



A study on the benefit incidence of a place-based education fee reduction program: Evidence from a local housing market in China

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ABSTRACT

This paper studies an Education Fee Reduction and Exemption Program for preschool childcare in Jinan, China, to explore the benefit incidence among different stakeholders by observing how housing prices and rents change in response to this program and by employing a method of difference-in-differences combined with boundary discontinuity. The empirical findings indicate that the housing prices in the experimental area rose by 5–7 percent while the rents rose by 10–13 percent due to the capitalization effects of this equalization program. Falsification tests are conducted using artificial boundaries and fake policy implementation dates. A back-of-the-envelope welfare analysis demonstrates that a considerable portion of the program's benefits is offset by house price increases for new home buyers and rent increases for tenants, with significant distributional implications for different stakeholders.

1. Introduction

With the rapid industrialization and urbanization in developing economies, a substantial number of people migrate from rural to urban areas. As per the national census in China, the internal migrant population increased from 221 million in 2010 to 375 million in 2020, with a significant proportion being rural workers living in rented accommodations. These immigrants usually have less chance to obtain local Hukou (household registration)¹ and do not have equal opportunities to

access public services as local urban residents or homeowners, which has been the source of inequality and has been widely criticized by scholars and observers. To narrow the welfare gap among different social groups, on the one hand, China's central government has initiated a series of top-down reform programs, including earmarked transfers to local governments in areas with large population influxes. On the other hand, bottom-up policy experiments from grassroots governments have played a crucial role in addressing these disparities. Various localized inclusive social programs have been proposed and implemented at the

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¹ Hukou, also known as household registration, refers to the legal documents issued by the national household administration department to record and retain the basic information of households, as well as the identity certificate of each citizen. For a long time, hukou has been closely linked to the local public services available to residents, and it is only after obtaining a local hukou that migrants can enjoy the same public services as locals. Buying a house is usually one of the prerequisites for applying for a local hukou in large cities, especially in the case studied here. Recently, China has been working to change its urban public service delivery system by attempting to break the link between access to public services and Hukou, and to relax the home purchase requirement in the household registration application. However, this change has also faced significant difficulties.

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local level. Evaluating these experiments is essential for promoting more effective reforms and understanding the differential impacts on related stakeholders, such as homeowners, tenants, and local governments. This paper studies a bottom-up policy experiment, the preschool Education Fee Reduction & Exemption Program (R&E program hereafter), launched by Lixia District, Jinan City, in February 2014. The study aims to analyze the program's impact on different social groups, including incumbent homeowners, new home buyers, and tenants. Specifically, we focus on the distributional effects of the R&E program by observing the response of housing prices and rents to the policy implementation.

The R&E program is particularly relevant to our research, as access to public services, including education and social welfare in China, is frequently linked to homeownership or Hukou status. A unique aspect of this program is that eligibility is based solely on permanent residence within Lixia District, regardless of an individual's local Hukou or homeownership status. Consequently, this inclusive approach extends the program's benefits to a broader demographic, including renters and non-local Hukou holders. Meanwhile, the program is only implemented in Lixia District, Jinan, and no similar programs have been launched simultaneously in the surrounding areas of the district, which provides an opportunity to identify the program's effects.

In line with Black (1999), Bayer et al. (2007), and subsequent literature utilizing the boundary analysis method (Dhar and Ross, 2012; Gibbons et al., 2013), our empirical strategy employs a causal identification through the comparison of home sales data located within 500m and 750m buffer zones on either side of the administrative border of the Lixia District. The treatment group comprises observations within the Lixia boundary, while the control group comprises observations outside. We employ a hedonic difference-in-differences (DID) design, using second-hand house transaction and rental data along the border of the Lixia District around the time of the introduction of the R&E program. Incorporating the DID model with border analysis helps strengthen the parallel pre-trend assumption.

Our findings indicate an approximate 5 to 7 percent increase in housing prices, and a roughly 10 to 13 percent increase in rents in the program-eligible area compared to the non-eligible area. The results suggest that incumbent homeowners can enjoy the benefits of the R&E program and the appreciation of housing value, while tenants have to pay higher rent to access the R&E program. In other words, implementing equal opportunity-oriented social programs, such as the R&E program, may lead to income redistribution effects that favor incumbent homeowners rather than tenants due to the capitalization effect of incremental improvements in public services. We then propose two novel placebo tests to validate the capitalization effect of the R&E program. The first placebo test creates a fake Lixia administrative boundary by moving the actual Lixia boundary 10 km northwestward on the map and then resampling data to replicate the previous empirical test. The second placebo test is conducted by creating a fake policy implementation date. Both placebo tests fail to find significant policy effects on housing prices and rents, which further confirms that the implementation of the R&E program causes the empirical results above.

The heterogeneity analysis in housing sizes yields further findings. We find a significant increase in the price of larger homes, while smaller homes did not experience the same increase. Additionally, rents for smaller homes increased significantly, whereas rents for larger homes did not. These results deepen the understanding of the effects of income redistribution generated by the R&E program.

This paper is related to the economics of place-based public policy (Glaeser and Gottlieb, 2008; Kline and Moretti, 2014; Neumark and

Simpson, 2015). Though a large body of literature has studied the economic effects of enterprise or economic zone programs,² there is less research on place-based social programs. Several research papers related to our study deserve to be discussed in depth. LeGower and Walsh (2017) used 21 education programs and a difference-in-differences method to study the impact of scholarships on public school enrollments and housing prices in and around areas where Promise Programs were launched. They found that the Promise Programs substantially impacted the high-quality school districts and areas where housing prices are at a medium or high level. Sohn et al. (2017) studied the effect of the Say Yes to Education program launched in Syracuse and Buffalo, New York. The results showed that as enrollment in public schools increased in Syracuse, enrollment in the suburbs decreased. Meanwhile, there was an increase in housing prices in Syracuse and a decline in the suburbs. In contrast, the rise in public school enrolments in Buffalo was accompanied by a decrease in private school enrolments, while housing prices in Buffalo remained relatively stable. Bartik and Sotherland (2015) used data from the US Community Survey to estimate the average effect of eight Promise Programs on population migration and local housing markets. They found that these Promise Programs effectively reduced the outflow of local populations but did not draw a definitive conclusion on the impact of Promise Programs on housing prices. Miller (2018) used a difference-in-differences strategy to study the effects of the Kalamazoo Promise and found that Kalamazoo's housing prices did not seem to be affected by the program. The studies mentioned above are from developed countries. In this study, we present evidence from a city in China experiencing rapid urbanization of the migrant agricultural population. Moreover, our focus goes beyond the changes in enrollment and house prices by exploring the distributional effect of the R&E program and its benefits among various social groups, i.e., the benefit incidence of the R&E program and the wealth redistribution effects among different social groups.³

This paper also expands on the literature on China's Hukou system reforms, which has demonstrated a significant disparity in access to local public services and economic opportunities in urban China between local urban Hukou holders and non-Hukou migrants (e.g., Liu, 2005; Lu and Song, 2006; Whalley and Zhang, 2007; Afridi et al., 2015). Recently, Hukou control has been gradually relaxed in urban areas, reducing this disparity (Bosker et al., 2012). However, few empirical studies have systematically assessed the actual incidence or distributional effect of these Hukou-related reforms, making this paper valuable to the existing literature.

The remainder of the paper is organized as follows. Section 2 briefly introduces the background of the R&E program, describing the data and the empirical methodology used to estimate the impact of the R&E program on housing prices and rents. Sections 3 and 4 present the main results on housing prices and rents, respectively. Section 5 conducts falsification tests. Heterogeneity analysis in housing size is reported in section 6. Some possible concerns about the spillover effect and household sorting are discussed in section 7. The theoretical and policy implications of the findings are further explored in Section 8. Finally, section 9 concludes the paper.

2. Policy background, data, and methodology

Before discussing the empirical methodology, we briefly describe the

² For example, Neumark and Kolko (2010) studied the employment effect of California's enterprise zone program. Gobillon et al. (2012) evaluated the French enterprise zone program initiated in 1997, which aimed at helping unemployed workers find jobs. Busso et al. (2013) evaluated Round I of the federal urban Empowerment Zone (EZ) program in the United States.

³ Hilber (2017) synthesizes the recent literature exploring the conditions under which public and private investments and intergovernmental transfers are capitalized into local house prices and the economic implications of such capitalization.

context of the R&E program.

In the 21st century, with the progress of urbanization in China, the shortage of public kindergartens and the high expenses associated with private kindergartens in urban areas have become significant societal issues. As a response, the State Council of China and the Shandong Province Government have enforced policies to strengthen the inclusive nature of preschool education, with a focus on fulfilling governmental obligations through enhanced public investment.⁴

In order to implement the central and provincial preschool education development plan, Jinan City formulated its first three-year action plan for preschool education (2011–2013). According to the action plan, Jinan would build more kindergartens for the public and propose establishing a financing system for preschool education, including public financial support and government subsidies. In addition, the funds required for preschool education will be included in the fiscal budget, and new education funds will be allocated to preschool education as a priority. The first action plan had achieved the goal of building more kindergartens, but the expensive kindergarten admission fee was still a concern to households even after the kindergartens were built. To address this concern, the Lixia District government first introduced a proposal in October 2013 to reduce and exempt early childhood education fees. Following a three-month survey, the government officially issued the Implementation Rules on Reducing and Exempting Early Childhood Education Fees for students in the Lixia District in February 2014.⁵

As per the program's regulations, the Lixia fiscal authority allocates 100 million yuan each year to subsidize or lower fees for eligible families. Referred to as the *Lixia Reduction & Exemption* program, this initiative has sparked widespread discussion among Jinan City residents, particularly among households with young children, as it alleviates their financial strain on education expenses. Prior to commencing the formal economic analysis, we are concerned with two aspects of the R&E program: the eligibility criteria for applicants and the structure of the fee reduction program.

Regarding eligibility, three major types of applicants are eligible to apply for the R&E program.

- (1) Direct descendants (children or grandchildren) of Lixia Hukou holders who reside in their own Lixia property.
- (2) Direct descendants (children or grandchildren) of non-Lixia Hukou holders who own and have resided in a Lixia property for at least two years.
- (3) Direct descendants (children only) of individuals without a Lixia Hukou who have rented and worked in Lixia for a minimum of two years.

From the above requirements, we can see that the R&E program adheres to the principle of residence, which makes it different from most

cases in China, where residents are usually required to have a local Hukou to access urban public services.

Regarding the fee reduction structure, all preschoolers enrolled in state-owned or private kindergartens are exempt from their three-year preschool education fees based on the ranking of each kindergarten. Specifically, the fee reduction per child per month is 460 yuan for provincial top-10 kindergartens, 440 yuan for municipal top-10 kindergartens, 400 yuan for provincial demonstration kindergartens, and 300 yuan, 260 yuan, and 200 yuan for municipal first-tier, second-tier, and third-tier kindergartens, respectively.

According to the data from 2014, each eligible child could apply for a fee reduction twice a year, and the annual educational subsidy was between 3 and 6 thousand yuan. The application deadline is in February for the Spring semester and August for the Fall semester. In February 2014, this fee reduction policy benefited 15,419 children from 81 kindergartens. In August 2014, an additional 5481 children enjoyed the fee reduction, and this policy also covered three more kindergartens. In August 2015 and August 2016, 6937 and 7440 children were approved for the R&E program, respectively. In 2019, the program covered 27,183 students, with a total fee reduction of 150 million yuan.⁶ However, a few applicants who had Lixia Hukou were rejected because they neither lived in nor had a house in Lixia District when they applied for the R&E Program.⁷

Next, we focus on the empirical methodology. We use the hedonic price model as the benchmark to estimate residents' marginal willingness to pay. This model regresses housing prices on a number of possible factors or characteristics that would affect housing prices, including the R&E program. We first construct a basic difference-in-differences (DID) model with the implementation time of the R&E program as the breakpoint. We then compare housing price changes inside the Lixia District boundary with those outside. Houses inside the Lixia District administrative boundary constitute the treatment group, and houses outside the boundary belong to the control group. The treatment effect along the administrative boundary is explored by combining a boundary discontinuity (BD) design with the DID setting. The BD-DID analysis provides further control over the differences in time-invariant location characteristics in areas around the administrative boundary.

The DID model does not require the treatment and control groups to be identical in their characteristics, but it relies on the assumption of parallel pre-trends. In the absence of treatment, both groups should show similar trends over time, maintaining any pre-existing differences unchanged. Precisely testing the assumption of parallel trends is challenging; however, our methodology in this study, which involves sampling from the buffer zones on each side of the administrative boundary, enhances the likelihood of meeting this assumption.

As for the data, we use second-hand housing transaction data to test the capitalization effect of the R&E program. The data are collected from the domestic large-scale real estate trading platform www.fang.com, covering the period from February 2012 to December 2015. We organize the data into a quarterly repeated cross-sectional dataset containing 15,780 valid observations after data cleaning. The dataset includes various property transaction information, such as price, building areas,

⁴ China's National Plan for Medium and Long-term Education Reform and Development (2010–2020) states that educational equity is an essential foundation for social equity, and that promoting educational equity is a fundamental policy of the State. Preschool education plays an essential role in the national education system and is of great significance in young children's physical and mental health, habit formation, and intellectual development. However, the shortage of public kindergartens and the high prices of private kindergartens in urban areas have been social issues of concern since the 21st century as urbanization progresses. To address this issue, the State Council issued the Opinions on the Current Development of Preschool Education ([2010] No. 41), followed by the General Office of the People's Government of Shandong Province issuing the Notice on the Preparation of a Three-Year Action Plan for Preschool Education ([2011] No. 7). These policies aim to strengthen preschool education's public and inclusive nature, focusing on fulfilling government responsibilities through increased public investment.

⁵ For further information on the childcare market in Jinan, including the financing sources and admission rules, please see Appendix I.

⁶ Relevant data were collected from <http://www.lixia.gov.cn/>.

⁷ An important reason for this situation is that the Jinan High-tech Zone, which is adjacent to Lixia District, is not an independent administrative division. Therefore, the residents of the high-tech zone would not have the high-tech zone Hukou but would have Hukou in other districts. Bounded by Jing-shi Road, the residential area in the northern High-tech Zone belongs to Lixia District, and the residential area in the southern High-tech Zone belongs to Licheng District. Therefore, there have been cases where people have Lixia Hukou but live in the High-tech Zone. For related information, please refer to "Jinan Lixia District Education Bureau to answer the question of why it is difficult to enjoy the subsidy with the Lixia Hukou", <http://www.sdchild.com/news/xwsd/2014-03-10/36591.html>.

layout, age of the house, floor number, orientation, and location of each house. Furthermore, the dataset also includes community characteristics corresponding to each house, such as the floor area ratio and green plot ratio.

The baseline model is specified as follows:

$$Price_{imt} = \alpha + Q_t + D_m + \beta(Post \cdot Treat)_{imt} + X'_{im} \gamma + \pi_m Trend_m + \varepsilon_{imt} \quad (1)$$

where $Price_{imt}$ represents the housing price or the natural logarithm of the housing price for property i in district m at time t (quarterly). $Post$ is a policy indicator that shows whether the R&E program has been implemented. Before launching the R&E program, i.e., before February 2014, $Post = 0$; after February 2014, i.e., after implementing the R&E program, $Post = 1$. $Treat$ is an indicator variable used to distinguish treatment and control groups. Specifically, $Treat = 1$ if a property is in Lixia District and $Treat = 0$ if a property is in other districts. X_{im} stands for all other community and housing characteristics, including housing age, layout, floor number, orientation, location of the house, the floor area ratio and green plot ratio, etc.⁸ Q_t stands for the quarterly fixed effects. $Trend_m$ denotes the district or neighborhood-specific time trends. We assume that different geographic units (neighborhoods) have different trends in housing prices. Therefore, we could use $Trend_m$ to control for the heterogeneous time trends among neighborhoods to a certain degree. D_m stands for the administrative district where the property is located and can be used to reflect the regional effects on housing prices. ε_{imt} is the random error term clustered at the administrative districts or neighborhoods. In other words, the random error terms within the same administrative district (neighborhood) are allowed to be correlated. The coefficient β on the interaction term $Post \cdot Treat$ is then the causal effect of the R&E program on housing prices or rents.

Based on the above design, we employ the BD-DID strategy to create an artificial local random experiment. Along the administrative boundary of Lixia District, a buffer zone is created by setting 750 or 500 m as the buffer distance on both sides of the administrative boundary. The houses in the buffer zone inside the Lixia District boundary belong to the treatment group, while those outside the boundary belong to the control group (see Fig. 1). Since the two groups are geographically close, the unobservable neighborhood features affecting housing prices are similar, and the issue of omitted variables in the design of the estimation strategy is less of a concern.

Departing from the boundary fixed effects model (Black, 1999) using segmented borders as the dummy variables, our model creates dummy variables for geographically adjacent houses by the following two methods. The first method uses GIS software to divide a specific area into multiple identical geographical units (fishnets) in which houses are geographically adjacent. The second method uses the zip code of each residence as the dummy variable to capture the neighborhood fixed effects. Specifically, we set up local random experiments by drawing observations from the adjacent area on both sides along the boundary of Lixia District. As in Eq. (2), we replace the administrative district variable in Eq. (1) with the neighborhood dummy variable NF, where NF represents zip codes or fishnets.⁹

$$Price_{imt} = \alpha + Q_t + NF_n + \beta(Post \cdot Treat)_{imt} + X'_{im} \gamma + \pi_m Trend_m + \varepsilon_{imt} \quad (2)$$

Regarding creating fishnets, since this paper employs a boundary difference-in-differences strategy using the sample drawn from both sides of the Lixia border, we create 10#10 fishnets using Lixia District's border as the framework, and the size of each grid is about 1 square kilometer. This method ensures that a local random experiment is conducted along the district boundary. Fig. 2 demonstrates a graph of the fishnets, where the green line represents the Lixia boundary, the small purple dots represent the location of the houses, and the gray square represents the fishnet.

One thing worth noting when using postcodes as the dummy variable is that the same postal district may straddle two or three administrative districts. We looked up the postcodes of Jinan City on the China Postcode Database website¹⁰ and found that many zip codes may straddle multiple administrative regions. Taking postcode 250012 as an example, we can find that Lixia, Shizhong, and Tianqiao Districts share the same postcode at the junction. Another example is postcode 250014, where several streets on the border straddle both the Lixia and Licheng Districts. The above evidence demonstrates that a postal district straddling the administrative boundaries of Lixia District may contain observations from both the control and the treatment groups.

Fig. 3 shows the quarterly average price of second-hand housing transactions before and after implementing the R&E program. The 0 point on the horizontal axis indicates the R&E program's starting time, i.e., the first Quarter of 2014. As shown in Fig. 3, the quarterly average price of second-hand housing transactions had similar trends in the treatment group (houses in Lixia District) and the control group (houses in other districts) in 2013. However, after implementing the R&E program, the average transaction price diverged sharply between the treatment and control groups.

Finally, we present the statistics of the variables in Appendix Table 1. Concerning data availability and other possible unobservable impacts on data over time, we report the mean and mean difference of the variables, covering the time horizon from one year before, i.e., the year 2013, to six months after the R&E program was introduced. The upper panel in Appendix Table 1 reports the summary statistics of the transaction data incurred before the policy implementation. The data include samples from the control and treatment groups in the whole area, the 750-m buffer zone, and the 500-m buffer zone. We can see that in the buffer zones on both sides of the boundary, most variables do not show significant differences in the means between the treatment and control groups, although the difference in means test is not a prerequisite of employing the DID strategy. The lower panel in Appendix Table 1 reports the summary statistics of the transaction data incurred after implementing the R&E program.

3. Capitalization of the R&E program on housing prices

Based on Eq. (1), we first use the whole regional data of Jinan City from the first Quarter of 2013¹¹ to the fourth Quarter of 2015 to examine the policy effects of the R&E program. The dependent variable is the logarithm of the transaction price or the transaction price of the second-hand houses. The coefficient for the interaction term in the DID model is of most interest. Columns (1) and (2) in Table 1 show the empirical results using the second-hand housing price as the dependent variable. When housing and community characteristics are not controlled, the average second-hand housing price in Lixia District is statistically significantly higher by 738 yuan compared to other districts as a result

⁸ There are some missing values for the green plot ratio and floor area ratio. We use two methods to fill them up. One obtains supplementary information from other real estate platforms (such as Anjuke, Jinan Real Estate Network). The other uses the Google Earth image map to estimate the community's green plot ratio and the building's height to calculate the reasonable floor area ratio. Due to the enormous amount of manual entry, we only filled in those missing values in the buffer area. However, there might be errors in this supplementary information. For this reason, we also reported the regression analysis results without covariates as a comparison in the subsequent empirical analysis.

⁹ The definition of a neighborhood varies according to the model specifications. In the analysis of the neighborhood effect in the same postcode area, the postcode denotes a neighborhood-fixed effect. In the analysis of using a 10 by 10 fishnet as a neighborhood, the neighborhood effect is defined by a fishnet.

¹⁰ The China Postcode Database website, <https://www.youbianku.com/>.

¹¹ There are only a few observations in 2012 in the dataset we collected, so we use the data from 2013 to 2015 for the regression.

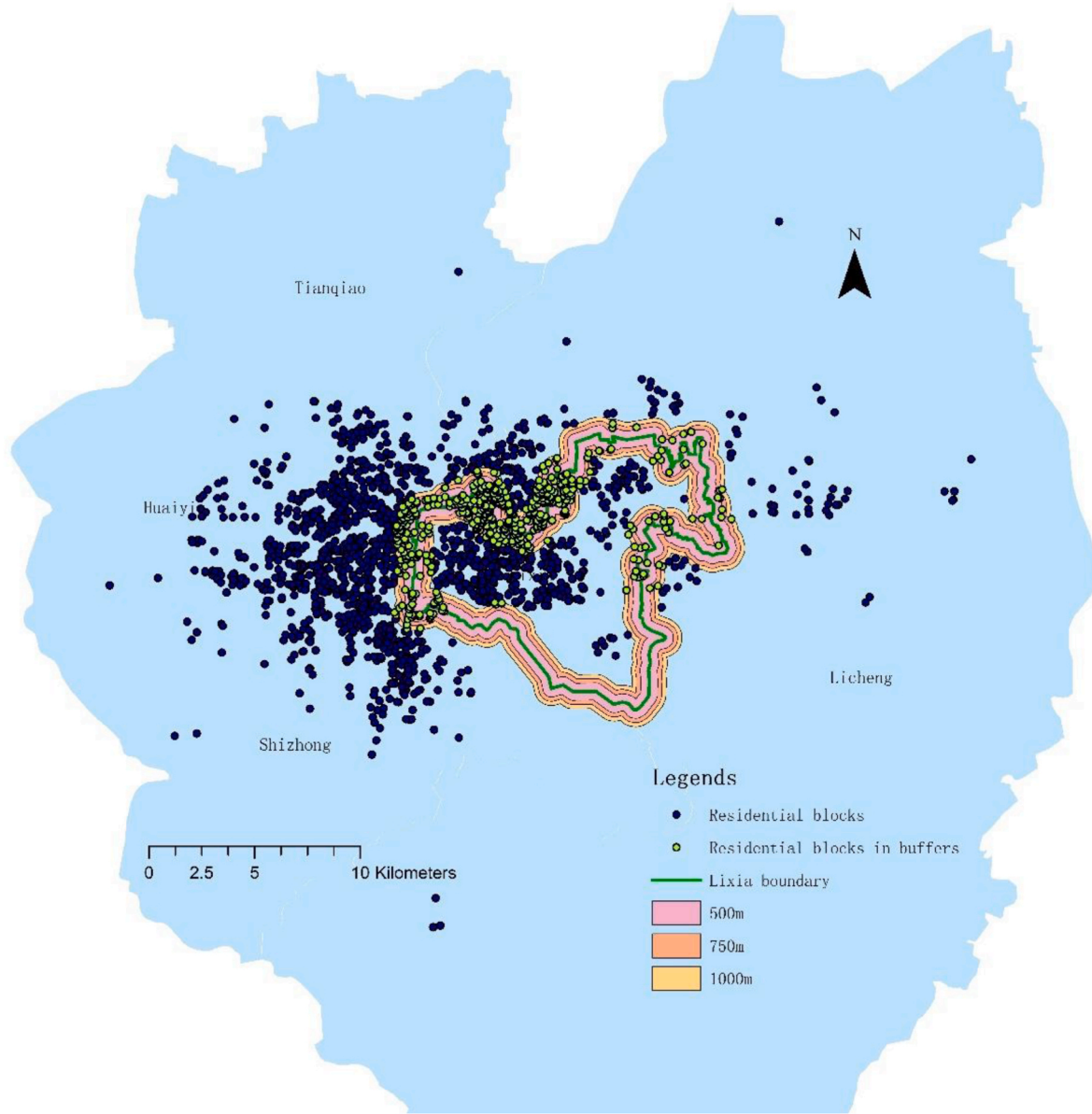


Fig. 1. Buffers (750m and 500m) along the Lixia administrative boundary.

of the implementation of the R&E program at a significance level of 0.01. In contrast, when housing and community characteristics, time fixed-effects, jurisdiction fixed-effects, and district or area-specific time trends are controlled, the second-hand housing price in Lixia District is 698 yuan higher than that in other districts on average due to the implementation of the R&E program, which is statistically significant at the significance level of 0.01. Columns (3) and (4) in Table 1 show the empirical results of using the logarithm of the second-hand housing price as the dependent variable. We find that the R&E program leads to

an increase in housing prices by 5–6 percent. However, since the second-hand houses in the entire regional sample are situated across multiple urban areas in Jinan City, precise control of all the unobservable housing and neighborhood characteristics of these properties poses a challenge.

Then, we conduct regression analysis based on Eq. (2) using second-hand housing transaction records on both sides of the Lixia administrative boundary, as illustrated in Fig. 1.¹² Table 2 presents the capitalization effects of the R&E program within the 750-m and 500-m buffer zones, with postcode acting as a dummy variable for

¹² Since we cannot obtain the distance from each house to the border of the administrative area, we use the community where the house is located for positioning. Because the school district may significantly impact housing prices, we also report the empirical results that control the quality of the school district. Identifying the school district for each house i is time-consuming, so we only define the school districts for the homes within the 750-m and 500-m buffer zones. The quality of the school district is defined by whether the primary school is the key school at the city level or district level. If it is, the quality of the school district is 1; otherwise, it is 0.

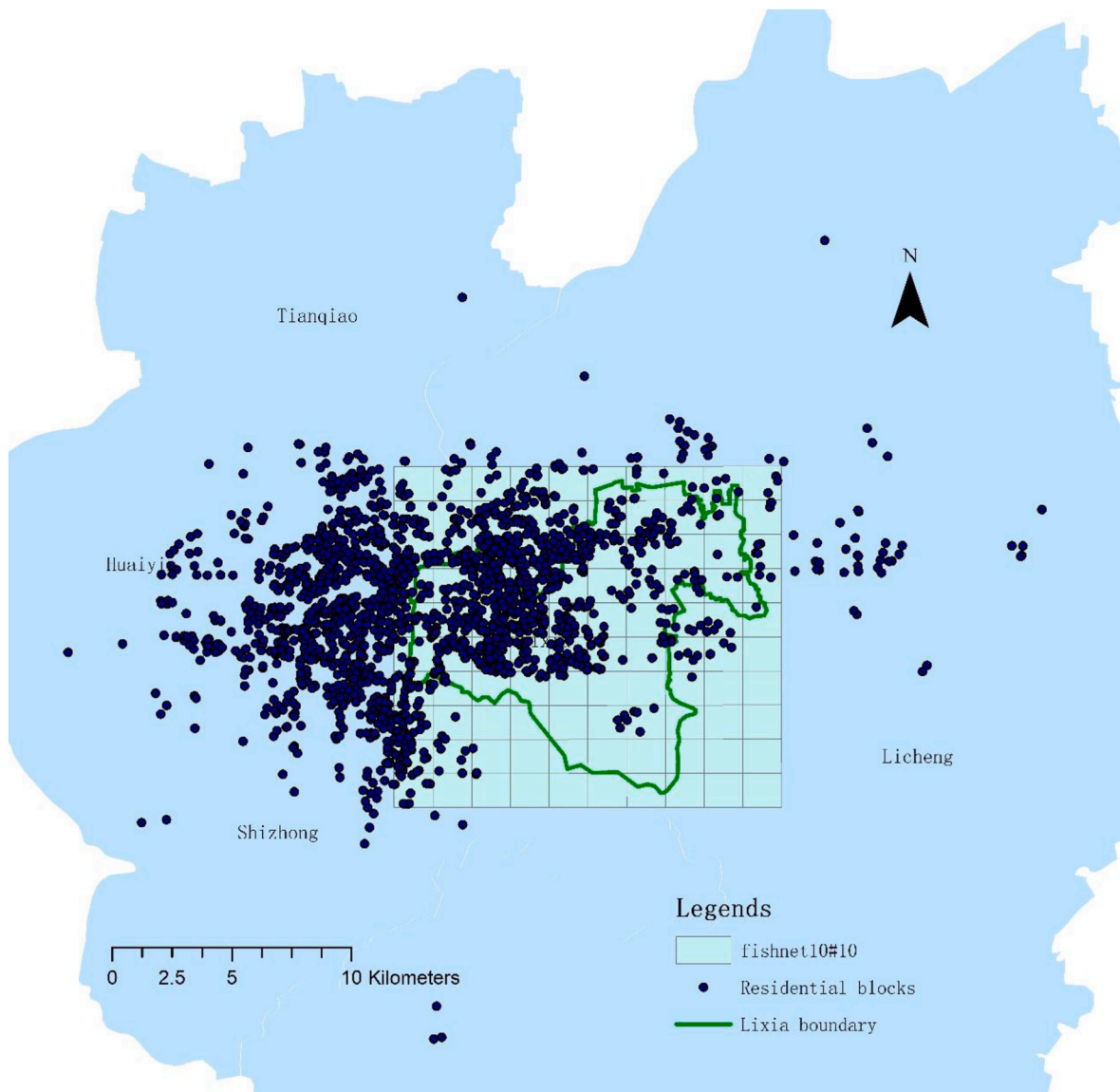


Fig. 2. 10#10 fishnets framed by the border of the Lixia District

Notes: 100 fishnets are created by ArcGIS along the border of Lixia District, and the area of each grid is about 1 square km.

neighborhood fixed effects. The regression results presented in columns (1) to (8) show that, despite adjusting for housing characteristics, community attributes, and school quality, the policy increases second-hand housing prices in Lixia District by 5%–8% compared to other districts.

We then use GIS software to construct 10*10 fishnets based on the boundary of Lixia District. Each fishnet grid corresponds to a neighborhood dummy variable. Table 3 reports the regression results of using the fishnet to identify the neighborhood fixed effects. The results show that within both the 750 and 500-m buffer zones, the impacts of the R&E program on housing prices are statistically significant, at least at the significant level of 0.1. The R&E program has increased second-hand housing prices in Lixia District by approximately 5–7 percent. The results are robust regardless of whether housing characteristics, neighborhood characteristics, and school quality are controlled.

As part of the routine analysis of the regression discontinuity design (RDD), we plot the discontinuity graphs before and after the implementation of the program and examine the spatial changes in housing prices within and outside the boundary of Lixia. The left panel of Fig. 4 illustrates the changes in housing prices relative to the distance from the Lixia boundary in 2013, prior to the introduction of the R&E program.

On the other hand, the right panel of Fig. 4 demonstrates the spatial changes in housing prices relative to the distance from the Lixia boundary in 2015, after the introduction of the R&E program. In the left panel, we did not observe a significant jump in housing prices across the Lixia border. However, in the right panel, there is a noticeable gap near the boundary with the housing prices within the Lixia district significantly higher than those just outside, indicating the impact of the R&E program implemented in the Lixia district.¹³

4. Capitalization of the R&E program on rents

As mentioned in Section 3, we argue that the program's benefits will be included in housing prices, resulting in a rise in home values. This

¹³ To enhance the robustness of our empirical approach, we present regression discontinuity design (RDD) graphs depicting the changes in housing characteristics, community or neighborhood attributes, and major points of interest at the boundary during the pre- and post-policy periods. We are grateful for the reviewer's valuable suggestion. For a comprehensive view of the information presented in the graphs, please refer to Appendix Graphs 1–3.

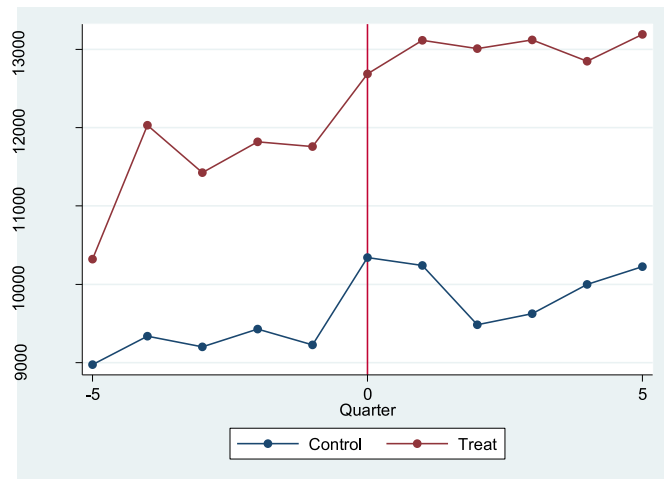


Fig. 3. Average Price dynamics of Lixia District and surrounding districts
Note: The average housing price is calculated per square meter. The treatment group includes houses from the Lixia District, and the control group includes houses from the other five districts. 0 on the horizontal axis indicates the 1st Quarter of 2014 when the R&E program was introduced.

Table 1
Capitalization of the R&E program: all administrative districts in Jinan.

	(1) Price	(2) Price	(3) Log (Price)	(4) Log (Price)
<i>Post • Treat</i>	738.57*** (86.88)	698.5*** (169.38)	0.0588*** (0.0105)	0.0565*** (0.0143)
House Characteristics	No	Yes	No	Yes
Community Characteristics	No	Yes	No	Yes
Quarter Fixed Effects	Yes	Yes	Yes	Yes
District# Time Trend	Yes	Yes	Yes	Yes
District Fixed Effects	Yes	Yes	Yes	Yes
Obs.	15,593	13,009	15,593	13,009
R-squared	0.367	0.401	0.398	0.434

Note: The housing characteristics include the building area, layout of the house, towards, housing age, floor and total floors of the building. The community characteristics include the floor area ratio and the green plot ratio. Standard errors are in parentheses and are clustered by administrative districts. * <10%, ** <5%, *** <1%.

Table 2
Capitalization of the R&E program (Identifying neighborhoods with postcodes).

	(1) Buffer:750 m Log(Price)	(2)	(3)	(4)	(5) Buffer:500 m Log(Price)	(6)	(7)	(8)
<i>Post • Treat</i>	0.0820** (0.0348)	0.0626* (0.0307)	0.0703** (0.0308)	0.0575** (0.0243)	0.0827*** (0.0254)	0.0544* (0.0301)	0.0789*** (0.0229)	0.0515** (0.0226)
House Characteristics	No	No	Yes	Yes	No	No	Yes	Yes
Community Characteristics	No	No	Yes	Yes	No	No	Yes	Yes
Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District# Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Neighborhood Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Quality	No	Yes	No	Yes	No	Yes	No	Yes
Obs.	3079	3079	3079	3079	1531	1531	1531	1531
R-squared	0.632	0.637	0.664	0.666	0.298	0.318	0.358	0.375

Note: The housing characteristics include the building area, layout of the house, towards, housing age, floor and total floors of the building. The community characteristics include the floor area ratio and green plot ratio. Standard errors are in parentheses and are clustered by postcodes. * <10%, ** <5%, *** <1%.

increase will enable current homeowners to enjoy public services and an appreciation of their property value. We now focus on the potential impact of the capitalization effect on tenants' welfare. Will an increase in rents offset the benefits of the R&E program for tenants? In this

section, we will estimate the impact of the R&E program on rents.

To increase comparability, we choose a specific housing layout (2 bedrooms) and show the dynamics of the monthly average rents of houses from the treatment and the control groups within the 750-m buffer zones on both sides of the boundary.¹⁴ In Fig. 5, we see that prior to the R&E program, the average rent for the treatment group was very close to that of the control group in the buffer zone, at approximately 25 yuan per sq.m per month, with only slight fluctuations. However, after the implementation of the R&E program, rents in the treatment group demonstrated an upward trend compared to the control group.

Further, we examine the impact of the R&E program on rents in more detail. We first report the regression results using a sample from all administrative districts in Jinan and then the results derived from regressions using the samples in the buffer zones on both sides of the Lixia boundary(1st Quarter, 2013 - 4th Quarter, 2016). The specification of the regression model is similar to that of the housing price model.

In Table 4, columns (1) and (2) report the findings based on the full sample. Without controlling housing and community characteristics, the R&E program leads to an approximate 11% rise in rents in Lixia District. In contrast, upon controlling for these factors, the policy's impact weakens and becomes statistically insignificant, suggesting the potential entry of high-quality apartments into the rental market in Lixia.

Using data from 750-m and 500-m buffer zones, columns (3) to (6) of the regression analysis control for 10 × 10 fishnet fixed effects, with estimated errors clustered by the fishnets. The regression outcomes suggest that the R&E program has been integrated into rents, leading to an increase of approximately 10%–13%. The economic implication of these findings is that tenants must pay higher rents to access the benefits of the R&E program. It is important to note that, as stipulated by the R&E program, the program is accessible to direct descendants of residents without a Lixia Hukou who have rented and worked in Lixia for a minimum of two years. Therefore, non-hukou residents must currently rent in the Lixia district in order to qualify for the program after two years. As a result, rental prices will respond upon the program's introduction.

Corresponding to the analysis at the end of Section 3, we present discontinuity graphs for rental prices before and after the R&E program's implementation. The left graph of Fig. 6 shows how rental prices varied spatially with proximity to the Lixia border in 2013, before the implementation of the R&E program. The right graph of Fig. 6, on the other hand, shows the spatial variation of rental prices in 2015, after the implementation of the program. The left graph does not show a signif-

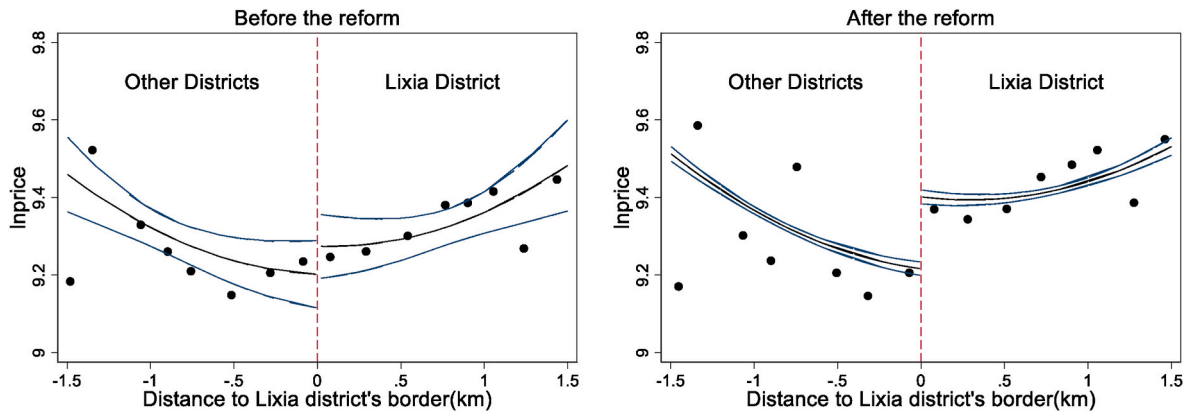
¹⁴ The other reason we choose houses with two bedrooms is that this type of layout is popular with tenants with a child or children.

Table 3

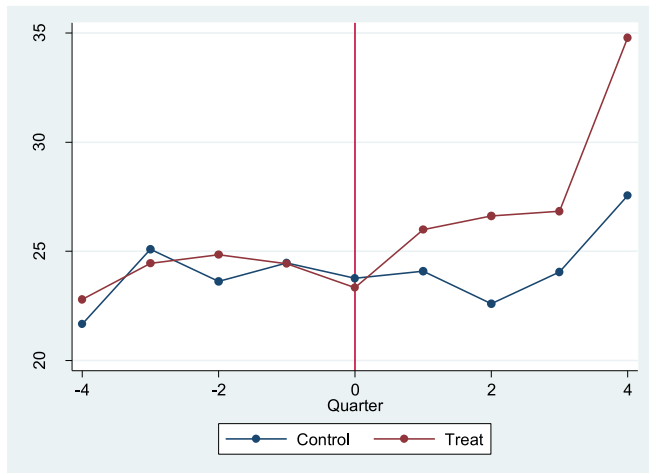
Capitalization of the R&E program(Identifying neighborhoods with the 10#10 fishnet).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Buffer:750 m				Buffer:500 m			
	Log (Price)				Log (Price)			
Post • Treat	0.0681** (0.0310)	0.0581* (0.0311)	0.0588** (0.0270)	0.0490* (0.0262)	0.0728*** (0.0218)	0.0713** (0.0281)	0.0576* (0.0281)	0.0538* (0.0272)
House Characteristics	No	No	Yes	Yes	No	No	Yes	Yes
Community Characteristics	No	No	Yes	Yes	No	No	Yes	Yes
Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District# Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Neighborhood Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Quality	No	Yes	No	Yes	No	Yes	No	Yes
Obs.	3079	3079	3079	3079	1531	1531	1531	1531
R-squared	0.638	0.640	0.674	0.676	0.389	0.389	0.450	0.450

Note: The housing characteristics include the building area, layout of the house, towards, housing age, floor and total floors of the building. The community characteristics include the floor area ratio and the green plot ratio. Standard errors are in parentheses and are clustered by the 10#10 fishnet. * <10%, ** <5%, *** <1%.

**Fig. 4.** Comparison of housing prices across the border before and after the reform (2013–2015).

Notes: The x-axis denotes the distance from the location of a house to the Lixia border, where positive numbers refer to the treatment group (Lixia district), and negative numbers refer to the control group (other districts around Lixia). The dark dots show the natural logarithm of the housing price averaged over 200m wide bins in distance from the border. The black lines fit local quadratic polynomial regressions within 1.5 km bandwidth on both sides of the boundary. The blue lines denote 95 percent confidence interval. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

**Fig. 5.** Average rents dynamics of Lixia District and surrounding districts
Note: The average rent is calculated monthly per square meter. To increase comparability, we only compare houses with two bedrooms. The sample was drawn within a buffer of 750m on either side of the boundary. 0 on the horizontal axis indicates the 1st Quarter of 2014 when the R&E program was introduced.

icant jump in rental prices across the Lixia boundary. However, the right graph reveals a distinct gap near the boundary, with rentals inside Lixia commanding noticeably higher prices than those just outside. This disparity highlights the influence of the R&E program on rental prices within Lixia district.

5. Falsification tests

In this section, we propose two novel falsification tests to further examine the capitalization effect of the R&E program initiated at the beginning of 2014.

First, we create a fake Lixia administrative boundary by shifting the real Lixia boundary 10 km to the northwest on the map, keeping the implementation time of the R&E program and the coordinates of the communities unchanged. Then, we can redefine the buffer zones, draw observations from these zones, and establish a fake treatment and control group (as shown in Fig. 7).

Ceteris paribus, the second placebo test can be conducted by creating a fake policy implementation date. It would be preferable to conduct a placebo test only for observations before the policy shock. However, the sample size would be significantly reduced. Given this consequence, we only conducted a time-scale placebo test using samples from all regions and assumed that the policy would occur at the end of the third quarter of 2013. The pre-policy period is from the first to the third Quarter of 2013, while the post-policy period is from the fourth Quarter of 2013 to the first Quarter of 2014.

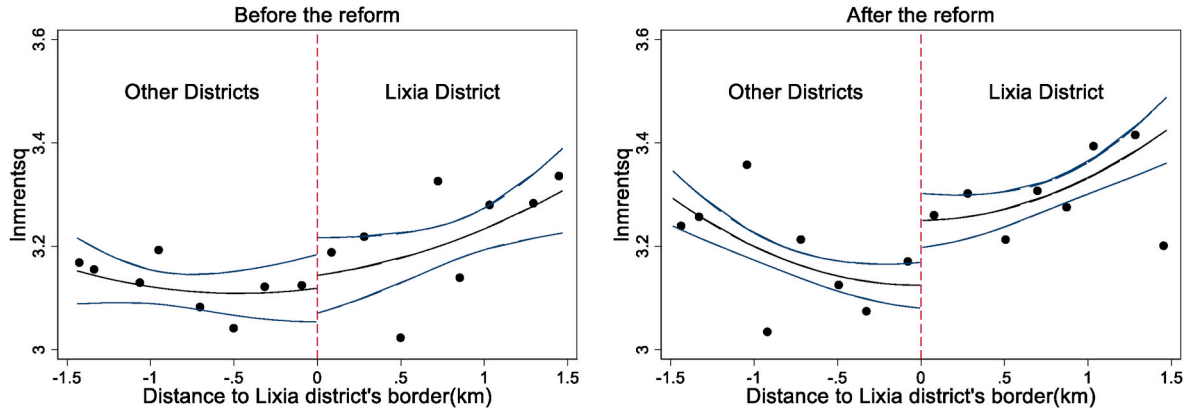
The results of the first placebo test are reported in columns (1) to (6)

Table 4

Capitalization of the R&E program on rents per sq.m. per month (dependent variable:Log(mrentsq)).

	(1)	(2)	(3)	(4)	(5)	(6)
	all administrative districts		Buffer:750 m		Buffer:500 m	
Post • Treat	0.112** (0.036)	0.012 (0.034)	0.107** (0.045)	0.096** (0.040)	0.139** (0.062)	0.140*** (0.048)
House Characteristics	No	Yes	No	Yes	No	Yes
Community Characteristics	No	Yes	No	Yes	No	Yes
Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
District# Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes				
10#10 Fishnets Fixed Effects			Yes	Yes	Yes	Yes
Obs.	6337	4788	682	562	555	452
R-squared	0.133	0.298	0.383	0.532	0.412	0.550

Note: The housing characteristics include the building area, layout of the house, towards, housing age, floor and total floors of the building. The community characteristics include the floor area ratio and the green plot ratio. Standard errors are in parentheses and are clustered by administrative districts (column 1–2) or 10#10 fishnets (column 3–6). * <10%, ** <5%, *** <1%.

**Fig. 6.** Comparison of rental prices across the border before and after the reform for transactions with two bedrooms. (2013–2015)

Notes: The x-axis denotes the distance from the location of a house to the Lixia border, where positive numbers refer to the treatment group (Lixia district), and negative numbers refer to the control group (other districts around Lixia). The dark dots show the natural logarithm of the rental price averaged over 200m wide bins in distance from the border. The black lines fit local quadratic regressions within 1.5 km bandwidth on both sides of the boundary. The blue lines denote 95 percent confidence interval. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

in Table 5, while the results of the second test are reported in columns (7) and (8). We find that the coefficients of the interaction term are all statistically insignificant, indicating no policy effects under these two placebo tests. Table 5 further confirms the findings from Tables 1–3 and reflects that the policy effects on housing prices indeed come from the R&E program rather than other factors. Similarly, we apply the two strategies mentioned above to conduct placebo tests for the capitalization effect on rents. Please refer to Appendix Table 2 for further information.¹⁵

6. Heterogeneity analysis

This section examines the heterogeneity of policy effects in housing floor areas. Since 2001, Jinan City has implemented policies that enable individuals to obtain household registration (hukou) by purchasing a house, provided that the property exceeds a certain area threshold. The household registration policy in Jinan, which remained unchanged from 2008 to 2017, specified that individuals who acquired a property measuring 90 square meters or more were eligible for local household registration (Chen et al., 2019). According to the provisions outlined in the policy background of Section 2, property owners without a Lixia hukou are eligible for the R&E program if their family has resided in

their Lixia property for a minimum of two years. In contrast, property owners who possess a Lixia hukou can instantly qualify for the program. This distinction shapes housing preferences, notably among families with kindergarten-age children, who typically favor homes larger than 90 square meters if they have adequate financial resources. Consequently, this housing demand triggered by the R&E program results in a higher price for larger properties.

Immigrants with limited financial resources, including migrant workers, can only participate in the R&E program by renting a house in the Lixia district. On one hand, renters face tighter financial constraints, leading them to prefer smaller properties. On the other hand, choosing to rent a larger house does not allow renters to acquire local hukou, nor does it improve their chances of enrolling in higher-quality schools or expedite access to the R&E program. Therefore, renters are more inclined to choose relatively smaller houses. As a result, rental prices for small houses are expected to experience a significant increase compared to those for larger houses. Thus, we propose the following Hypothesis for testing.

Hypothesis: The introduction of the R&E program in Lixia district is anticipated to result in a substantial increase in prices for larger houses (over 90 sqm), as well as a significant rise in rental prices for smaller homes.

Table 6 presents the results regarding the above hypothesis. We classify houses as either large or small, utilizing a cut-off point of 90 square meters. The results presented in Table 6 indicate a statistically significant increase in housing prices for houses with large floor areas as a result of the R&E program (refer to Columns 1–4). The underlying

¹⁵ We attempt different approaches to move the Lixia boundary in various directions and conduct placebo tests. The fundamental results remain unchanged.

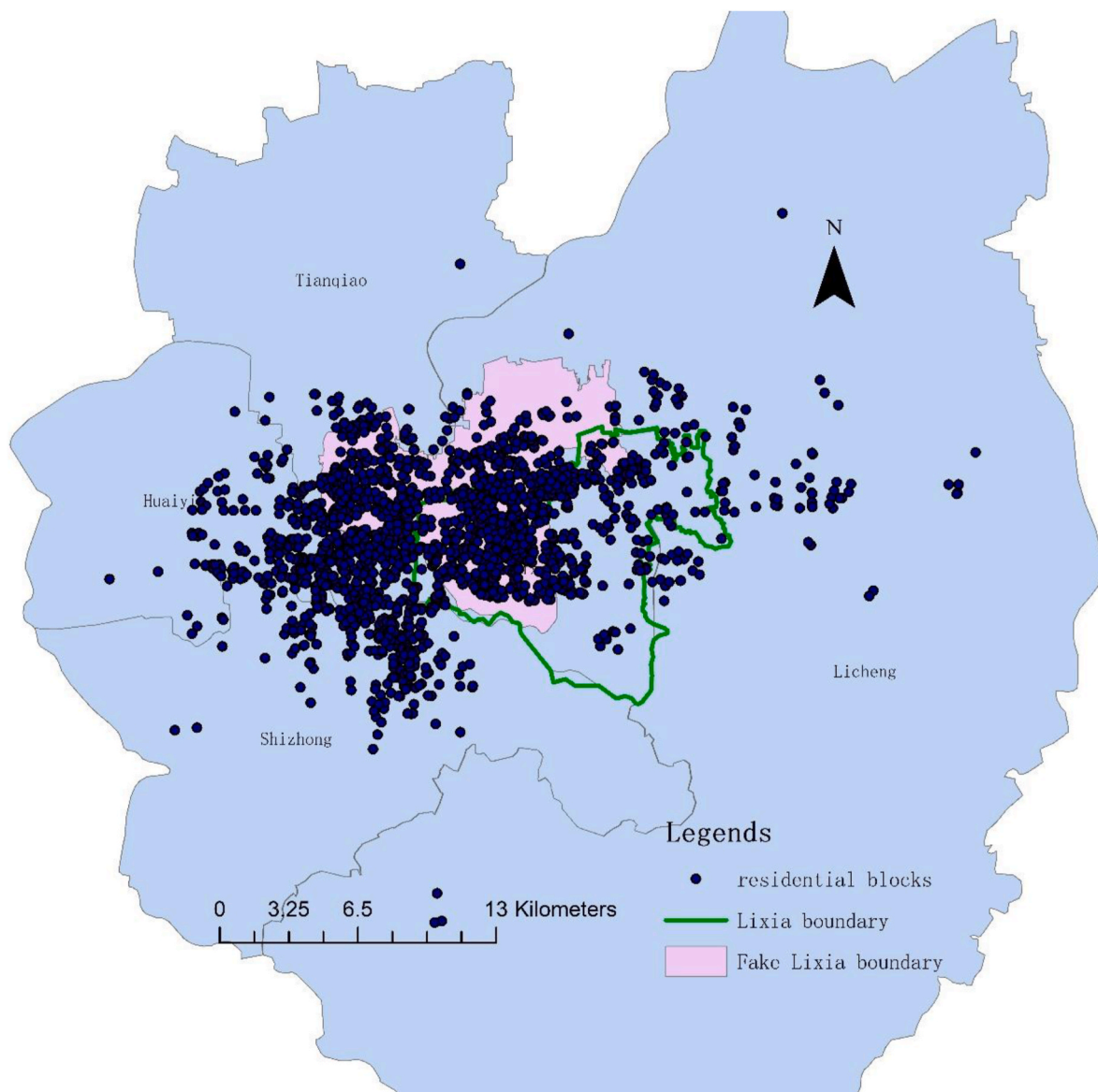


Fig. 7. Assuming the administrative boundary of the Lixia District moves northwestward.

Table 5

Placebo tests of capitalization of the R&E program on housing price (dependent variable: Log(Price)).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Fake administrative boundary						Fake policy implementation date	
	Full sample		750 m	750 m	500 m	500 m	Sample before 1stQ 2014	
Post • Treat	−0.0216 (0.0239)	0.0011 (0.0182)	−0.0149 (0.0325)	0.0095 (0.0292)	0.0181 (0.0480)	0.0301 (0.0420)	0.0092 (0.0681)	0.0201 (0.0653)
House Characteristics	No	Yes	No	Yes	No	Yes	No	Yes
Community Characteristics	No	Yes	No	Yes	No	Yes	No	Yes
Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District# Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Neighborhood Fixed Effects	No	No	Yes	Yes	Yes	Yes	No	No
Obs.	15,593	13,009	4812	4099	3312	2837	575	476
R-squared	0.398	0.433	0.586	0.615	0.536	0.594	0.400	0.466

Note: The housing characteristics include the building area, layout of the house, towards, housing age, floor and total floors of the building. The community characteristics include floor area ratio and the green plot ratio. Standard errors are in parentheses and are clustered by administrative districts in columns (1), (2), (7), (8), and by the 10#10 fishnet based on the fake Lixia District administrative boundary in columns (3)–(6). * <10%, ** <5%, *** <1%.

Table 6

Heterogeneity analysis in housing floor areas on housing price/rental price.

	housing price				rental price			
	Buffer:750m		Buffer:500 m		Buffer:750m		Buffer:500 m	
Post • Treat • Small	0.0287 (0.0463)	0.0387 (0.0377)	0.0323 (0.0286)	0.036 (0.0352)	0.133** (0.0486)	0.105** (0.0399)	0.166** (0.0640)	0.146*** (0.0450)
Post • Treat • Large	0.0866*** (0.0293)	0.0695** (0.0263)	0.0881*** (0.0283)	0.0679** (0.0270)	0.0316 (0.0410)	0.0512 (0.0443)	0.0635 (0.0516)	0.0922* (0.0508)
House Characteristics	No	Yes	No	Yes	No	Yes	No	Yes
Community Characteristics	No	Yes	No	Yes	No	Yes	No	Yes
Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District# Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Neighborhood Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Quality	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	3079	3079	1531	1531	682	562	555	452
R-squared	0.641	0.675	0.411	0.454	0.393	0.54	0.422	0.561

Note: The housing characteristics include the building area, layout of the house, towards, housing age, floor and total floors of the building. The community characteristics include the floor area ratio and the green plot ratio. Standard errors are in parentheses and are clustered by the 10#10 fishnet. * <10%, ** <5%, *** <1%.

economic logic is that non-hukou residents seeking immediate program benefits may need to purchase larger houses that meet the minimum size requirement for local hukou registration. As a result, the cost per unit for these houses would be higher when compared to smaller alternatives. Alternatively, these residents would need to wait for a period of two years to become eligible for the program.

On the other hand, there is a statistically significant rise in rents for houses with smaller floor areas as a consequence of the R&E program (refer to Columns 5–8). This indicates that renters must rent a house in the Lixia district in advance in order to become eligible for the program after a two-year period. These results align with the above hypothesis.

7. Concerns on spillover effect and household sorting

R&E is a place-based policy. While the R&E program is implemented within well-defined administrative boundaries, rendering only residents within these boundaries eligible, it may have an impact on surrounding areas through various potential channels, giving rise to spatial spillovers. This section presents evidence to examine the presence of spatial spillovers. The underlying concept is as follows: if the R&E program influences surrounding areas, the prices or rents of houses near the boundary will be more impacted than those further away. Then, we take homes outside the Lixia district but close to the administrative boundary as the treatment group, and homes far from the boundary as the control group. If the house prices for the two groups have different trends after the introduction of the R&E program, it indicates a spatial spillover. Otherwise, there is no significant spillover effect. Alternatively, we test whether a price gradient exists outside the boundary resulting from the R&E program in Lixia. Our findings indicate no evidence of spatial spillovers, as reported in [Appendix Tables 3 and 4](#).

Another concern when evaluating place-based policy is household sorting. If the R&E program causes education-quality sensitive households or households with a higher ability to pay to move to the Lixia district, the capitalization effect of R&E will be overestimated. Directly controlling for demographic characteristics in the regression model is not feasible because we cannot access demographic characteristics near the Lixia district boundary. Instead, we resort to the revealed preference principle to mitigate the challenges posed by household sorting. The underlying concept is as follows: if a significant number of high-income families with children, who possess a greater ability to pay, relocate to Lixia district, market-driven off-campus training institutions will subsequently emerge. This is because affluent families are more inclined to prioritize their children's after-school educational training.¹⁶ Thus, we can use the clustering of off-campus education and training institutions

as a proxy for the spatial clustering of high-income households. In our regression model, we precisely control the number of education and training agencies within a 500-m radius of a house. Considering the establishment of education and training agencies tends to lag behind the move of households, we use the number of agencies operated before 2015 as a proxy for the demographic characteristics before the R&E program, and the number of agencies operating from 2015 to 2019 as the corresponding proxy after the introduction of the program. There is evidence of a higher number of training agencies established in Lixia district after the implementation of the R&E program (see [Appendix Table 5](#)). However, the effects of the R&E program on housing prices and rent remained nearly unchanged after accounting for potential household sorting effects. For further details, refer to [Appendix Tables 6 and 7](#).

8. Discussion

What can be learned from the policy experiment of the R&E program? The results of our empirical analysis demonstrate that the R&E program was capitalized into transaction prices and rents of second-hand houses. However, our findings suggest that the program's benefits were unevenly distributed among various stakeholders. Incumbent homeowners who resided in Lixia District prior to the implementation of the R&E program were able to enjoy the public service without any additional costs. In contrast, new homebuyers had to pay more for houses after the program was introduced due to the capitalization of benefits into housing prices. Consequently, the increased housing expenses offset the program's benefits for new homebuyers, either partially or fully. Additionally, eligible tenants may have benefited little from the program due to landlords' ability to adjust rents in the short run, which potentially offset the program's benefits. Thus, landlords appear to be the primary beneficiaries of the R&E program.

We could do a back-of-the-envelope welfare calculation based on our empirical findings. Given that the housing price premium due to the capitalization of the R&E program is 5 percent, the average price of second-hand houses is 10,000 yuan per sq.m. and the floor area of a house is 90 sq.m.,¹⁷ we can calculate that the potential housing price premium due to the implementation of the program is 45,000 yuan. On the other hand, suppose the preschool education fee reduction is 300 yuan per month for one child, then with ten schooling months a year and three years in total for kindergarten education, the total fee reduction for each child within three years is 9000 yuan. Children generally

¹⁶ It includes interest-based training, such as art and dance, and subject-based training, such as English and Math.

¹⁷ It is not arbitrary to choose 90 sq.m. According to Jinan City's settlement policy in 2014, 90 sq.m. is the minimum building area requirement for people to apply for an urban Hukou by purchasing houses (Chen et al., 2019). That is to say, only by purchasing a house with a building area of 90 square meters or more can a non-Hukou holder obtain the urban Hukou.

continue their nine-year compulsory education in the nearby school district after their preschool education. Therefore, the minimum number of years a family would hold the home, i.e., the turnover period for a house, is 12 years.¹⁸ If we assume that the property right of a house is 50 years old,¹⁹ the house can be transferred to different families four times on average. That is, four families sequentially living in the house within 50 years can enjoy a total of 36,000 yuan from preschool fee reduction. Considering that the property right of a house may be longer than 50 years, or some families may have a second child who benefits from the fee reduction,²⁰ we can estimate that the aggregated fee deduction received by all families living in a house eligible to access the R&E program should be greater than 36,000 yuan, which is close to the estimated housing price premium of 45,000 yuan.²¹

With regard to rents, according to our estimation in section 6, we assume the R&E program increases rents in Lixia District by 10 percent. Considering an average rent of 25 yuan per square meter and a house size of 90 square meters, the resulting monthly increase in rent amounts to 225 yuan. This rent premium falls within the range of the subsidy amounts provided for municipal second-class and third-class kindergartens, which are 260 yuan and 200 yuan per student per month, respectively. The increase in rent nearly offsets the benefits provided by the R&E program, underscoring the significance of capitalization effects in determining the actual and intended beneficiaries of public policies.²²

¹⁸ On the one hand, the considerable costs associated with relocating, including financial aspects like transaction taxes and fees, as well as intangible factors such as rebuilding social ties and ensuring an optimal educational environment for children, often discourage families from moving. Once a family has settled in their chosen residence, they will likely remain there throughout their children's educational journey, from nursery to compulsory schooling. On the other hand, in some elite school districts with limited capacity, there's a prevailing rule that children of potential homebuyers cannot apply for new school seats if the children of the current homeowners are already occupying them. This rule aims to prevent multiple families from using a single house to apply for school seats within the same timeframe. This is one of the factors influencing our estimation of the housing turnover cycle, which we calculate by combining the duration of preschool (3 years) with that of compulsory schooling (9 years).

¹⁹ Article 6.1.1 of the National Mandatory Standard "Code for Residential Buildings" (GB50368-2005) stipulates that the design life of residential structures shall not be less than 50 years.

²⁰ In 2000, The 5th Chinese National Census showed that the total fertility rate for that year was 1.22. The results of the 6th census in 2010 indicated that the total fertility rate for that year was only 1.18.

²¹ In some instances, homeowners may choose not to sell their house upon the completion of their children's schooling. In accordance with the R&E policy, buying a house in Lixia extends the opportunity for their children and grandchildren to benefit from the program. This scenario, where future generations stand to gain from current investments, reflects a form of intergenerational altruism intrinsic to Chinese family culture. However, it is important to note that the assumption of intergenerational altruism is not necessarily a prerequisite for homebuyers who are willing to pay a price premium to secure eligibility for the educational subsidy that future generations will benefit from. The rights or eligibility for educational subsidies linked to a specific residence would be capitalized into the property's market value. Should homeowners opt not to utilize these rights for their descendants, they can sell the property at a premium (relative to properties without R&E program eligibility), a decision rooted in self-interest. Consequently, irrespective of whether these rights are exercised within the family due to altruism or transferred upon selling, the initial house price incorporates the capitalized value of these subsidies, reflecting the potential benefits for future eligible children over the property's lifespan. As a back of envelop calculation, we did not consider the issue of discounting in this section.

²² Here we also do not consider non-monetary returns. For example, equalization policies create a sense of psychological fairness among new immigrants or tenants, and the social integration between natives and immigrants increases, for which new immigrants or tenants may be willing to pay higher house prices or rents.

In summary, the actual and the targeted beneficiaries of public policies may differ due to the capitalization effects. Combining the findings in the heterogeneity analysis, we can see that incumbent homeowners with large homes benefit the most from significant housing price premiums in addition to the benefits from the program. In contrast, tenants who rent small houses benefit the least from the program, though they are eligible for the R&E program. Thus, the incidence of the program might be more conducive to incumbent homeowners rather than tenants. Hence, the income redistribution effect caused by the capitalization of public policy deserves policymakers' attention.²³

How can we equalize the benefits incidence among different stakeholders? One solution is central planning. The central authorities synchronize the "big push" to simultaneously equalize the level and quality of public services across regions. However, the "big push" is hindered by information asymmetry, as the central authorities may not have sufficient information to address the diverse public demands that exist, which results in efficiency losses. An alternative solution is the quasi-market solution (Tiebout, 1956), which aims to establish an inter-regional competition system among local governments to deliver public services so that the level and quality of local public services in different regions would converge to equalization with the assistance of intergovernmental transfer. What can be done to induce local governments to compete to provide better public services? In theory, two kinds of incentives can be formulated. One is the fiscal incentive, meaning that local governments can generate more revenue by making efforts to improve local public services. The other is the political incentive, meaning that local officials may win political support from residents who benefit from the housing price premium due to the improvements in local public services.

Though both incentives are theoretically plausible, they are not flawless in the Chinese context. First, fiscal incentives based on the capitalization of public services are not significant in China because local governments currently do not levy property taxes on households. Instead, they generate their primary revenue from turnover taxes and rely mainly on tax sharing with the central government. Though Chinese local governments are highly dependent on land transfer revenue, this kind of revenue is a one-shot revenue that accompanies land grants, and once the parcel of land is transferred to a developer, a local fiscal incentive breaks. Second, "voting by hand" as a political incentive plays a relatively minor role in China. The democratic decision-making mechanisms for public policy in China are not yet well developed and may weaken the effectiveness of such political incentives. Third, central planning and decentralized solutions should be complementary in achieving the equalization of public services. The central planning could satisfy the basic requirements for public services, while the decentralized solution could be designed to reveal and meet heterogeneous local public needs. Balancing distributive justice and allocative efficiency can be challenging for policymakers, but different instruments can be used to target different policy objectives.

²³ Other possible policies could confound the results, such as the book fee and school uniform fee exemptions at the compulsory education stage, while the benefits of the R&E program to households are much more than the benefits of the book and uniform fee exemptions in compulsory education. According to the "Jinan City Primary and Secondary Education Fees and Implementation Standards," each student in Lixia District can save 1075 yuan on textbooks and save about 3000 yuan on uniform expenditure during the 9-year compulsory education stage. So, the annual monetary benefit from textbook and uniform fee exemption is about 452 yuan, much less than the annual benefit from the R&E program in this paper. Meanwhile, besides fee reduction, the R&E program may include other non-monetary benefits, such as improvements in children's academic performance, mental status, and behavior patterns.

9. Conclusion

This paper examines the impact of the preschool childcare and education fee reduction and exemption (R&E) program in Lixia District, Jinan, China, on the welfare of both homeowners and tenants, thus investigating the effects of an equal rights experiment. To analyze the effects of the policy, we employ a boundary discontinuity (BD) design combined with a Differences-in-Differences (DID) approach, constructing a BD-DID framework. Our empirical results indicate that the effect of the R&E program was capitalized into the second-hand housing prices and rents in Lixia District, leading to approximately a 5 to 7 percent increase in housing prices and a 10 to 13 percent increase in rents in the program-eligible area compared to the non-eligible area. A back-of-the-envelope welfare analysis reveals that the benefits of the program are largely counterbalanced by the increasing housing prices for new home buyers or rising rents for tenants. The empirical findings are robust to a variety of model specifications. Additionally, we conduct two placebo tests by assuming a fake Lixia administrative boundary and a fake policy implementation time. Both placebo tests indicate that the effect of the fake policy is statistically insignificant on housing prices and rents, which further confirms that the R&E program may lead to changes in housing prices and rents.

This study also has some political economic implications. Decentralized public policies, such as R&E program aimed at empowering disadvantaged groups, may lead to a redistribution of wealth in favor of advantaged groups. Policymakers often overlook the distributional effects caused by the capitalization of public policy. Therefore, the benefit incidences for different stakeholders should be evaluated comprehensively. To promote the equalization of public services, big pushes from central authorities can eliminate the distortion of the income distribution caused by the capitalization effect. However, it usually cannot satisfy heterogeneous demands from different regions, leading to misallocation of resources and substantial efficiency losses. A competitive local fiscal system to induce local governments to provide better public services should be established by improving the local taxation system based on population agglomeration, such as property taxation or general consumption taxation levied on consumers. These findings and discussions may be relevant for local public finance reforms during the

urbanization process in developing countries.

CRedit authorship contribution statement

Yugang Tang: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Meng-Wei Chen:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Hehe Zhang:** Writing – review & editing, Visualization, Software, Methodology, Investigation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix I. Preschool Education in China and Jinan City

Preschool education providers can be divided into local government-sponsored public kindergartens, kindergartens sponsored by state-owned enterprises and institutions primarily for their employees' children, and privately owned kindergartens. Lixia District has a total of 94 kindergartens, half of which are local government-sponsored, state-owned enterprise or institution-sponsored, or other collective organization-sponsored public kindergartens, while the other half belong to private inclusive kindergartens and fully market-oriented private kindergartens according to a 2018 statistical report by the Jinan Municipal Education Bureau.

The local government will provide financial support to public kindergartens. Financial subsidies from the government will also be available to inclusive private kindergartens, provided that their fees do not exceed those of public kindergartens. The Jinan education bureau categorizes public and inclusive private kindergartens into six ranks based on their quality. These ranks include Provincial Top 10, Municipal Top 10, Provincial demonstration, Municipal first tier, Municipal second tier, and Municipal third tier. The higher the rank, the higher the fees charged by the kindergarten. The highest ranked kindergartens, Provincial Top 10, charge the highest fees. The fees for non-inclusive private kindergartens are generally determined by the market and regulated by local government.

In China, public schools, encompassing kindergartens and primary schools, enroll children of nearby residents, with enrollment priority varying by resident categories. The highest priority is given to residents who have both local household registration (*hukou*) and property ownership. Following this, residents who own property in the school district but lack local *hukou* are considered, and finally, independent migrant renters. In essence, public schools in Lixia prioritize enrollment for children of families with residency, property ownership, and local *hukou*, specifically catering to direct second or third-generation descendants of the property owners or head of the household. In areas with sufficient school seats, children of residents who have been in the neighborhood for an extended period (usually more than six months) enjoy equal access to daycare and schooling. In contrast, in areas with limited school seats availability, enrollment follows the established order of priority as previously outlined.

The enrollment criteria for private kindergartens are typically less stringent. Usually, these institutions accept children living in nearby areas, without strict requirements on household registration, property ownership, or actual residency. However, the quality of private kindergartens can vary significantly, leading to a wide range in their fees.

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http://www.lixia.gov.cn/art/2022/6/13/art_95817_4816191.html

<http://www.lixiayiyou.com/zszl/zongyuan/zszx/2020-05-18/195.html>
<http://www.lixia.gov.cn/attach/0/d8647b7ba79742b192244b25c781dd0d.pdf>.

Appendix Table 1

Descriptive statistics for the control and treatment groups

Before policy implementation	full sample			buffer:750 m			buffer:500 m		
	control	treat	Diff	control	treat	Diff	control	treat	Diff
Price per sqm	9687.4 [186.87]	11952.87 [177.18]	2265.468*** [264.546]	10179.45 [249.70]	10763.51 [268.72]	584.059 [384.646]	10191.96 [285.08]	10366.22 [227.37]	174.266 [360.350]
layout of the house	6.56 [0.16]	6.47 [0.18]	-0.092 [0.238]	6.45 [0.41]	6.2 [0.30]	-0.252 [0.498]	6.17 [0.50]	6.33 [0.39]	0.159 [0.628]
building area	99.92 [2.75]	97.21 [2.75]	-2.711 [3.971]	97.17 [5.49]	94.62 [5.16]	-2.551 [7.715]	93.19 [6.59]	99.99 [5.40]	6.8 [8.437]
floor	1.83 [0.05]	1.87 [0.06]	0.047 [0.083]	1.74 [0.14]	1.76 [0.12]	0.014 [0.188]	1.96 [0.16]	1.89 [0.16]	-0.068 [0.230]
total floors	11.56 [0.58]	8.24 [0.44]	-3.319*** [0.767]	5 [0.25]	4.36 [0.34]	-0.644 [0.458]	4.7 [0.30]	3.93 [0.34]	-0.77 [0.465]
towards	0.85 [0.02]	0.86 [0.03]	0.004 [0.035]	0.81 [0.07]	0.87 [0.05]	0.06 [0.086]	0.91 [0.06]	0.93 [0.05]	0.013 [0.079]
green plot ratio	35.83 [0.45]	32.76 [0.77]	-3.070*** [0.854]	38.52 [0.83]	33.24 [1.07]	-5.272*** [1.467]	37.57 [0.86]	33.93 [1.30]	-3.639** [1.619]
floor area ratio	2.08 [0.04]	1.98 [0.05]	-0.097 [0.067]	2.08 [0.12]	1.88 [0.10]	-0.2 [0.152]	1.93 [0.10]	2.14 [0.11]	0.208 [0.154]
housing age	13.48 [0.53]	16.78 [0.65]	3.296*** [0.832]	16.84 [1.15]	17 [1.19]	0.161 [1.720]	16.35 [1.44]	15.81 [1.19]	-0.533 [1.855]
After policy implementation									
Price per sqm	10063.59 [128.70]	12884.72 [116.76]	2821.134*** [188.416]	10375.21 [261.71]	12293.19 [217.74]	1917.974*** [341.531]	10721.05 [343.51]	11857.24 [253.44]	1136.195*** [418.237]
layout of the house	6.51 [0.09]	7.11 [0.11]	0.598*** [0.149]	7.03 [0.25]	7.5 [0.20]	0.469 [0.319]	7.32 [0.33]	7.27 [0.29]	-0.044 [0.442]
building area	97.16 [1.65]	105.72 [2.07]	8.555*** [2.662]	99.94 [3.88]	105.6 [3.59]	5.654 [5.415]	101.61 [5.26]	101.12 [4.56]	-0.481 [6.928]
floor	1.76 [0.03]	1.81 [0.04]	0.055 [0.055]	1.89 [0.11]	1.81 [0.08]	-0.072 [0.135]	2 [0.13]	1.82 [0.12]	-0.184 [0.176]
total floors	11.4 [0.37]	8.31 [0.33]	-3.087*** [0.537]	4.72 [0.21]	4.6 [0.20]	-0.117 [0.300]	4.58 [0.27]	4.2 [0.21]	-0.371 [0.339]
towards	0.81 [0.02]	0.83 [0.02]	0.015 [0.027]	0.89 [0.04]	0.87 [0.04]	-0.017 [0.055]	0.9 [0.05]	0.94 [0.03]	0.039 [0.058]
green plot ratio	35.49 [0.32]	31.74 [0.59]	-3.752*** [0.615]	35.77 [1.04]	33.82 [0.86]	-1.946 [1.351]	36.27 [0.89]	32.76 [1.20]	-3.520** [1.550]
floor area ratio	2.09 [0.03]	2.05 [0.04]	-0.042 [0.052]	2.11 [0.08]	1.89 [0.08]	-0.218* [0.122]	2.06 [0.06]	1.95 [0.11]	-0.106 [0.138]
housing age	13.23 [0.35]	16.71 [0.45]	3.480*** [0.565]	18.11 [1.04]	16.15 [0.78]	-1.961 [1.274]	17.88 [1.16]	17.39 [0.82]	-0.487 [1.388]

Note: The houses in Lixia District are the observations in the treatment group, and the houses in other districts are the observations in the control group. Standard errors in parentheses. The significance levels are as follows: * <10%, ** <5%, *** <1%.

Appendix Table 2

Placebo tests of capitalization of the R&E program on rents (dependent variable: Log(mrentsq))

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Fake Boundary				fake policy implementation time			
	Buffer:750 m		Buffer:500 m		Buffer:750 m		Buffer:500 m	
Post • Treat	0.033 (0.041)	0.041 (0.035)	0.036 (0.047)	0.056 (0.040)	0.0682 (0.073)	-0.0030 (0.088)	0.0399 (0.102)	-0.127 (0.112)
House Characteristics	No	Yes	No	Yes	No	Yes	No	Yes
Community Characteristics	No	Yes	No	Yes	No	Yes	No	Yes
Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District# Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Neighborhood Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1424	1121	1022	829	259	225	206	174
R-squared	0.467	0.624	0.483	0.648	0.433	0.649	0.508	0.668

Note: Columns 1–4 correspond to the placebo tests that permit Lixia's administrative boundary to move 10 km westward, and columns 5–8 correspond to the placebo tests that assume the fake policy implementation time was June 2013. The housing characteristics include the building area, layout of the house, towards, housing age, floor and total floors of the building. The community characteristics include the floor area ratio and the green plot ratio. Standard errors are in parentheses and are clustered by 10#10 fishnets. * <10%, ** <5%, *** <1%.

The first strategy is to create fake buffer zones along a fake Lixia administrative boundary but keep the implementation time of the R&E program unchanged. The second strategy is to keep the geospatial information unchanged and artificially assume the R&E program initiated before 2014. Under the second strategy, considering the availability of data, we assume that the R&E program was implemented at the end of June 2013, and we use the rental data in 2013 to conduct a placebo test.

Appendix Table 2 reports the empirical results on rents under the above two strategies. Using the fake Lixia boundary to conduct a BD-DID analysis, we can find that the estimated coefficients (columns 1 to 4) for the interaction term are not statistically significant whether the samples are from the 750-m or 500-m buffers. The results indicate that the policy effects on rents in the fake buffer zones are not statistically significant and, therefore, enhance the credibility of the empirical findings reported in Table 4.

Columns 5 to 8 show the empirical results of rents under the second strategy. We assume that the policy shock occurred at the end of June 2013 and define that the pre-policy period is from January to June 2013, while the post-policy period is from July to December 2013. The coefficients for the interaction term (the treatment and the fake policy time variable) are not significant in both the 750-m and 500-m buffer zones, which indicates that the R&E program with fake implementation time has no significant policy effect on rents, further confirming the results in Table 4. Therefore, the policy effects on rents are due to the R&E program rather than other factors that change over time.

Appendix Table 3
Tests on Spillover Effect: Strategy A

	(1)	(2)	(3)	(4)
	Spillover test	Spillover test	Spillover test	Spillover test
	Housing price	Housing price	Rental price	Rental price
Post#Treatspillover	0.0116 (0.0857)	0.0269 (0.0678)	-0.0643 (0.0551)	-0.0417 (0.0596)
House Characteristics	No	Yes	No	Yes
Community Characteristics	No	Yes	No	Yes
Quarter Fixed Effects	Yes	Yes	Yes	Yes
District# Time Trend	Yes	Yes	Yes	Yes
Neighborhood Fixed Effects	Yes	Yes	Yes	Yes
Observations	1389	1389	366	297
R-squared	0.719	0.778	0.373	0.538

Note: Only observations in the control group are used in this table. Treatspillover = 1 if the observation falls within the 500m buffer; Treatspillover = 0 if the observation falls within the 500–750m buffer. The housing characteristics include the building area, layout of the house, towards, housing age, floor and total floors of the building. Community characteristics include floor area ratio (FAR) and green plot ratio (GPR). Standard errors are in parentheses and are clustered by 10#10 fishnets. * <10%, ** <5%, *** <1%.

Appendix Table 4 Tests on Spillover Effect: Strategy B.

To address the spillover issue explicitly, we performed the following regression using data beyond the Lixia boundary.

$$Price_{imnt} = \alpha + Q_i + NF_n + \beta(Post \cdot Distance)_{imnt} + X'_{imnt} \gamma + \varepsilon_{imnt}$$

where *Distance* represents the shortest distance to the Lixia boundary for house *i*. *NF_n* represents the 2 km#2 km fishnet. The remaining variables are the same as those in Equation (1). The term *Post·Distance* in our regression indicates the price gradient outside the boundary resulting from the R&E program. This approach allows us to better capture the potential spillover effects and provide a clearer understanding of how the R&E program impacts housing prices and neighborhood quality in areas outside Lixia district. The results of the analysis are tabulated in Appendix Table 3, from which we have deduced the following primary findings: The housing price and rent for homes outside the Lixia District boundary do not show significant variation with distance from the boundary. This suggests that there are no spatial spillover effects.

Appendix Table 4
Spillover Effect: Strategy B

	(1)	(2)	(3)	(4)
	Log(Price)		Log (mrentsq)	
Post • Distance	-0.035 (0.023)	-0.040 (0.024)	0.013 (0.015)	0.003 (0.012)
House Characteristics	NO	YES	NO	YES
Community Characteristics	NO	YES	NO	YES
Quarter Fixed Effects	YES	YES	YES	YES
Neighborhood Fixed Effects	YES	YES	YES	YES
School Quality	NO	NO	NO	NO
Observations	2654	2058	1458	924
R-squared	0.739	0.625	0.604	0.668

Notes: The table includes exclusively control group observations located outside Lixia, within a 1500-m buffer. Distance is defined as the shortest distance between the court and the boundary of the Lixia district in kilometers. The housing characteristics include the building area, layout of the house, towards, housing age, floor and total floors of the building. Community characteristics include floor area ratio (FAR) and green plot ratio (GPR). Standard errors are shown in parentheses and are clustered by the 2 km × 2 km fishnet. * <10%, ** <5%, *** <1%.

Appendix Table 5 R&E program and the establishment of market education institutions

We employ a Difference-in-Differences (DID) design in which we use the R&E program as a policy shock and the number of market education institutions within each primary school district as the dependent variable.

$$number_{it} = \alpha + Q_i + SF_i + \beta(Post \cdot Treat)_{it} + \varepsilon_{it}$$

Here, *number_{it}* is the number of market education institutions within primary school district *i* at time *t*. *Treat* = 1 if the school district is located within Lixia district, and *Treat* = 0 otherwise. *SF_i* denotes the fixed effects of the primary school district. All other variables in the equation are

consistent with those in Equation (1).

The results are presented in [Appendix Table 5](#). Our analysis reveals that the R&E program has a positive impact on the number of market education institutions in each primary school district within the Lixia district. This finding supports the notion that higher income households tend to demand after-school education more, leading to an agglomeration of these households around market education institutions. Therefore, we use the number of market education institutions as a proxy for the concentration of high-income households.

Appendix Table 5

R&E program and the establishment of market education institutions

	(1)	(2)	(3)	(4)
	Number of market education institutions			
<i>Post • Treat</i>	0.120** (0.047)	0.137*** (0.045)	0.085 (0.051)	0.101** (0.049)
Quarter Fixed Effects	YES	YES	YES	YES
School District Fixed Effects	NO	NO	YES	YES
Observations	1461	1772	1461	1772
R-squared	0.068	0.066	0.210	0.205

Note: Because of the potential delay in the establishment of market-oriented educational institutions, we extended the sample timeframe in columns 3 and 4. Specifically, the first two columns of our sample spans from 2010 to 2015, while columns 3 and 4 span from 2010 to 2016. Standard errors are in parentheses and are clustered by the primary school district. * <10%, ** <5%, *** <1%.

Appendix Table 6

Capitalization of the R&E program on housing price: considering possible household sorting

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Buffer:750 m				Buffer:500 m			
	Log (Price)				Log (Price)			
<i>Post • Treat</i>	0.0597 (0.0363)	0.0481 (0.0365)	0.0550* (0.0284)	0.0447 (0.0281)	0.0697*** (0.0221)	0.0674** (0.0288)	0.0576** (0.0272)	0.0536* (0.0262)
Education & training agencies	−0.00886 (0.00648)	−0.00914 (0.00626)	−0.00645 (0.00422)	−0.00656 (0.00401)	−0.00306 (0.00529)	−0.00314 (0.00537)	−0.00170 (0.00524)	−0.00176 (0.00527)
House Characteristics	No	No	Yes	Yes	No	No	Yes	Yes
Community Characteristics	No	No	Yes	Yes	No	No	Yes	Yes
Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District# Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Neighborhood Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Quality	No	Yes	No	Yes	No	Yes	No	Yes
Obs.	3079	3079	3079	3079	1531	1531	1531	1531
R-squared	0.648	0.651	0.679	0.681	0.392	0.392	0.451	0.451

Note: The housing characteristics include the building area, layout of the house, towards, housing age, floor and total floors of the building. The community characteristics include the floor area ratio and the green plot ratio. The neighborhoods are identified by 10#10 fishnets. The *education and training agencies* indicator represents the number of after-school educational training agencies within a 500-m radius of a community. Standard errors are in parentheses and are clustered by the 10#10 fishnet. * <10%, ** <5%, *** <1%.

Appendix Table 7

Capitalization of the R&E program on rents per sq.m. per month: considering possible household sorting

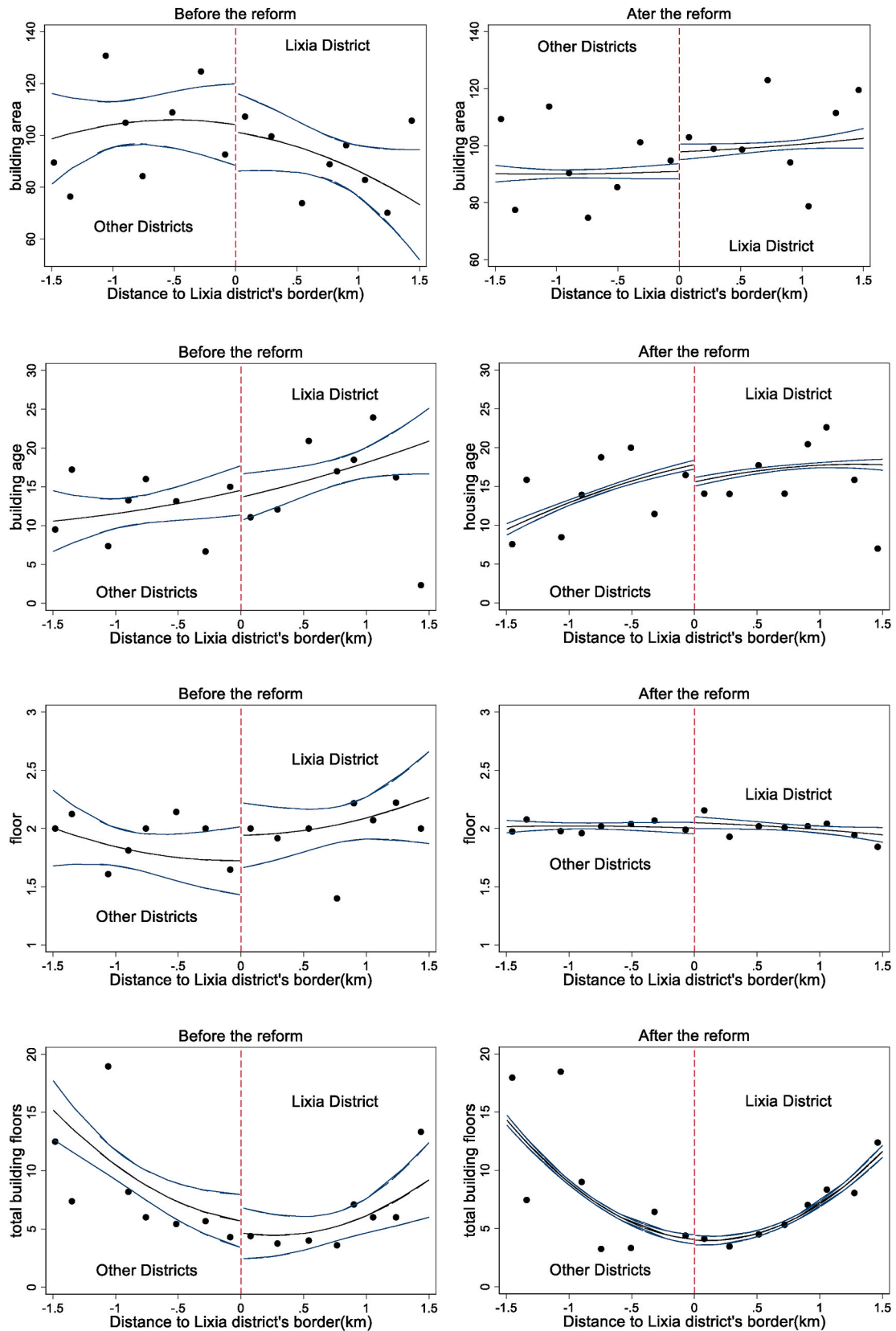
	(1)	(2)	(3)	(4)
	Buffer:750 m		Buffer:500 m	
<i>Post • Treat</i>	0.105** (0.045)	0.101** (0.040)	0.135** (0.060)	0.137*** (0.048)
Education & training agencies	−0.001 (0.004)	0.002 (0.002)	−0.004 (0.003)	−0.002 (0.004)
House Characteristics	No	Yes	No	Yes
Community Characteristics	No	Yes	No	Yes
Quarter Fixed Effects	Yes	Yes	Yes	Yes
District# Time Trend	Yes	Yes	Yes	Yes
Neighborhood Fixed Effects	Yes	Yes	Yes	Yes
Obs.	682	562	555	452
R-squared	0.384	0.533	0.414	0.551

Note: The dependent variable is the rental price per sq.m. per month (log). The housing characteristics include the building area, layout of the house, towards, housing age, floor and total floors of the building. The community characteristics include the floor area ratio and the green plot ratio. The neighborhoods are identified by 10#10 fishnets. The *education and training agencies* indicator represents the number of off-campus educational training agencies within a 500-m radius of a community. Standard errors are in parentheses and are clustered by 10#10 fishnets. * <10%, ** <5%, *** <1%.

Appendix Figs. 1–3

Summary:

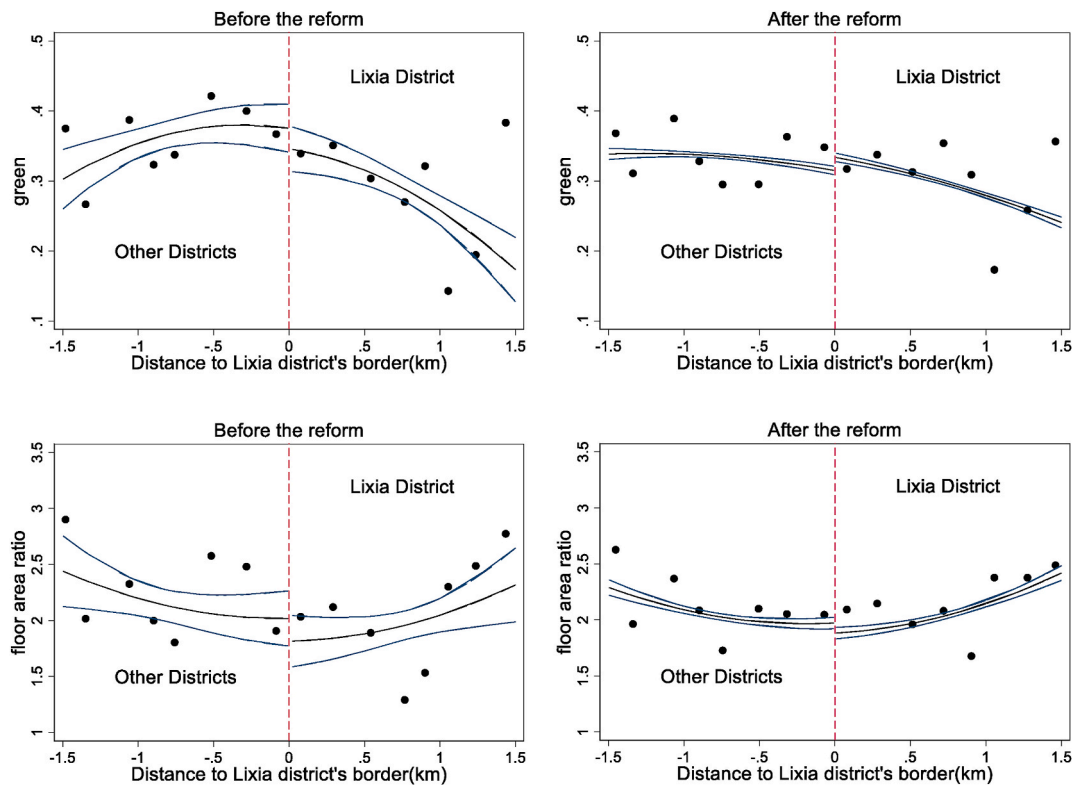
We present RDD graphs for housing characteristics, community or neighborhood attributes, and major POIs. For housing characteristics ([Appendix Fig. 1](#)), including building areas, housing ages, floor categories (low, middle, and high), and building heights (total floors), these variables



Appendix Fig. 1. Balance of housing characteristics across the border before and after the reform (2013–2015)

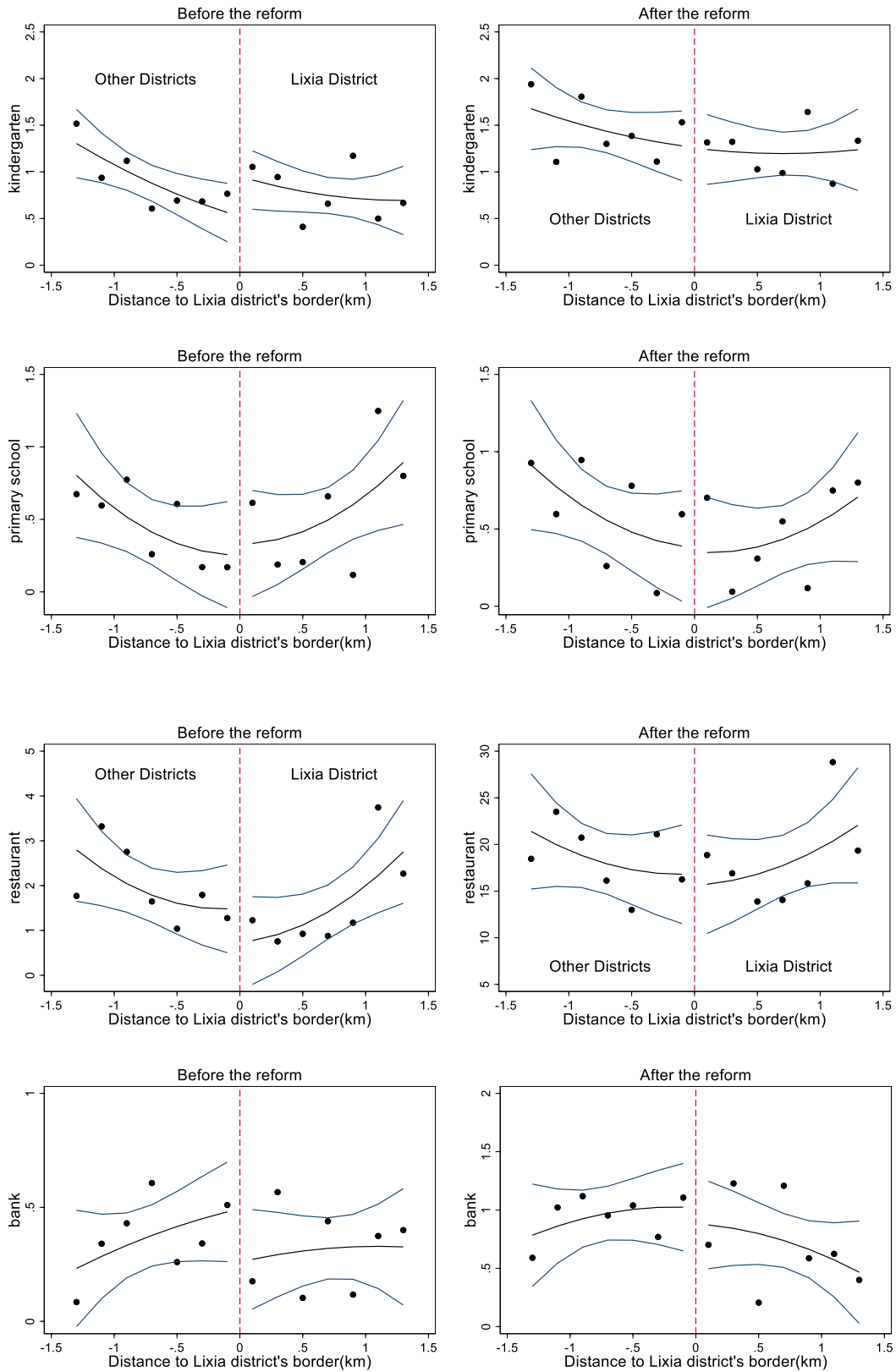
Notes: The housing characteristics include the building area, housing age, floor (low, middle, and high), and total floors of the building. The x-axis denotes the distance from the location of a house to the Lixia border, where positive numbers refer to the treatment group (Lixia district), and negative numbers refer to the control group (other districts around Lixia). The dark dots show the corresponding housing characteristics values averaged over 200m wide bins in distance from the border. The black lines fit local quadratic polynomial regressions within 1.5 km bandwidth on both sides of the boundary. The blue lines denote 95 percent confidence interval.

remain continuous both before and after the R&E program. Regarding neighborhood characteristics (Appendix Fig. 2), such as green plot ratio, floor area ratio, and POIs (e.g., the number of kindergartens, primary schools, restaurants, and banks that potentially affect housing and rental prices in Appendix Fig. 3), no discontinuities are detected across the boundary, regardless of the R&E program's implementation status. These graphs present further evidence supporting the parallel pre-trends assumption.



Appendix Fig. 2. Balance of community characteristics across the border before and after the reform (2013–2015).

Notes: The community characteristics include the green plot ratio and the floor area ratio. The x-axis denotes the distance from the location of a house to the Lixia border, where positive numbers refer to the treatment group (Lixia district), and negative numbers refer to the control group (other districts around Lixia). The dark dots show the corresponding community characteristics values averaged over 200m wide bins in distance from the border. The black lines fit local quadratic polynomial regressions within 1.5 km bandwidth on both sides of the boundary. The blue lines denote 95 percent confidence interval.



Appendix Fig. 3. Balance of other characteristics across the border before and after the reform. (2013–2015)

Notes: The other characteristics include the amounts of kindergartens per square km, the amounts of primary schools per square km, the amounts of restaurants per square km, and the amounts of banks per square km. The x-axis denotes the distance to the Lixia border, where positive numbers refer to the treatment group (Lixia district), and negative numbers refer to the control group (other districts around Lixia). The dark dots show the corresponding amounts averaged over 200m wide bins in distance from the border. The black lines fit local quadratic polynomial regressions within 1.5 km bandwidth on both sides of the boundary. The blue lines denote 95 percent confidence interval.

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