School Districting and the Origins of Residential Land Price Inequality

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Abstract

This paper examines how education policy generates residential sorting and changes residential land price inequality within a city. In 1974, Seoul shifted away from an exam based high school admission system, created high school districts and randomly allocated students to schools within each district. I examine how residential land prices change across school districts using a first differenced boundary discontinuity design. By focusing on the immediate years before and after the creation of school districts and using general functional forms in distance, I find that residential land price increases by about 13% point more on average and by about 26% point across boundaries in the better school district. In sum, residential land prices increase with the creation of school districts and more pointedly in the better school districts. Such change could impact low-income renter households unless school districting is accompanied by a comparable increase in wages.

Keywords: School Districting, Residential Sorting, Urban Inequality, Boundary Discontinuity, Hedonic Valuation

JEL Codes: I21, I28, R23, R30

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1. Introduction

Within city across neighborhood inequality, whether in income or housing prices, is a feature common to many cities around the world. Economists have long studied the causes of urban inequality. The literature examines Tiebout types of sorting but also finds that limited provision of public goods to migrants and slums (Feler and Henderson 2011), discrimination in mortgage markets (Ladd 1998), transportation constraints (Holzer et al. 2003), and tipping and racial preferences (Card et al. 2008, Boustan 2010) impact urban inequality. This paper examines how educational policy generates sorting and affects urban residential land price inequality.

Specifically, I utilize the origins of school districts in Seoul to examine whether shifting student assignment from an exam to a school district based system generates selective residential sorting by income and alters residential land prices. Though a large literature examines sorting either through structural estimation (Epple and Pratt 1998, De Bartelome 1990) or empirical examination of equilibrium outcomes (Bayer et al. 2007, Rothstein 2006, Urquiola 2005, Black 1999), there is little direct empirical evidence of residential sorting. Baum-Snow and Lutz (2011) use the change in desegregation laws and examine sorting by race in the US. Similarly, I use an education regime shift in Seoul to empirically confirm residential sorting. Previously, each high school administered its own entrance exam and admitted students based on exam results. In 1974, the central government initiated a reform that abolished the exam based policy for a district based system where students would randomly be allocated to schools. The policy rationale for this drastic regime shift was the belief that exam based admission promotes inequality and randomly allocating students within school districts would likely reduce inequality (Kang et al., 2007).

If households desire better schools and high school quality is heterogeneous across districts, higher income households would sort towards and could differential increase residential prices in the better school districts when the regime shifts. The underlying reasoning is that under exam based assignment households compete in test score which is determined by many factors including student ability but under district based assignment households compete in housing price which is predominantly determined by household income. Hence, when districts are created the wealthier households outbid the poorer households, sort towards and potentially increase residential prices more at better school districts. This paper formalizes this intuition in a stylized model and empirically substantiates the prediction on residential prices.

I examine the change in residential land prices pre and post regime change across newly established school districts in Seoul. Furthermore, a unique event that occurred concurrently with the regime shift helps the identification of residential sorting and price changes. The government relocated then South Korea's most prestigious high school from the city center to the city periphery in order to reduce central city congestion. This event exogenously divorced school quality from neighborhood characteristics. I use difference in difference estimation across districts to examine the change in residential land prices at the district level, but also adapt a boundary discontinuity to control for neighborhood location and estimate the impact of the reform on the change in residential land prices across boundaries. Economists have used hedonic regressions that include school district boundary fixed effects to estimate household valuation of school quality. (Black 1999, Bayer et al. 2007, Gibbons et al. 2012) These methods rely on the idea that the boundary fixed effects capture unobserved neighborhood components that would otherwise impact housing prices. I extend this framework to a first differenced analysis and compare outcomes from the same neighborhood over time. The additional time dimension enables the assumption that unobserved neighborhood characteristics must be the same for observations across boundaries to be relaxed.

I find that the change in residential land price in the better school district increases by about 13 percentage points more on average when the regime shifts. Also, along boundaries I find that the differential growth in housing land price to be around 26% points between the better and its neighboring district. To confirm that the increase in price is a demand response and not a supply shift I examine the change in the number of households and find no discrete jump along district boundaries. Also, the discrete jump in the change in residential land price only appear between 1973 and 1975 but not during the periods prior to the regime shift. The empirical results confirm that school districting generated differential increases in residential prices across the city. The distributional impact of such change is more nuanced. Because the top-tier high school relocated to a previously less desired district, school districting reduced the residential land price inequality within the city. The residential land price Gini coefficient decreased from 0.374 in 1973 to 0.316 in 1975. During the same period, residential land prices increased across the whole city and more pointedly on District 3. The differential increase would have likely impacted the low income renter households in that district, unless school districting was accompanied by a comparable increase in wages in that short period of time.

The paper proceeds as follows. The next section presents a simple model and summarizes predictions for the empirical work. Section 3 provides the background on the high school districting that occurred in Seoul and describes the data. Section 4 presents the empirical framework of the boundary discontinuity design, Section 5 discusses results and implications, and Section 6 concludes.

2. Theoretical Examination

The model aims to understand how households match to schools of different quality under the exam and district regimes and derive testable predictions on residential prices. The model is in the spirit of Epple and Platt (1998) and Epple and Romano (1998). Consider a city where households are randomly distributed over N neighborhoods and each neighborhood has one high school with quality θ. Quality varies and the ranking of high schools are known. All other amenities are the same across neighborhoods. Schools are centrally financed, i.e., there is no local taxation for school financing. Each neighborhood (or district) has a fixed number of houses and each household consumes one unit of housing and pays a housing cost of r. Under exam based assignment students take high school entrance exams and schools choose students based on exam results. Once the regime shifts to district assignment, neighborhoods become school districts and students attend the high school in the district where they live.

Each household has one adult and one child and is identified by (y,a), where y denotes household income and a is the child's ability. The household's utility function $U(\cdot)$ increases with numeraire consumption c and the educational achievement of the child t, and is continuous and twice differentiable in both variables. High school achievement, e.g., performance on the college entrance exam, $t=t(a,\theta)$ is a continuous and increasing function of child's ability a and high school quality θ. Each household maximizes $U(c, t(a,\theta))$ subject to the budget constraint $c + r = y$, which returns the indirect utility function $V(r,\theta; y,a) = U(y-r, t(a,\theta))$. One property naturally stems from the above set up. The implicit function theorem implies:

$$\left.\frac{dr}{d\theta}\right|_{V=\overline{V}} = -\frac{\partial V/\partial\theta}{\partial V/\partial r} = \frac{U_2}{U_1}\frac{\partial t}{\partial\theta} > 0 .$$

The above characterizes the household's indifference curve in the (r, θ) plane. The indifference curve slopes up in the (r, θ) plane and illustrates the natural feature that people are willing to pay higher residential prices for better schools. I assume two properties of the household's indifference curve in the *(r, θ)* plane:

$$\frac{\partial r_\theta}{\partial y} = \partial\left(\frac{\partial V/\partial \theta}{-\partial V/\partial r}\right)\Big/\partial y > 0 \text{ and } \frac{\partial r_\theta}{\partial a} = \partial\left(\frac{\partial V/\partial \theta}{-\partial V/\partial r}\right)\Big/\partial a \geq 0\,.$$

The first condition implies that, all else equal, higher income households are willing to pay more for school quality.[1] The second condition implies that, all else equal, households with higher ability students will not pay less for school quality.

Schools care about reputation, either for prestige or alumni support, and aim to obtain the brightest students. Hence, schools optimize by choosing the highest performing students it can admit under the exam regime. On the other hand, under district assignment schools simply admit those who reside in their districts. Hence, schools' choices are muted under the district regime.

The following simple parametric model helps illustrate the equilibrium properties under each regime.

(1) $$U = (y - r)\cdot t(a,\theta)$$

$$t(a,\theta) = a^{\beta}\theta^{\gamma}\,,\ 0<\beta<1,\ 0<\gamma<1$$

Assume five schools ($\theta_5 > ... > \theta_1$), each in a different neighborhood or school district. Under the exam regime households sort based on performance on the high school entrance exam, $t_m(a,\bar{\theta}\ ) = a^{\beta_m}\bar{\theta}^{\gamma_m}$, $0<\beta_m<1$, $0<\gamma_m<1$. I make the simplification that middle school quality $\bar{\theta}$ is homogenous across schools to focus on the high school allocation rules. The contextual basis for this assumption is the fact that the military dictatorship closed down elite middle schools in Seoul to equalize middle school quality but left the elite high schools intact (Korea Education Development Institute 1998). Hence, under the exam regime student ability *a* determines high

[1] Sufficient conditions on *U* for single-crossing in income is $U_{11} \leq 0$ and $U_{12} \geq 0$, with at least one having strict inequality.

school entrance exam scores, and since all schools prefer high achieving students, the better quality schools are matched with the higher ability students under the exam regime.

On the other hand, under the district regime the household's location choice determines the school its child will attend. Everyone wants to live in the better school district and is willing to pay additional housing price to access the better district. The additional price each household is willing to pay is determined by its endowment of (*y*,*a*) and the quality of the school. Households will sort based on the willingness to pay for school quality. The assumption that higher income households are willing to pay more for school quality implies that willingness to pay increases with income. In the parametric model, the willingness to pay for school quality $\theta_{j+1} > \theta_j$ for household type (*y*,*a*) living in district *J* and paying r_j can be expressed as

$$\tilde{r} = r_j \left(\theta_j / \theta_{j+1}\right)^{\gamma} + y\left(1 - \left(\theta_j / \theta_{j+1}\right)^{\gamma}\right) \quad (2)$$

which is increasing in household income. I simulate this simple economy and Figure 1A and 1B illustrate the equilibrium allocation of households to schools in the (*y*, *a*) space. In an exam equilibrium, households segment into schools by ability because ability directly maps entrance exam scores. In a district equilibrium, households stratify based on willingness to pay for school quality and since willingness to pay is directly mapped by income in (2), households perfectly segment into schools by income. I can enrich the model so that income can directly impact one's achievement via tutoring. Adding tutoring *x* in achievement, so that $t = t(x, a, \theta)$, does not change the main implication unless one makes the unrealistic assumption that ability plays only a minimal role in determining one's achievement. Appendix A describes the specifics of the extended model. I present here the graphical results in Figure 1C and 1D. The nature of sorting remains the same as in the simpler model. In both cases, the main implication is that matching to high school quality becomes predominantly determined by income under the district regime.

Up to now the model assumed school quality to be constant in both regimes. School reputation and facilities would change minimally when regimes shift, especially over a short period of time. However, peer groups would automatically change with the shift from an exam to a district regime. Given that peer quality is a factor of school quality, overall school quality would change. Nonetheless, incorporating peer effects in school quality will unlikely alter the main prediction that household income becomes an important factor in determining residential choice under the district regime relative to the exam regime. I provide a heuristic discussion, and for expositional convenience will refer to peer quality separately from school quality. School quality will imply factors that do not change between regimes. With peer effects in the model households desire to gain access to high quality schools and high ability peers. Under an exam equilibrium, the better quality schools have the higher ability students and hence, automatically the higher ability peer groups. Higher ability students, regardless of income level, congregate at the better quality schools and form better peer groups. Thus, the nature of sorting under the exam regime does not differ whether or not peer effects are included in the model. Under the district regime, wealthier households can buy both high quality schools and high ability peers through the housing market. If school quality and peer quality are complementary in the production function, households will eventually sort by income. Hence, income plays a stronger role in determining residential location choice in the district regime.

The main point to take away from the theoretical examination in this section for empirical analysis is that the shift to a district regime will increase residential prices in the better school districts. However, if income were already geographically correlated with school quality, so that high income households were already living close to the better schools under the exam regime, we would see no sorting. Furthermore, if housing prices were already discretely higher in the high income neighborhoods we would see no increase in housing prices.[2] Given that cities are formed over a long period of time and the places where affluent people congregate over generations often have historic and prestigious high schools, pre-sorting is not an unlikely scenario. To confirm the predictions of sorting in the data, I would either need to know the degree of pre-sorting in the city or have a unique experiment that generates variation in school quality not, or weakly, correlated with neighborhood income. The relocation of the top-tier high school in Seoul exogenously generated changes in school district quality and helps the identification of residential sorting.

3. School districting in Seoul and the data

3.1 The origins of school districts in Seoul

When the central government shifted Seoul to the high school district system in 1974, five high school districts were created. Under the new system students would no longer take exams individually administered by each high school but take one city-wide high school eligibility exam, and if the student was above the cutoff would be randomly allocated to a high school in his or her district. Figure 2 illustrates the 5 districts and the number of high schools in each district. In general, two to four middle school districts formed one high school district and students graduating from middle schools in a high school district would be randomly selected to one of the district's high schools. Many high schools were concentrated near downtown and moreover, the top-tier schools were also near downtown. Those living far from the city center, and hence attending middle schools in the outer middle school districts would have a clear disadvantage in terms of which high school they could attend if the downtown area formed its

[2] Even with pre-sorting, housing prices could increase. If the marginal household's willingness to pay for higher school quality is larger than the pre-existing price gap between the districts, then we would still observe housing price increases when the regime shifts even if households already pre-sorted.

own school district. To smooth the sudden transition from exam based selection to district assignment the city created a coalition of high schools in downtown called the Unified Central District (UCD), a 4km radius circle with Gwanghwamun (the gate of Kyungbok Palace) as the center. The UCD was created on top of the original five districts. Students in each district would be randomly chosen from a pool of all schools in the UCD and his or her own district. The slots for the UCD from each district were adjusted by population so that about 50% of students from each original district would be allocated to high schools in the UCD.

Meanwhile, in October 1972, the Education Minister announced that Gyeonggi High School, the ranking one high school, would be relocated to District 3 and the new campus opened in 1976. As shown in Appendix Table 1 Gyeonggi High School was the unambiguously top school back then dominating entrance to Seoul National University (SNU), the nation's most respected university, under the exam system. More than 50% of its students would gain admission to SNU annually.[3] High schools were often ranked by the number of students admitted to SNU. Hence, the relocation of Gyeonggi High School and access to it without any exam was an attractable option to many households. Also, Hweemun High School, another top-tier private high school, finished construction of its new campus in 1978 in District 3 and sold its old campus in the city center to Hyundai Group. Several other high schools followed suit. Appendix Table 1 lists top-tier high schools in Seoul and their location changes to District 3. What these relocations imply in terms of timing is that when the policy shifted from exam to district assignment in 1974, people already knew that the most prestigious high school and other top-tier high schools would relocate to District 3 in years soon to come. Given the reputation and prestige associated with the elite high schools, the exogenous relocation of high schools substantially increased how households *perceived* school quality in District 3.

[3] Donga Daily 1972.2.7

3.2. The land price data

The main data used in the empirical analysis is the neighborhood-level residential land price appraisal data assessed by the Korea Appraisal Board. The assessments were done on three representative properties per neighborhood for high, medium, and low quality residential locations. Each location were assessed annually over time and created in reports. Assessment values are determined based on comparable market transactions and prices are reported per *pyoung*, an area that corresponds to $3.3m^2$. I copied the reports on Seoul for the odd number years between 1971 and 1977 and digitized the data. In order to calculate distance I generate the centroid for each neighborhood and calculate the distance to district boundaries using GIS software. I also collect the number of household for each neighborhood for the same period. I match neighborhoods from each data set and obtain 656 observations. Figure 3 illustrates each neighborhood in dots and labels the high school districts and the boundaries between adjacent districts.

To compare high school quality between districts, I utilize the 1969 college eligibility exam pass rate for each high school in Seoul and link it to the 1974 districts to generate district averages. The January 17, 1969 edition of the daily newspaper, Kyeonghyang Shinmun reported, for each high school in Seoul, the number of applicants and the percentage of students who pass the college eligibility exam. There was no formal assessment of school quality back then other than reports on how schools performed in matriculating their students to colleges. Hence, the public perception of school quality was largely shaped by how well a school did in sending their students to colleges, especially the top tier colleges. I match each high school to the school district and average the pass rate weighted by the size of each high school's applicant pool. Figure 2 presents what the expected quality for district *i* would have been by calculating 0.5(pass rate of UCD)+0.5(pass rate of district *i*), *i*=1,..,5. Note that the five districts in general had a much lower pass rate than the schools in the UCD with the UCD having an average pass rate of 0.75. District 2 had the highest pass rate among all districts. District 2 includes parts of Old Seoul and had several good schools, such as the Annex High School of Seoul National University. For district 3, I include Gyeonggi High School in the calculation. The number in parenthesis for District 3 indicates what the expected pass rate would have been if Gyeonggi High School had not moved. The movement of one school increases the expected pass rate drastically from 0.4 to 0.6. Given this sudden variation in school quality I expect that residential land prices in District 3 would have increased more than other districts.[4] Table 1 provides summary statistics of the main variables used in the analysis.

4. The Boundary Discontinuity Design with a Regime Shift

To motivate my main estimation equation, I first discuss the underlying hedonic framework of residential land prices under two different regimes. Recall that school quality is not valued in residential land prices in the exam regime but is valued in the district regime. Denoting the exam regime 1 and the district regime 2, prices can be expressed as

$$P_{2ijd} = \alpha T_d + \beta_2 X_{2ijd} + \gamma_2 Z_{2jd} + \varepsilon_{2ijd}$$

$$P_{1ijd} = \beta_1 X_{1ijd} + \gamma_1 Z_{1jd} + \varepsilon_{1ijd}$$

where P_{ijd} is the price of residential land *i* in neighborhood *j* in district *d*. T_d represents the quality of school district. X_{ijd} represents the characteristics of the plot and Z_{jd} represents neighborhood characteristics and district characteristics other than school quality. Since these

[4] An important point for analysis is whether school qualities remained the same once the regime shifted. The teacher quality, facility, and resources would not have changed drastically. As shown in Appendix Table 1, Gyeonggi High School and Seoul High School ranked number one in terms of students sent to SNU among district based high schools in Seoul, even in 1980. Also, as the number of CEOs and ranking indicate it continues to maintain a strong reputation in Korea's economy.

are two different regimes, I allow the valuation of both of *X* and *Z,* i.e., β and γ to differ between regimes. Taking first differences:

$$(3) \qquad \Delta P_{ijd} = \alpha T_d + \Delta(\beta X_{ijd}) + \Delta(\gamma Z_{jd}) + \varepsilon_{ijd}\ .$$

Note that the differenced variables can be decomposed to $\Delta(\beta X_{ijd}) = \Delta\beta X_{2ijd} + \beta_1 \Delta X_{ijd}$ and $\Delta(\gamma Z_{jd}) = \Delta\gamma Z_{2jd} + \gamma_1 \Delta Z_{jd}$. Controlling for all the characteristic variables, i.e., $X, \Delta X, Z, \Delta Z$ would be ideal for estimating (3). In reality I do not observe most variables and I am only interested in identifying the coefficient α. Furthermore, I want to incorporate household sorting in this framework and allow for the possibility that some of the neighborhood demographic characteristics can change, i.e., some components of ΔZ or ΔX is not zero. Also, the marginal valuations in the equation may differ across regimes so that $\Delta\beta$ and $\Delta\gamma$ are not zero and I do not observe many components of *X* and *Z*. The strategy I employ is to first focus on a narrow time period right before and after the education regime change so that the neighborhood or plot characteristics that would have changed would have been due to the education regime shift only or any other change was not systematically related to the regime shift. Next, I control for the location of each neighborhood within the city and map the dependent variables using general functions. The underlying idea is that location abstractly captures information of plot and neighborhood characteristics and by including functions that vary across space I allow the change in land prices to vary in a general way. The idea that location captures information of the dependent variable is not new. One of the earliest boundary discontinuity paper (Holmes 1998) examines how right-to-work laws affect business activity by comparing counties across state borders. In that paper location specific traits in manufacturing activity are captured through general functional forms that move along state boundaries. Dell (2010) provides another recent application related to labor rights.

There could be multiple ways to identify location in the two dimensional space. The method I use, which naturally stems from a monocentric city with boundaries that extend out from the city center, is to use distance from the city center and distance to the district boundaries to identify the location of each neighborhood. Figure 4 visually illustrates how land price is related to location. For each district, each line represents a local linearized fit of the log of residential land prices in 1975 on the distance to the city center. There is a strong spatial trend that maps the monocentric city model. Identification using distance from district boundaries requires assignment of sides. I denote the better school district along each boundary the positive side. This identification method is tied to each boundary. Hence, what I will be testing is whether I see a jump in the change in residential land prices across each boundary, especially for Boundary 3 which borders the district receiving the good schools and has the larger discrepancy in average pass rate across borders. Figure 5 visually illustrates the identification strategy. In practice, I perform the following regression:

$$(4) \qquad \Delta P_{i,(1973,1975)} = \tau_b \phi_{ib} D_{ib} + f(d_{ic}) + g_b(d_{ib}) + D_b * g'_b(d_{ib}) + Z_i + \phi_{ib} + \xi_i \, .$$

$\Delta P_{i,(1973,1975)}$ is the change in log residential land price between 1973 and 1975. Each observation is matched to its nearest boundary and ϕ_{ib} represents the set of dummies which equal one if *i*'s nearest boundary is *b* (=1,..,5) and zero otherwise. D_{ib} is an indicator equal to one if *i* is in the better school district along *i*'s relevant boundary. d_{ib} is the distance from neighborhood *i* to its closest boundary *b*, and d_{ic} is the distance from *i* to the city center (center of the UCD). $f(d_{ic})$ is the polynomial that captures trends from the city center. $g_b(d_{ib})$ and $g'_b(d_{ib})$ are polynomials across each boundary. Note that the *g* functions differ for each boundary and on both sides of each boundary. I allow $f(d_{ic})$ to be a fifth order polynomial and $g(d_{ib})$'s to be linear or quadratic functions.[5] Z_i is the set of additional control variables: dummy variables indicating the location quality of the land (low and high, where medium is the omitted category), and the set of school district dummies interacted with the UCD dummy. I focus on the residential neighborhoods while flexibly controlling for the downtown area with these set of interacted dummies. The UCD overlaps with the central business district and depopulates throughout the 1970s.

Note that the above specification allows for the most flexible form by allowing the differential changes in residential land prices between boundaries to differ across districts. This flexibility allows the possibility that perceived differences in school quality across boundaries could differ between districts. I am interested in whether the coefficient estimates of τ_b are statistically significantly positive, especially for Boundary 3. As discussed previously, boundary 3 saw the largest change in the difference in perceived school district quality after the regime shift. I estimate the above framework on sub-samples based on distance to the boundaries (1km to 4km), and fit different functional forms to obtain ranges of estimates in the empirical analysis.[6]

The identifying assumption is that the change in factors that affect residential land price between 1973 and 1975 was due to the shift in educational policy, that is, there is no systematic relation between the residual and D_b once the spatial trends are accounted for in (4). Focusing on a narrow time period pre and post regime change helps control for other demand factors that could change relative to examining a longer time horizon. Another concern is the potential change in housing supply. Hence, I also test whether housing supply differentially shifts across boundaries by examining the number of households. Another relevant test is to see if there are

[5] Whether I use a 3rd, 4th, or 5th order polynomial for f does not change the empirical results. I opt for the more flexible form.
[6] Focusing on sub-samples better fit polynomials around the boundaries without being subject to outliers farther from the boundary. The 4km sub-sample contains 90.2% of the observations.

any differential jumps across boundaries before the regime change. This is akin to testing the parallel trends assumption in difference in difference regressions. For this, I examine the change in residential land price between 1971 and 1973.

5. Empirical Results and Implications

5.1. Descriptive evidence of residential sorting at the district level

Before getting to the land price data, I first descriptively compare how the population composition changed at the school district level using census data in Figure 6. The 1975 and 1980 censuses provide information on the number of college graduates by 5 year age groups for each administrative district. Each school district is comprised of two to four administrative districts. As Seoul was undergoing considerable population growth, several administrative districts and school districts were split by 1980. Hence, I aggregate to the school district boundaries created in 1974 as in Figure 2. The black line in Figure 6 indicates the change in the percent of college educated for each age group between 1975 and 1980 for district 3. The share of college graduates increases steadily from the younger age group, peaks at the 40 to 44 age group and then continues to decline. The other four districts track each other with percentage change for the younger age group around zero and the older cohorts slightly above zero. What is stark in Figure 6 is how the college educated people in the age group with school aged children (ages 30 to 49) differentially sorted towards District 3. On the other hand, the difference between District 3 and the other districts become much smaller for those above 50 years old. Figure 6 is consistent with higher income households with school aged children responding to the regime shift by moving towards the newly formed high quality school district.

Though Figure 6 is consistent with residential sorting, examining a 5 year span during periods of urban development in District 3 could raise concern that other factors potentially have played a role. For instance, a differential increase in jobs that particularly cater towards college educated people between the ages 30 to 49 in District 3, compounded with plentiful housing supply between 1975 and 1980, could also return patterns consistent with Figure 6. Thus, I now focus on the narrower time period of 1973 to 1975. Since detailed population data is not available for this time period, I use the land price data from now on.

Table 2 reports the regression of the change in log residential land prices between 1973 and 1975 on district dummies and controlling for the location quality. The omitted district is District 1 in column (1). The difference in the price change is largest and significant for District 3 at 0.15. No other district reports a significant increase or drop. Column (2) omits all other districts other than District 3 and returns an estimate of 0.13 which is also significant. The population patterns in Figure 6 and the results in Table 2 indicate that residential sorting of high educated households predominantly occurred towards District 3 when the regime shifted and resulted in differential increases in residential land prices. If school quality additively enters the residential land price equation when the regime shifts then the first differenced regression in Table 6 would return precise estimates of the valuation of school quality. However, as discussed previously, the underlying hedonic framework for residential land price under each regime would likely differ because school district quality newly enters the hedonic equation under the district regime, altering the marginal valuation of the other variables in the model.

5.2. The boundary discontinuity results

I first graphically examine patterns across each boundary to see if there are any visually identifiable jumps as well as to choose the reasonable order of polynomial to fit across boundaries. Figure 7 plots the change in log residential land price between 1973 and 1975 by distance to each boundary. I restrict the plot to residential neighborhoods outside the UCD. The right hand side of the boundary indicates the better school district and the solid lines are quadratic fits with the shaded region representing 95% confidence intervals. The solid circles are averages for the observations in each 1 km bin, e.g., 0.5 indicates observations between 0 and 1 km. There is an increasing trend in residential land prices over the years for all boundaries but the discrete jump in the change in residential land price is evident and significant for Boundary 3 only. In order to test whether there are any differential changes in the supply of housing, Figure 8 plots the change in the log number of households between 1973 and 1975. All boundaries display no jump. The graphs for boundary 3 in figures 7 and 8 are consistent with a price increase driven by demand forces. I next test whether the observed patterns hold and estimates are significant in the regression framework.

Table 3 reports the results for equation (4). The dependent variable in Panel A is the change in log residential land prices between 1973 and 1975. Column (1) presents result for the 1km boundary sub-sample that compares levels across border. Coefficient estimates are positive and significant only for Boundary 3. Column (2) uses 2 km boundary samples with linear trends, and column (3) uses 4 km boundary samples with quadratic trends. Both specifications indicate a positive and significant increase for Boundary 3 only. The estimates imply that the residential land price increase in District 3 was about 26 to 54 percentage points higher than District 4 around Boundary 3. Panel B examines the change in the log number of households which serves as a proxy for the quantity of houses. The estimates for all boundaries in columns (1) through (3) are statistically indistinguishable from zero confirming the visual inspections found in Figure 8.

The combination of results from Panel A and Panel B again supports a demand driven change in residential land prices.

If the policy, not some differential trend across districts, generated the jump then we should see no significant increase in the change in prices before the policy change. As robustness checks, I examine the periods before the policy change. I first visually inspect the change in residential land prices in Figure 9 Panel A and the change in log number of households in Figure 9 Panel B. I pool all districts in the visual inspection but present results for each boundary in the regression specification below. As before, the right hand side indicates the better performing district based on the college entrance exam pass rate. In Panel A, the jump along the border is evident for the 1973 to 1975 period and is significant as the confidence bands do not overlap. On the other hand, there is no evident discontinuity in the 1971 to 1973 period. This 1973 to 1975 jump would correctly identify the demand of school quality if the change in other characteristics were smooth along the border. One thing I can test for is the number of households. Panel B plots the change in log number of households across the boundaries for both the 1971 to 1973 and 1973 to 1975 periods. The values are smooth across the boundaries for both periods.

I next take this to a regression framework and examine if there are any jumps across each boundary for the different periods. Table 4 reports results using the quadratic trend specification used in Table 3 column (3). Column (1) presents the 1971 to 1973 results, column (2) the same 1973 to 1975 results in Table 2, and column (3) the 1975 to 1977 results. Between 1971 and 1973, no boundary exhibits a change in log residential land prices that is significantly different from zero. The 1975 to 1977 results show increases along the better districts of Boundary 1 and 5, which may represent a lag effect. Panel B presents results on the change in log number of households. There are no significant jumps across any of the boundaries in all time periods. In sum, the results indicate that school districting increased residential land prices, particularly in District 3 which was the district that saw the largest increase in perceived school district quality when the regime shifted.

5.3 Implications of residential land price inequality

The shift away from an exam based student allocation system to a district system generated residential sorting and differential increases in residential land price in Seoul during the 1970s. The area of District 3 of Seoul in the early 1970s was one of the least desired residential areas at the fringe of Seoul. As can be seen in Table 5 column (4) District 3 had the lowest residential land price. However, the creation of school districts and the receipt of the most prestigious high school had made District 3 relatively more desirable than before and attracted higher income households. Initially, this could be conceived as a successful case of reducing inequality as higher income households moved to a relatively poor neighborhood equalizing residential land price across the city. Table 5 directly reflects such change by presenting the residential land price Gini coefficients within Seoul and within District 3 for the years 1971, 1973, 1975, and 1977. The Gini coefficient drops from 0.374 to 0.312 between 1973 and 1975 in Seoul and drops from 0.433 to 0.370 in District 3. The distribution of residential land price becomes less unequal with the creation of school districts. In a counterfactual setting where there were no school movements and high income households were already near the better schools, one could also think of cases where inequality would increase or not change much.

Nonetheless, the reduction in inequality is coming from the sudden rise in residential land price and that especially from the lower tail of the distribution. Table 6 describes the dynamics of residential land prices by district in Seoul. The first three columns represent how the change in log residential land price evolved over two year intervals between 1971 and 1977 across all districts. The change in log residential land prices for Seoul between 1973 and 1975 was 0.68, which is much larger than the numbers for the 1971 and 1973 change or the 1975 and 1977 change. The creation of school districts and the new valuation of education likely had a significant impact on the growth of residential land prices overall. One can also see that for the 1973 and 1975 change District 3 saw the largest increase confirming the findings from previous sections.

Columns (4) to (6) show the level of residential land prices by districts for 1973, 1975, and 1983. Residential land price for District 3 in 1973 was the lowest of all districts in Seoul but increased substantially becoming more comparable with other districts. Assessing the distributional impact of such change is difficult because of the difficulty to come up with a valid counterfactual experiment. However, the sudden increase in residential land price when school districts were created would likely have burdened low-income renter households, unless they were compensated with comparable wage increases in such a short period of time.

Furthermore, there is evidence of dynamic sorting and change in residential prices that would exacerbate such impact. As the sorting literature points out, families sort to neighborhoods with similar income levels which would further push District 3 residential prices up. The endogenous sorting does not stop with families. Appendix Table 1 shows that though Gyeonggi High School was the only school that the central government relocated to District 3, many other prestigious high schools from the UCD decided to relocate to neighborhoods in District 3 in the following years. When school boards of prestigious high schools were confronted with the decision to relocate out of the central business district, neighborhoods that showed persistently increasing income levels would likely have been more attractive compared to the other districts of Seoul. As Table 5 column (6) indicates, by 1983 residential land prices for District 3 became the highest in Seoul. In the second quarter of 2012, average apartment prices for Gangnam, an area of District 3, was 9.25 million KRW per square meter compared to 4.99 million won per square meter for Seoul overall.[7]

6. Conclusion

This paper provides evidence on one mechanism by which residential land price inequality can change, the creation of school districts. By examining the origins of high school districts in Seoul, I am able to provide direct evidence of sorting, which the literature has examined mostly through equilibrium outcomes. Furthermore, the sorting across districts breaks the equilibrium growth path of residential land prices in parts of the city, which can disproportionately burden low-income renter households.

Though this paper illustrates the impact of the creation of high school districts, given that middle schools and primary schools are all part of the school district system, income segmentation would naturally arise over the whole spectrum of primary and secondary education, further solidifying the stratification of school districts by income. Policy tends to focus on creating differential margins within the status quo institutional set up. As much as expanding school choice within a district based system is an option, the inherent inequality of residential land price continues to segregate the fundamental structure of cities.

[7] Source: KB bank's real estate information accessed at nland.kbstar.com.

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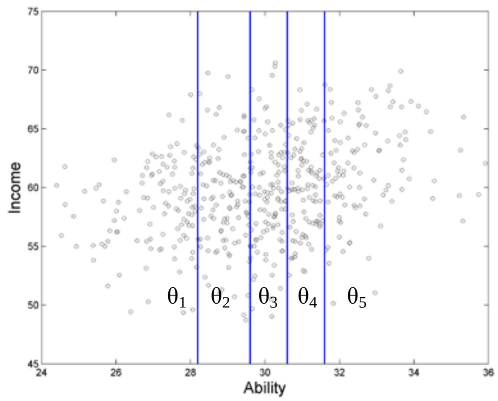
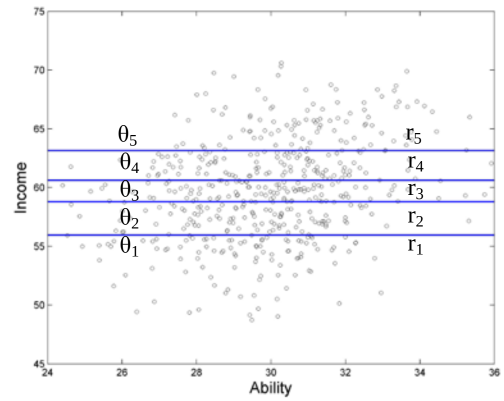
Figure 1. Equilibrium school allocation - Simulation results

I. Household to school allocation from the base model

A. Exam based selection

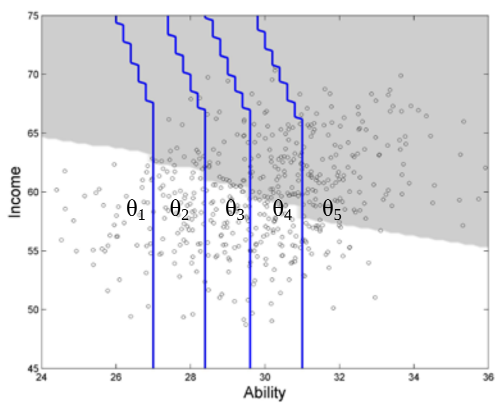


B. District assignment

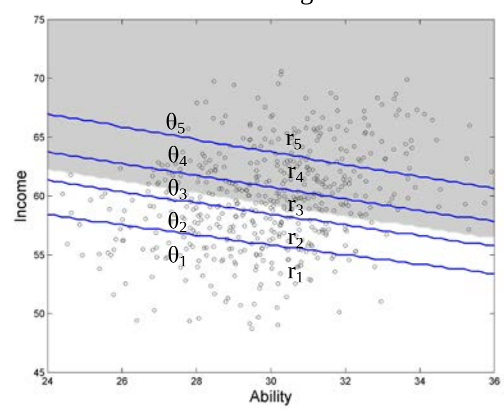


II. Household to school allocation from the extended model

C. Exam based selection

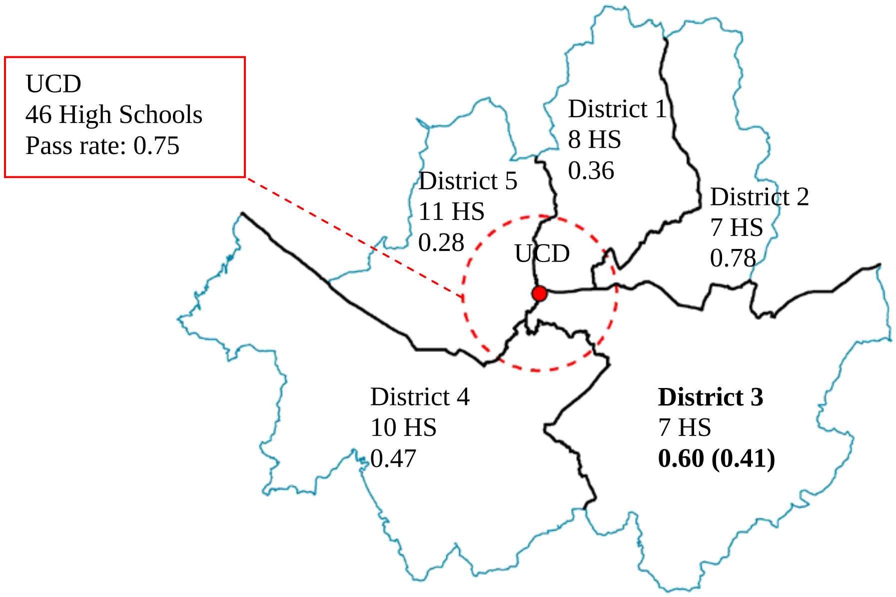


D. District assignment



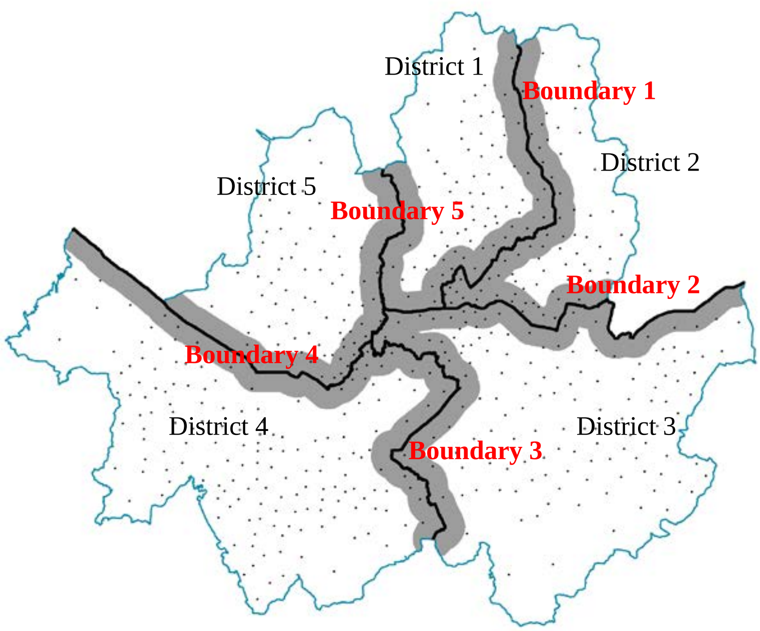
Notes: Each dot represents a household where the correlation between income and ability is 0.3. The solid line represents the stratification of households to schools. There is one school per neighborhood/district and each school is represented by school quality θ where $\theta_1 < \theta_2 < \theta_3 < \theta_4 < \theta_5$. Under exam based tracking all neighborhoods pay the same price for housing. Rent premium emerges under district assignment and $r_1 < r_2 < r_3 < r_4 < r_5$. The shaded area identifies the households that decide to tutor.

Figure 2. School Districts created in 1974



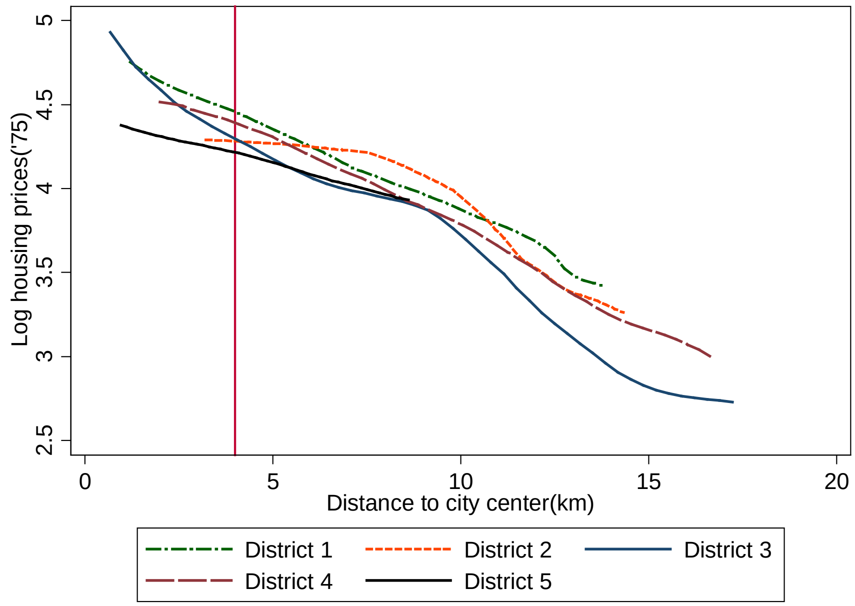
Note: The Unified Central District was formed as a 4km radius circle with the center at Gwanghwamun, indicated by the red dot. Under each district is listed the number of general high schools and the average pass rate in the college eligibility exam are listed.

Figure 3. Neighborhoods as unit of observation and school district boundaries



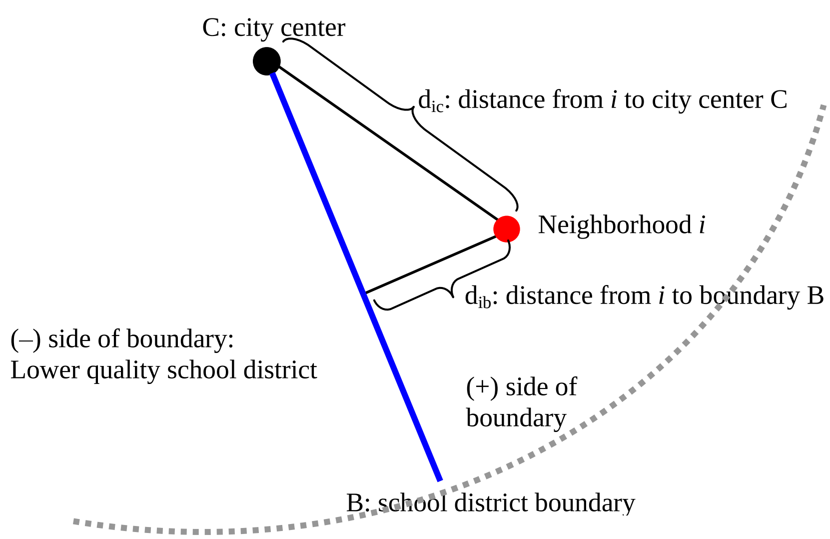
Note: Each dot indicates the geographic center of each neighborhood, the unit of analysis in the empirical work. The five boundaries across school districts are defined and labeled as in the above figure. The gray area illustrates the boundary sample where each neighborhood center is within 1km of each boundary.

Figure 4. Log residential land prices in 1975 by distance from the city center by district



Notes: Each line indicates a local linearized fit for each district using an Epanechnikov kernel with 2km bandwidths. The vertical red line identifies the 4km point, the boundary for the Unified Central District (UCD). There is an evident trend based on the distance to city center that follows a monocentric city model. The main point is that the spatial trend can be captured by distance.

Figure 5. Identifying neighborhood location based on distance from city center and distance from a school district boundary



Notes: Distance from each neighborhood to its relevant boundary is assigned a positive or negative number. For each boundary the plus side is defined to be the side with the better school quality.

Figure 6. The change in percent college educated between 1975 and 1980 by district and age group

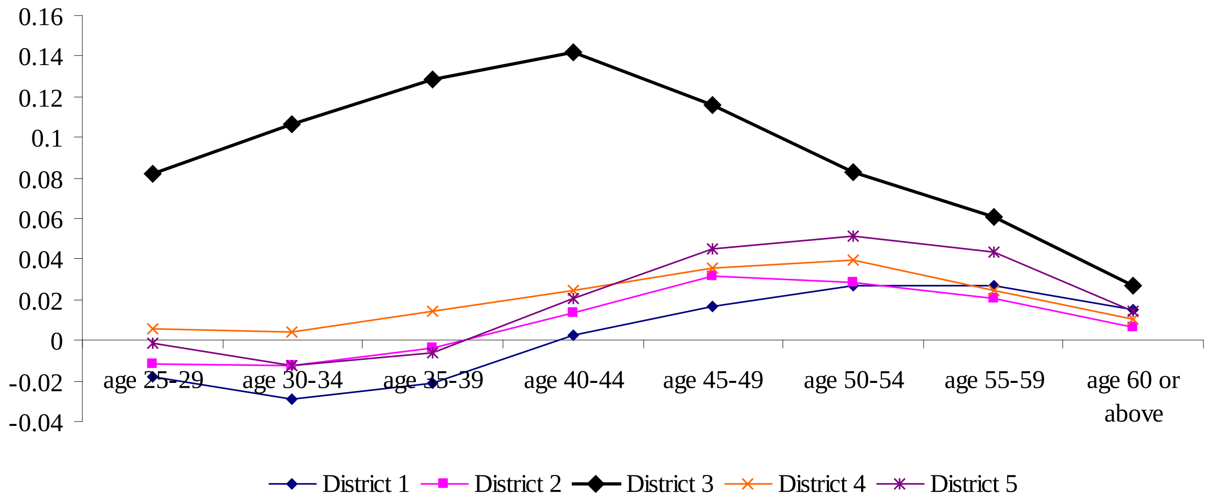
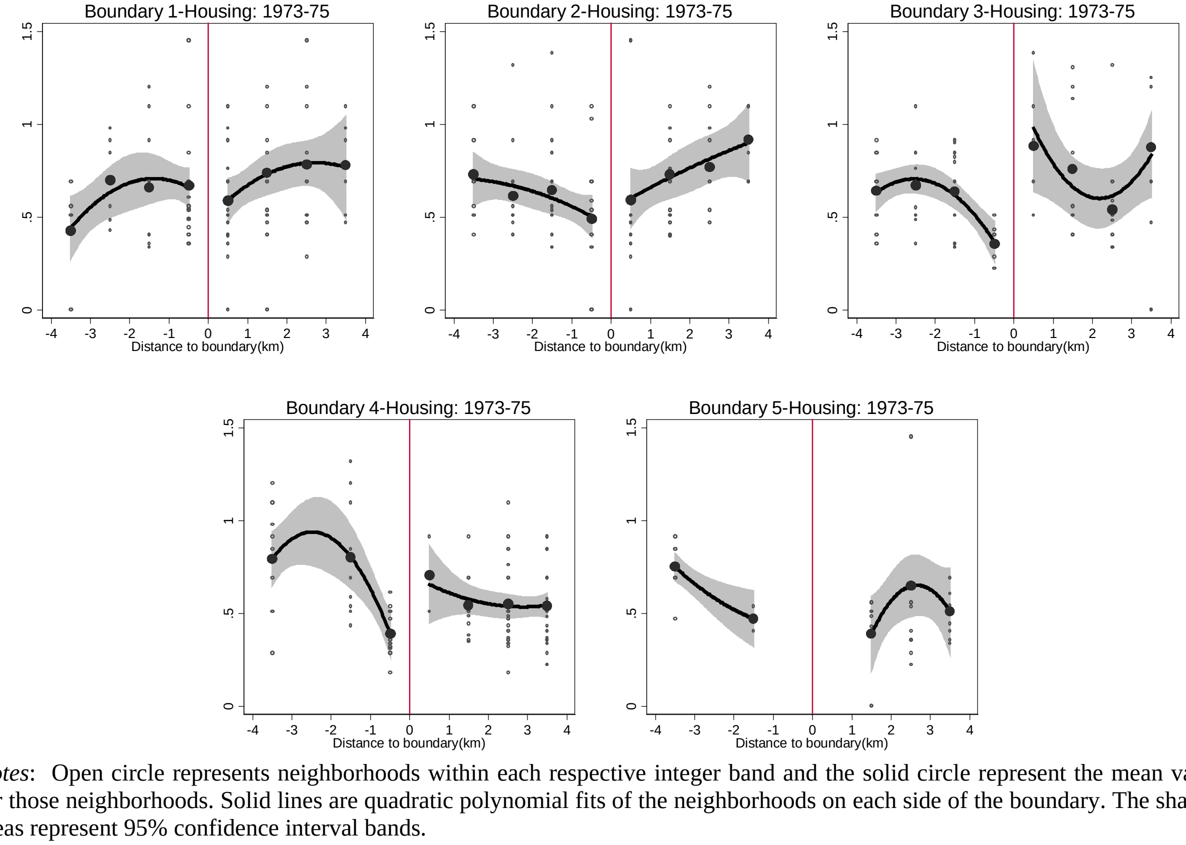
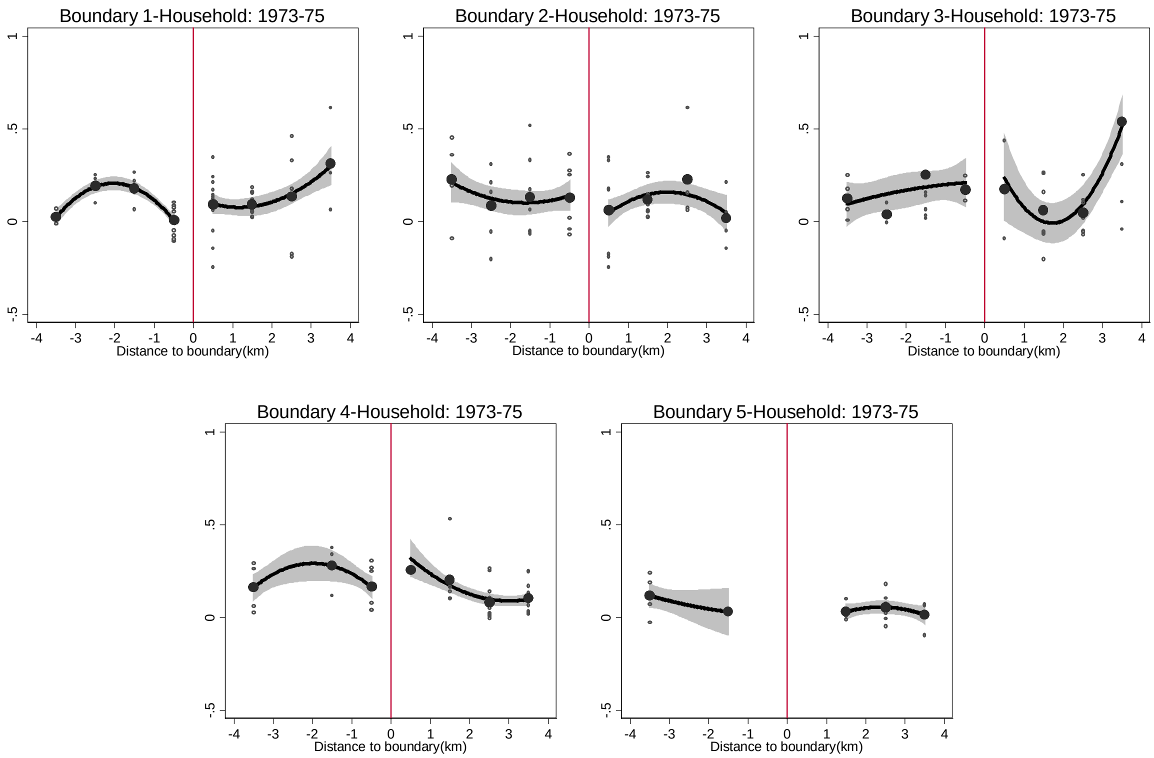


Figure 7. Change in log housing land prices across all boundaries outside the UCD between 1973 and 1975



Notes: Open circle represents neighborhoods within each respective integer band and the solid circle represent the mean value for those neighborhoods. Solid lines are quadratic polynomial fits of the neighborhoods on each side of the boundary. The shaded areas represent 95% confidence interval bands.

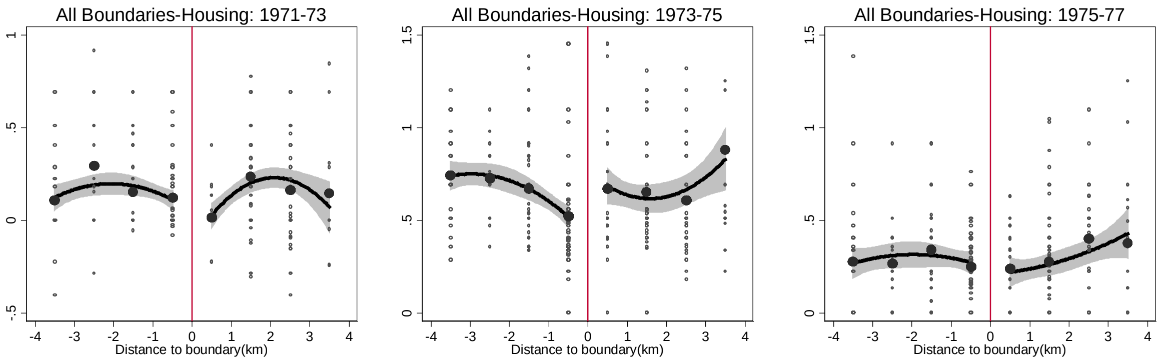
Figure 8. Change in log number of households across all boundaries outside the UCD between 1973 and 1975



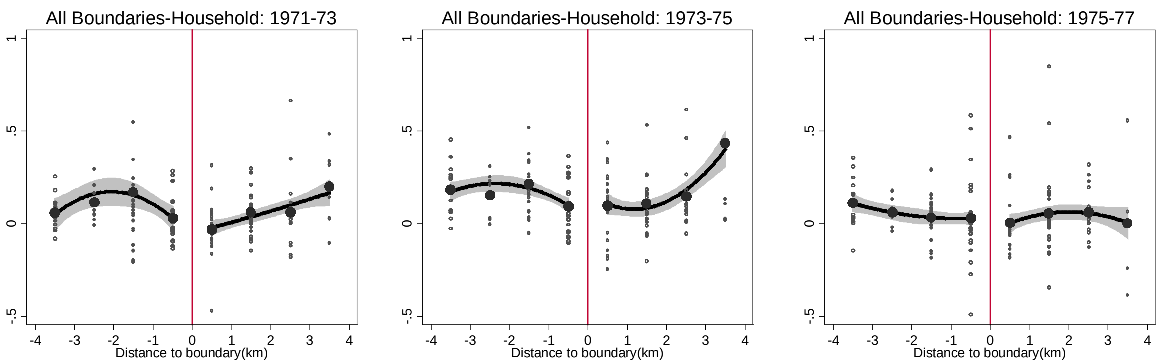
Notes: Open circle represents neighborhoods within each respective integer band and the solid circle represent the mean value for those neighborhoods. Solid lines are quadratic polynomial fits of the neighborhoods on each side of the boundary. The shaded areas represent 95% confidence interval bands.

Figure 9. Changes in housing land prices and number of households over time for all boundaries

A. Change in log housing land price



B. Change in log number of households



Notes: Open circle represents neighborhoods within each respective integer band and the solid circle represent the mean value for those neighborhoods. Solid lines are quadratic polynomial fits of the neighborhoods on each side of the boundary. The shaded areas represent 95% confidence interval bands. Make scale consistent.

Table 1. Summary Statistics

Variable	Mean	Std. Dev.
Change in log housing land price (1971-1973)	0.108	0.236
Change in log housing land price (1973-1975)	0.587	0.340
Change in log housing land price (1975-1977)	0.286	0.283
Change in log number of households (1971-1973)	0.052	0.216
Change in log number of households (1973-1975)	0.140	0.224
Change in log number of households (1975-1977)	0.035	0.206
Distance to nearest boundary (m)	1.853	1.762
Within 1km to nearest boundary	0.396	0.490
Within 2.5km to nearest boundary	0.771	0.420
Within 4km to nearest boundary	0.902	0.297
In District 1	0.154	0.361
In District 2	0.168	0.374
In District 3	0.198	0.399
In District 4	0.259	0.439
In District 5	0.221	0.415
In Unified Central District	0.267	0.443

Notes: Data is based on the Korea Land Appraisal Annals (1971-1977) and Seoul Statistics Annal for and summary statistics is for the base 656 observations.

Table 2. District level change in log residential land prices between 1973 and 1975

	Difference in difference estimates:	
Dependent variable:	Relative to District 1	Relative to all districts other than District 3
Change in log housing land prices	(1)	(2)
District 2	0.0869	
	(0.0594)	
District 3	0.150**	0.130**
	(0.0693)	(0.0617)
District 4	-0.0192	
	(0.0431)	
District 5	0.0301	
	(0.0501)	
Location quality dummies	Y	Y
Observations	656	656
R squared	0.058	0.047

Notes: Standard errors are clustered at the neighborhood level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 3. Neighborhood level boundary sample estimates

	Fitted trend across school district boundaries		
	Levels	Linear trend	Quadratic trend
Distance from boundary	1 km	2 km	4 km
	(1)	(2)	(3)
A. Change in log housing land price			
Boundary 1*Better district	-0.168	0.0709	-0.0439
	(0.134)	(0.100)	(0.110)
Boundary 2*Better district	-0.0300	0.0614	-0.0748
	(0.185)	(0.147)	(0.192)
Boundary 3*Better district	0.262**	0.429***	0.535**
	(0.123)	(0.163)	(0.260)
Boundary 4*Better district	-0.101	0.00276	0.100
	(0.137)	(0.119)	(0.115)
Boundary 5*Better district	-0.0659	-0.103	-0.309
	(0.217)	(0.144)	(0.220)
Location quality dummies	Y	Y	Y
Observations	260	455	592
R-squared	0.501	0.459	0.487
B. Change in log number of households			
Boundary 1*Better district	0.0245	0.0676	0.0887
	(0.175)	(0.0771)	(0.106)
Boundary 2*Better district	-0.0826	0.0199	0.109
	(0.224)	(0.176)	(0.217)
Boundary 3*Better district	-0.126	-0.370	-0.128
	(0.175)	(0.223)	(0.342)
Boundary 4*Better district	-0.0808	0.0115	0.0568
	(0.212)	(0.115)	(0.117)
Boundary 5*Better district	-0.0564	0.0746	0.240
	(0.194)	(0.180)	(0.220)
Observations	90	159	206
R-squared	0.251	0.317	0.505
C. Controls in Panels A and B			
Fifth order polynomial in the distance from city center	Y	Y	Y
Boundary dummies	Y	Y	Y
District*UCD dummies	Y	Y	Y

Notes: Functional forms are allowed to vary on each side of the boundary and for each boundary. Standard errors are clustered at the neighborhood level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 4. Boundary sample estimates over time – Quadratic trends and 4km boundary sample

Distance from boundary	1971 to 1973	1973 to 1975	1975 to 1977
	(1)	(2)	(3)
A. Change in log housing land price			
Boundary 1*Better district	-0.155	-0.0439	0.233*
	(0.122)	(0.110)	(0.138)
Boundary 2*Better district	-0.202	-0.0748	-0.0629
	(0.180)	(0.192)	(0.195)
Boundary 3*Better district	-0.209	0.535**	-0.198
	(0.167)	(0.260)	(0.187)
Boundary 4*Better district	0.0566	0.100	0.0438
	(0.0979)	(0.115)	(0.183)
Boundary 5*Better district	0.285	-0.309	0.687***
	(0.248)	(0.220)	(0.251)
Location quality dummies	Y	Y	Y
Observations	588	592	594
R-squared	0.276	0.487	0.342
B. Change in log number of households			
Boundary 1*Better district	-0.0881	0.0887	0.0289
	(0.0724)	(0.106)	(0.0668)
Boundary 2*Better district	-0.115	0.109	0.00922
	(0.174)	(0.217)	(0.167)
Boundary 3*Better district	0.306	-0.128	-0.295
	(0.200)	(0.342)	(0.335)
Boundary 4*Better district	0.0680	0.0568	-0.0254
	(0.148)	(0.117)	(0.157)
Boundary 5*Better district	-0.0212	0.240	-0.201
	(0.0786)	(0.220)	(0.166)
Observations	203	206	206
R-squared	0.288	0.505	0.253
C. Controls in Panels A and B			
Fifth order polynomial in the distance from city center	Y	Y	Y
Boundary dummies	Y	Y	Y
District*UCD dummies	Y	Y	Y

Notes: Functional forms are allowed to vary on each side of the boundary and for each boundary. Standard errors are clustered at the neighborhood level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 5. Residential land price Gini coefficient by year

	1971	1973	1975	1977
Seoul	0.387	0.374	0.316	0.312
District 3	0.452	0.433	0.370	0.375

Table 6. The dynamics of residential land price inequality

District	Change in log residential land price			Residential land price per square meter (10,000 KRW)		
	1971-1973 (1)	1973-1975 (2)	1975-1977 (3)	1973 (4)	1975 (5)	1983 (6)
1	0.20	0.63	0.29	38.7	67.4	118.9
2	0.14	0.72	0.18	38.2	70.0	122.7
3	0.18	0.81	0.24	24.7	48.8	132.2
4	0.03	0.58	0.47	34.1	57.3	133.9
5	0.07	0.70	0.16	32.9	61.2	117.6
Seoul	0.12	0.68	0.29	33.3	59.9	418.5

Appendix Table 1. The Location Change of the Top-tier High Schools in Seoul

High School	1974 District	Present Location as of 1974 District	Year of Move	Admission to Seoul National University in 1972		Admission to Seoul National University in 1980		Num. of CEO as of 2005 (rank)
				Number of students	Rank nationwide	Number of Students	Rank among district based schools in Seoul	
Public High Schools								
Gyeonggi High School	UCD	District 3	1976	333	1	59	1	221(1)
Seoul High School	UCD	District 3	1980	248	2	59	1	112(3)
Gyeongbok High School	UCD	UCD	no move	212	3	n/a		118(2)
Private High Schools								
Joongang High School	UCD	UCD	no move	n/a		n/a		58(9)
Baejae High School	UCD	District 3	1984	n/a		n/a		28(21)
Hweemun High School	UCD	District 3	1978	n/a		34	8	n/a
Bosung High School	UCD	UCD	1989	n/a		43	5	56(8)

Sources: Donga Daily 1972.02.07 and 1980.1.29 accessed via Naver's Digital News Archive at dna.naver.com. Location information retrieved from each high school's websites. CEO data from Keun Lee's "Evolution of the Firms in Korea since 1945, Vol. I," Seoul National University Press.

APPENDIX. MODEL WITH TUTORING CHOICE

I illustrate here a model that allows an additional choice variable, tutoring, where tutoring *x* directly impacts test scores and the price of tutoring is p. The set up is

$$U = (y + \delta t(x,a,\theta) - r - px) \cdot t(x,a,\theta)$$

$$t(x,a,\theta) = (x+k)^{\alpha} a^{\beta} \theta^{\gamma}\text{ , } 0<\delta,\ 0<\alpha<1,\ 0<\beta<1,\ 0<\gamma<1$$

which satisfies both single crossing in income and ability. Note that I allow intergenerational contracting in the model, in the sense that households can borrow against child's achievement. This illustrates a general feature often observed in developing countries where grown children support the old parents. The model is not explicitly solvable, so I graphically illustrate the equilibrium properties by simulation. I draw 500 households from a joint normal distribution with a correlation of 0.3 in the (*y*, *a*) space and simulate equilibrium where there are five schools each comprising a neighborhood or school district.

Households solve:

$$\max_{x} (y + \delta(x+k)^{\alpha} a^{\beta} \theta^{\gamma} - r - px)(x+k)^{\alpha} a^{\beta} \theta^{\gamma}, \quad s.t.\ x \geq 0.$$

All households have the same base level of home input, *k*, and can choose the corner solution of no tutoring, *x*=0. The Kuhn-Tucker conditions give the general condition when households will decide to provide tutoring:

$$x^* > 0 \text{ if } y > pk - 2\alpha\delta k^{\alpha} a^{\beta} \theta^{\gamma} + r.$$

This implies that households with higher income *y*, ability *a*, or school quality θ will more likely choose to tutor. The underlying reason is the intergenerational contracting that makes consumption, both of the numeraire good *c* and tutoring *x*, increase with achievement. Given that income, ability, and school quality increase achievement, tutoring will also increase correspondingly. At an interior solution the first and second order properties along with the implicit function theorem, indicates that the amount of tutoring will increase monotonically with income, ability, and school quality in the above parametric model.

To solve the model, I set $\alpha = 0.3,\ \beta = 0.7,\ \gamma = 0.5,\ \delta_m = 0.1,\ \delta = 0.13,\ k = 10.5,\ p = 2$. School quality θ increases by 10% for each better school with the lowest starting at 10. Figures (a) and (b) depict how households are matched to school quality and their tutoring decisions under each regime. There is one school per neighborhood/district and each school is represented by school quality θ where $\theta_1 < \theta_2 < \theta_3 < \theta_4 < \theta_5$. Under tracking all neighborhoods pay the same price for housing. Rent premium emerges under the district regime and $r_1<r_2<r_3<r_4<r_5$. The solid lines in Figures 1C and 1D represent the stratification of households to schools. The shaded region indicates households that choose tutoring amount greater than zero. Any reasonable or even extreme parameter specifications still support that district equilibrium results in a higher income gradient than exam equilibrium. The underlying reason is because tutoring choice does not change much between the two regimes but the added component of the housing under a district regime is largely driven by income.