The Out of State Tuition Distortion*

Brian Knight† Nate Schiff‡

March 25, 2016

Abstract

Public universities in the United State 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.

*PRELIMINARY AND INCOMPLETE. Please do not cite without permission of the authors. We thanks James Bernard for research assistance.

†Brown University

‡Shanghai University of Finance and Economics

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 UCLA, for example, charging $13,806 for California residents and $37,830 for non-residents during the 2015-2016 academic year. 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 makes sense from the perspective of 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. To see this, consider a hypothetical example of two students, one living in Illinois and one in Wisconsin. Suppose further that both have competitive application profiles so that neither is constrained by the admissions process. 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, and, in the absence of tuition differences, both would choose to 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 result: preference heterogeneity across students over institutions and enrollment responses to changes in tuition.

While this example is extreme, it illustrates a more general point. Distinguishing between residents and non-residents when setting tuition rates may lead to inefficiencies from a national perspective, with students matching to institutions that may not be the best fit for them. In this research, we first formalize this idea in the context of a simple two-state 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 (Chetty (2008)), we show that narrowing this tuition gap leads to a welfare gain, and this gain can be characterized by a sufficient statistic relating the fraction of in-state students to non-resident tuition.

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 dispro-

portionately 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 on the in-state side of the border to students living on the out-of-state side of the border.[1] 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, we use 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). 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 three additional pieces of evidence. First, we address an alternative explanation for our baseline findings based upon the idea that it might be more difficult for non-residents to be admitted to public institutions. In particular, we show that the results continue to hold for high ability students, who should be unconstrained by admissions criteria. Likewise, we show that the baseline results continue to hold at less selective institutions, for which admissions criteria are less salient. Second, we document smaller border discontinuities for private institutions. Consistent with this result, we also document, using separate data on student payments, smaller financial advantages for residents at private institutions. Financial advantages for residents at private institutions do exist, however, due to state aid programs that can be used at in-state private institutions. Third, in a tuition discontinuity design, we compare the discontinuity along borders with small and large differences between out-of-state and in-state tuition. Using this, we document larger discontinuities along borders with larger differences between out-of-state and in-state tuition.

Finally, we use our baseline estimates to conduct a welfare analysis. In particular, we consider a marginal reduction in out-of-state tuition, offset by a revenue-neutral increase in resident tuition. We show that the welfare gains are substantial, implying a significant distortion associated with the existing gap between in-state and 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.

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

2 Literature Review

This is of course not the first study examining the role of non-resident tuition in non-resident enrollment of colleges and universities. Existing studies on this issue 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.

More broadly, this paper contributes to a literature on the role of tuition and financial aid in college attendance. Studies in this literature include Avery and Hoxby (2004) and Dynarski (2003). 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. In this regard, our paper is related to Cohodes and Goodman (2014), who analyze a program in Massachusetts that provided certain students with tuition waivers at in-state public colleges. Using a regression discontinuity design, which compares students just above and below the eligibility threshold, the authors show that eligible students disproportionately attended in-state institutions and had lower college completion rates.

This paper is also related to research analyzing the DC TAG program, which was implemented around 2000, is financed by the federal government, and offers residents of the District of Columbia up to $10,000 per year to cover tuition at select out-of-state institutions. Kane (2007) evaluates this program, finding 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 among recent D.C. high school graduates, an effect that was concentrated at less selective institutions.

This research is also related to a literature examining 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 (financed via higher state subsidies) lead to increases in college enrollment and the subsequent stock of college educated workers. This is in contrast to Bound et al. (2004), who, in reduced form work, find little relationship between the production of college graduates and the subsequent stock of college educated workers.

This paper is related to recent theoretical research on the market for higher education, accounting for both supply and demand factors. Epple et al. (2013) consider both private and public universities and, in the latter case, resident and non-resident tuition. 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 lead to a reduction in college attendance, with little switching to private universities.

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 hinges on the idea 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 two-state theoretical model in which students, accounting for tuition policies, choose between colleges. We first develop expressions for welfare and then consider how a social planner maximizing national welfare would set policies. We then consider how state governments, maximizing state welfare, set in-state and out-of-state tuition policies. Finally, we link our expressions for welfare to a literature on sufficient statistics.

3.1 Setup

Consider two states (s), East ($s = E$) and West ($s = W$), each with population normalized to one. 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:

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

where q_c represents (exogenous) quality of college c, d_{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 ($d_{ic} = 0$ for in-state colleges) and assume positive travel costs for ($d_{ic} = \delta > 0$) for out-of-state colleges.

Then, let P_s denote the probability that a student from s attends the in-state institution. For 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. 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.

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 $0.5V_E + 0.5V_W$, 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 these required changes in resident tuition are characterized by the following two equations:

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

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

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, following standard logic in welfare economics, there is also no welfare loss in the absence of a behavioral response (i.e. $\frac{\partial P_E}{\partial r_E} = \frac{\partial P_W}{\partial r_W} = 0$). 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. As shown, it is always feasible for colleges to set non-discriminatory tuition such that $r = n = m$. At this point, we have that $\frac{\partial r}{\partial n} = \frac{-(1-P)}{P}$. That is, resident tuition can be reduced by an amount equal to $\frac{1-P}{P}$ 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. 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^* and additional increases in non-resident tuition require increases in resident tuition. That is, beyond n^*, there is no additional scope for reducing in-state tuition. This is due to the fact that, beyond this minimum 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.

Using the above expression for $\frac{\partial r}{\partial n}$, we 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.

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 pre-existing 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 rates.

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.[2] 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, 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

[2] We thus abstract from the possibility that state governments and state universities may have different objectives (Groen and White (2004)).

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, $\frac{\partial n}{\partial \rho} < 0$.

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 the rents earned by students attending out-of-state institutions.

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 tuition policies are set by national planners and state governments. As shown, the welfare of residents (V_W) is increasing in non-resident tuition until the point at which resident tuition is minimized. Further increases beyond this point lead to reductions in total revenue raised from non-residents and resident tuition must thus increase. Thus, welfare for residents has a similar shape to the relationship between resident and non-resident tuition, as documented in Figure 1, and state governments thus maximize state welfare by setting higher tuition for non-residents. Non-resident welfare (V_E), as shown, is strictly declining in non-resident tuition and equals resident tuition when there is no distinction between residents and non-residents (i.e. $n_W = r_W = m$). Combined welfare ($V_W + V_E$) is hump-shaped, with a maximum attained under non-discriminatory tuition (i.e. $n_W = r_W = m$).

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.

4.1 Federal Intervention

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. Moreover, federal courts have given states significant leeway in defining residency for tuition purposes, allowing, for example, one-year residency requirements (Palley (1976)). Moreover, 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.[3] There are two key details that need to be addressed when designing such a policy. 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.

4.2 Reciprocity Agreements

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 with other states in which students can pay in-state tuition rates at out-of-state institutions.

Generally speaking, there are three types of agreements in the United States. Regional exchanges provide tuition discounts to non-residents. As of 2012, there are four exchanges with substantial activity for undergraduate students: 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 these exchanges (Marsicano, 2015). While potentially useful in reducing economic distortions, there are several limitations of these agreements

[3]For further information on a possible federal interstate payment plan, see Palley (1976).

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. 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.[4]

Second, specific state universities may 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.[5]

Third, 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.[6]

In designing reciprocity programs, there are two important issues that must be addressed. First, should students pay the in-state tuition rate in the state of residence or in the state of attendance? Second, mirroring issues discussed above in the context of a federal interstate payment system, how should states with low tuition and/or net inflow of students be compensated by other states? In general, the Minnesota reciprocity program involves students paying the maximum of the tuition in the home state and in the state in which the institution is located. Regarding interstate payments, these programs typically involve 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.

4.3 Residence-based tuition vouchers

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-

[4]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 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).

[5]See http://www.umassd.edu/undergraduate/tuition/ (accessed October 16, 2015).

[6]The information here is taken from http://archive.leg.state.mn.us/docs/2015/mandated/150402.pdf (accessed October 16, 2015).

of-state institutions as residents of E would pay tuition equal to r_E regardless of institution. The closest such system is the DC-TAG 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.

There are at least two problems with this voucher system. First, state E would effectively be transferring resources from taxpayers in state E to state W, and it is not clear that it would be in their best interests to do so, especially if there are economic distortions associated with raising these revenues. Second, 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 explained below, based upon the institution-specific geographic distribution of students. 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 codes of their permanent residence. 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. These tuition measures are taken from the Integrated Postsecondary Education Data System (IPEDS) at the National Center for Education Statistics (NCES). To summarize, our analysis uses information on the zip code of the student, institution state, institutional status (public or private), and tuition and fees.

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 not necessarily a representative sample of institutions as institutions 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.[7]

To implement the border discontinuity design, we use zip code maps to first calculate the

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

distance from each zip code centroid to every state border. 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. 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.

Given our border discontinuity design, we exclude several types of observations. First, we exclude students who attend an institution in a state other than the closest state or the home state. Second, we focus on bandwidths of 20km and thus exclude students who are not close to state borders. As a robustness check, we also present results for 10km and 30km. Third, we exclude students attending institutions that had fewer than 100 respondents to the survey in that year. Finally, to focus on a consistent set of institutions, we exclude students attending two-year institutions.

Using this sample, we then collapse zip codes into larger geographic units, which we refer to as distance bands. In our baseline analysis, which uses a bandwidth of 20 kilometers on either side of the border, there are 20 distance bands 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.

Finally, while the HERI data include information on official, or "sticker" price tuition and fees, these measures do not include any information on payments made by students and thus only vary across, rather than within, institutions. Given this, we also incorporate information from the restricted access version of the National Postsecondary Student Aid Study (NPSAS), collected by the NCES. We analyze data from the following waves: 1999-2000, 2003-2004, 2007-2008, and 2011-2012. These data have information on both official tuition and fees, separate for residents and non-residents, and as well as actual payments made by students surveyed. In the analysis to follow, we use two measures of such payments, one being tuition and fees paid and the second being net tuition and fees, which subtracts out any grants received by the student.

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 discuss 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 issue 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:

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

where N_{bct} is the number of students from distance band b, which, as noted above, are collections of zip codes, attending college c in year t, and d_{bct} represents the distance from b to the border associated with c. The function f is a smooth function of 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 border-band fixed effects.

Thus, ρ^{BD} is the percent change in enrollment when crossing the border:

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

Using the theoretical model outlined above, we have that, considering the college c, this key border discontinuity parameter can be re-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 to tuition, and $(n_c - r_c)$, the tuition gap. To measure the change in welfare, note that the key object above, $(\partial P / \partial r)(n-r)$ can be written as $-\rho P(1-P)(n-r)$. Thus, the estimated parameter can be plugged directly into the welfare calculations, after multiplying by $-P(1-P)$.

Note that the coefficient from this regression discontinuity design captures the product of two underlying reasons for enrollment discontinuities: the existing tuition gap $(n-r)$ and the responsiveness to tuition (ρ). 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 paid by students attending institution c from distance band b at time t. This equals in-state tuition for residents and out-of-state tuition for non-residents. That is, $t_{bct} = n_{ct} 1[d_{bct} < 0] + r_{ct} 1[d_{bct} > 0]$. 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:

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

Thus, by incorporating measures of 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 (other than 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 a hybrid discontinuity design that includes both distance and tuition. In particular, the specification in this case is given by:

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

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 contributing to the border discontinuity, and the parameter from the tuition discontinuity design (ρ^{TD}) isolates the role of tuition.

7 Results

We begin by providing 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, followed by results from the tuition discontinuity design and, finally, the hybrid discontinuity design.

7.1 Tuition differences

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, the 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. To examine actual student payments, we turn to evidence from the NPSAS, as described above, using 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 $8,000 less than out-of-state students, and this difference is statistically significant at conventional levels. This gap is similar in magnitude to the $9,000 average gap across the HERI sample years, as documented in Table 1. As shown in column 2, which uses the sticker price adjusted for whether or not the student is a resident or a non-resident, an increase in the sticker price of one dollar is 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 $6,000 less than non-residents on net. Likewise, sticker prices seem to matter, with an increase in the sticker price of one dollar associated with a 63 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.

For comparison purposes, we next present analogous results for private institutions. As shown, residents pay a bit less, around $500, in tuition payments than non-residents. This difference, however, is small when compared to the sample average of almost $20,000 in tuition payments. The gap is larger for net payments, with residents paying roughly $2,500 less than residents. This implies that residents receive $2,000 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.[8] Likewise, the Hope scholarship in Georgia is available to state residents attending either public or private institutions in the state of Georgia.

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 for public institutions. This is then followed by an analysis of private institutions.

7.2.1 Public Institutions

Figure 3 plots the number of students in the HERI data attending a given institution in a given year from a given distance band. The x-axis depicts distance, in kilometers, from the border, where negative distance represents out-of-state bands and positive distance represents in-state bands. Naturally, as distance on the x-axis crosses zero, bands change from being non-resident to resident. Each bar represents the average enrollment in that distance band across all public institutions. For example, on average across public institutions and years 1997-2011, there are almost 10 students in bands between 0 and 2 kilometers inside the border.

As shown, there is a striking discontinuity in enrollment, jumping from roughly 3 on the out-of-state side of the border to over 10 on the in-state side of the border. Also, there is no discernible slope in enrollment on either side of the border, with roughly 2 to 3 students attending out-of-state public institutions and roughly 10 to 12 students attending in-state public institutions, 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 band attending a given institution is scaled by the total number of students attending that institution in the HERI data. As shown, we see a similar discontinuity, with an increase from roughly 0.03 percent of enrollment on the non-resident side of the border to roughly 1 percent of enrollment in a given band on the in-state side of the border.

To measure the percent change in enrollment, we next measure the natural log of enrollment in every band and institution and plot these in Figure 5. As shown, there is a roughly 100 percent increase in enrollment when crossing the border, as log enrollment increases from roughly 0.5 to 1.5.

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

Table 4 presents regression versions of these figures, in which we estimate border discontinuity regressions using a 20km bandwidth around the border. These specifications all include institution-year fixed effects and either band-year fixed effects or, in some specifications, state-year fixed effects. As shown, there is an increase of roughly 14 students when crossing the border when including state-year fixed effects and an increase of 22 students when including band-year fixed effects. Columns 3 and 4 present results using the log of enrollment. Again, consistent with the figures, we have that enrollment increases 106 percent when crossing the border (state-year fixed effects) but over 150 percent when using band-year fixed effects.

As robustness checks, Tables 5 and 6 present results for alternative bandwidths. As shown in Table 5, when considering all zip codes within a smaller bandwidth, 10 kilometers, around the border, the results are similar in magnitude to the baseline results in Table 1. Likewise, as shown in Table 6, the results are also similar when using a larger bandwidth, 30 kilometers. Thus, the baseline results are robust to alternative bandwidths.

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. Of course, this evidence does not conclusively document a role for tuition. While we have controlled for the role of geography, there could be many other reasons for an increase in enrollment when crossing the border. To provide additional evidence regarding the role of tuition, we next provide three analysis. First, we address an alternative explanation for these border discontinuities based upon differences in admissions thresholds between residents and non-residents. Second, we compare our results for public institutions to those for private institutions, for which, as documented above, financial differences between residents and non-residents are smaller. Finally, we use measures of tuition to examine whether border discontinuities are larger along borders with a larger difference between resident and non-resident tuition.

7.2.2 Differences in Admissions

One alternative explanation for our results involves admissions thresholds. While our theoretical model did not include an admissions margin, state universities may also have an incentive to ease admissions standards for residents, relative to non-residents. Indeed, there is some evidence that state universities set lower admissions standards for resident students (Groen and White (2004)). In this case, our border discontinuity 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. To address this, we next restrict the sample to high ability students, defined as students with SAT/ACT test scores that are above the sample median, defined separately for each institution and year in our data. Presumably these students were unconstrained by the admissions process at the institution. As shown in Table 7, our results

are still 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 by a sharp change in student ability when crossing the state border.

As an additional test of the role of differences in admissions, 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 thresholds should be less binding for non-residents. As shown in Table 8, however, our results for these less selective institutions are very 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.

7.2.3 Private Institutions

For comparison purposes, Figures 6-8 present border discontinuity results, again using a bandwidth of 20km, for private institutions. As shown, we still find a discontinuity for private institutions, with enrollment increasing from roughly 2 students per band on the out-of-state side of the border to roughly 4 students on the in-state side of the border. While this increase of 2 students is less than the increase of roughly 10 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 7 presents results based upon the percent of enrollment at a given institution from a given zip code. As shown, the fraction of students attending a given institution increases by roughly 0.5 percentage points, from 0.05 percent to 1 percent. This is smaller than the jump, as documented in Figure 4, of almost 1 percent for public institutions. Finally, Figure 8 presents results using log enrollment. As shown, we find an increase of roughly 30 percent when crossing the border, relative to an increase of roughly 100 percent for public institutions (Figure 5). Table 9 presents regression versions of these figures, in which we estimate border discontinuity regressions for private universities. As shown in columns 1 and 2, we again find an increase of roughly 3 students when crossing the border, an increase of 40 to 50 percent, as reported in columns 3 and 4.

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. On the other hand, the finding is consistent with the evidence, as shown in Table 3, that residents pay less on net than non-residents, even at private institutions. As noted above, 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.

Finally, while we do find discontinuities for private institutions, they are uniformly smaller than the border discontinuities for public institutions. This is also consistent with the evidence in

Tables 2 and 3, which documented that residents make net payments of around $6,000 less, when compared to non-residents, at public institutions but only $2,500 less at private institutions.

7.3 Tuition and Hybrid Discontinuity Designs

To further explore the role of tuition, we next present results for the tuition discontinuity design. 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.

These 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 out-of-state rate for out-of-state zip codes and the in-state rate for in-state zip codes, as reported in IPEDS. As shown, when including state-year fixed effects (column 1), a decrease in tuition of $1,000 is associated with an increase of just over one student (1.086). Thus, achieving the baseline border discontinuity of 13.788 in column 1 of Table 4 requires a decrease in tuition of roughly $13,000. As shown in column 2, which includes band-year fixed effects, the tuition discontinuity is similar in size. Columns 3 and 4 report results using the natural log of enrollment. As shown, a decrease in tuition of $1,000 is associated with an increase in enrollment of 10 percent when including state-year fixed effects (column 3) and 12 percent when including zip code-year fixed effects (column 4).

Finally, we present results in Table 11 from our hybrid discontinuity design, in which we control for both the simple border discontinuity and the tuition discontinuity. 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. While this analysis includes only public institutions, it is consistent with our finding of an enrollment discontinuity for private institutions, which do not distinguish between residents and non-residents for tuition purposes.

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, statistically significant, and economically significant in the specifications based upon the natural log of enrollment. Thus, while the hybrid design does suggest a somewhat smaller role for tuition, when compared to the tuition discontinuity design, the coefficients on tuition do remain negative and statistically significant.

Taken together, these results suggest that tuition does play an important role in explaining why so many students attend in-state institutions in the United States. Moreover, these results are consistent with our hypothesis that the non-resident tuition gap generates welfare losses, an issue that we next attempt to quantify.

8 Welfare Consequences

Finally, we use these estimated coefficients to measure 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 begin with the coefficients from the enrollment discontinuity design in Table 4. In particular, recalling that the key coefficients measures the product of the underlying parameter ρ and the tuition gap [i.e., $\rho^{RD} = \rho(n_c - r_c)$],we plug this coefficient in for the relevant product above. As shown in column (1) of Table 12, we begin by using the coefficient of 1.055 from column (3) of Table 4. Further, we assume an in-state fraction of 75 percent, which is similar to the national fraction of students attending in-state institutions. As shown in the second panel of Table 12, there is a mechanical benefit for non-residents, whose welfare rises by 25 cents, when reducing non-resident tuition by one dollar. In the absence of a behavioral responses, resident tuition rises 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 increase by only 6 cents, leading to a welfare reduction for residents equal to 4 cents, as shown in the bottom panel. Thus, aggregate welfare rises by 21 cents. In column (2), we use the border discontinuity estimated in Table 4 when including band-year fixed effects. As shown, this leads to even larger welfare gains: resident tuition can actually be decreased by 4 cents, and aggregate welfare thus rises by 28 cents when reducing non-resident tuition by one dollar.

Columns (3) and (4) of table 12 present results using coefficients from the tuition discontinuity design and the hybrid design. Recall in this case that the tuition discontinuity design identifies the key theoretical precision parameter [$\rho^{TD} = \rho$], and we thus directly plug this value into the welfare calculations. In this case, the researcher must also specify a tuition gap, and we use a gap of \$10,000 in table 12. We begin by using the estimated tuition discontinuity of -0.118 from

column (4) of Table 10. Again, we find substantial welfare gains: reducing non-resident tuition by one dollar requires an increase for resident tuition of only 3 cents, and there is an aggregate welfare gain of 23 cents. In column (4), we use the more conservative estimate of -0.043 from the hybrid discontinuity design (column 4 of Table 11). As shown, the welfare gain in this case is somewhat smaller, equal to 10 cents in aggregate.

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 federal 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 strong 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. Finally, back-of-the envelope calculations suggest substantial welfare gains from reducing the tuition gap.

Appendix: 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, $\frac{\partial P_E}{\partial r_E} = -\frac{\partial P_E}{\partial r_W}$, and, plugging this into the expressions above, we have:

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

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

Adding these two conditions together, we have:

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

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

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

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

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

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:

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

Appendix: 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.

Appendix: 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, using the fact that $P = exp(-\rho r)/[exp(-\rho r) + exp(-\rho n - \rho\delta)]$ and the fact that $n-m = (1/\rho P)$, we can solve for r as follows:

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

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, $\frac{\partial n}{\partial \rho} < 0$.

References

Abraham, K. G. and M. A. Clark (2006). Financial aid and students college decisions evidence from the district of columbia tuition assistance grant program. *Journal of Human Resources 41*(3), 578–610.

Avery, C. and C. M. Hoxby (2004). Do and should financial aid packages affect students' college choices? In *College choices: The economics of where to go, when to go, and how to pay for it*, pp. 239–302. University of Chicago Press.

Besley, T. and S. Coate (2003). Centralized versus decentralized provision of local public goods: a political economy approach. *Journal of public economics 87*(12), 2611–2637.

Black, S. E. (1999). Do better schools matter? parental valuation of elementary education. *Quarterly journal of economics*, 577–599.

Bound, J., J. Groen, G. Kezdi, and S. Turner (2004). Trade in university training: cross-state variation in the production and stock of college-educated labor. *Journal of Econometrics 121*(1), 143–173.

Chetty, R. (2008). Sufficient statistics for welfare analysis: A bridge between structural and reduced-form methods.

Cohodes, S. R. and J. S. Goodman (2014). Merit aid, college quality, and college completion: Massachusetts' adams scholarship as an in-kind subsidy. *American Economic Journal: Applied Economics 6*(4), 251–285.

Dynarski, S. M. (2003). Does aid matter? measuring the effect of student aid on college attendance and completion. *American Economic Review 93*(1), 279–288.

Epple, D., R. Romano, S. Sarpça, and H. Sieg (2013). The us market for higher education: A general equilibrium analysis of state and private colleges and public funding policies.

Groat, H. T. (1964). Internal migration patterns of a population subgroup college students, 1887-1958. *American Journal of Sociology*, 383–394.

Groen, J. A. and M. J. White (2004). In-state versus out-of-state students: the divergence of interest between public universities and state governments. *Journal of Public Economics 88*(9), 1793–1814.

Inman, R. P. and D. L. Rubinfeld (1997). Rethinking federalism. *The Journal of Economic Perspectives*, 43–64.

Kane, T. J. (2007). Evaluating the impact of the dc tuition assistance grant program. *Journal of Human resources 42*(3), 555–582.

Kennan, J. (2015). Spatial variation in higher education financing and the supply of college graduates.

Knight, B. (2013). State gun policy and cross-state externalities: evidence from crime gun tracing. *American Economic Journal: Economic Policy 5*(4), 200–229.

Morgan, J. N. (1983). Tuition policy and the interstate migration of college students. *Research in Higher Education 19*(2), 183–195.

Noorbakhsh, A. and D. Culp (2002). The demand for higher education: Pennsylvania's nonresident tuition experience. *Economics of Education Review 21*(3), 277–286.

Oates, W. E. (1972). Fiscal federalism.

Oates, W. E. (1999). An essay on fiscal federalism. *Journal of economic literature*, 1120–1149.

Palley, D. B. (1976). Resolving the nonresident student problem: Two federal proposals. *The Journal of Higher Education*, 1–31.

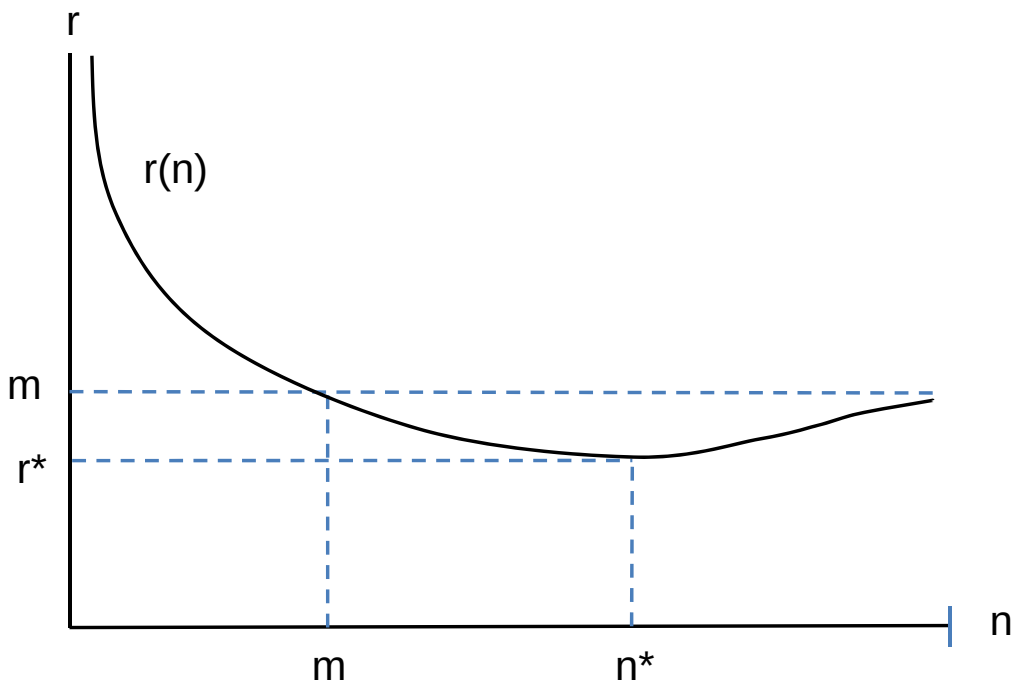


Figure 1: Resident and Non-Resident Tuition

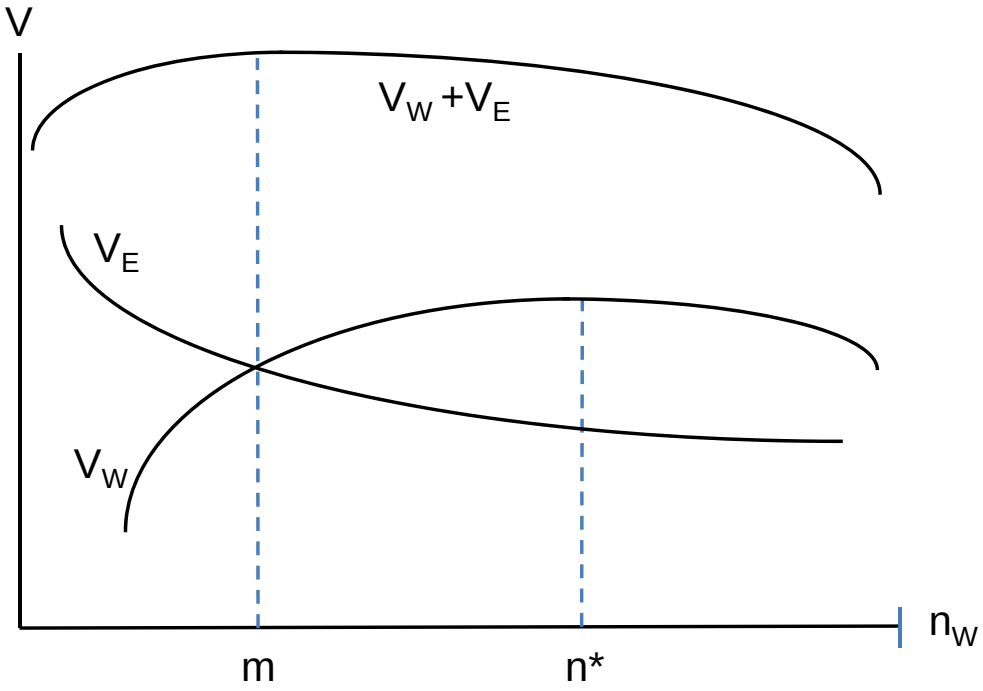


Figure 2: Welfare and Non-Resident Tuition

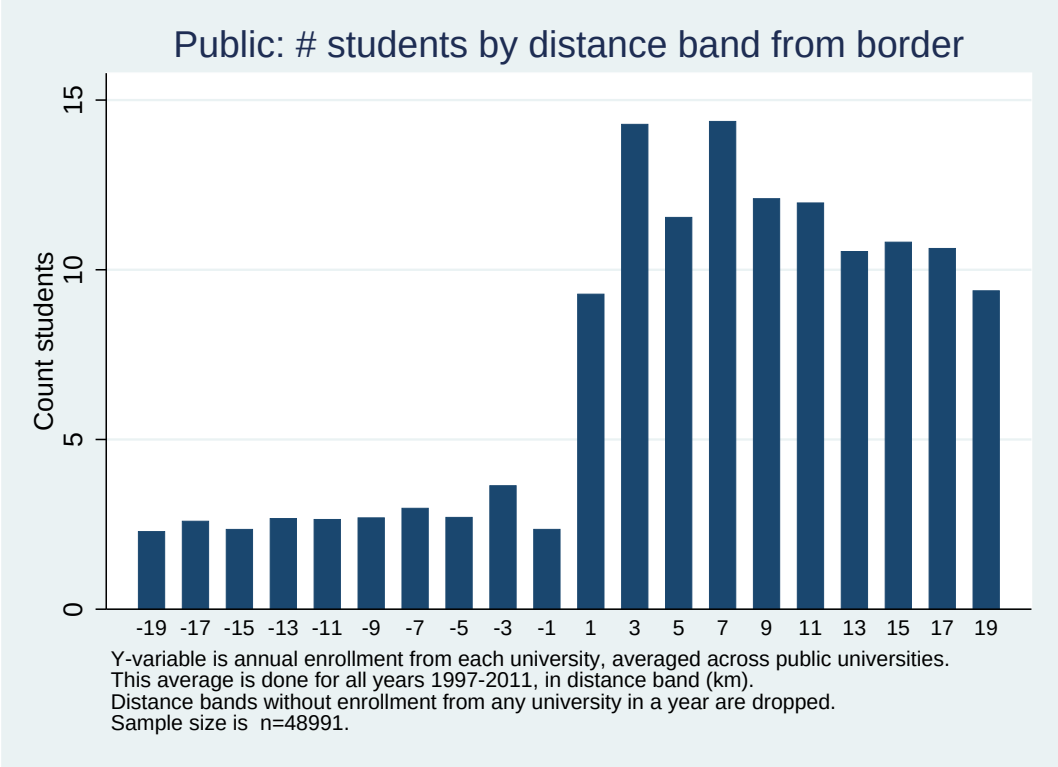


Figure 3: Discontinuity in Enrollment: Public Institutions

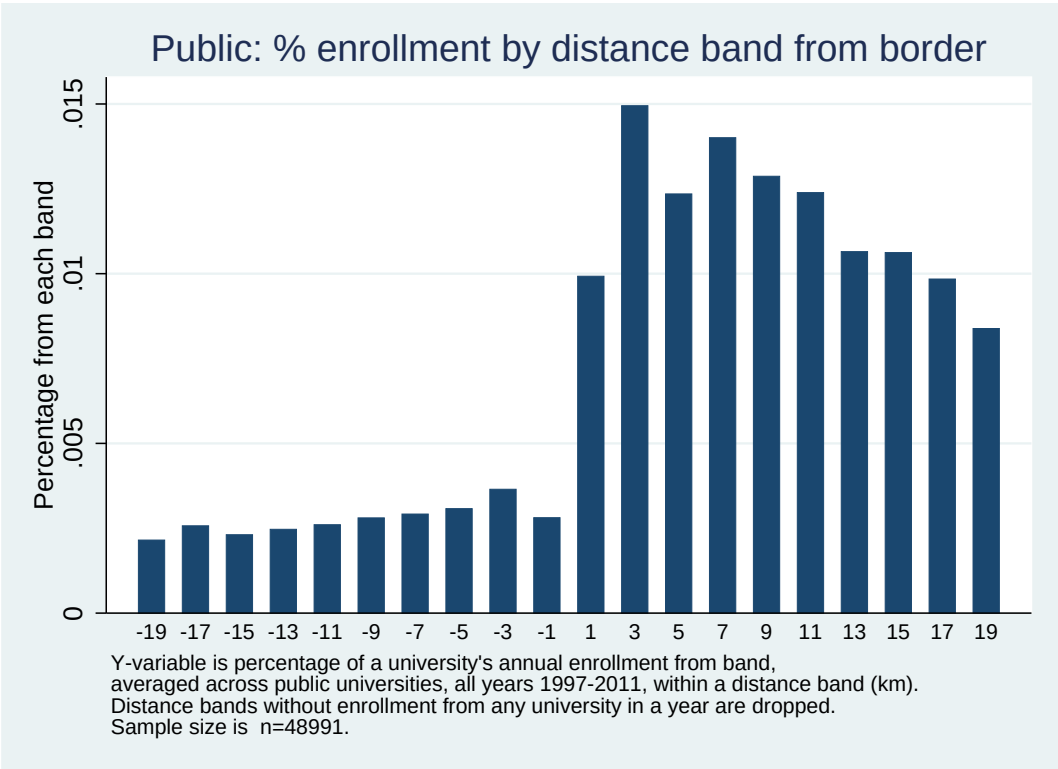


Figure 4: Discontinuity in Percentage Enrollment: Public Institutions

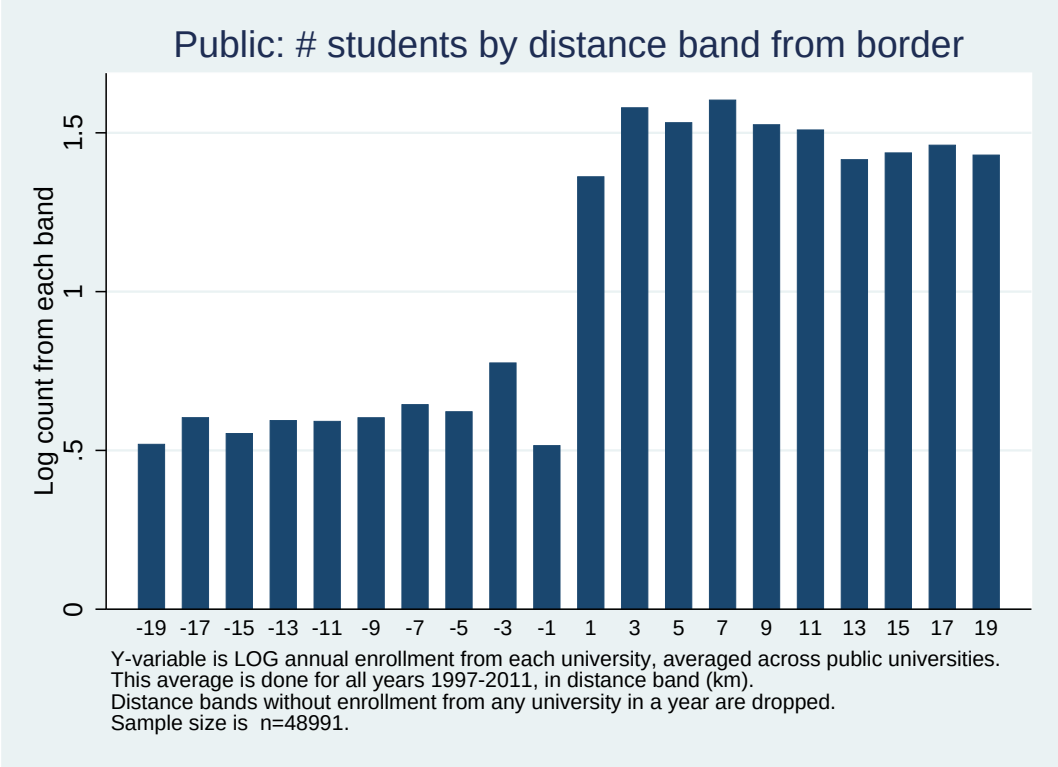


Figure 5: Percentage Change in Enrollment: Public Institutions

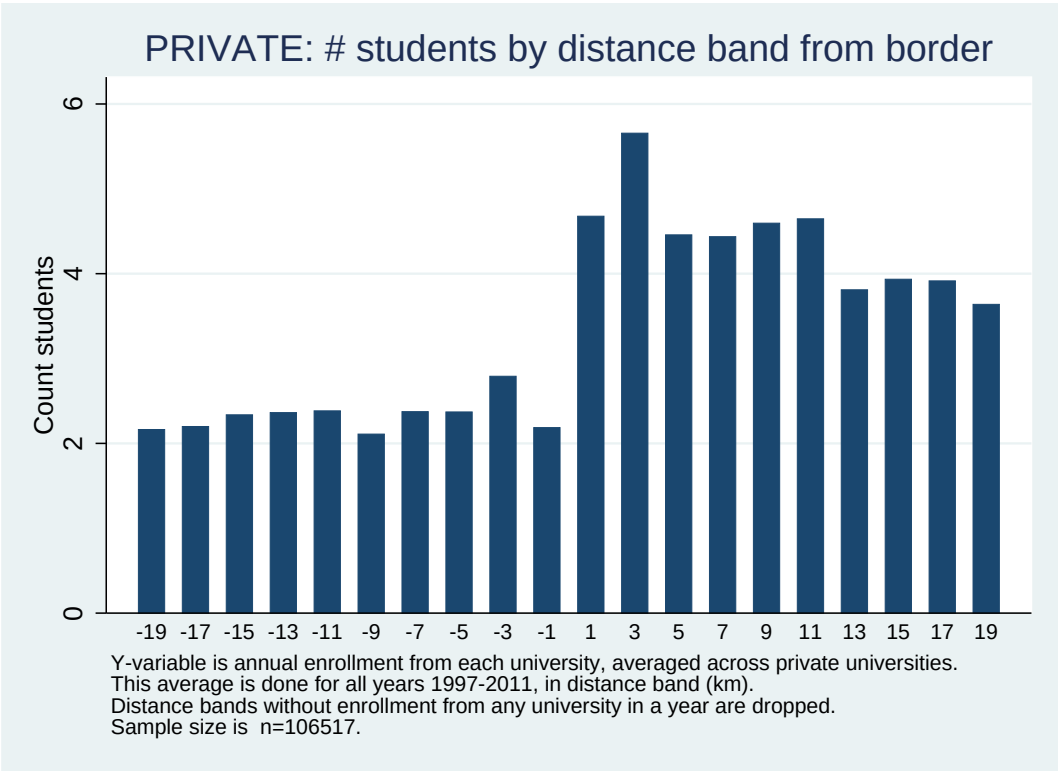


Figure 6: Discontinuity in Enrollment: Private Institutions

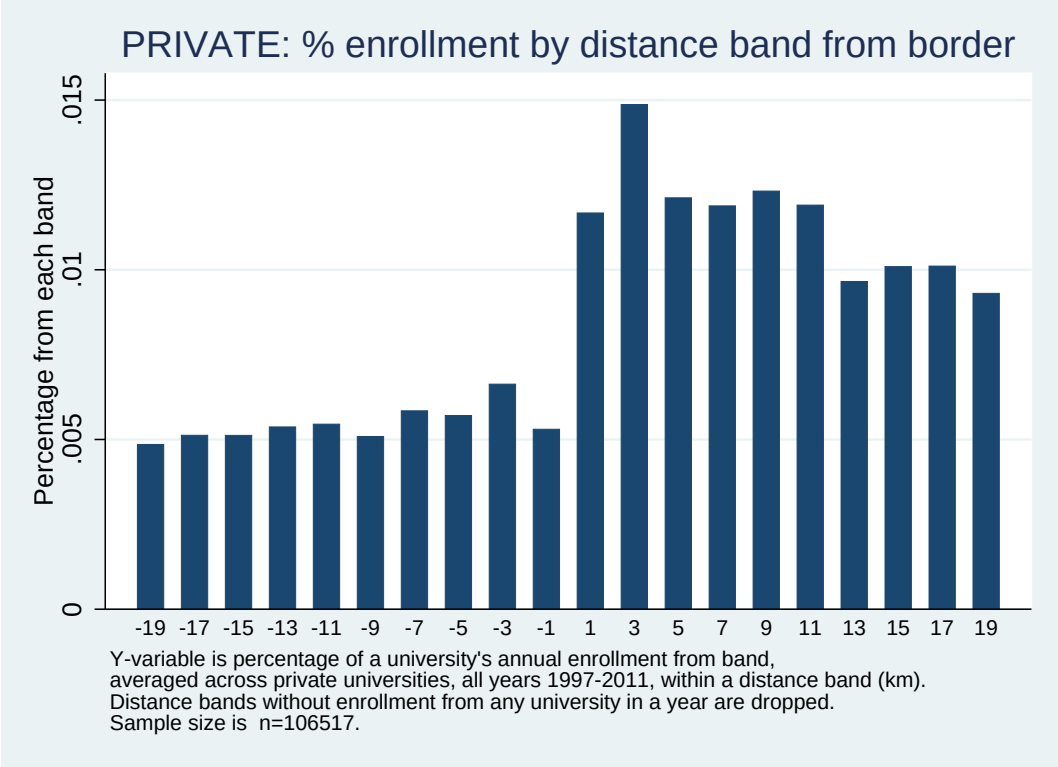


Figure 7: Discontinuity in Percentage Enrollment: Private Institutions

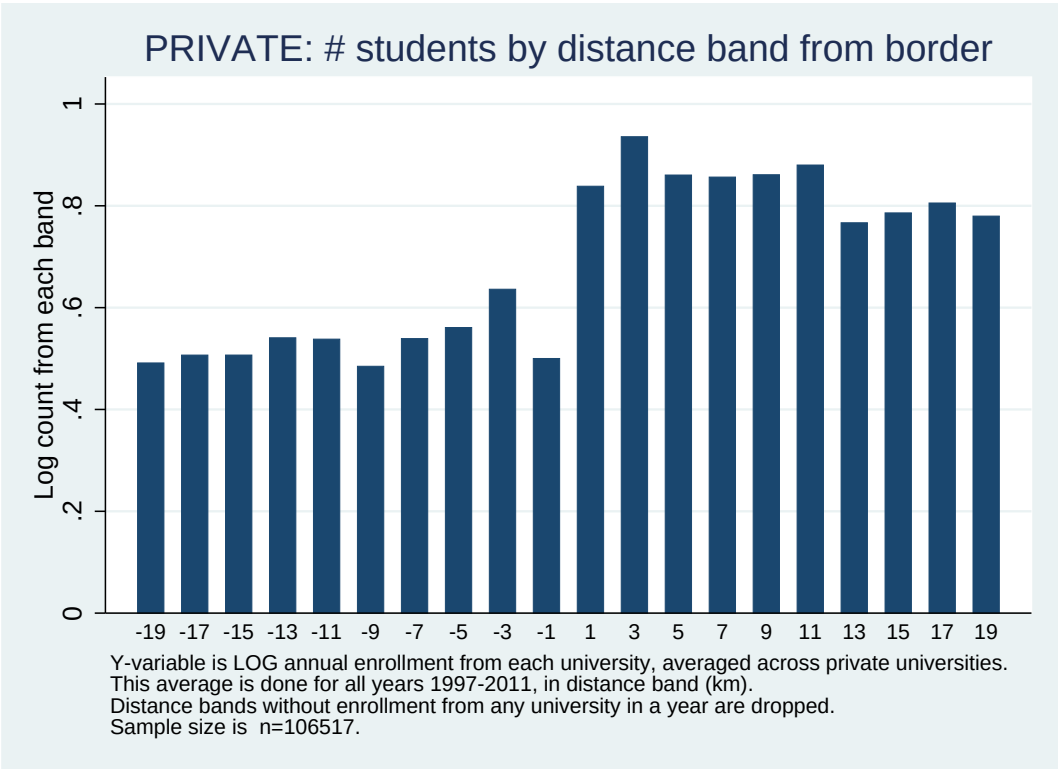


Figure 8: Percentage Change in Enrollment: Private Institutions

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		0.755***	0.521***		0.625***	0.534***
		(0.015)	(0.032)		(0.019)	(0.032)
in-state	-7.693***		-3.059***	-5.915***		-1.199***
	(0.233)		(0.353)	(0.226)		(0.305)
LHS mean	6.695	6.723	6.695	2.374	2.396	2.374
N	83,621	85,134	83,621	83,621	85,134	83,621
R^2	0.614	0.598	0.621	0.284	0.276	0.285

All specifications include institution-by-year and state-of-residence-by-year 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: 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	-0.520***	-2.481***	0.460***	1.286***	0.032	0.182***
	(0.098)	(0.157)	(0.028)	(0.032)	(0.099)	(0.040)
LHS mean	19.737	10.651	1.743	0.862	5.503	0.977
N	69,973	69,973	69,973	69,973	69,973	69,973
R^2	0.569	0.296	0.180	0.244	0.362	0.076

All specifications include institution and state of residence fixed effects 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 full-time students attending four-year private institutions.

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

Table 4: 20km distance bands specification, public institutions

	(1) enroll	(2) enroll	(3) ln(enroll)	(4) ln(enroll)
in-state	13.788***	22.074***	1.055***	1.538***
	(0.966)	(1.610)	(0.049)	(0.061)
distance	0.034	-0.137**	0.009***	-0.000
	(0.044)	(0.064)	(0.003)	(0.003)
in-state*distance	-0.156**		-0.012***	
	(0.066)		(0.004)	
N	48991	48991	48991	48991
R^2	0.216	0.559	0.324	0.695
FE level		band-year	state-year	band-year

Regressions run at border-band level; all specifications include university-year FE.

Public universities only, 1997-2011, excludes two-year colleges

Standard errors clustered at univ-band level

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

Table 5: 10km distance bands specification, public institutions

	(1) enroll	(2) enroll	(3) ln(enroll)	(4) ln(enroll)
in-state	13.114***	21.657***	1.007***	1.506***
	(1.458)	(2.477)	(0.074)	(0.092)
distance	-0.191	-0.077	-0.003	0.005
	(0.127)	(0.188)	(0.008)	(0.008)
in-state*distance	0.529**		0.029**	
	(0.209)		(0.012)	
N	24519	24519	24519	24519
R^2	0.235	0.604	0.351	0.716
FE level	state-year	band-year	state-year	band-year

Regressions run at border-band level; all specifications include university-year FE.
Public universities only, 1997-2011, excludes two-year colleges
Drops university-years with total enrollment under 100
Standard errors clustered at univ-band level
* p<0.1 ** p<0.05 *** p<0.01

Table 6: 30km distance bands specification, public institutions

	(1) enroll	(2) enroll	(3) ln(enroll)	(4) ln(enroll)
in-state	13.203***	21.597***	1.043***	1.535***
	(0.757)	(1.286)	(0.040)	(0.051)
distance	0.035*	-0.160***	0.011***	-0.001
	(0.021)	(0.031)	(0.002)	(0.001)
in-state*distance	-0.201***		-0.017***	
	(0.034)		(0.002)	
N	71142	71142	71142	71142
R^2	0.193	0.548	0.306	0.683
FE level	state-year	band-year	state-year	band-year

Regressions run at border-band level; all specifications include university-year FE.
Public universities only, 1997-2011, excludes two-year colleges
Drops university-years with total enrollment under 100
Standard errors clustered at univ-band level
* p<0.1 ** p<0.05 *** p<0.01

Table 7: 20km distance bands specification, above median students

	(1) enroll	(2) enroll	(3) ln(enroll)	(4) ln(enroll)
in-state	5.919***	9.658***	0.822***	1.272***
	(0.531)	(0.911)	(0.048)	(0.063)
distance	0.025	-0.012	0.006**	-0.001
	(0.030)	(0.039)	(0.003)	(0.003)
in-state*distance	-0.037		-0.007*	
	(0.039)		(0.004)	
N	32412	32412	32412	32412
R^2	0.247	0.603	0.318	0.716
FE level	state-year	band-year	state-year	band-year

Regressions run at border-band level; all specifications include university-year FE.
Public universities only, 1997-2011, excludes two-year colleges
Sample limited to students above median test score in univ-yr
Drops university-years with above-median enrollment under 50
Standard errors clustered at univ-band level
* p<0.1 ** p<0.05 *** p<0.01

Table 8: 20km distance bands specification, less selective public institutions

	(1) enroll	(2) enroll	(3) ln(enroll)	(4) ln(enroll)
in-state	12.431***	21.832***	1.016***	1.530***
	(1.041)	(2.310)	(0.059)	(0.093)
distance	0.023	-0.220**	0.010***	-0.002
	(0.035)	(0.086)	(0.003)	(0.004)
in-state*distance	-0.176***		-0.015***	
	(0.065)		(0.004)	
N	30755	30755	30755	30755
R^2	0.212	0.614	0.300	0.702
FE level		band-year	state-year	band-year

Regressions run at border-band level; all specifications include university-year FE.
Less selective public universities only, 1997-2011, excludes 2yr colleges
Drops university-years with total enrollment under 100
Standard errors clustered at univ-band level
* p<0.1 ** p<0.05 *** p<0.01

Table 9: 20km distance bands specification, private institutions

	(1) enroll	(2) enroll	(3) ln(enroll)	(4) ln(enroll)
in-state	3.195***	3.640***	0.423***	0.477***
	(0.258)	(0.412)	(0.024)	(0.028)
distance	0.014	-0.029*	0.006***	0.001
	(0.010)	(0.015)	(0.001)	(0.001)
in-state*distance	-0.082***		-0.010***	
	(0.019)		(0.002)	
N	106517	106517	106517	106517
R^2	0.251	0.370	0.302	0.527
FE level	state-year	band-year	state-year	band-year

Regressions run at border-band level; all specifications include university-year FE.
Public universities only, 1997-2011, excludes two-year colleges
Drops university-years with total enrollment under 100
Standard errors clustered at univ-band level
* p<0.1 ** p<0.05 *** p<0.01

Table 10: 20km distance bands tuition specification, public institutions

	(1) enroll	(2) enroll	(3) ln(enroll)	(4) ln(enroll)
tuition	-1.086***	-1.463***	-0.096***	-0.118***
	(0.088)	(0.115)	(0.005)	(0.005)
distance	0.038	0.248***	0.009***	0.022***
	(0.040)	(0.049)	(0.002)	(0.002)
tuition*distance	0.006		0.000	
	(0.004)		(0.000)	
N	48670	48670	48670	48670
R^2	0.209	0.550	0.318	0.687
FE level		band-year	state-year	band-year

Regressions run at border-band level; all specifications include university-year FE.
Public universities only, 1997-2011, excludes two-year colleges
Drops university-years with total enrollment under 100
Standard errors clustered at univ-band level
* p<0.1 ** p<0.05 *** p<0.01

Table 11: 20km distance bands hybrid specification, public institutions

	(1)	(2)	(3)	(4)
	enroll	enroll	ln(enroll)	ln(enroll)
tuition	0.267**	-0.161	-0.016**	-0.043***
	(0.116)	(0.109)	(0.007)	(0.006)
distance	-0.383***	-0.139**	-0.011**	-0.000
	(0.092)	(0.065)	(0.006)	(0.003)
tuition*distance	0.028***		0.001***	
	(0.006)		(0.000)	
in-state	16.046***	20.985***	0.933***	1.210***
	(1.499)	(1.942)	(0.079)	(0.081)
in-state*distance	0.077		-0.000	
	(0.084)		(0.005)	
N	48670	48670	48670	48670
R^2	0.217	0.560	0.327	0.698
FE level	state-year	band-year	state-year	band-year

Regressions run at border-band level; all specifications include university-year FE.

Public universities only, 1997-2011, excludes two-year colleges

Drops university-years with total enrollment under 100

Standard errors clustered at univ-band level

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

Table 12: Welfare calculations

inputs	(1)	(2)	(3)	(4)
tuition gap			10,000	10,000
estimated tuition discontinuity			-0.118	-0.043
border discontinuity [implied in (3) and (4)]	1.055	1.538	1.180	0.430
in-state fraction	0.75	0.75	0.75	0.75
effects on non-residents				
change in tuition	-$1.00	-$1.00	-$1.00	-$1.00
welfare change for non-residents	$0.25	$0.25	$0.25	$0.25
without behavioral response				
change in resident tuition	$0.33	$0.33	$0.33	$0.33
welfare change for residents	-$0.25	-$0.25	-$0.25	-$0.25
combined welfare change	$0.00	$0.00	$0.00	$0.00
with behavioral response				
change in resident tuition	$0.06	-$0.04	$0.03	$0.20
welfare change for residents	-$0.04	$0.03	-$0.02	-$0.15
combined welfare change	$0.21	$0.28	$0.23	$0.10