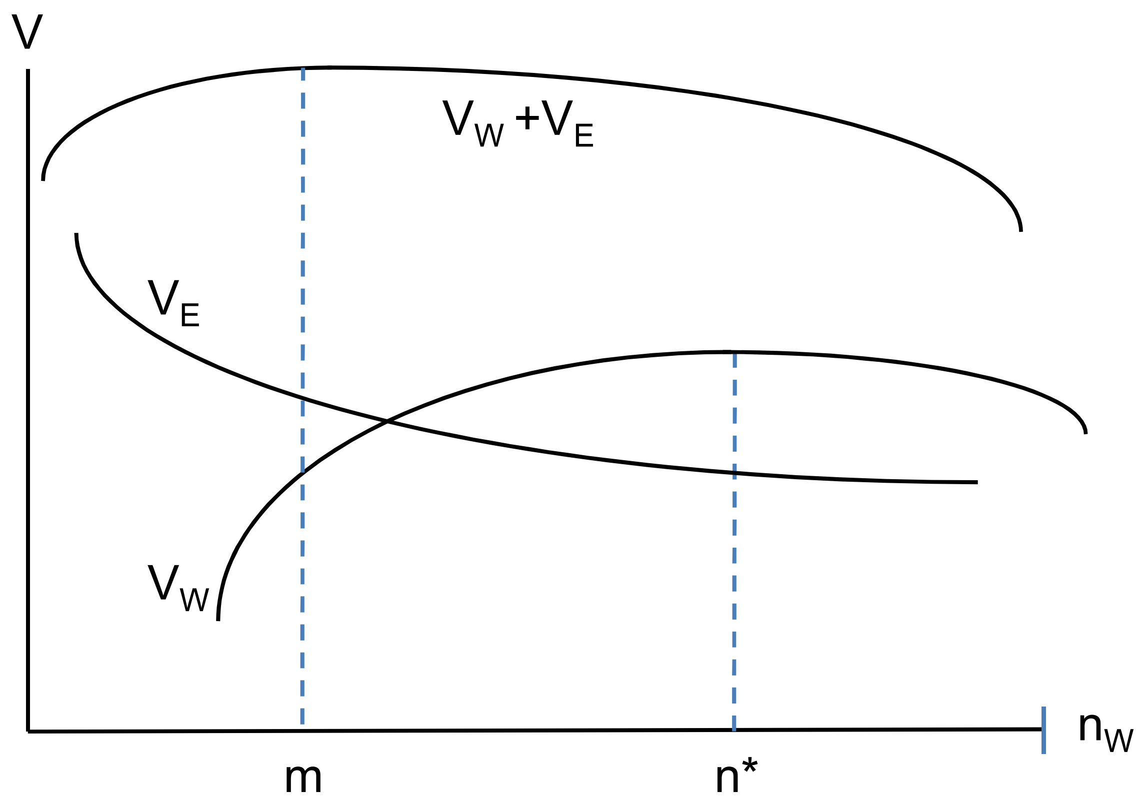

Figure 2: Welfare and Non-Resident Tuition

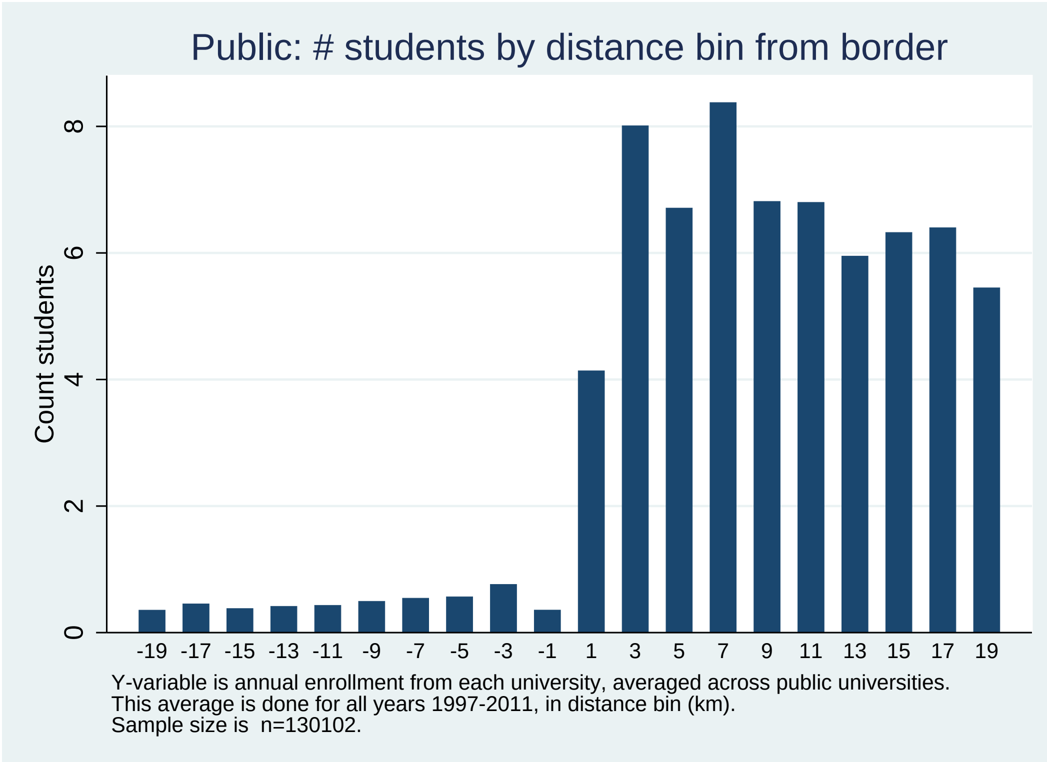

Figure 3: Discontinuity in Enrollment: Public Institutions

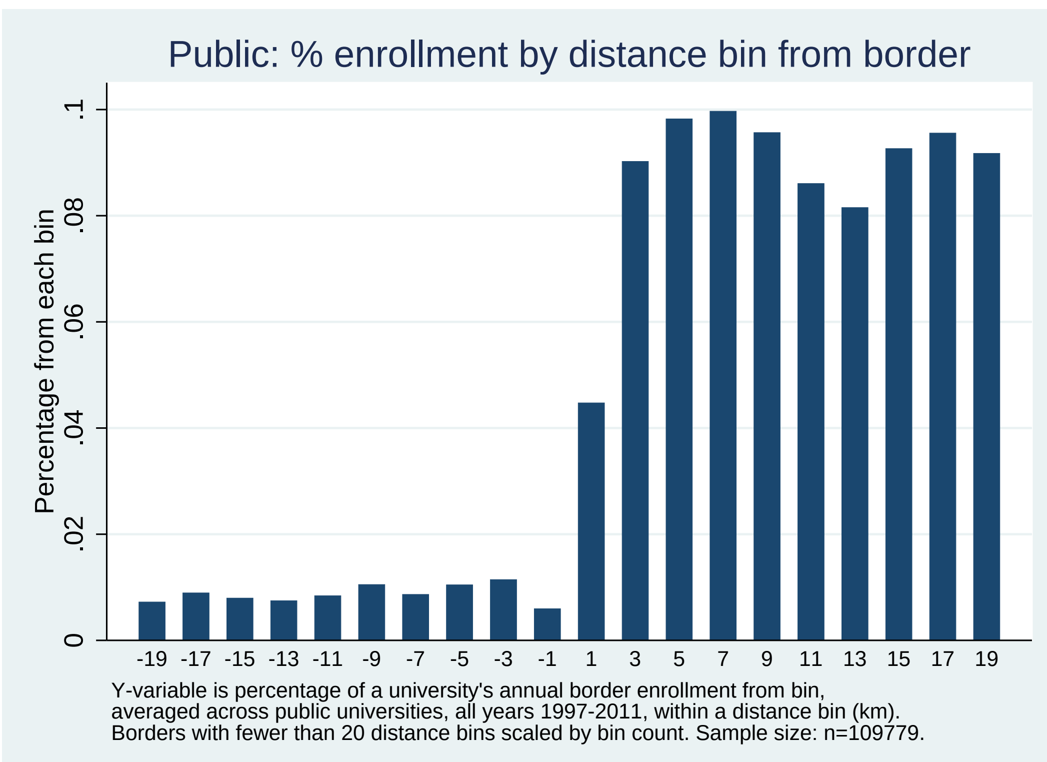

Figure 4: Discontinuity in Percentage Enrollment: Public Institutions

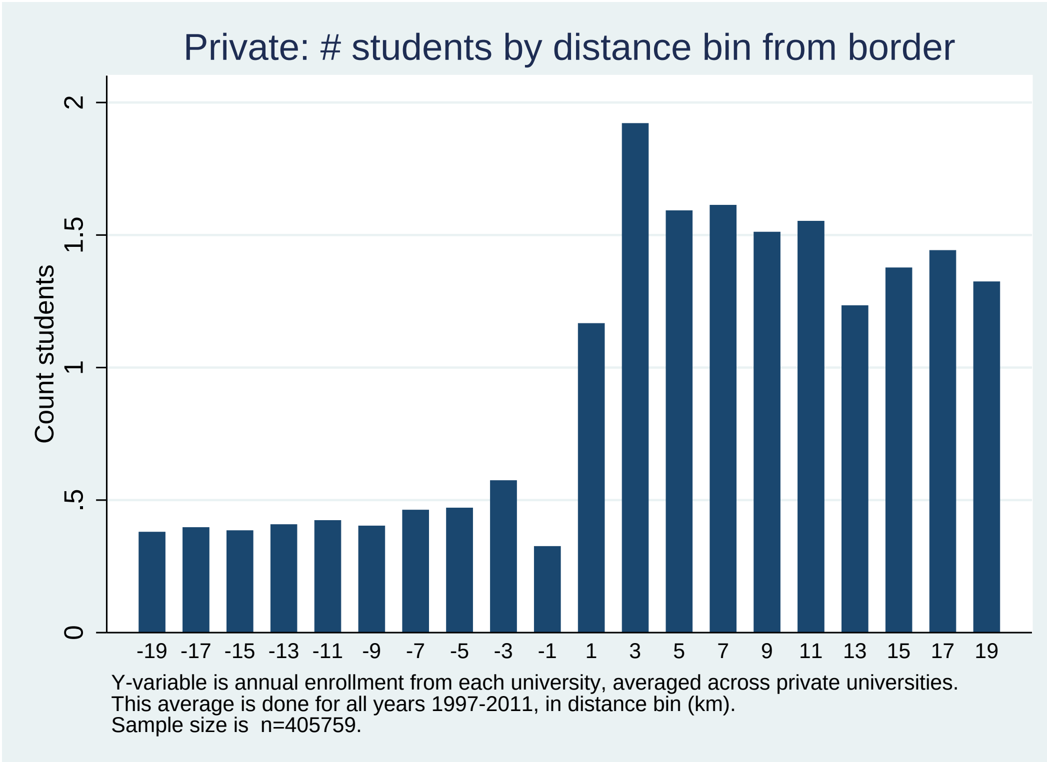

Figure 5: Discontinuity in Enrollment: Private Institutions

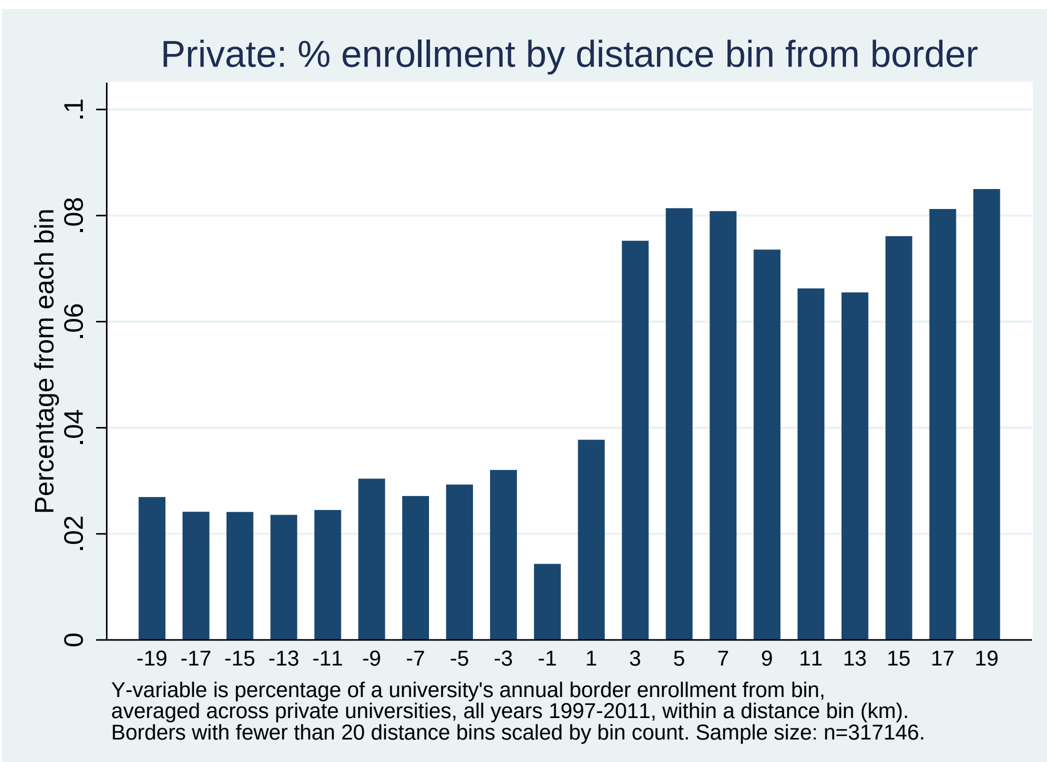

Figure 6: Discontinuity in Percentage Enrollment: Private Institutions

Table 1: Tuition Differences in HERI sample: Public Institutions

year	out-of-state	in-state	gap
1997	13.536	5.324	8.252
1998	13.880	5.361	8.519
1999	13.679	5.190	8.487
2000	13.398	5.194	8.205
2001	13.520	5.336	8.184
2002	14.109	5.643	8.466
2003	14.688	6.023	8.647
2004	15.292	6.517	8.776
2005	16.101	6.771	9.330
2006	16.252	6.859	9.392
2007	16.447	6.956	9.492
2008	16.940	6.938	10.002
2009	17.406	7.320	10.086
2010	18.040	7.608	10.432
2011	19.379	8.338	11.042
average	15.511	6.358	9.154

All dollar values are in thousands of 2011 dollars.

Measures are based upon annual posted tuition and fees for full-time students.

Table 2: Student payments in NPSAS data: public

	(1) tuition/ fees paid	(2) tuition/ fees paid	(3) tuition/ fees paid	(4) net tuition/ fees paid	(5) net tuition/ fees paid	(6) net tuition/ fees paid
sticker price		0.761***	0.699***		0.701***	0.704***
		(0.016)	(0.029)		(0.022)	(0.038)
in-state	-7.174***		-0.771***	-6.416***		0.039
	(0.231)		(0.268)	(0.285)		(0.353)
LHS mean	6.263	6.271	6.271	1.963	1.967	1.967
N	56,110	55,700	55,700	56,110	55,700	55,700
R^2	0.612	0.647	0.648	0.315	0.333	0.333

All specifications include, institution-by-year, state-of-residence-by-year, and cohort fixed effects.

Net tuition and fees paid is net of all grants received by the student.

All dollar values are in thousands of 2011 dollars.

Sticker price represents the price of tuition and fees, adjusted for whether a student is in or out of state.

The sample consists of full-time students attending four-year public institutions.

* p<0.1 ** p<0.05 *** p<0.01

Table 3: 20k border-sides specification, public institutions

	(1) enroll	(2) enroll(%)	(3) ln(enroll)
in-state	59.9542***	0.8119***	1.7361***
	(5.8517)	(0.0077)	(0.0517)
Observations	17312	13862	17312
R^2	0.445	0.895	0.760

Regressions run at border-side level for 20k range.
Sample is public universities only, 1997-2011, excluding two-year colleges.
All specifications include univ-year and border-side-year FE.
Standard errors clustered at university-border-side level.
* p<0.1 ** p<0.05 *** p<0.01

Table 4: 10k border-sides specification, public institutions

	(1) enroll	(2) enroll(%)	(3) ln(enroll)
in-state	32.9971***	0.7964***	1.4545***
	(3.1806)	(0.0085)	(0.0498)
Observations	16550	12094	16550
R^2	0.444	0.873	0.734

Regressions run at border-side level for 10k range.
Sample is public universities only, 1997-2011, excluding two-year colleges.
All specifications include univ-year and border-side-year FE.
Standard errors clustered at university-border-side level.
* p<0.1 ** p<0.05 *** p<0.01

Table 5: 30k border-side specification, public institutions

	(1) enroll	(2) enroll(%)	(3) ln(enroll)
in-state	78.6061***	0.8222***	1.9129***
	(6.9741)	(0.0074)	(0.0531)
Observations	17482	14616	17482
R^2	0.460	0.907	0.770

Regressions run at border-side level for 30k range.
Sample is public universities only, 1997-2011, excluding two-year colleges.
All specifications include univ-year and border-side-year FE.
Standard errors clustered at university-border-side level.
* p<0.1 ** p<0.05 *** p<0.01

Table 6: 20k distance-bin specification, public institutions

	(1)	(2)	(3)
	enroll	enroll(%)	ln(enroll)
in-state	8.2553***	0.0751***	0.8603***
	(0.5536)	(0.0021)	(0.0273)
distance	-0.0350	0.0004***	0.0032***
	(0.0222)	(0.0001)	(0.0011)
Observations	130102	109779	130102
R^2	0.381	0.409	0.619

Regressions run at distance-bin level for 20k range.
All specifications include university-year FE and distance band-year FE.
Sample is public universities, 1997-2011, excluding two-year colleges.
Standard errors clustered at university-bin level
* p<0.1 ** p<0.05 *** p<0.01

Table 7: 20k border-side, non-border public institutions

	(1)	(2)	(3)
	enroll	enroll(%)	ln(enroll)
in-state	46.7364***	0.8135***	1.6519***
	(5.3967)	(0.0083)	(0.0501)
Observations	16092	12536	16092
R^2	0.462	0.892	0.779

Regressions run at border_side level for 20k range.
Sample is public universities only, 1997-2011, excluding two-year colleges.
Sample also drops universities within 30k of border.
All specifications include univ-year and border_side-year FE.
Standard errors clustered at university-border_side level.
* p<0.1 ** p<0.05 *** p<0.01

Table 8: 20k border-side specification, public, above median students

	(1) enroll	(2) enroll(%)	(3) ln(enroll)
in-state	20.6244***	0.7919***	1.2816***
	(2.2066)	(0.0091)	(0.0447)
Observations	17312	12016	17312
R^2	0.443	0.867	0.721

Regressions run at border-side level for 20k range.
Sample is limited to students above median test score in univ-year,
public universities only, 1997-2011, excluding two-year colleges.
All specifications include univ-year and border-side-year FE.
Standard errors clustered at university-border-side level.
* p<0.1 ** p<0.05 *** p<0.01

Table 9: 20k border-side specification, less-selective public institutions

	(1) enroll	(2) enroll(%)	(3) ln(enroll)
in-state	41.1921***	0.8388***	1.4875***
	(6.2068)	(0.0091)	(0.0736)
Observations	9336	6974	9336
R^2	0.483	0.930	0.739

Regressions run at border_side level for 20k range.
Sample is less-selective public universities, 1997-2011, excl. 2yr colleges.
All specifications include univ-year and border_side-year FE.
Standard errors clustered at university-border_side level.
* p<0.1 ** p<0.05 *** p<0.01

Table 10: 20k border-side tuition specification, public institutions

	(1) enroll	(2) enroll(%)	(3) ln(enroll)
tuition	-6.2595***	-0.0813***	-0.1856***
	(0.5735)	(0.0016)	(0.0055)
Observations	17152	13745	17152
R^2	0.438	0.805	0.745

Regressions run at border_side level for 20k range.
Sample is public universities only, 1997-2011, excluding two-year colleges.
All specifications include univ-year and border_side-year FE.
Standard errors clustered at university-border_side level.
* p<0.1 ** p<0.05 *** p<0.01

Table 11: 20k border-side hybrid specification, public institutions

	(1) enroll	(2) enroll(%)	(3) ln(enroll)
in-state	49.7362***	0.7483***	1.2608***
	(9.3996)	(0.0203)	(0.1004)
tuition	-1.3432*	-0.0083***	-0.0610***
	(0.7595)	(0.0022)	(0.0098)
Observations	17152	13745	17152
R^2	0.447	0.901	0.765

Regressions run at border_side level for 20k range.
Sample is public universities only, 1997-2011, excluding two-year colleges.
All specifications include univ-year and border_side-year FE.
Standard errors clustered at university-border_side level.
* p<0.1 ** p<0.05 *** p<0.01

Table 12: 20k border-side, public, tuition reciprocity agreements

	(1)	(2)	(3)
	enroll	enroll(%)	ln(enroll)
in-state	69.0345***	0.8197***	1.7558***
	(8.8296)	(0.0085)	(0.0734)
in-state x exchange	-22.0051**	-0.0187	-0.0478
	(10.8870)	(0.0162)	(0.0989)
Observations	17140	13594	17140
R^2	0.445	0.893	0.758

Regressions run at border_side level for 20k range.
Sample is public universities only, 1997-2011, excluding two-year colleges.
All specifications include univ-year and border_side-year FE.
Standard errors clustered at university-border_side level.
* p<0.1 ** p<0.05 *** p<0.01

Table 13: Analysis of Institution Acceptance Decisions

	(1)	(2)
	accept	accept
in-state	0.0436***	0.0698***
	(0.0146)	(0.0161)
sat	0.0006***	
	(0.0000)	
gpa	0.2065***	
	(0.0108)	
cases	public	public
N	11,510	11,510
R^2	0.1672	0.8380
student FE	no	yes

Linear probability models of student-reported acceptance decisions with institution fixed effects

Sample of students consists of those reporting SAT and GPA scores

Includes four-year institutions with at least 10 appearances in student application sets

* p<0.1 ** p<0.05 *** p<0.01

Table 14: Analysis of Choice Set Data

	(1)	(2)	(3)	(4)	(5)	(6)
	enroll	enroll	enroll	enroll	enroll	enroll
in-state	0.3763***		0.1972	0.2446**		0.0189
	(0.1048)		(0.1380)	(0.1058)		(0.1413)
tuition		-0.0360***	-0.0326**		-0.0410***	-0.0396**
		(0.0121)	(0.0164)		(0.0124)	(0.0165)
distance	-0.5226***	-0.4961***	-0.5234***			
	(0.1482)	(0.1340)	(0.1486)			
distance squared	0.1092***	0.0957***	0.1088***			
	(0.0363)	(0.0333)	(0.0364)			
log distance				-0.1731***	-0.1801***	-0.1784***
				(0.0305)	(0.0277)	(0.0307)
cases	8,300	8,300	8,300	8,300	8,300	8,300
students	2,690	2,690	2,690	2,690	2,690	2,690

All specifications represent alternative-specific conditional logit models estimated via maximum likelihood

The sample of students consists of those reporting a choice set of at least two and attending a single institution

Includes four-year public and private institutions with at least 10 appearances in student choice sets

Tuition represents the sticker price of tuition and fees, adjusted for whether a student is in or out of state

* p<0.1 ** p<0.05 *** p<0.01

Table 15: 20k border-side specification, private institutions

	(1) enroll	(2) enroll(%)	(3) ln(enroll)
in-state	9.4527***	0.5099***	0.7375***
	(0.8903)	(0.0072)	(0.0256)
Observations	50940	37316	50940
R^2	0.349	0.582	0.649

Regressions run at border_side level for 20k range.
Sample is private universities only, 1997-2011, excluding two-year colleges.
All specifications include univ-year and border_side-year FE.
Standard errors clustered at university-border_side level.
* p<0.1 ** p<0.05 *** p<0.01

Table 16: Welfare calculations

inputs	(1)	(2)
tuition gap	$6,416	$6,416
estimated tuition discontinuity	-0.1856	-0.0610
border discontinuity [implied in (3) and (4)]	1.1908	0.3914
in-state fraction	0.75	0.75
effects on non-residents		
change in tuition	-$1.00	-$1.00
welfare change for non-residents	$0.25	$0.25
without behavioral response		
change in resident tuition	$0.33	$0.33
welfare change for residents	-$0.25	-$0.25
combined welfare change	$0.00	$0.00
with behavioral response		
change in resident tuition	$0.03	$0.21
welfare change for residents	-$0.02	-$0.16
combined welfare change	$0.23	$0.09

A Appendix (For Online Publication)

Derivation of $\frac{\partial r_W}{\partial n}$ and $\frac{\partial r_E}{\partial n}$

We derive expressions for the change in resident tuition given a uniform increase in non-resident tuition. Note that, for state W, the budget constraint $f_W r_W + (1-f_W)n_W = m$ can be re-written as:

$$P_W(r_W,n_E)[r_W-m]+[1-P_E(r_E,n_W)][n_W-m]=0$$

Then, considering a change in n_E, we have that:

$$\left(\frac{\partial P_W}{\partial r_W}\frac{\partial r_W}{\partial n_E}+\frac{\partial P_W}{\partial n_E}\right)[r_W-m]+P_W\frac{\partial r_W}{\partial n_E}-\frac{\partial P_E}{\partial r_E}\frac{\partial r_E}{\partial n_E}[n_W-m]=0$$

Similarly, considering a change in n_W, we have that:

$$\left(\frac{\partial P_W}{\partial r_W}\frac{\partial r_W}{\partial n_W}\right)[r_W-m]+P_W\frac{\partial r_W}{\partial n_W}-\left(\frac{\partial P_E}{\partial r_E}\frac{\partial r_E}{\partial n_W}+\frac{\partial P_E}{\partial n_W}\right)[n_W-m]+(1-P_E)=0$$

Now, direct effects are given by $\frac{\partial P_E}{\partial r_E}=-\rho P_E(1-P_E)$ and cross-effects are given by $\frac{\partial P_E}{\partial n_W}=\rho P_E(1-P_E)$. Thus, $\frac{\partial P_E}{\partial r_E}=-\frac{\partial P_E}{\partial n_W}$, and, plugging this into the expressions above, we have:

$$\left(\frac{\partial P_W}{\partial r_W}(\frac{\partial r_W}{\partial n_E}-1)\right)[r_W-m]+P_W\frac{\partial r_W}{\partial n_E}-\frac{\partial P_E}{\partial r_E}\frac{\partial r_E}{\partial n_E}[n_W-m]=0$$

$$\left(\frac{\partial P_W}{\partial r_W}\frac{\partial r_W}{\partial n_W}\right)[r_W-m]+P_W\frac{\partial r_W}{\partial n_W}-\left(\frac{\partial P_E}{\partial r_E}(\frac{\partial r_E}{\partial n_W}-1)\right)[n_W-m]+(1-P_E)=0$$

Adding these two conditions together, we have:

$$\left(\frac{\partial P_W}{\partial r_W}(\frac{\partial r_W}{\partial n_E}+\frac{\partial r_W}{\partial n_W}-1)\right)[r_W-m]+P_W(\frac{\partial r_W}{\partial n_E}+\frac{\partial r_W}{\partial n_W})-\frac{\partial P_E}{\partial r_E}(\frac{\partial r_E}{\partial n_W}+\frac{\partial r_E}{\partial n_E}-1)[n_W-m]+(1-P_E)=0$$

Letting $\frac{\partial r_W}{\partial n}=\frac{\partial r_W}{\partial n_E}+\frac{\partial r_W}{\partial n_W}$ and $\frac{\partial r_E}{\partial n}=\frac{\partial r_E}{\partial n_E}+\frac{\partial r_E}{\partial n_W}$, we have

$$\left(\frac{\partial P_W}{\partial r_W}(\frac{\partial r_W}{\partial n}-1)\right)[r_W-m]+P_W\frac{\partial r_W}{\partial n}-\frac{\partial P_E}{\partial r_E}(\frac{\partial r_E}{\partial n}-1)[n_W-m]+(1-P_E)=0$$

Now, by symmetry, for the case of state E, we have:

$$\left(\frac{\partial P_E}{\partial r_E}(\frac{\partial r_E}{\partial n}-1)\right)[r_E-m]+P_E\frac{\partial r_E}{\partial n}-\frac{\partial P_W}{\partial r_W}(\frac{\partial r_W}{\partial n}-1)[n_E-m]+(1-P_W)=0$$

In the symmetric case, these simplify to:

$$\left(\frac{\partial P}{\partial r}(\frac{\partial r}{\partial n}-1)\right)[r-n]+P\frac{\partial r}{\partial n}+(1-P)=0$$

Solving, we have that:

$$\frac{\partial r}{\partial n}=\frac{-(1-P)-\frac{\partial P}{\partial r}(n-r)}{P-\frac{\partial P}{\partial r}(n-r)}$$

Proof of Proposition 1

Using some results from the prior Appendix, we have that:

$$\left(\frac{\partial P_W}{\partial r_W}(\frac{\partial r_W}{\partial n_E}-1)\right)[r_W-m]+P_W\frac{\partial r_W}{\partial n_E}-\frac{\partial P_E}{\partial r_E}\frac{\partial r_E}{\partial n_E}[n_W-m]=0$$

$$\left(\frac{\partial P_W}{\partial r_W}\frac{\partial r_W}{\partial n_W}\right)[r_W-m]+P_W\frac{\partial r_W}{\partial n_W}-\left(\frac{\partial P_E}{\partial r_E}(\frac{\partial r_E}{\partial n_W}-1)\right)[n_W-m]+(1-P_E)=0$$

When $r_W=n_W=m$, these simplify to:

$$\frac{\partial r_W}{\partial n_E}=0$$

$$\frac{\partial r_W}{\partial n_W}=\frac{-(1-P_E)}{P_W}$$

For the case of the budget of state E, we have that, by symmetry:

$$\frac{\partial r_E}{\partial n_W}=0$$

$$\frac{\partial r_E}{\partial n_E}=\frac{-(1-P_W)}{P_E}$$

Recall the original formula for the change in welfare:

$$0.5\left[\{-P_W\frac{\partial r_W}{\partial n_W}-(1-P_E)-P_E\frac{\partial r_E}{\partial n_W}\}\Delta n_W+\{-P_E\frac{\partial r_E}{\partial n_E}-(1-P_W)-P_W\frac{\partial r_W}{\partial n_E}\}\Delta n_E\right]$$

Plugging in the above expressions, we have that there is no welfare gain when considering changes in non-resident tuition when $r_W=n_W=m$ and $r_E=n_E=m$. Thus, non-discriminatory policies are optimal.

Proof of Proposition 2

In the symmetric case, we have that $\frac{\partial P}{\partial n} = \rho P(1-P)$ and thus $n-m = 1/\rho P$. Further, using the budget constraint, one can show that $P = (n-m)/(n-r)$. Combining these, we have that:

$$r = n - \rho(n-m)^2$$

Further, note that $P = exp(-\rho r)/[exp(-\rho r) + exp(-\rho n - \rho\delta)]$, which can be re-written as $r = n + \delta + (1/\rho)ln[P/(1-P)]$. Next, note that $n-m = (1/\rho P)$ and thus $P/(1-P) = \rho(n-m) - 1$. Combining these two expressions, we have that:

$$r = n + \delta + (1/\rho)ln[\rho(n-m) - 1]$$

The first expression for r is quadratic in n, with a peak at $n = m + (0.5/\rho)$, at which point $r = m + (0.25/\rho)$. Beyond this peak, the expression in decreasing in n. The second expression for r equals negative infinity when $n = m + (0.5/\rho)$ and is strictly increasing in n. Moreover, when $n = m + (2/\rho)$, $r = m + (2/\rho) + \delta$. This is greater than $m + (0.25/\rho)$, and hence there is a single crossing between $n = m + (0.5/\rho)$ and $n = m + (2/\rho)$. At this single crossing, we have that $r < m < n$.

To show the comparative static, combining the two expressions above, note that n can be implicitly defined by:

$$-\rho^2(n-m)^2 = \rho\delta + ln[\rho(n-m) - 1]$$

Considering a change in ρ,we have that:

$$-2\rho(n-m)^2 - 2\rho^2(n-m)\frac{\partial n}{\partial \rho} = \delta + \frac{(n-m) + \rho\frac{\partial n}{\partial \rho}}{\rho(n-m) - 1}$$

Re-arranging, we have that

$$(-2\rho(n-m)^2 - \delta)[\rho(n-m) - 1] - 2\rho^2(n-m)\frac{\partial n}{\partial \rho}[\rho(n-m) - 1] = (n-m) + \rho\frac{\partial n}{\partial \rho}$$

Finally, solving, we have,

$$\frac{\partial n}{\partial \rho} = \frac{(-2\rho(n-m)^2 - \delta)[\rho(n-m) - 1] - (n-m)}{\rho + 2\rho^2(n-m)[\rho(n-m) - 1]}$$

Thus, since $\rho(n-m) - 1 > 0$ and $n > m$, we have that the numerator is negative and the denominator is positive. Thus, $\frac{\partial n}{\partial \rho} < 0$.

Theoretical Extension: Fixed Costs

We next extend the theoretical model to include fixed costs. In particular, continue to assume that educating a student requires a constant expenditure, or marginal cost, equal to m, but that institutions also incur a fixed cost equal to F. Then, college W faces the following budget constraint:

$$P_W r_W + (1-P_E)n_W = (P_W + 1 - P_E)m + F$$

Then, re-deriving $\frac{\partial r_W}{\partial n}$ and $\frac{\partial r_E}{\partial n}$ in the first appendix, we have that the budget constraint can be re-written as:

$$P_W(r_W, n_E)[r_W - m] + [1 - P_E(r_E, n_W)][n_W - m] = F$$

Then, considering a changes in n_E and n_W we have that the key conditions are unchanged:

$$\left(\frac{\partial P_W}{\partial r_W}\frac{\partial r_W}{\partial n_E} + \frac{\partial P_W}{\partial n_E}\right)[r_W - m] + P_W\frac{\partial r_W}{\partial n_E} - \frac{\partial P_E}{\partial r_E}\frac{\partial r_E}{\partial n_E}[n_W - m] = 0$$

$$\left(\frac{\partial P_W}{\partial r_W}\frac{\partial r_W}{\partial n_W}\right)[r_W - m] + P_W\frac{\partial r_W}{\partial n_W} - \left(\frac{\partial P_E}{\partial r_E}\frac{\partial r_E}{\partial n_W} + \frac{\partial P_E}{\partial n_W}\right)[n_W - m] + (1 - P_E) = 0$$

Thus, the key conclusions from the welfare analysis remain unchanged.

We next consider tuition policies set under decentralization with fixed costs. In the symmetric case, Nash equilibrium out-of-state tuition continues to be characterized by:

$$n = m + \frac{(1-P)}{\partial P/\partial n}$$

Using institutional budget constraint under symmetry $[Pr + (1-P)n = m + F]$ and using the fact that $\partial P/\partial n = \rho P(1-P)$, this can be re-written as:

$$P(n-r) = -F + \frac{1}{\rho P}$$

Thus, non-resident tuition continues to be higher than resident tuition so long as fixed costs are sufficiently small (i.e., $F < (1/\rho P)$).

Theoretical Extension: More Than Two States

We next extend the model from two states to S states, indexed by s. Let $P_s(t)$ denote the likelihood that a student from state s attends institution t. Then, in-state attendance probabilities are given by:

$$P_s(s) = \frac{\exp(\alpha\rho q_s - \rho r_s)}{\exp(\alpha\rho q_s - \rho r_s) + \sum_{t\neq s}\exp(\alpha\rho q_t - \rho n_t - \rho\delta)}$$

Likewise, attendance at an out-of-state institution $t \neq s$ occurs with the following probability:

$$P_s(t) = \frac{\exp(\alpha\rho q_t - \rho r_t - \delta)}{\exp(\alpha\rho q_t - \rho r_t - \delta) + \exp(\alpha\rho q_s - \rho r_s) + \sum_{r\neq s, r\neq t}\exp(\alpha\rho q_r - \rho n_r - \rho\delta)}$$

Then, the change in welfare given a uniform increase in non-resident tuition equals:

$$(1/S)\Delta n\left[\sum_s -P_s(s)\frac{\partial r_s}{\partial n} - \sum_{t\neq s}(1-P_s(t))\right]$$

Under symmetry, this reduces to:

$$\Delta n\left[-P\frac{\partial r}{\partial n} - (1-P)\right]$$

where P represents the likelihood of in-state attendance and $1-P$ represents the likelihood of out-of-state attendance, aggregated over all out-of-state institutions. Moreover, it remains the case that:

$$\frac{\partial r}{\partial n} = \frac{-(1-P) - \frac{\partial P}{\partial r}(n-r)}{P - \frac{\partial P}{\partial r}(n-r)}$$

Thus, the welfare calculations are unchanged with more than two states, under the interpretation that $1-P$ is the out-of-state attendance probability, aggregated over all possible out-of-state institutions.

Turning to decentralization, we have that state s again chooses non-resident tuition to minimize resident tuition. That is, $\partial r_s/\partial n_s = 0$. The institution budget constraint for college s in this case is given by:

$$P_s(s)(r_s - m) + \sum_{t\neq s} P_t(s)(n_s - m) = 0$$

Taking the derivative with respect to non-resident tuition (n_s), we have that:

$$\frac{\partial P_s}{\partial r_s}\frac{\partial r_s}{\partial n_s}[r_s - m] + P_s\frac{\partial r_s}{\partial n_s} + \sum_{t\neq s} P_t(s) + \sum_{t\neq s}\frac{\partial P_t(s)}{\partial n_s}[n_s - m] = 0$$

Since $\frac{\partial r_s}{\partial n_s} = 0$ in equilibrium and using the fact that $\frac{\partial P_t(s)}{\partial n_s} = -\rho P_t(s)[1-P_t(s)]$, we have that:

$$\sum_{t\neq s} P_t(s) = \sum_{t\neq s}\rho P_t(s)[1-P_t(s)][n_s - m]$$

In the symmetric case, we have that $P_t(s) = (1-P)/(S-1)$ for $t \neq s$, where P is the probability of in-state attendance. Then, this can be written as:

$$(1-P) = \frac{\rho(1-P)(S+P-2)(n-m)}{S-1}$$

Solving for non-resident tuition, we have that:

$$n = m + \frac{1}{\rho}\frac{S-1}{(S+P-2)}$$

Since $P \leq 1$, we have that $n \geq m + 1/\rho$, and, moreover, non-resident tuition converges to $m + 1/\rho$ as the number of states grows large.

To further investigate how tuition policies change with the number of states, we next calibrate the model to match current tuition and in-state attendance probabilities. To do so, we first invert the above non-resident pricing rule to solve for ρ as follows:

$$\rho = \frac{1}{n-m}\frac{S-1}{(S+P-2)}$$

We use in-state attendance probabilities of $P = 0.75$. Tuition is taken from the overall averages in Table 1, yielding $n =$15.511 and $r = 6.358$. This implies that $m = 8.646$. Finally, using $S = 50$, we have that $\rho = 0.1464$. With this estimate of ρ, we then choose δ to match $P = 0.75$. This yields $\delta = 24.947$.

With these parameters in hand, we can then estimate how pricing changes given a change in the number of states. As shown in Table 17, increasing the number of states beyond 50 does yield a reduction in non-resident tuition, falling from 15.512 to 15.503 for 90 states. This decrease is quite small however, and, as noted above, non-resident tuition is bounded from below by $m + 1/\rho$, which equals 15.477. Thus, there is little scope in the model for reducing non-resident tuition via an increase in the number of states. In addition, while non-resident tuition does fall as the number of states increases, the gap between non-resident and resident tuition actually rises. This reflects the fact that the choice set also increases for students, yielding an increase in non-resident attendance, allowing universities to reduce in-state tuition. Likewise, as the number states decreases below 50, non-resident tuition increases but so does resident tuition, leading to a reduction in the gap between non-resident and resident tuition.

Table 17: Competition and Tuition Policies

number of states (S)	out-of-state tuition (n)	in-state tuition (r)	in-state attendance (P)
10	15.533	8.097	0.926
20	15.525	7.588	0.867
30	15.520	7.132	0.819
40	15.515	6.728	0.782
50	15.512	6.362	0.750
60	15.509	6.027	0.724
70	15.507	5.718	0.701
80	15.505	5.431	0.681
90	15.503	5.163	0.663

Student Payments: Private Institutions

In parallel to Section 7.1, we present in Table 18 results on student payments to private institutions using NPSAS data. As shown, residents pay a bit less, around $260, in tuition payments than non-residents. This difference, however, is small when compared to the sample average of over $20,000 in tuition payments. The gap is larger for net payments, with residents paying roughly $2,800 less than residents. This implies that residents receive around $2,500 more in grants than non-residents at private universities. To further explore the source of this difference, we next decompose total grants into their four components: federal grants, state grants, institution grants, and other grants. As shown, the bulk of the difference is explained by state grants. This finding is consistent with several state aid programs that generate financial differences between residents and non-residents at private institutions. For example, the Cal Grant Program is a state-funded program that provides aid to California residents attending California institutions, both public and private.[27] Likewise, the Hope scholarship in Georgia is available to state residents attending either public or private institutions in the state of Georgia. Finally, we note that these differences in payments between residents and non-residents are smaller than those documented for public institutions.

[27] For further details, see http://www.csac.ca.gov/doc.asp?id=568 (accessed October 16, 2015).

Table 18: Student payments in NPSAS data: private

	(1) tuition/ fees paid	(2) net tuition/ fees paid	(3) federal grants	(4) state grants	(5) institution grants	(6) other grants
in-state	-0.259**	-2.847***	0.634***	1.761***	-0.086	0.278***
	(0.113)	(0.213)	(0.041)	(0.039)	(0.142)	(0.063)
LHS mean	21.435	9.63	1.636	1.195	7.721	1.253
R^2	0.587	0.318	0.164	0.283	0.356	0.110

All specifications include institution-by-year, state-of-residence-by-year, and cohort FE.
Net tuition and fees paid is net of all grants received by the student.
All dollar values are in thousands of 2011 dollars.
The sample consists of 32,130 full-time students attending four-year private institutions.
* p<0.1 ** p<0.05 *** p<0.01

Analysis of Private Institution Acceptance Decisions

In parallel to Section 7.4, Table 19 presents results on private institution acceptance decisions using ELS data. As shown, private institutions are also more likely to admit residents, when compared to non-residents. The difference is only statistically significant, however, when including applicant fixed effects. In addition, the magnitude of any differences is smaller than the corresponding differences for public institutions.

Table 19: Analysis of Private Institution Acceptance Decisions

	(1) accept	(2) accept
in-state	0.0206	0.0396**
	(0.0174)	(0.0198)
sat	0.0007***	
	(0.0001)	
gpa	0.1457***	
	(0.0169)	
R^2	0.2445	0.8206
student FE	no	yes

Linear probability models of acceptance decisions with institution FE
Sample consists of 5,960 students reporting SAT and GPA scores
Four-year institutions with at least 10 appearances in student application sets
* p<0.1 ** p<0.05 *** p<0.01