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Housing Regulation, Externalities, and Residential Property Prices*

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Abstract. This paper examines the effects of quantity restrictions on residential property prices in the presence of neighborhood externalities. It examines the effects of a Bringham Young University policy limiting students' location choices in the private housing market (leaving non-students unconstrained). The exogenous policy change provides a natural experiment for studying the externality and quantity restriction effects on property values as well as the difference between announcement and enactment effects. The flexible hedonic model allows price effects to vary across different directions in order to control for non-student population spatial sorting by type. The estimates show significant positive quantity restriction and student agglomeration effects on student housing prices. There are also significant differences in the negative student externality across non-student neighborhoods, with the quantity restriction reinforcing (offsetting) the student price premium (discount) at the boundary. Further, the announcement effect fully accounts for the policy price adjustments.

JEL classification: R33, H23, R52

Key Words: land use regulation, housing supply, housing supply restriction, student externality

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Housing Regulation, Externalities, and Residential Property Prices

1. Introduction

Residential land use regulation provides a means of correcting spatial externalities as well as a means of restricting the mix or supply of housing. Empirical tests of the regulation-real estate price relationship tend to focus on the extent to which regulation increases house prices by restricting supply. While by no means conclusive, there is a growing body of empirical evidence across jurisdictions and metropolitan areas that supports the intuitively appealing notion that regulation-induced supply constraints, whether intended or unintended, lead to higher real estate prices (Quigley and Rosenthal, 2005; Ihlanfeldt, 2007). This literature, however, yields little direct empirical evidence regarding price effects arising from concomitant changes in the externalities that land use regulation intends to control. There is an extensive separate literature focusing on price effects of externalities, but this body of empirical research does not yield much insight into the separate price effects that may result from unintended supply restrictions that often come with efforts to control such externalities.[1]

This paper examines the effects of quantity restrictions on residential property prices when the restricted use is associated with neighborhood externalities. It examines the effects of a Bringham Young University (BYU) policy limiting students' location choices in the private housing market (non-students remain unconstrained). The BYU policy resembles hierarchical zoning or municipal ordinances that restrict the number of residents per structure. But while the BYU policy is not unique, the implementation of the policy does offer a unique opportunity to empirically sort out the separate effects of the quantity restrictions and resultant changes in externalities on property prices. The policy is exogenously and newly imposed on a group of residents (students living off campus) who are both easily identified and comprise a relatively small part of the Provo housing market—features that simplify empirical analysis of separate announcement and implementation effects.

The theoretical model examines the effects of a spatial constraint on student locations using a framework based on the racial preference model underlying the Kern (1981) and Yinger (1976)

1 See Munneke and Slawson (1999) and Sirmans, et al. (2006) and the references therein.

studies of price effects arising from ethnic segregation in order to take into account possible asymmetric spatial externalities between students and non-students. While the supply restriction increases student housing prices inside the student area, the predicted effects on non-student housing inside and on the boundary of the student area are complicated by changes in the externality induced by the policy. The spatial restriction on students also increases the density of the student population in the controlled area, leading to externality effects on both non-students and students. It turns out that the constraint on student housing sharpens the boundary effect on prices when the positive externality of surrounding students on other students dominates the negative externality on non-students. On the other hand, the constraint weakens the boundary effect on prices when the negative externality of students on nearby non-students dominates.

The empirical analysis uses private condominium sales data drawn from the urban area surrounding Brigham Young University before and after a fundamental change in its student off-campus housing policy. Under BYU's honor code, all single undergraduate students living off-campus must reside in housing that is registered with the university and meets restrictions on separation of the sexes and other requirements. In 2003, the University announced a new student housing policy for 2007 restricting students to live within a boundary established approximately two miles from campus. This exogenous policy change provides a natural experiment for studying the externality and quantity restriction effects on condominium prices as well as the difference between announcement and enactment effects. The new regulation removed about 1500 private units (both apartments and condominiums) outside the new boundary from the stock of approved housing. The changes immediately affected a significant number of students. The policy introduced a binding spatial constraint on student location choice while at the same time removing the student externality from neighborhoods outside the newly created student zone and possibly intensifying the externality inside the zone. The data allow us to separately examine the extent to which the market inside and outside the student residence boundary responded to these changes in spatial supply and externalities at the announcement and at enactment.

The hedonic estimation method allows price effects to vary across different directions in order to allow for non-student population spatial sorting by income, preferences and other factors. The empirical results show a significant positive quantity restriction effect on student housing prices. At the same time, the externality results indicate a strong externality effect in the form of a positive student housing agglomeration externality; students prefer to live near other students. The estimates also reveal differences in the negative student externality value effects across non-student neighborhoods. As expected, the supply restriction effect reinforces the observed student price premium and offsets the price discount observed at the boundary. Further, most of the price adjustments are observed after the announcement but before the policy enactment.

The discussion is organized as follows. Section 2 briefly explains the essential elements of the BYU student housing policy change and the setting. Section 3 uses the land market model to draw out the quantity restriction and externality effects induced by the policy. Section 4 describes the data and reports the empirical results. Section 5 concludes.

2. The Setting

Brigham Young University (BYU) is a private university sponsored by the Church of Jesus Christ of Latter-Day Saints and is located in Provo, Utah. BYU enrolls approximately 34,000 students during the fall and winter semesters. Of these students, about 25,000 are single students, the majority of which are undergraduates. This number exceeds the on-campus single-student housing capacity, which is less than 5,000. Therefore, nearly 20,000 single students live off-campus. Approximately 5,000 single students who live off-campus reside in condominiums.[2]

In connection with an honor code (see appendix), BYU has a policy that all single undergraduate students, living off campus, must reside in an approved dwelling. These off-campus dwellings must first be approved by and maintain contracts with the off-campus housing office. BYU requires four standards to be met by all off-campus contracted rental units:

> The owners of contracted rental units agree to: (1) adequately separate single men and women, (2) exercise reasonable efforts to maintain BYU Residential Living Standards, (3) maintain the facilities in good repair, and (4) not abuse basic tenant rights.[3]

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2 Data provided by BYU off-campus student housing office for year 2006.

3 From http://housing.byu.edu/offcampus/approval/byuApproval.html. In addition to following these four standards, landlords

In addition to requiring off-campus housing to be contracted or approved for student occupancy, BYU recently initiated another off-campus housing stipulation by creating a boundary that all contracted housing must fall within. This roughly circular boundary has approximately a two-mile radius centered on the campus of BYU; the boundary is illustrated in Figure 1.

The policy was announced on December 8, 2003 and enacted April 30, 2007. It invalidated the contracts for any dwellings outside of the boundary. The policy removed two apartment complexes, two condominium complexes, and about 50 individual houses from the student housing supply, totaling a loss of approximately 1500 student housing units.

3. Theoretical Model

In order to capture the essential features of the BYU student housing market as a component of the larger Provo, Utah, metropolitan area market, consider the long narrow urban land market depicted in Figure 2. We first consider the model without a student externality and then introduce the externality to see how it modifies the model predictions.

3.1 Quantity restriction without student externality.

The metropolitan area is an open city for central business district (CBD) oriented non-students, with no long run impediments to in-migration or out migration. Therefore, the equilibrium land rent curve for non-student households, denoted r in the figure, satisfies the usual household location equilibrium condition that all non-student households enjoy the level of utility equal to that prevailing in other urban areas. For the non-student part of the land market, utility is exogenous and population endogenous. This curve is exogenous to the student submarket and remains unaffected by changes in the quantity of land available to the student sub-market.[4]

At the same time, however, the BYU student sub-market is modeled as a closed city. This represents a significant departure from modeling similar regulations, like hierarchical zoning, in

must satisfy the following requirements: complete a two-page facility verification, complete a Provo City Zoning verification, submit floor plans, be personally interviewed by a housing official, take and pass a 40 question multiple-choice exam (covering the *Off Campus Housing Handbook*), and have their unit inspected. Further, the contract must be renewed on a yearly basis.

4 The non-student bid rent curve may be positively or negatively sloped with respect to distance from BYU, depending on the direction. To limit the number of cases considered, the discussion here assumes a constant non-student bid rent. Extending the results for the upward sloped and downward sloped r cases is straightforward.

which inter-urban area migration is open to all types of land users, unregulated as well as regulated. The closed city assumption used here reflects the fact that BYU students cannot freely migrate into or out of the housing market since the university enrolment is set by university policy and all students must reside somewhere in the city. Therefore, student utility is endogenous, student population exogenous and the resultant student bid rent shifts in response to changes in land available to the student population.

Students commute to the BYU campus, the origin in the figures, so the student land rent curve is symmetric around that site. The equilibrium land rent curve for student households, denoted R in the figure, corresponds to the level of student utility that holds when the quantity of land demanded by students equals the quantity supplied in the BYU submarket area indicated by the interval $[0,a]$ in Figure 2. When there is no student externality on the non-student population, the boundaries of the BYU submarket are determined by the intersection of the non-student and student land rent curves at a.

In this case, the BYU policy restricting student housing to a specific geographic zone has straightforward effects on the student housing market. Limiting the allowed area to $[0,b]$ restricts the supply of student housing, driving student rents higher to R' and introducing rent gaps $R(b)' - r > 0$ between student and non-student property at the new boundary b in Figure 2. Of the observed rent gap, however, only the difference in the post policy rent level $R(b)'$ and the pre-policy rent level $R(b)$ can be attributed to the student housing supply restriction created by the geographical constraint. In principle, quantity restriction price effects can be estimated with standard hedonic models by explicitly controlling for pre- and post-policy price differences at the boundaries. This straightforward econometric approach, however, will not in general yield correct estimates of the supply restriction effects in the presence of a student externality.

3.2 Quantity restriction with negative student externality on non-students.

Now consider how the presence of a student externality modifies the results. We adapt the Yinger-Kern racial preference model (Kern, 1981; Yinger, 1976) to our purpose by assuming non-student households suffer a negative externality that increases with the proportion of neighboring housing units occupied by students. The value of this externality is reflected in the downward shift in the non-student land rent curve to the dashed curve r-ε in Figure 3 where ε is the decrease in non-student bid rent necessary to compensate non-students for living among students.

Analogous to the racial preference case in a monocentric environment examined by Kern (1981), in this application the student externality leads to spatial sorting of non-students and students with a rent premium for non-students to the right of the boundary a in Figure 3 reflecting the (avoided) externality value, ε.[5]

When the student area restriction $[0,b]$ is imposed in this case, the quantity restriction drives student rent upwards to R' as in the previous case. If the increased concentration of students increases the negative externality on non-students then ε increases to ε' as well and the non-student rent shifts downwards from the curve drawn in the figure. In the post policy equilibrium, the rent for non-student housing in the neighborhood to the right of b is r and to the left $r - \varepsilon'$. Therefore, if the increase in student density to the left of b increases the non-student externality then the difference between non-student rents at this point increases as well; the non-student bid rent to the left of b is $r - \varepsilon'$ and to the right is r. In this case, the policy induces a greater externality effect on non-student housing prices.

Before the student housing restriction, the model suggests that non-student housing at b will exhibit a discount relative to student housing at b corresponding to the rent difference $R(b) - (r - \varepsilon)$. After the student housing restriction, the non-student housing at b will exhibit a discount corresponding to the rent difference $R(b)' - (r - \varepsilon')$. Thus, the observed pre- and post-policy change in the discount is $R(b)' - R(b) + (\varepsilon - \varepsilon')$. The true supply restriction effect on student rent, however, is $R(b)' - R(b)$, which is less than the observed change. Once again, observed gross boundary value differences by themselves do not yield clear estimates of the supply restriction effect.

3.3 Quantity restriction with positive student externality on students.

5 The boundaries between the non-student and student areas are determined by the intersection of the non-student rent curve r-ε and the student rent curve R. This yields the standard result that the type of residents being avoided by others end up occupying more land than without the racial preference or externality in the unregulated land market (Rose-Ackerman, 1975).

Suppose instead that students enjoy agglomeration economies, external benefits that increase with the proportion of neighbors who are fellow students. Denoting the externality (positive in this case) by α, the student rent for student neighborhoods is R+α while the student rent for non-student neighborhoods is r. This case again leads to spatial segregation of household types in the theoretical model, but with no rent discount for non-students to the right of boundary a as in Figure 4.

Figure 4 also depicts the effects of restricting student housing to the area [0,b]. As before, the quantity restriction drives student rents higher to R'+α inside the restricted area (not pictured). However, if the greater concentration of students increases the externality then this curve shifts upwards to reflect the greater α*'* arising from the greater concentration of students. In this case depicted in figure 4, the observed pre- and post-policy non-student/student price differences observed at the boundary equal (R(b) + α) – r and (R(b)*'* + α*'*) – r, respectively. Taking the difference in these observed values at b yields R(b)*'* - R(b) + α*'* – α. Therefore, as in the previous externality model, pre- and post-policy differences in boundary value differences do not yield correct estimates of the quantity restriction effect on price, R(b)*'*- R(b). Direct controls for student density changes leading to α*'* – α must be included in the hedonic price model in order to obtain unbiased estimates of the quantity restriction effect.

In summary, a straightforward hedonic analysis of changes in price changes at the boundary yields an estimate of the quantity restriction effect on student housing prices when there is no student externality. When student externalities exist, however, additional empirical controls for the student density need to be included in the hedonic models in order to control for the externality effects on pre- and post-policy prices.

4. Empirical Analysis

4.1 The data

We use sales information for condominiums surrounding BYU to examine the price effects of the student housing restriction policy. The student condominium market represents a substantial portion of the total private student off-campus housing supply; condominiums house about one quarter of the off-campus student population. Most of the student housing in our sample are units owned by non-students and rented to students, although some units are student owned.

The data set covers condominium unit transactions in Provo, Utah, from January 1996 through September 2008. The transaction variables are drawn from the local Multiple Listing Service (MLS) and the property characteristic data are constructed from information supplied by the Utah County Assessor's office supplemented by on-site property inspections. In all, the sample contains information on the sale of 3,305 condominiums units. While the sample is rich with complex and unit level characteristics, several additional variables were constructed to examine agglomeration effects and several others are worthy of additional explanation.

In 2003, the University announced a new student housing policy to be implemented in 2007. The policy requires single undergraduate students to live within a boundary set approximately two miles from campus. Complexes within the boundary must also meet certain requirements for the units to be *contracted* (allowed student housing). The result was that complexes within the boundary were either exclusively student or non-student housing complexes. The variable $CONTRACTED_i$ represents units that are or will be placed under the University housing policy, depending on when the unit was sold. This variable, when coupled with the timing of the policy, will provide a base price level for student housing units. The underlying assumption is that contracted units were student housing units prior to the policy. The University's policy requires all units in a complex to meet the policy requirements for any one to be contracted, which makes it easier and less costly for the complexes serving students before the policy to be contracted under the policy.

We categorize complexes as below average, average, good, or excellent condition based on on-site inspection. The architectural design of each condominium complex is also based on inspection and is included as a control in the price equation. The variable $DSGN\_INT\_HALL_i$ represents buildings that are similar to a hotel where access to each unit is from a common interior hallway. The variable $DSGN\_EXT\_HALL_i$ represents a building that is similar to a roadside motel where each unit is accessed from an exterior walkway. Condominiums with a contemporary design that provides for attractive rooflines and alternative access points to each unit are represented by the variable $DSGN\_CONTEMP_i$. Complexes with a townhouse design are divided into complexes with multiple buildings with greater than four units per building ($DSGN\_MULTIPLEX_i$) and those limited to three and four units per building ($DSGN\_TRI\_QUADPLEX_i$).

Several variables representing the concentration of housing units were also constructed. The variable $CON050T_i$ represents the total number of units within one-half mile of the *i*th parcel at the time of its sale. The construction of this variable takes into account new complexes within the sample as they are built. Similar variables for contracted ($CONTRACTED_i$ = 1) and non-contracted ($CONTRACTED_i$ = 0) properties are also constructed, $CON050C_i$ and $CON050NC_i$, respectively. The price equation includes the ratio of these variables to control for the density of rental units nearby and the mix of student/non-student units.

Table 1 reports a list of variables and descriptive statistics, including the descriptive statistics for subsamples of transactions inside and outside the BYU policy boundary. A simple comparison of the mean prices suggests that condominium units within the boundary sell for a premium compared with units outside the boundary. Although not reported in Table 1, the average price of a contracted condominium unit within the boundary is greater than the average price of a unit within the boundary that is not contracted. In addition, each of the years within the full sample contains an average of 254 transactions with the minimum number of transactions in a year being 154 in 2008, with a high of 370 units in 2006.

Based on the full sample, condominium units sell for an average price of approximately $130,200, based on the 13 years of transactions. The average living area is approximately 1,050 square feet and the average age of a unit at the time of sale is approximately 13 years. On average, 62 units are found in a complex, with nearly half of the complexes having a contemporary design. Condominium units are located an average of 1.26 miles from the center of campus. This statistic reflects the high concentration of units near the campus, as well as the relatively small size of the study area.

The full sample, presented in Table 1, is broken down into several sub-samples based on whether the property involved in the transaction is located inside or outside of the boundary; first ignoring the timing of the policy and then based on if the transaction occurred pre- or post-policy. The pre- and post-policy subsamples use the policy announcement date as the breakpoint between pre- and post-policy.[6] Overall, the relationships found within each of the inside and outside sub-samples hold across each of the sub-samples. The mean unit price appears to be higher for units within the boundary. The mean price increases between the pre- and post-policy periods. The complexes within the boundary tend to contain fewer units and occupy smaller parcels relative to complexes outside the boundary. A greater percentage of the units outside the boundary are found in complexes rated in good or excellent condition, but in both areas, the percentage of units found in complexes rated in good or excellent condition is greater than 50%. A majority of units inside the boundary are located in complexes noted as having a contemporary design. While this design is also popular outside the boundary, complexes utilizing a townhouse design in unit clusters of more than 4 units per building account for roughly 45% of the units outside the boundary.

Units inside the boundary tend to be newer, slightly smaller in the number of square feet, and on average have more bathrooms per unit than units outside the boundary. Units outside the boundary appear more likely to have basements, as well as have a two level design. The higher density of the complexes inside the boundary is reflected by the higher frequency of units located on the second floor or higher.

The concentration of units within one-half mile is significantly greater inside the boundary. On average, units inside the boundary have over 600 units within one-half mile, while only approximately 240 units fall within one-half mile of units outside the boundary. Nearly 80% of the units located inside the boundary are contracted.

4.2 The Empirical Model

In constructing the empirical model, one must account for the fact that BYU represents a relatively small part of the overall property market. Provo's city center falls just to the southwest of BYU's campus and the Wasatch mountain range lies to the east of the campus. These factors dictate that

6 Descriptive statistics utilizing the enactment date as the breakpoint are available from the authors upon request.

the empirical model must be flexible enough to allow for variation in the house price gradient with respect to the direction from BYU.[7] Recent studies by Cameron (2006) and Colwell and Munneke (2009) show that failure to account for directional variation may obscure the measured effect of distance.

A price equation capable of incorporating directional variability in the gradient can be written as:

$$P_i = A_i^{\gamma} e^{\alpha + \eta f(\theta_i) u_i + \beta X_i} \qquad (1)$$

where P_i is the nominal selling price of the *i*th parcel, A_i represents a vector of area measures (e.g. building area, lot area), u_i is the distance to the center of campus, and X_i represents a vector of other location characteristics, as well as control variables for time (annual dummy variables). The distance variable is interacted with a directional weighting function, $f(\theta_i)$, where θ_i is the direction from the origin to condominium unit *i* (measured in radians clockwise from due North). If one simply sets $f(\theta_i) = 1$, the estimation of the price equation would yield a directionally constant price gradient. The function $f(\theta_i)$ could be defined as a discontinuous function (Soderberg and Janssen, 2001). For example, the range of θ_i can be divided into *k* intervals, which is equivalent to extending *k* rays from the origin to create *k* geographic sectors. Dichotomous variables then could be used to identify a parcel location within a particular sector. The price equation would be estimated using a set of *k*-1dummy variables interacted with distance to the origin, resulting in directional price gradients that would vary inter-sector, but not intra-sector. Cameron (2006) and Cheshire and Sheppard (1995) overcome the lack of intra-sector variation by defining $f(\theta_i)$ using periodic function(s). Specifically, Cameron (2006) defines $f(\theta_i) = 1 + \cos(\theta_i) + \sin(\theta_i)$. This specification results in one peak and one valley (directionally) over the entire 360^{o} of arc with the estimated gradient increasing in amplitude with increased distance from the site. The author notes that defining $f(\theta_i)$ as $1 + \cos(K\theta_i) + \sin(K\theta_i)$ would allow K peaks and valleys.[8]

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7 The study of price gradients has a long tradition in the field of urban economics (see Haas 1922a, 1922b, 1927; Mills,1971; Kau and Sirmans, 1979; Colwell and Munneke, 1997, 1999, 2003; de Leeuw, 1993; McMillen, 1996; McMillen and McDonald, 1989, 1991; Phillips-Patrick and Rossi, 1996; Thorsnes and McMillen, 1998; Holmes and Horvitz, 1994; Hunter and Walker, 1996) and numerous studies have allowed directional variation in the estimation of the price gradient (Alperovich and Deutsch, 2002; Cameron, 2006; Cheshire and Sheppard, 1995; Majumdar et al., 2006; Soderberg and Janssen, 2001).

8 Note that *K* must be constrained to be an integer as not to introduce discontinuity at ends of the gradient function.

The approach taken here instead follows the approach taken by Colwell and Munneke (2009), which defines $f(\theta_i)$ as a piecewise linear continuous function. This approach is similar to the dummy variable approach in that the range of θ_i is first divided into k intervals using k rays. A parcel location is not only defined by its distance from the city center, but also by a weighted average of the distance to the sector boundaries (the rays) along an arc from the origin. For example, Figure 5 depicts a four-quadrant region with four rays: R_0 (due north), R_{90} (due east), R_{180} (due south), and R_{270} (due west). Each of the R_k represents a weighted location variable. In this figure, Point 1 falls in the NE quadrant and is located a distance along the arc from due north and distance b along the arc from due east, while Point 2 is in the SE quadrant and is located c distance along the arc from due south and distance d along the arc from due east. Recall that the length of the arc is equal to the radius (u_i) multiplied by the magnitude of the angle in radians (θ). Thus, the arc length of a is $\theta_a\ u_i$. For Point 1, the weighted location variable is defined as: $R_0 = \frac{a}{a+b} = \frac{\theta_b}{\theta_a+\theta_b}$, $R_{90} = \frac{\theta_a}{\theta_a+\theta_b}$, $R_{180} = 0$, and $R_{270} = 0$. Note that for each point falling along the same ray as Point 1, the weighted location variable will be identical. For Point 2 in the SE quadrant, R_{90} is defined as $\frac{\theta_c}{\theta_c+\theta_d}$ and R_{180} is defined as $\frac{\theta_d}{\theta_c+\theta_d}$ with R_0 and R_{270} equal to zero. Rewriting Eq. (1) to incorporate these weighted location variables:

$$P_i = A_i^{\gamma} e^{\alpha+\delta_1 R_0 u_i + \delta_2 R_{90} u_i + \delta_3 R_{180} u_i + \delta_4 R_{270} u_i + \beta X_i}. \tag{2}$$

Note that each direction within a sector has its own gradient in this estimation approach. The price-distance gradient for an observation in a particular quadrant is defined as a linear combination of the coefficients estimated for the direction related variables. For example, the gradient for Point 1 in Figure 5 is a linear combination of the gradients of the sector endpoints, $\delta_1 R_0 + \delta_2 R_{90}$. Note that there is a constant rate of change in the gradient as one moves along an arc between the endpoint rays. The linear relationship between the rays indicates that the maxima or minima will be found along the rays and not in between, a limitation of the approach. There need not, however, be a maximum or a minimum gradient along any particular ray. In principle, the study area can be divided into any number of possible sectors to accommodate additional variation in the price surface if the data set is sufficiently large. Our choice of rays in this study reflects important dimensions of the Provo market, specifically taking into account the non-student attraction nodes to the north (temple) and southwest (CBD) of the BYU campus while allowing for the absence of student housing to the northeast (mountains and owner occupied single family housing).

The theoretical model clearly shows the importance of allowing the house price gradient to change beyond the boundary; therefore, the empirical model must be structured to allow the gradient inside the boundary to vary from the gradient outside the boundary. The theoretical model also implies that the empirical model should allow for price discontinuities at the boundary in order to account for possible student externalities and supply restriction effects. Such a price equation can be written as:

$$P_i = A_i^{\gamma} e^{\alpha + \left[\sum_{s=1}^{4} \delta_s R_s u_i + \sum_{s=1}^{4} \gamma_s R_s U\_EDGE_i + \sum_{s=1}^{4} \eta_s R_s D\_EDGE_i \right] + \left[\sum_{s=1}^{4} \delta_s^P R_s u_i + \sum_{s=1}^{4} \gamma_s^P R_s U\_EDGE_i + \sum_{s=1}^{4} \eta_s^P R_s D\_EDGE_i \right] (POST_i) + \beta X_i}$$

where U_EDGE_i is the distance to the edge of the boundary, D_EDGE_i is an boundary shift variable defined as 1 if properties are located outside the boundary and 0 if located inside boundary, and $POST_i$ is the policy shift variable. Note that the location weighting variables are interacted not only with the gradient variables, but also the boundary shift variables in order to allow the impact of the externality to vary along the boundary.

4.3 Empirical Results

Tables 2 and 3 report the model estimates. In each of the cases, the model is sufficiently flexible to allow for different slopes inside and outside the boundary as well as different slope and shift effects for each of the rays indicating different directions from BYU. In both tables, the policy effects are reported under the marginal policy effects headings on the right hand side columns.

4.3.1 Announcement effects.

Table 2 reports estimates for the model investigating policy announcement effects. The first set of results in Table 2 reports the analysis for pre-announcement and post-announcement effects. The *CONTRACTED* variable controls for properties under the BYU student occupancy contract requirements before the boundary policy is announced. The coefficient is not significantly different from zero, indicating no stable price effect on student housing before the policy announcement. The *CONTRACTED * POST_A* variable controls for properties under the student occupancy contract after the policy announcement. The coefficient indicates a significant price premium of about 3.5% for these properties (Halvorsen and Palmquist, 1980). These are student housing units inside the announced boundary. Therefore, this price premium measures the vertical shift (average across all locations inside the boundary) *R'-R* inside the boundary indicated in Figures 2-4. This is the average supply restriction effect across all locations inside the boundary.

Following Figures 2-4 the student externality and the policy effect on the student externality can be deduced by the changes in any gaps between the pre- and post-policy rent curves at the policy boundary once the supply restriction effect is removed. The pre- announcement price gradients running from BYU exhibit the coefficient of R_k *U_BYU* inside the boundary (i.e., to the left of point *b* in Figures 2-4) and the coefficient of R_k *U_EDGE* outside the boundary (i.e., to the right of point *b*), with an additional vertical gap at the boundary indicated by the coefficient of R_k *D_EDGE*. The coefficients on the interactive variables R_k *U_BYU * POST_A*, R_k *U_EDGE * POST_A*, and R_k *D_EDGE * POST_A* for each of the rays show the change in gradient characteristics along the indicated rays after the policy announcement. Figure 6 depicts the pre- and post-policy price surfaces along each of the rays implied by these estimates. The curves to the left of the gaps in Figure 6 therefore capture the price curve *R* in Figures 2-4 and the dashed and solid curves to the right of the gaps capture the price curves $r - \varepsilon$ and *r*, respectively. The solid lines represent pre-announcement and the dashed lines represent post-announcement price curves with the supply restriction effect removed. The gaps correspond to the new student boundary *b.* While the theoretical model yields no specific predictions regarding changes in the price *slopes* inside or outside the boundary, the different slope effects observed along different rays both illustrate the importance of using a flexible estimation technique.

Looking at the price surface gaps evaluated at the policy boundary, panels 6A and 6C for rays R_{120} and R_{240} show a situation like that depicted in Figure 3 when the boundary is set to the left of point *c*; the initial externality gap R- $(r - \varepsilon)$ declines to $R - r$, the marginal gap effect reflecting the value of student externality eliminated by the policy outside the boundary. A similar result is depicted in panel 6D for ray R_{300}, although the decline in the externality gap in this case appears to be driven by the change in the interior price surface along this ray rather than anticipated changes in the exterior price surface. Overall, the externality shift attributable to the student externality effect on non-students is significantly positive in these directions.

On the other hand, the positive initial gaps between the internal and external price surfaces along rays R_{180} and R_{360} are consistent with the boundary being imposed to the right of point *a*. This certainly is possible, given that the spatial restrictions in the other directions (along the other rays) allow for an expansion along these rays. The upward shift in the external price surface along ray R_{360} closely follows the situation depicted in Figure 3 when the boundary is set to the right of *a.* In particular, the restriction on student locations increases the vertical gap, the expected effect of removing the negative student externality along the external price curve.

In contrast, the ray R_{180} results illustrated in panel 6B are hard to interpret. The initial price curves suggest a boundary set to the right of *a* in Figure 3, in which case the post-policy price curve exhibits a downward shift consistent with a greater student externality outside the new boundary. While it is reasonable to expect that the spatial sorting of non-student households yields populations outside the student housing policy boundary that have different attitudes towards living around students, this specific pattern is puzzling.

Overall these estimates clearly show that there is a student externality on some parts of the non-student population. But is there a positive student agglomeration effect on other students? As a rudimentary control for a positive externality on other students, the model includes a variable measuring the total number of complexes within ½ mile of the sold unit while controlling for the ratio of student complexes to non-student complexes within ½ mile of the unit when it is sold (*CON050T* and *CON050C/CON05NC*, respectively). These variables together control for the density of rental units nearby and the mix of student/non-student units. The coefficient on the ratio of student to non-student complexes is significantly positive, indicating a positive student agglomeration effect. These condominium sales prices indicate that students prefer to live near clusters of other students, as in the case portrayed in Figure 4.

To summarize these estimates, Figure 7 provides topographical maps of the estimated pre- and post-announcement value surfaces (with student agglomeration effects removed), in Panels A and B, respectively. Darker shading indicates greater market value. The pre-announcement value pattern reflects the non-student points of attraction at the temple to the north of campus, the business district to the southwest and another attraction to the southeast. (The area to the northeast of campus yields no condominium sales data because it is an area comprising owner occupied single family housing and surrounding mountains.) Looking at Panel B, the area covered by the higher value darker shading increases inside the new student housing boundary after the policy announcement, reflecting the announcement effect on student housing. The outside the boundary gradient towards the CBD to the southwest is less steep while that to the southeast is unchanged. The value effects of the policy announcement observed at various points along the regulated boundary vary.

Comparing the two panels, the post-announcement land value surface shows a greater non-student housing premium across the policy boundary to the north of BYU, the residential area outside the boundary most accessible to both the temple and an important retail and restaurant district. The areas to both the southwest and southeast, in contrast, exhibit greater price discounts across the policy boundary after announcement. The pre-announcement price discount across the boundary for the area directly to the south, on the other hand, largely disappears after the policy announcement. This pattern implies different types of non-student residents outside the boundary as we move different directions from BYU; this is not surprising given the different points of attraction for non-students in Provo. For example, to the north the non-student premium outside the boundary arising from the policy is consistent with the notion that non-student residents of the temple neighborhood suffer greater negative student externalities than do residents living to the southwest or southeast of BYU. The observed differences in price responses to the policy along the different rays reveals the importance of using an econometric technique that allows for different price responses in different directions from BYU arising from the tendency of residents to sort across neighborhoods by income as well as strength of preferences for non-student neighbors.

4.3.2 Announcement versus implementation effects.

Table 2 reports estimates when using the policy announcement date to define the pre- and post-variables. In contrast, the models reported in Table 3 are estimated with the pre- and post-variables defined based on the policy enactment date. Comparing these estimates with the announcement effects model for R_{240}, for example, we see that there is no change in the internal price gradient running between BYU and the CBD pre- and post-implementation. Even the change in the gradient outside the boundary found for the post-announcement case does not appear when the comparison is based on implementation. The comparison of student agglomeration estimates yields the same conclusions. It appears that both modes of analysis yield qualitatively identical empirical conclusions in these regards.

Turning to the quantity restriction effect on prices inside the boundary, though, the $CONTRACTED_i$ coefficient estimate in model 3.1 shows that being contracted with BYU for student occupancy significantly increases price even before the boundary policy is enacted. This is not surprising, given that the pre-enactment sample includes a large number of such units sold post-announcement. The $CONTRACTED_i$ * $POST\_E_i$ coefficient, on the other hand, is quite puzzling by itself. The significant negative coefficient indicates that contracted units sold after policy enactment sell at a discount relative to student units sold before the policy. The sum of the $CONTRACTED_i$ and $CONTRACTED_i$ * $POST\_E_i$ coefficients, is not significantly different from zero**,** indicating that the student units sold after policy enactment do not sell at a premium relative to non-student housing inside the boundary.

In order to probe into this puzzling pattern more deeply, model 3.2 reported in Table 3 includes the interactive variable $CONTRACTED_i$ * $POST\_A_i$, where $POST\_A_i$ is a dummy variable indicating a transaction after the announcement dates. This variable captures the announcement effect and the interactive $CONTRACTED_i$ * $POST\_E_i$ variable captures the differential post-enactment effect. The coefficients indicate no significant contract effect before announcement, a significant effect post-announcement, and no significant additional effect after implementation. So what appears to be happening is that the announcement effect fully capitalizes the student housing restriction.

5. Conclusion

This paper examined how restrictions imposed by BYU to limit private market student housing to a restricted area affects property prices in the presence of student externalities. Given the different natures of the two populations in terms of inter-urban area mobility, we use a land market model that combines the open city assumption for non-students with the closed city assumption for students. The model shows how student externalities complicate the interpretation of observed property price effects arising from the quantity restriction. Spatially constraining student housing sharpens price differences observed at the boundary of the student-restricted area when student agglomeration economies are stronger than any extant negative student externalities on non-students. The spatial constraint on private sector student housing weakens the observed boundary effect on prices when the negative externality on non-students dominates. The theoretical model emphasizes the need for carefully controlling student externality effects when evaluating supply restriction price effects.

Using private sales data for condominiums sold before and after the policy change, we find a significant positive quantity restriction effect on student housing prices. Neighborhoods appear to be subject to a positive student housing agglomeration externality. Consistent with that evidence, BYU's spatial student housing supply restriction reinforces the observed student price premium (non-student discount) observed at the boundary of the regulated area. The analysis of announcement versus enactment effects reveals significant price adjustments occur after the announcement but before the policy is enacted.

Appendix

A complete copy of the BYU honor code is found at: www.honorcode.byu.edu. Related excerpts are as follows:

Brigham Young University…exists to provide an education in an atmosphere consistent with the ideals and principles of The Church of Jesus Christ of Latter-day Saints. That atmosphere is created and preserved through commitment to conduct that reflects those ideals and principles.

Residential Living Standards

As stated in its Honor Code, Brigham Young University is committed to providing a learning atmosphere consistent with the principles of the Church. The university is likewise committed to creating such an atmosphere for students residing on and off campus. To achieve this, BYU has established living standards to help students learn some of the high ideals and principles of behavior expected at Brigham Young University.

Off-Campus Housing

Visitors of the opposite sex are permitted in living rooms and kitchens but not in bedrooms in off-campus living units. The use of the bathroom area by members of the opposite sex is not appropriate unless emergency or civility dictate otherwise; and then only if the safety, privacy and sensitivity of other residents are not jeopardized. Visiting hours may begin at 9 a.m. and extend until midnight. Friday night visiting hours may extend until 1:30 a.m. Landlords may establish a shorter visiting period if proper notice is given to residents. This policy applies to all housing units occupied by single students.

Conduct

All students and residents are required to conduct themselves in a manner consistent with the Honor Code. Students must abstain from the use of alcohol, tobacco, and illegal substances and from the intentional misuse or abuse of any substance. Sexual misconduct; obscene or indecent conduct or expressions; disorderly or disruptive conduct; participation in gambling activities; involvement with pornographic, erotic, indecent, or offensive material; and any other conduct or action inconsistent with the principles of The Church of Jesus Christ of Latter-day Saints and the Honor Code is not permitted.

TABLE 1: Descriptive Statistics

		Full Sample	Inside Boundary	Outside Boundary	Announcement Date: IN PRE-A	Announcement Date: OUT PRE-A	Announcement Date: IN POST-A	Announcement Date: OUT POST-A
Unit Characteristics								
PRICE$_i$	Mean	130196	136469	121456	119182	103108	158083	142030
Selling price of *i*th unit	s.d.	50067	40647	59733	28806	28936	42906	76381
AGE_AT_SALE$_i$	Mean	13.265	11.879	15.196	9.396	13.934	14.985	16.611
Age at time of sale	s.d.	10.099	8.937	11.246	7.863	10.422	9.226	11.953
LIV_AREA_SQFT$_i$	Mean	1052.1	1023.9	1091.3	1015.7	1057.9	1034.1	1128.9
Living area of *i*th unit (sq ft)	s.d.	258.27	238.41	279.00	234.69	237.34	242.74	315.31
BSMT_AREA_SQFT$_i$	Mean	63.978	28.926	112.81	30.084	122.96	27.477	101.43
Basement area of *i*th unit (sq ft)	s.d.	198.08	111.54	269.27	114.40	284.02	107.91	251.42
#_BATHSROOMS$_i$	Mean	1.617	1.675	1.537	1.642	1.482	1.717	1.598
Number of bathrooms	s.d.	0.578	0.535	0.625	0.533	0.595	0.534	0.652
FIREPLACE$_i$	Mean	0.208	0.199	0.222	0.201	0.200	0.195	0.246
1, if unit has fireplace; 0, else	s.d.	0.406	0.399	0.415	0.401	0.400	0.397	0.431
DRYER_HOOKUP$_i$	Mean	0.906	0.917	0.891	0.910	0.893	0.925	0.888
1, if unit has dryer hookup; 0, else	s.d.	0.292	0.276	0.312	0.286	0.309	0.263	0.316
TWO_FLOOR_UNIT$_i$	Mean	0.204	0.127	0.310	0.142	0.318	0.109	0.301
1, if unit has a 2nd story; 0, else	s.d.	0.403	0.333	0.463	0.349	0.466	0.312	0.459
ON_1STFLR$_i$	Mean	0.519	0.409	0.672	0.407	0.652	0.412	0.694
1, if unit is located on the 1^{st} story; 0, else	s.d.	0.500	0.492	0.470	0.491	0.477	0.492	0.461
ON_2NDFLR$_i$	Mean	0.310	0.378	0.216	0.370	0.236	0.387	0.194
1, if unit is located on the 2^{nd} story; 0, else	s.d.	0.463	0.485	0.412	0.483	0.425	0.487	0.395
ON3RDFLR_OR_HIGHER$_i$	Mean	0.171	0.213	0.112	0.223	0.112	0.201	0.112
1, if unit is loc. on the 3rd flr or higher; 0, else	s.d.	0.377	0.410	0.316	0.416	0.316	0.401	0.316
Complex Characteristics								
UNITS_TOTAL$_i$	Mean	62.493	58.876	67.532	60.168	66.693	57.26	68.473
Total number of units in complex	s.d.	53.521	61.478	39.342	61.300	39.802	61.698	38.830
U_BYU$_i$	Mean	1.259	0.790	1.911	0.799	1.883	0.779	1.943
Distance to BYU measured in miles	s.d.	0.702	0.279	0.583	0.285	0.555	0.272	0.612
LAND_AREA_AC$_i$	Mean	3.635	2.792	4.809	2.860	4.589	2.706	5.056
Land area of complex measured in acres	s.d.	3.602	3.660	3.166	3.656	2.761	3.665	3.553
ELEVATOR$_i$	Mean	0.083	0.096	0.066	0.110	0.038	0.077	0.097
1, if elevator present in complex; 0, else	s.d.	0.276	0.294	0.248	0.314	0.192	0.267	0.296
COND_BLW_AVG$_i$	Mean	0.134	0.073	0.219	0.067	0.232	0.081	0.204
1, if complex in below avg. cond.; 0, else	s.d.	0.341	0.261	0.414	0.251	0.422	0.273	0.404
COND_AVG$_i$	Mean	0.283	0.376	0.154	0.382	0.158	0.37	0.149
1, if complex in avg. cond.; 0, else	s.d.	0.451	0.485	0.361	0.486	0.365	0.483	0.356
COND_GOOD	Mean	0.405	0.378	0.442	0.415	0.448	0.332	0.435
1, if complex in good. cond.; 0, else	s.d.	0.491	0.485	0.497	0.493	0.498	0.471	0.496
COND_EXCELLENT$_i$	Mean	0.178	0.172	0.186	0.136	0.163	0.218	0.212
1, if complex in excellent cond.; 0, else	s.d.	0.382	0.378	0.389	0.343	0.370	0.413	0.409
CPARK$_i$ / *UNITS_TOTAL$_i$*	Mean	1.139	1.306	0.907	1.259	0.897	1.364	0.919
Covered parking spaces (*CPARK*) per unit	s.d.	0.751	0.792	0.618	0.646	0.619	0.941	0.618
UPARK$_i$ / *UNITS_TOTAL$_i$*	Mean	0.964	1.101	0.773	1.081	0.810	1.127	0.731
Uncovered parking spaces (*UPARK*) per unit	s.d.	0.694	0.777	0.499	0.730	0.490	0.832	0.506
DSGN_CONTEMP$_i$	Mean	0.471	0.554	0.357	0.561	0.389	0.544	0.321

1, if contemporary design; 0, else	s.d.	0.499	0.497	0.479	0.496	0.488	0.498	0.467
DSGN_INT_HALL$_i$	Mean	0.073	0.075	0.070	0.043	0.052	0.115	0.091
1, if interior hall unit access; 0, else	s.d.	0.260	0.263	0.256	0.203	0.222	0.319	0.287
DSGN_EXT_HALL$_i$	Mean	0.154	0.245	0.027	0.252	0.019	0.236	0.035
1, if exterior unit access; 0, else	s.d.	0.361	0.430	0.162	0.434	0.137	0.425	0.185
DSGN_MULTIPLEX$_i$	Mean	0.255	0.110	0.457	0.127	0.462	0.088	0.452
1 if townhouse design > 4 units per bldg; 0 , else	s.d.	0.436	0.313	0.498	0.333	0.499	0.283	0.498
DSGN_TRI_QUADPLEX$_i$	Mean	0.047	0.017	0.089	0.017	0.078	0.018	0.101
1 if townhouse design 3-4 units per bldg; 0 , else	s.d.	0.212	0.130	0.285	0.129	0.268	0.131	0.302
Neighborhood Characteristics								
CON050T$_i$	Mean	464.14	625.04	239.98	605.69	251.79	649.24	226.73
Total number of units within 0.5 miles	s.d.	286.04	243.20	164.59	247.10	169.99	236.16	157.39
CON050C$_i$ / *CON050NC*$_i$	Mean	3.177	5.376	0.113	5.452	0.117	5.282	0.109
The number of contracted unit divided by non-contracted units within 0.5 mi.	s.d.	4.157	4.253	0.184	4.381	0.189	4.088	0.179
Policy Characteristics								
CONTRACTED$_i$	Mean	0.461	0.792	0.000	0.789	0.000	0.795	0.000
1, if will or does fall under policy; 0, else	s.d.	0.499	0.406	0.000	0.409	0.000	0.404	0.000
	Obs.	3305	1924	1381	1069	730	855	651

TABLE 2: Estimation of Condominium Prices: Policy Change Defined by Announcement Date

	Model 2		Model 2
Internal Gradients		***Marginal Impact of Policy on Internal Gradients***	
$R_{120\,i} * U\_BYU_i$	0.0833	$R_{120\,i} * U\_BYU_i * POST\_A_i$	-0.0351
*U_BYU_i defn. in note**	(2.42)	*$POST\_A_i$ defn. in note**	(1.31)
$R_{180\,i} * U\_BYU_i$	-0.0723	$R_{180\,i} * U\_BYU_i * POST\_A_i$	-0.0453
	(2.39)		(1.44)
$R_{240\,i} * U\_BYU_i$	-0.0519	$R_{240\,i} * U\_BYU_i * POST\_A_i$	-0.0148
	(1.90)		(0.66)
$R_{300\,i} * U\_BYU_i$	-0.0555	$R_{300\,i} * U\_BYU_i * POST\_A_i$	-0.0526
	(2.31)		(3.24)
$R_{360\,i} * U\_BYU_i$	-0.1690	$R_{360\,i} * U\_BYU_i * POST\_A_i$	-0.0313
	(4.39)		(0.78)
External Gradients		***Marginal Impact of Policy on External Gradients***	
$R_{120\,i} * U\_EDGE_i$	0.2520	$R_{120\,i} * U\_EDGE_i * POST\_A_i$	-0.0346
*U_EDGE_i defn. in note**	(2.04)		(0.21)
$R_{180\,i} * U\_EDGE_i$	-0.2240	$R_{180\,i} * U\_EDGE_i * POST\_A_i$	0.2111
	(4.01)		(2.90)
$R_{240\,i}\ U\_EDGE_i$	0.3488	$R_{240\,i} * U\_EDGE_i * POST\_A_i$	-0.2139
	(5.64)		(2.42)
$R_{300\,i} * U\_EDGE_i$	-0.0209	$R_{300\,i} * U\_EDGE_i * POST\_A_i$	-0.2550
	(0.25)		(2.64)
$R_{360\,i} * U\_EDGE_i$	-0.0404	$R_{360\,i} * U\_EDGE_i * POST\_A_i$	-0.0375
	(2.48)		(1.89)
Externality Shift		***Marginal Impact of Policy on Externality Shift***	
$R_{120\,i} * D\_EDGE_i$	-0.1878	$R_{120\,i} * D\_EDGE_i * POST\_A_i$	0.0709
*D_EDGE_i defn. in note**	(1.10)		(0.34)
$R_{180\,i} * D\_EDGE_i$	0.0533	$R_{180\,i} * D\_EDGE_i * POST\_A_i$	-0.2166
	(1.01)		(3.18)
$R_{240\,i} * D\_EDGE_i$	-0.2611	$R_{240\,i} * D\_EDGE_i * POST\_A_i$	0.0453
	(6.21)		(0.73)
$R_{300\,i} * D\_EDGE_i$	-0.1234	$R_{300\,i} * D\_EDGE_i * POST\_A_i$	0.0698
	(4.15)		(2.08)
$R_{360\,i} * D\_EDGE_i$	0.2283	$R_{360\,i} * D\_EDGE_i * POST\_A_i$	0.1296
	(6.33)		(2.59)
Supply Restriction (Overall)		***Marginal Impact of Policy on Supply Restriction***	
$CONTRACTED_i$	3.6E-05	$CONTRACTED_i * POST\_A_i$	0.0360
	(0.00)		(2.83)
Student Agglomeration Effect			
$CON050T_i$	0.0002		
	(10.57)		
$CON050C_i$ / $CON050NC_i$	0.0060		
	(3.69)		

Complex Characteristics.		**Unit Characteristics**	
$UNITS\_TOTAL_i$	-0.0019	ln ($LIV\_AREA\_SQFT_i$)	0.6277
	(15.17)		(47.52)
ln ($LAND\_AREA\_AC_i$)	0.0668	ln ($BSMT\_AREA\_SQFT_i$)	0.0197
	(11.76)		(13.80)
$ELEVATOR_i$	0.0463	$\#\_BATHSROOMS_i$	0.0607
	(3.14)		(11.05)
$COND\_BLW\_AVG_i$	-0.0116	$AGE\_AT\_SALE_i$	-0.0096
	(1.34)		(9.75)
$COND\_GOOD_i$	0.0234	$AGE\_AT\_SALE\_SQ_i$	7.9E-05
	(3.19)		(3.28)
$COND\_EXCELLENT_i$	0.1316	$FIREPLACE_i$	0.0704
	(10.94)		(10.16)
$CPARK_i$ / $UNITS\_TOTAL_i$	0.0261	$DRYER\_HOOKUP_i$	0.0735
	(6.03)		(5.63)
$UPARK_i$ / $UNITS\_TOTAL_i$	0.0076	$TWO\_FLOOR\_UNIT_i$	0.0075
	(1.75)		(0.93)
$DSGN\_INT\_HALL_i$	-0.0319	ON_2NDFLR_i	-0.0027
	(3.03)		(0.54)
$DSGN\_EXT\_HALL_i$	-0.0068	$ON3RDFLR\_OR\_HIGHER_i$	0.0213
	(0.96)		(3.72)
$DSGN\_MULTIPLEX_i$	-0.0226	Intercept	7.0006
	(2.28)		(74.91)
$DSGN\_TRI\_QUADPLEX_i$	-0.0850		
	(7.28)	Adj R-sq	0.9061

Note that the dependent variable is the natural logarithm of selling price. Asymptotic t-statistics are reported in parentheses. Annual time fixed effect variables are include in the estimation of the model, but are not reported. $POST\_A_i$ ($POST\_E_i$) is a dichotomous variable that identifies properties sold after the announcement (enactment) date. The variable U_BYU_i is defined as the distance from the center of campus for properties within the boundary and as the distance at the boundary for properties outside the boundary. The variable U_EDGE_i is zero for properties within the boundary and defined as the distance to the edge of the boundary along the ray from the center of campus. The variable D_EDGE_i identifies properties that fall outside the boundary (1 = outside the boundary).

TABLE 3: Estimation of Condominium Prices: Policy Change Defined by Enactment Date

	Model 3.1	Model 3.2		Model 3.1	Model 3.2
Internal Gradients			***Marginal Impact of Policy on Internal Gradients***		
$R_{120\ i} * U\_BYU_i$	0.0396	0.0584	$R_{120\ i} * U\_BYU_i * POST\_E_i$	0.0888	0.1069
U_BYU_i *defn. in note**	(1.21)	(1.83)	$POST\_E_i$ *defn. in note**	(2.35)	(2.89)
$R_{180\ i} * U\_BYU_i$	-0.0654	-0.0858	$R_{180\ i} * U\_BYU_i * POST\_E_i$	-0.1098	-0.0908
	(2.50)	(3.35)		(2.27)	(1.92)
$R_{240\ i} * U\_BYU_i$	-0.0542	-0.0659	$R_{240\ i} * U\_BYU_i * POST\_E_i$	0.0102	0.0372
	(2.06)	(2.56)		(0.39)	(1.45)
$R_{300\ i} * U\_BYU_i$	-0.0891	-0.0806	$R_{300\ i} * U\_BYU_i * POST\_E_i$	-0.0024	0.0031
	(3.81)	(3.52)		(0.10)	(0.13)
$R_{360\ i} * U\_BYU_i$	-0.1701	-0.1985	$R_{360\ i} * U\_BYU_i * POST\_E_i$	0.0152	0.0346
	(4.80)	(5.71)		(0.28)	(0.65)
External Gradients			***Marginal Impact of Policy on External Gradients***		
$R_{120\ i} * U\_EDGE_i$	0.1988	0.2136	$R_{120\ i} * U\_EDGE_i * POST\_E_i$	0.4981	0.4574
U_EDGE_i *defn. in note**	(1.84)	(2.03)		(1.56)	(1.47)
$R_{180\ i} * U\_EDGE_i$	-0.0963	-0.1332	$R_{180\ i} * U\_EDGE_i * POST\_E_i$	0.0849	0.1336
	(2.20)	(3.11)		(0.81)	(1.31)
$R_{240\ i} * U\_EDGE_i$	0.2025	0.2461	$R_{240\ i} * U\_EDGE_i * POST\_E_i$	-0.1018	-0.1487
	(3.77)	(4.68)		(0.54)	(0.81)
$R_{300\ i} * U\_EDGE_i$	-0.1352	-0.1417	$R_{300\ i} * U\_EDGE_i * POST\_E_i$	-0.2240	-0.2005
	(1.75)	(1.88)		(1.35)	(1.24)
$R_{360\ i} * U\_EDGE_i$	-0.0652	-0.0623	$R_{360\ i} * U\_EDGE_i * POST\_E_i$	0.0421	0.0446
	(4.82)	(4.70)		(1.30)	(1.41)
Externality Shift			***Marginal Impact of Policy on Externality Shift***		
$R_{120\ i} * D\_EDGE_i$	-0.1189	-0.1012	$R_{120\ i} * D\_EDGE_i * POST\_E_i$	-0.7308	-0.7421
D_EDGE_i *defn. in note**	(0.83)	(0.72)		(1.92)	(2.00)
$R_{180\ i} * D\_EDGE_i$	-0.1102	-0.0736	$R_{180\ i} * D\_EDGE_i * POST\_E_i$	0.1142	0.0851
	(2.62)	(1.79)		(1.10)	(0.84)
$R_{240\ i} * D\_EDGE_i$	-0.2211	-0.2372	$R_{240\ i} * D\_EDGE_i * POST\_E_i$	0.1298	0.1505
	(6.18)	(6.77)		(0.96)	(1.14)
$R_{300\ i} * D\_EDGE_i$	-0.0915	-0.1099	$R_{300\ i} * D\_EDGE_i * POST\_E_i$	0.1268	0.1366
	(3.41)	(4.18)		(2.22)	(2.44)
$R_{360\ i} * D\_EDGE_i$	0.2722	0.2893	$R_{360\ i} * D\_EDGE_i * POST\_E_i$	0.0960	0.0820
	(9.14)	(9.92)		(1.28)	(1.12)
Supply Restriction (Overall)			***Marginal Impact of Policy on Supply Restriction***		
$CONTRACTED_i$	0.0238	-0.0164	$CONTRACTED_i * POST\_A_i$	*omitted*	0.0991
	(2.37)	(1.59)			(12.31)
			$CONTRACTED_i * POST\_E_i$	-0.0451	-0.0944
				(2.68)	(5.59)
Student Agglomeration Effect					
$CON050T_i$	0.0002	0.0002			
	(9.86)	(10.65)			
$CON050C_i$ / $CON050NC_i$	0.0068	0.0055			
	(4.13)	(3.44)			

Complex Characteristics.			***Unit Characteristics***		
$UNITS\_TOTAL_i$	-0.0019	-0.0019	ln ($LIV\_AREA\_SQFT_i$)	0.6295	0.6321
	(15.45)	(15.89)		(47.01)	(48.29)
ln ($LAND\_AREA\_AC_i$)	0.0731	0.0708	ln ($BSMT\_AREA\_SQFT_i$)	0.0197	0.0199
	(12.78)	(12.66)		(13.67)	(14.13)
$ELEVATOR_i$	0.0338	0.0464	$\#\_BATHSROOMS_i$	0.0645	0.0628
	(2.27)	(3.18)		(11.58)	(11.54)
$COND\_BLW\_AVG_i$	-0.0030	-0.0097	$AGE\_AT\_SALE_i$	-0.0084	-0.0096
	(0.34)	(1.13)		(8.82)	(10.23)
$COND\_GOOD_i$	0.0192	0.0199	$AGE\_AT\_SALE\_SQ_i$	4.0E-05	7.6E-05
	(2.57)	(2.72)		(1.73)	(3.31)
$COND\_EXCELLENT_i$	0.1305	0.1301	$FIREPLACE_i$	0.0648	0.0699
	(10.76)	(10.98)		(9.31)	(10.25)
$CPARK_i$ / $UNITS\_TOTAL_i$	0.0268	0.0237	$DRYER\_HOOKUP_i$	0.0698	0.0780
	(6.14)	(5.54)		(5.32)	(6.07)
$UPARK_i$ / $UNITS\_TOTAL_i$	0.0072	0.0049	$TWO\_FLOOR\_UNIT_i$	-0.0018	0.0024
	(1.63)	(1.13)		(0.23)	(0.30)
$DSGN\_INT\_HALL_i$	-0.0240	-0.0244	ON_2NDFLR_i	-0.0014	-0.0019
	(2.26)	(2.35)		(0.28)	(0.39)
$DSGN\_EXT\_HALL_i$	-0.0059	-0.0057	$ON3RDFLR\_OR\_HIGHER_i$	0.0215	0.0212
	(0.82)	(0.81)		(3.70)	(3.73)
$DSGN\_MULTIPLEX_i$	-0.0152	-0.0166	Intercept	6.9956	7.0076
	(1.51)	(1.69)		(74.10)	(75.92)
$DSGN\_TRI\_QUADPLEX_i$	-0.0863	-0.0845			
	(7.32)	(7.32)	Adj R-sq	0.9031	0.9074

Note that the dependent variable is the natural logarithm of selling price. Asymptotic t-statistics are reported in parentheses. Annual time fixed effect variables are include in the estimation of the model, but are not reported. $POST\_A_i$ ($POST\_E_i$) is a dichotomous variable that identifies properties sold after the announcement (enactment) date. The variable U_BYU_i is defined as the distance from the center of campus for properties within the boundary and as the distance at the boundary for properties outside the boundary. The variable U_EDGE_i is zero for properties within the boundary and defined as the distance to the edge of the boundary along the ray from the center of campus. The variable D_EDGE_i identifies properties that fall outside the boundary (1 = outside the boundary).

Figure 1: BYU Contracted Housing Boundary

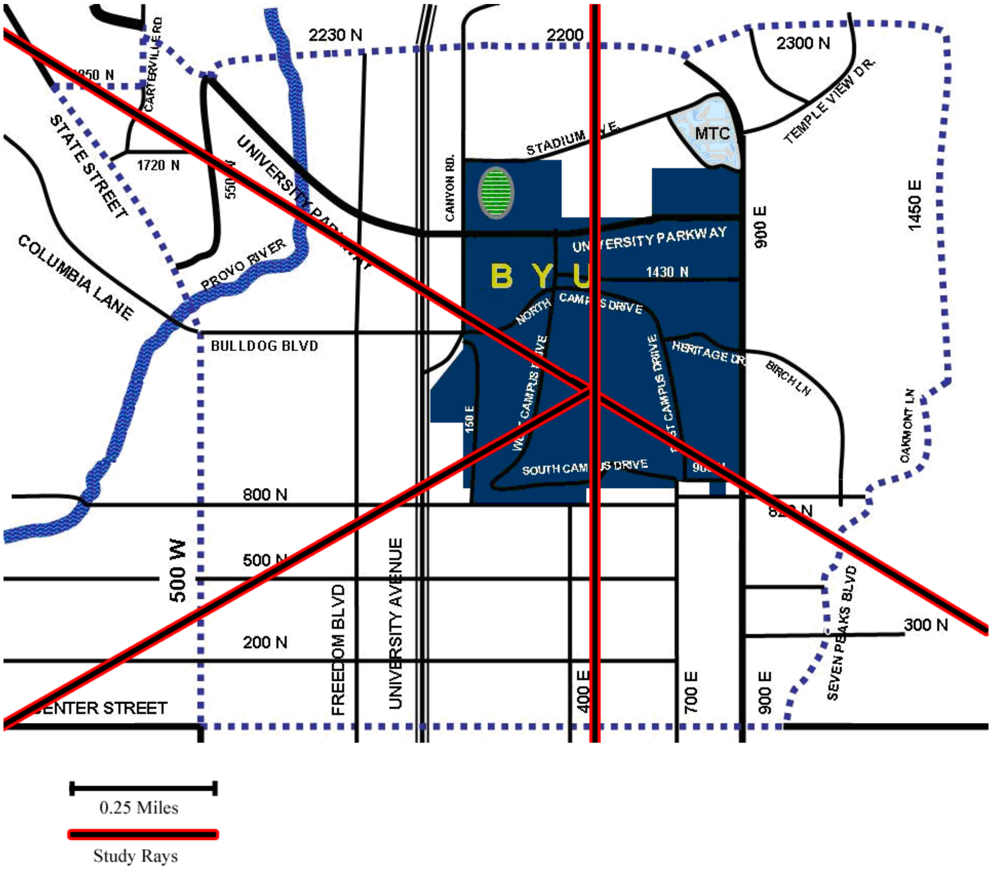


Figure 2: Student Location Restriction Effects on Land Rents without Student Externality.

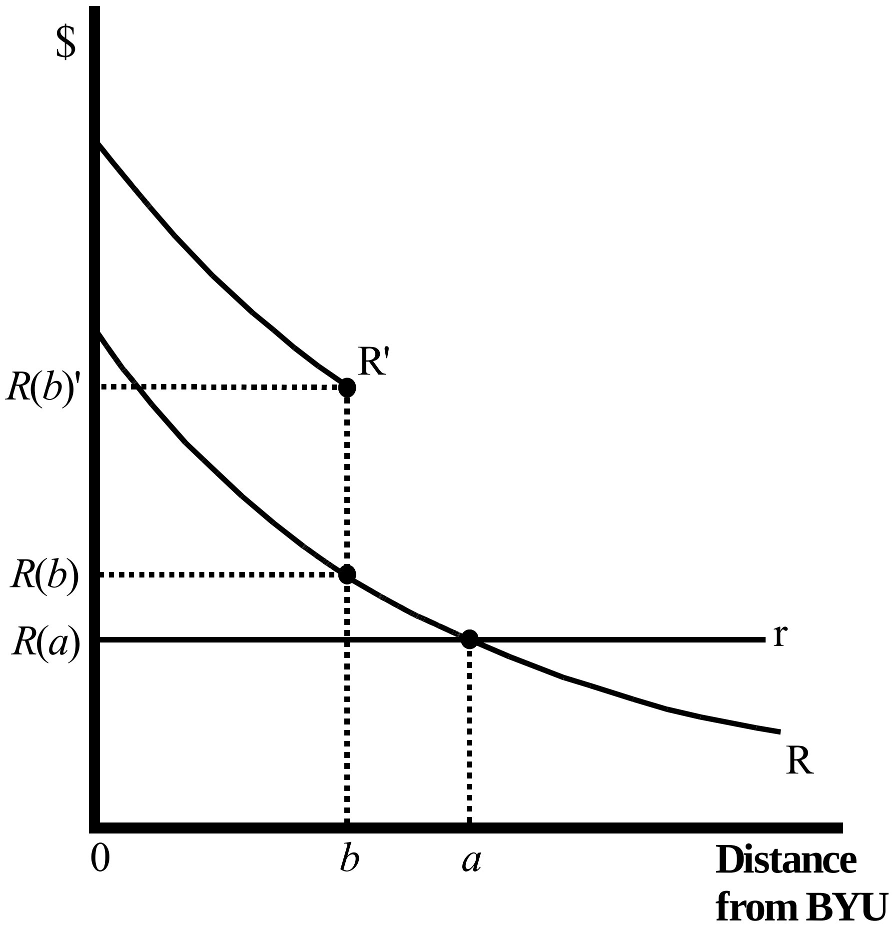


Figure 3: Student Location Restriction Effects on Land Rents with Student Externality on Non-students.

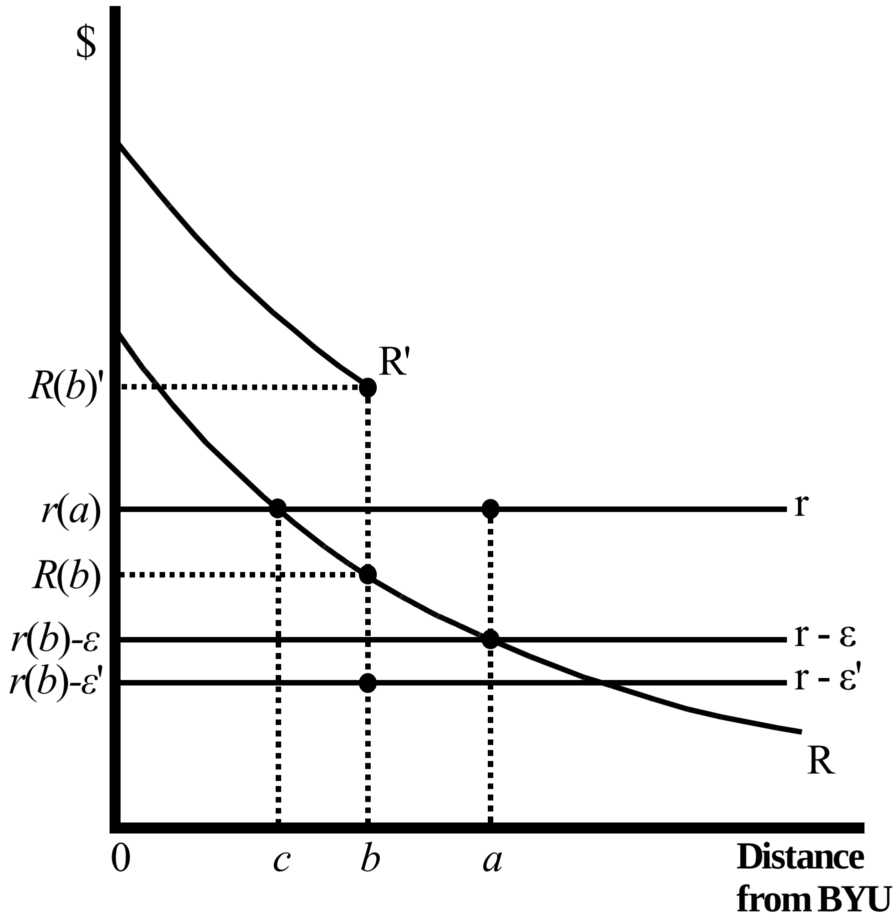


Figure 4: Student Location Restriction Effects on Land Rents with Student Agglomeration Effect.

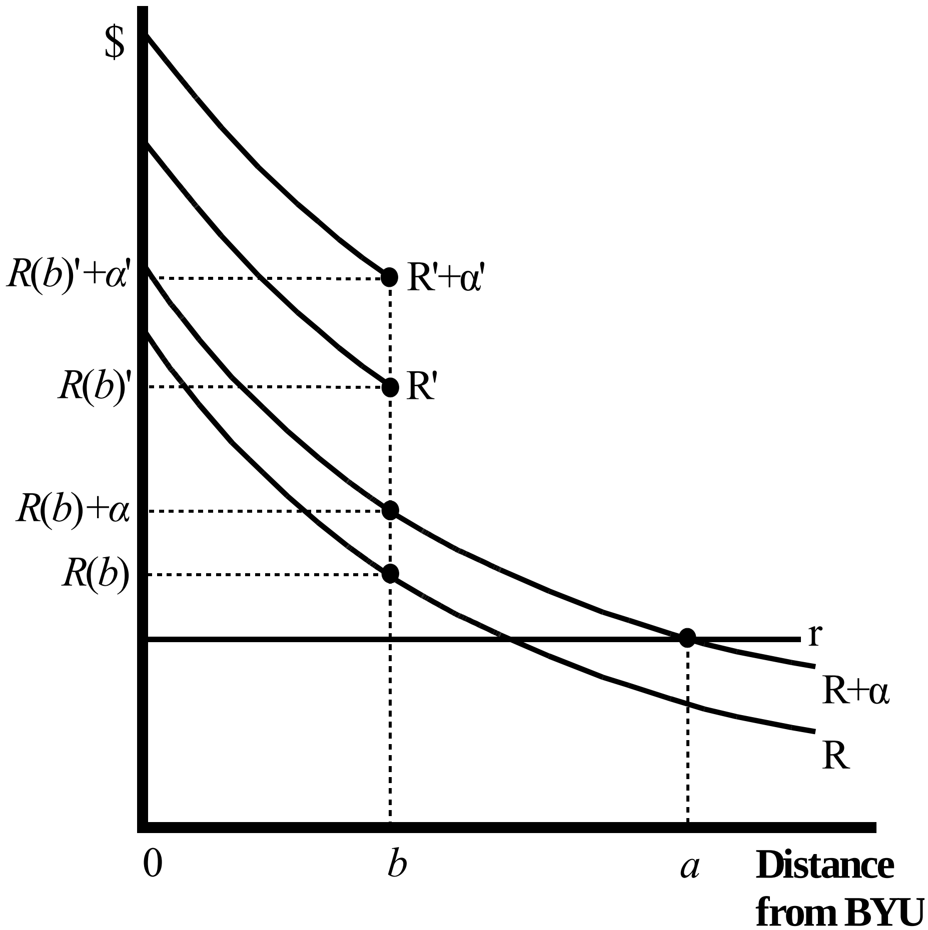


Figure 5. Weighted Location Variables

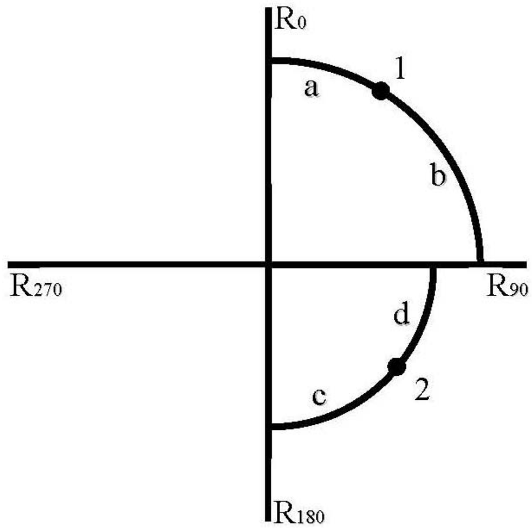
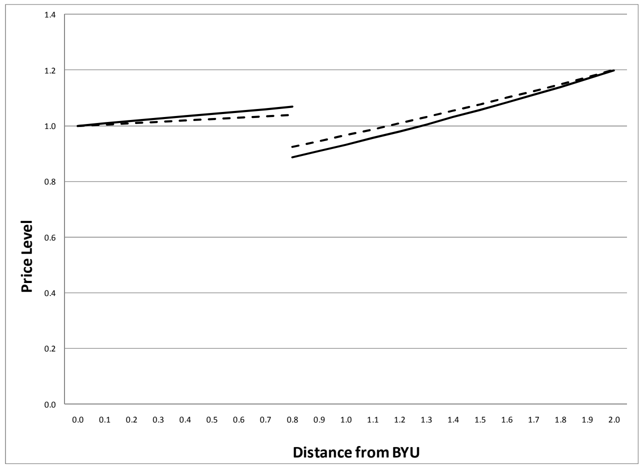
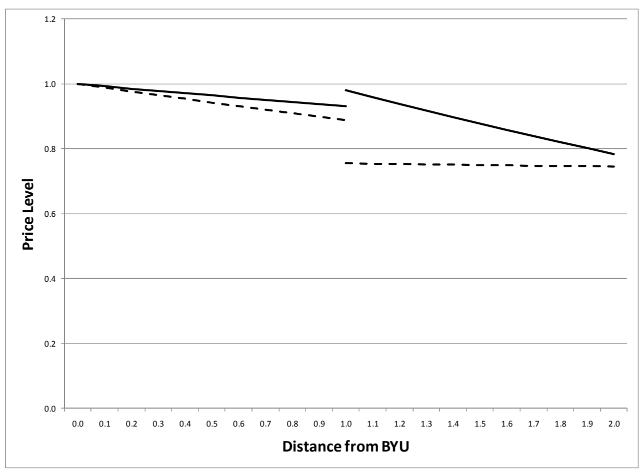


Figure 6. Price levels pre- and post-announcement
(pre- solid line, post- dashed line; gaps at policy boundary)

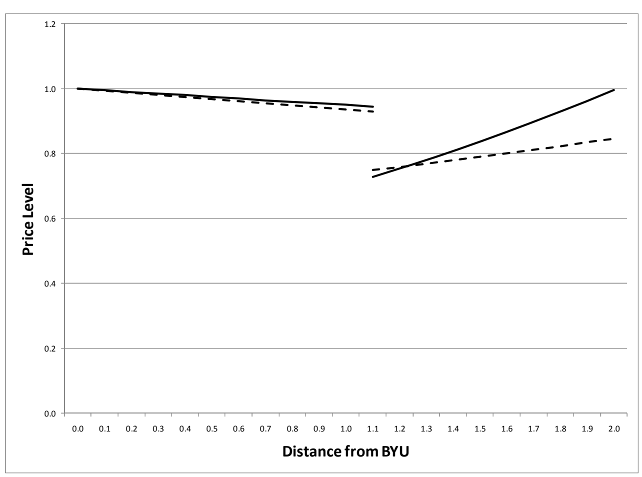
<u>Panel A</u><u>: Ray 120</u>



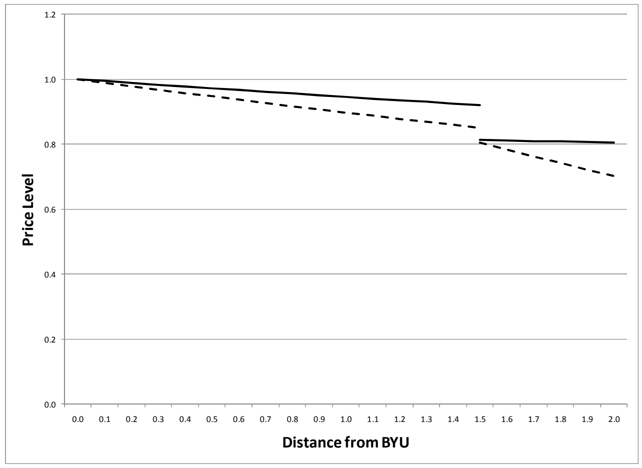
<u>Panel B</u><u>: Ray 180</u>



<u>Panel C</u><u>: Ray 240</u>



Panel D: Ray 300



Panel E: Ray 360

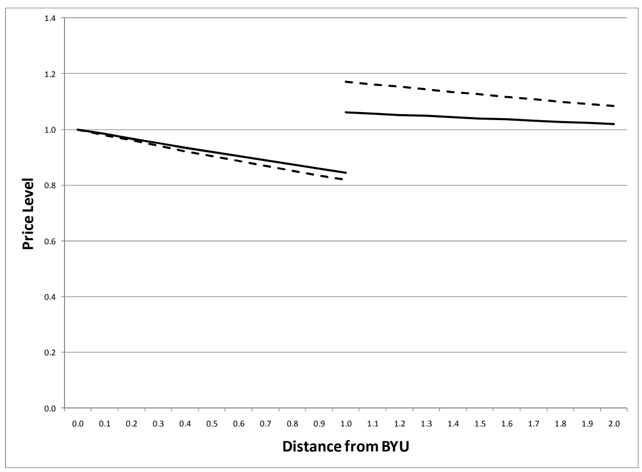
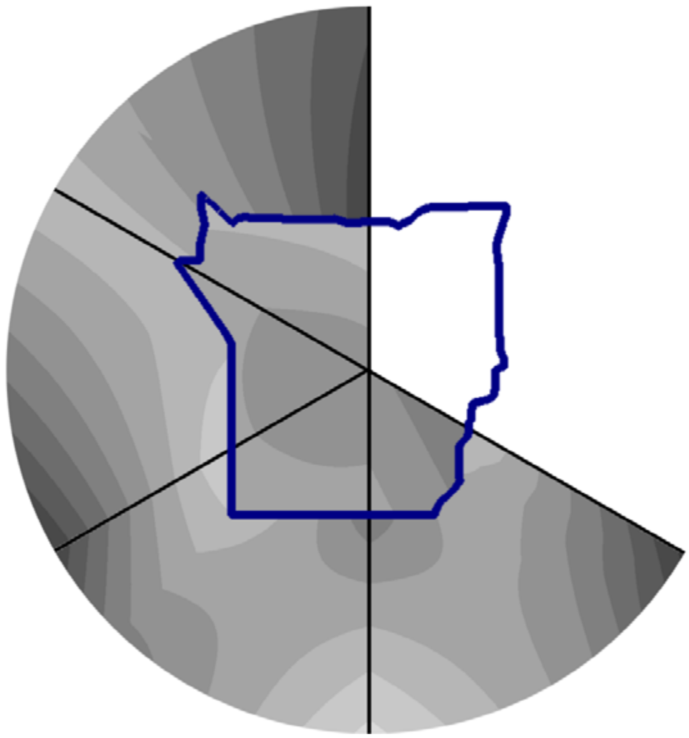
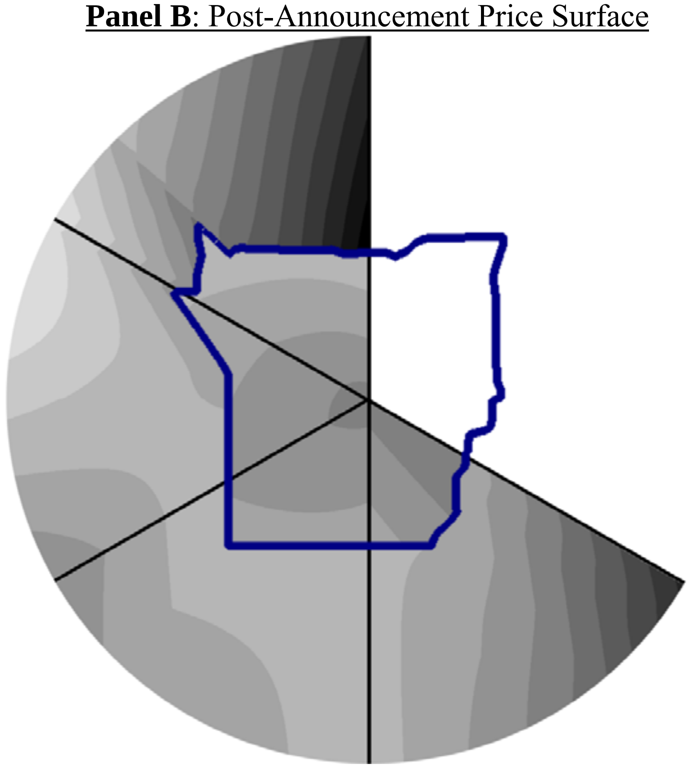


Figure 7. Pre- and Post-announcement price surfaces, with darker shading indicating higher prices for non-student (outside boundary) and student (inside boundary) housing units with identical characteristics.

Panel A: Pre-Announcement Price Surface



Panel B: Post-Announcement Price Surface



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