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The Effects of Urban Growth Boundaries on Urban Development: Evidence from Beijing

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Abstract

When estimating the causal effects of urban growth boundaries (UGBs) on urban development, existing studies used either a differences-in-differences (DID) approach or a regression discontinuity design (RDD) method based on boundary discontinuity. However, the DID method cannot exclude the confounding polices that coincide with the UGB policy; and the RDD method cannot address the endogeneity of the UGB's location, location-specific time trend, or confounding policies with a spatial discontinuity. We combine both the DID and RDD approach to address both types of issues and examine the effects of Beijing's urban growth boundaries on urban development.

In 2004, Beijing government implemented an urban planning regulation that is very similar to urban growth boundaries, restricting land development outside the UGBs. Using data on land use permits issued between 2003 and 2010, we find that this policy have to some extent curtailed urban development outside the UGBs. The development probability of land parcels located just outside the UGBs was seven percentage point smaller than those just inside UGBs. This finding is robust to various sensitivity checks.

JEL Classification: R14, R52, R58

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1. Introduction

The urban growth boundary (UGB) refers to a regional boundary set to curtail urban sprawl. A simple form of UGB mandates that the area inside the boundary be used for urban development and the area outside be reserved for agriculture, open space, and forests. As a typical urban containment policy to control urban sprawl, UGB has been adopted in many U.S. cities for decades. The survey by Pendall, Puentes and Martin (2006) shows that 16.4% of jurisdictions in the U.S. have urban containment programs. Some European countries also adopt UGB policies including Britain, Germany, Switzerland, and Netherlands. Many studies estimate the effects of UGB policy on land value, housing prices, and population growth, using hedonic model, differences-in-differences model, or spatial discontinuity model. This paper aims to estimate the effect of UGB policy in Beijing on land development using an improved empirical method, namely, a combination of differences-in-differences method and spatial discontinuity design method.

The UGB policy has attracted some interest from urban theorists. Pines and Sadka prove that a not-too-stringent UGB policy is a second-best policy to congestion tolls with the presence of unpriced traffic congestions, but Anas and Rhee (2007) show that UGB policy of any stringency is inefficient. Engle (1993) constructs a two-city model and shows that in the presence of negative externalities such as congestion or pollution, growth control policy may be welfare improving and housing prices may increase due to the amenity effect. Quigley and Swoboda (2007) present a general equilibrium analysis of the effects of critical habitat designation, which could be easily extended into the UGB case. By taking into account the re-sorting of households, their simulation results show that the prices and rents of non-critical habitat lands increase significantly. Based on the standard monocentric urban model, Brueckner (2009) shows that a city with a UGB imposed is smaller and has higher housing and land prices than a city without a UGB.

More empirical studies are available to evaluate the effects of UGB using different empirical strategies. Earlier studies use the hedonic model with a UGB dummy variable indicating whether a housing unit or a land parcel is located inside or outside UGB, typically also using cross-sectional data. For example Knaap (1985) estimates the effect of UGB on land value in metropolitan Portland, Oregon. Jun (2004, 2006) investigates the effects of UGB on the development rates of land parcels and housing prices in Portland. This simple hedonic regression cannot separate confounding factors from the UGB policy for at least two reasons. First, other policies may have been implemented in either side or both sides of the UGB. In practice, the implementation of the UGB usually comes along with policies that help combat urban sprawl and at the same time cause the change in the relative bid land rents. For example, local government may provide tax incentives to attract businesses to the downtown. Second, the UGB is usually specified according to location-specific characteristics such as the current land use and the provision of infrastructure or public facilities, implying the choice of UGB is selected or endogenous. Jacob and McMillen (2015) show that low-value property is more likely to be located near suburban municipal borders than within the interior of the municipality because municipalities tend to place land use of negative externalities at their borders. This likely holds in the context of urban growth boundary suggesting selection or endogeneity of in a hedonic model.

A few recent studies have used the instrumental variable approach (Boarnet, et al., 2011; McMillen and McDonald, 2002; Zhou et al., 2008) or a matching method (Lynch et al., 2007) to address the endogeneity issue. Dempsey and Plantinga (2013) employ a differences-in-differences (DID) method to estimate the effect of the UGB policy on land development. Their panel dataset can lower the endogeneity-related bias and the DID method can control for confounding factors common to both sides of the UGB, such as common growth trend inside and outside the UGB. Nonetheless, the DID approach is less likely to exclude confounding policies that are implemented around the same time when the UGB policy is implemented. Another issue is that the DID method can estimate only the average treatment effect and this may be biased toward zero if there is a large degree of locational heterogeneity across space.

The regression discontinuity design (RDD) approach compares the difference in outcome variables for groups below and above the threshold of a running variable and can estimate the local treatment effect. Geographic distance has been used as the running variable in the spatial discontinuity setting (Pence, 2006; Lavy, 2010; Dell, 2010; Gibbons et al., 2013). It has also been used in the UGB policy evaluation since the UGB defines a sharp treatment threshold. Grout et al. (2011) apply the RDD method to estimate the effect of UGB on land values in Portland, Oregon. The premise is that other policies do not have the same boundaries as the UGB. Nevertheless, if there is any factor that happens to have a discontinuity in space at the UGB's location or a discontinuity in time coinciding with the timing of the UGB policy—possibly due to the endogeneity of the UGB—it will be difficult to identify only the UGB's effects using the RDD approach.

We propose that combining both the DID approach and the RDD approach in evaluating the UGB policy can avoid both confounding factors with a spatial discontinuity or a temporal discontinuity that may coincide with the location of the UGB or the timing of the UGB. In addition, by comparing land parcels on both sides of the UGB with a reasonably short distance, the estimated local treatment effect is not contaminated by locational heterogeneity since neighboring locations can be considered relatively homogenous. This combined method has been used in Fu and Gu (2017) to test the effects of highway toll on air pollution and also in Persson and Rossin-Slater (2019).

We apply this combined method to evaluate the effects of Beijing's urban growth boundaries on urban development using a panel dataset of land development permit. The Beijing Urban Master Plan (2004-2020) (hereafter the 2020 Plan) was drafted in 2004 and approved by the State Council in Jan 2005 (Beijing Institute of City Planning, 2004). In this plan, urban growth boundaries were imposed separately for the central city and eleven new towns. Land development outside the UGBs usually is not allowed; there would be a more restrictive approval process if a development proposal were submitted. We use the issuance of construction land use permits as the indicator of land development rather than the change in satellite images (see e.g., Dempsey and Plantinga, 2013). This facilitates the use of the DID approach because the time lag between the issuance of land use permits and the completion of projects is no longer an issue here. We use the permits data in 2003 and the data from 2005 to 2010 to estimate the development likelihood of each land parcel before and after the UGBs were imposed. If a UGB policy is effective in restricting development outside the boundary, there would be a jump in the probability of land development across the boundary after the UGB is imposed, while there would be no such a discontinuity before that. This method can exclude the effect of any confounding factor that presents a discontinuity in its distribution at the boundary or that have a location-specific time trend. Any remaining confounding factors must have both a spatial discontinuity at the UGB and a temporal discontinuity at the same time when UGB policy is implemented, which is very unlikely even under the rapid urbanization of Chinese cities.

We first present a set of results using the DID method. After the UGBs were imposed, the development probability increased by 7.9-9.1 percentage points for land parcels located inside the UGBs, significantly higher than the 0.3-1.6 percentage points increase for land parcels outside the UGBs. However, if we move the original UGBs 1 kilometer inwards or outwards, the estimates of the placebo UGBs' effects are still statistically significant, suggesting that the results of the DID approach may be driven by some location-specific unobserved characteristics.

We then apply the RDD method to the land use permits data in 2003 (before the UGB policy) sample and between 2005 and 2010 (after the UGB policy) sample, respectively. Before the UGBs are imposed, there is no statistically significant difference in the development probability between land parcels just outside and outside the UGBs; after that, the development likelihood for the land parcels outside the UGBs is one to six times smaller (or 1.4-7.9 percentage points lower) than those inside. However, this before-and-after comparison may be confounded by any other city-level policies that are implemented at the same time when the UGB policy is implemented.

Finally, combining both the DID and the RDD methods, we find that after the UGBs are imposed, the gap in the development probability between land parcels just inside and outside the boundaries increases by 1.4-7.7 percentage points compared to that before the imposition of the UGB. These results show that urban planning in Beijing, to some degree, indeed play a role in shaping the internal spatial structure and may reduce the doubt about the enforcement of urban planning in Chinese cities.

Our study contributes to the literature on the UGB's effects by using an identification strategy that can deal with both confounding policies and endogenous UGB, which has not been well addressed in previous studies. We also provide the first empirical evidence on the UGB's effect for Chinese cities. The rest of the paper is organized as follows. Section 2 describes the background of Beijing's urban growth boundary policy. Section 3 introduces the data. Sections 4 and 5 explore the DID approach and the RDD approach separately. In Section 6, we present our identification strategy, estimation results, and robustness checks. Section 7 concludes.

2. Beijing's urban growth boundaries

Since the establishment of land markets in the early 1990s in China, urban growth boundaries have been imposed in some Chinese cities as part of the urban master plan and are updated when the urban master plan is revisited. According to the City

Planning Law of China issued in 1989, an urban master plan for a city should include "its designated function, development objectives and scales, main construction standard and quotas, land use pattern, function subdivision, integrated transportation system, water and green system, various specific plans and recent construction project plans" (Article 19). Of the various topics covered, the central focus of the urban master plan is to specify the overall land quota for urban development (built land quota or *jian she yong di zhi biao* in Chinese). This in turn depends on the population forecast and the per capita urban land quota specified by the City Planning Law. Under the strict national farmland reservation system, the forecast population and thus the overall urban land quota are in general underestimated.

In 2004, the Beijing municipal government started to compile a new urban master plan (the 2020 Plan) because the built land area in Beijing had already surpassed the quota set for year 2010 in the last plan. The State Council approved the 2020 Plan in January 2005. In this plan, the population of the Beijing City in 2020 is set to be 18 million and the urban land quota is 1,650 square kilometer, which are then allocated to the central city and the eleven new towns. On the basis of this, planners specify the development boundaries for the central city and for each new town separately, as well as the land use category for each land parcel. Due to the pressure from new town governments, these boundaries usually cover more than the assigned urban land quota, to allow certain planning adjustments in the future.

Though these boundaries have not been explicitly named as urban growth boundaries, but their functions are similar to the UGBs implemented in the U.S. cities such as Portland, Oregon.[1] The first step of any development project is to obtain a land use permit from the urban planning authority. The issuance of a land use permit depends on whether the proposed development project lies within the development boundary.[2] Land development outside the boundaries generally is not allowed; in addition, there is a more demanding approval process if a development proposal is submitted.

This study focuses on the UGBs in seven new towns, each of which has its planned built land concentrated in one or a few clusters (Figure 1). The UGB in each new town is set primarily based on its population forecast (conservative in most cases) and the per capita built land quota specified by the City Planning Law of China. In Tongzhou, Fangshan, and Miyun, there is one major UGB that contains nearly all planned built land, while in Yizhuang, Changping, Pinggu, and Yanqing, each UGB consists of multiple non-overlapping clusters, which are separated by rivers or freeways and could be drawn as one integrated boundary. The rest four new towns and the central city are left out in this study mainly because the planned built land is relatively scattered and thus it is hard to draw an urban growth boundary for any of them.[3]

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1 These boundaries are not literally called "urban growth boundaries." In Chinese they are named as "*yong di kong zhi bian jie*", meaning "land use control boundaries." They have almost identical meaning as urban growth boundaries.

2 More precisely, planning officials make decisions according to the detailed planning that is similar to the zoning in the U.S., and planners even do not draft the detailed planning for land parcels outside the boundaries.

3 Gu et al. (2009) show that there have been multiple job centers in the Beijing central city using the 2004 Beijing Economic Census data.

[Figure 1 here.]

Figure 1 shows that of these new towns, Tongzhou and Yizhuang are among the three key towns specified by the 2020 Plan that would receive increased government funding from 2004 to 2020. Changping and Fangshan are in the west of Beijing, and the other five are in the east. Changping, Tongzhou, and Yizhuang are close to downtown Beijing, while the other four are away from downtown.
With the rapid expansion of the Beijing City, the development boundaries defined in the last urban master plan are much smaller than those in the 2020 Plan. In the DID model setting, these old boundaries may create some spatial heterogeneities. But in the RD setting with the current UGBs as the treatment threshold, the old boundaries that lie further inside would not confound our estimation results.

3. Data

This study uses the issuance of land use permits as the indicator of land development. Compared to satellite images used in Dempsey and Plantinga (2013), land use permits data facilitate the estimation of UGBs' effects because we do not need to consider the time span of a development project when the DID approach is employed. All land use permits issued by the Beijing Planning Commission from 2003 to 2010, with their locations and issuance dates, are obtained from its web site.4 Here only one-year pre-treatment data are available because land use permits data before 2003 cover only the central city of Beijing.

All 40,540 land parcels within 5 kilometer distance to each of seven UGBs are selected for the estimation (Figure 1). Summary statistics are presented in Table 1. The average size of these parcels is 0.053 square kilometers. Roughly one fourth of land parcels are located within UGBs. The land parcels in the two key towns, Tongzhou and Yizhuang, account for more than half of the sample since the UGBs in these two towns are relatively large.

[Insert Table 1 here.]

We overlay the land parcel layer with the land use permit layer using the GIS software. In so doing, we construct a panel dataset that records whether a land parcel has been approved for development (or redevelopment) in each year between 2003 and 2010 for all parcels in our sample. Within the study area, the number of land use permits issued per year ranges between 148 and 418.[5]

We create a period dummy to indicate whether the UGB policy had been imposed, which takes 0 if it is year 2003 and 1 if it is year 2005 to 2010. We exclude year 2004 because during that year the UGB policies are being discussed and under approval; this may have

4 The original dataset is crawled by Dong Li and Jianghao Wang and released at http://beijingcitylab.org/data-released.
5 The number of land use permits issued in each year from 2003 to 2010 in the whole Beijing city is 1,240, 1,362, 1,309, 2,209, 2,155, 1,531, 2,305, and 3,134, respectively.

some effects on developers' expectation and behavior. In 2003, 0.4% of sample parcels were approved for development, lower than the 3.7% in 2005-2010. More importantly, in 2003 when UGBs had not been imposed, most of land use permits were issued to land parcels outside the UGBs, but since 2005, more than 50% of permits were issued to land parcels inside the UGBs annually (Figure 2). This provides a suggestive evidence of UGBs' effects on urban development.

[Insert Figure 2 here.]

For each land parcel, we know whether it was built land or not as of 2003 based on data compiled by planners at the Beijing Institute of City Planning. We include this dummy variable to control the difference in the approval likelihood between new development projects and redevelopment projects. Of 40,540 parcels, about 35% had already been developed in 2003 (Table 1). In general, such land parcels are more likely to obtain land use permits because in this case there would be no increase in the overall built land area. Within the study area, slightly more than half of the permits are issued to land parcels that had been developed in 2003. We also control for the land use status of each land parcel specified in the 2020 Plan because not all parcels outside UGBs are prohibited for development. About 82% of sample parcels are designated as built land in the 2020 Plan (Table 1). It is expected that such parcels are more likely to obtain land use permits.

The air distance from each land parcel's centroid to the corresponding UGB is used as the running variable when we use the RDD approach. We calculate three location variables for each land parcel: distance to Tian'anmen (the city center), distance to the closest major road, and distance to the closest subway station. On average, a parcel is about 30 kilometers away from the city center and 1 kilometer away from the urban road network (Table 1). Here we use the road network in 2006 since there is no annual road database available. Based on the authors' knowledge, there was no spatial discontinuity in the road provision across UGBs after 2004. Therefore, using a time-invariant variable here does not affect the estimation results when a DID and RDD combined methodology is used. The distance to the closest subway station is measured using the subway system in operation in each year. At the end of 2003, only four lines operate; after that, nine more lines are added to the system by December 2010. As a result, the average distance to the subway station decreases from 19 kilometers in 2003 to 7 kilometers in 2010. We also try a time-invariant distance variable on the basis of the planned 2015 subway system in Section 5 as a robustness check.

4. The differences-in-differences approach

In this section we use the DID approach to estimate the effects of Beijing's UGBs on urban development. We compare the change in the development probability of parcels inside and outside UGBs after the UGBs are imposed based on the following standard DID model specification:

$$Approve_{itc} = \alpha_c + \beta X_{it} + \gamma UGB_{ic} + \lambda After_t + \theta(UGB_{ic} \times After_t) + \varepsilon_{itc}, \quad (4.1)$$

Where $Approve_{itc}$ is a dummy variable that equals 1 if land parcel i located in town c

is issued a land use permit in year t; X_{it} is a vector of control variables of parcel i in year t; UGB_{ic} is a location dummy variable that equals 1 if parcel i in town c is inside the corresponding UGB and 0 outside; $After_t$ is the policy dummy variable set to 1 before the UGB policy (2003) and 0 after the UGB policy is implanted (2005-2010). α_c denotes the town fixed effect (when applicable). The main coefficient of interest, θ, shows the causal effect of the UGBs on urban development.

We estimate different versions of model (4.1) and present the results in Table 2. Columns (1) and (2) include only the UGB dummy, the policy dummy, and the interactive term of both. Columns (3) and (4) add a vector of control variables including two land use status dummies and three distance variables. Columns (5) and (6) add further new town fixed effects. Columns (1), (3), and (5) include observations in two periods: 2003 and 2005-2010. Here we take land use permits data between 2005 and 2010 as cross-sectional and pool them together, i.e., whether a parcel was approved for development during this period. In Columns (2), (4), and (6), we use only observations of year 2003 and 2005 as a robustness check. In all models, standard errors are clustered at the town level since planners make approval decisions separately for each new town on the basis of its built land quota.

Table 2 shows that a parcel is more likely to be approved for development or redevelopment if it has already been developed in 2003 or it is assigned as built land in the 2020 Plan. The development probability of a parcel decreases by 0.1-0.5 percentage points with every 10 kilometers away from the city center, by 0.5-1.9 percentage points with every 10 kilometers away from major roads (but not statistically significant across all specifications). The estimates of the subway variable are mixed. Column (5) shows a 10 kilometers increase in the distance to subway station is associated with a 0.8 percentage point decrease in the development likelihood.

The estimates of the interactive term in all columns are significantly positive. This indicates that the UGBs in these new towns have the intended effects in restricting land development. Before the UGBs are imposed, there is no significant difference in the development likelihood between parcels inside and outside UGBs. After the imposition of the UGBs, the development probability increased by 7.9-9.1 percentage points for parcels inside UGBs, significantly higher than the 0.3-1.6 percentage points increase for parcels outside UGBs according to estimates in Columns (1), (3) and (5) in Table 2.

[Insert Table 2 here.]

However, the identified UGBs' effects may be attributed to other policies implemented along with the UGB program. To show this possibility, we conduct two sets of placebo test by moving the original UGBs 1 kilometers inwards or outwards. The estimation results of Model (4.1) using these placebo UGBs are presented in Table 3. Here we still use land parcels within 5 kilometers distance to each of the original UGBs.[6] The estimates of placebo UGBs' effects are still significantly positive in all specifications, though the

[6] Using parcels within 5 kilometers distance to each of the placebo UGBs does not change the results much.

magnitudes are somewhat attenuated. Therefore, the identified UGBs' effects may simply arise from other policies that cause the change in the relative bid rents. For example, according to the 2020 Plan, new towns in Beijing would receive increased government funding, and thus it is not surprising that people would like to pay more for housing in these new town centers. To exclude the effects of confounding policies, we use a methodology that combines both the DID approach and an RDD approach in Section 6. Before that we present the RDD results.

[Insert Table 3 here.]

On the other hand, the placebo test results do not invalidate the estimated UGBs' effects. Moving UGBs inwards (outwards) means that some observations in the control (treatment) group are wrongly assigned to the treatment (control) group. In this case, we can still get significant results if the manipulation is moderate, which seems to hold in our analysis.

5. Regression discontinuity design method

An RDD method is used where the treatment depends on whether a running variable exceeds a known cutoff point (Lee and Lemieux, 2010). Thus, its use in our setting can effectively exclude the effects of confounding policies as long as these policies do not have the same boundaries as the UGB. We compare the development probability of land parcels just inside UGBs and that of parcels just outside UGBs based on the following standard spatial discontinuity design:

$$Approve_{itc} = \alpha_c + \beta X_{it} + \gamma UGB_{ic} + f(D_{ic}) + \varepsilon_{itc}, \quad (5.1)$$

Where D_{ic} is the distance between land parcel i located in town c and the corresponding UGB in that town (negative when outside boundaries) and used as the running variable $f(D_{ic})$ is a flexible, polynomial function of distance capturing unobserved location-specific characteristics that correlated with the distance to the UGB. Gelman and Imbens (2014) recommend that high-order polynomials should not be used in RDD and we use the linear and quadratic terms as the baseline results. The main coefficient of interest, γ, shows the local treatment effects of UGBs on urban development. The policy dummy *After* is omitted here because we estimate Model (5.1) using pre-treatment and post-treatment subsamples separately.

Table 4 presents the estimation results. All columns include the five control variables and town fixed effects but only the coefficient on UGB is reported. In 2003 when the UGBs are not implemented, the estimates of the UGB dummy in Panel 1 are all insignificant except one (Column (3)). In contrast, the estimates using the 2005-2010 sample in Panel 2 are significantly positive up to the seventh-order polynomial function of distance. This provides the evidence of a discontinuity in the development probability at the specified urban growth boundaries. On average, parcels located just inside UGBs are more likely to obtain a land use permit by 1.4-7.9 percentage points than those just outside UGBs. This effect is economically large since the probability that a parcel within 100 meters to the boundaries from outwards was issued a land use permit between 2005 and 2010 was only 1.3%. In other words, the development probability of parcels just inside UGBs is one to six times larger than that of parcels just outside UGBs. The estimates using only the 2005 subsample in Panel 3 are also significantly positive up to the fifth order polynomial.[7] The difference in the estimates using pre-treatment and post-treatment subsamples suggests that UGBs specified in the 2020 Plan indeed restrict land development outside UGBs.

[Insert Table 4 here.]

The above results should be interpreted with caution, however. When standard errors are clustered at the town level, the estimates of the UGB dummy using the 2005-2010 subsamples in Panel 5 are all positive but significant in only Columns (1) and (3), although the estimates using the pre-treatment subsample in Panel 4 are still insignificant in all specifications. As collaborative evidence, graphing the data lends support to the identified UGBs' effects on land development in the RDD setting. For a better illustration, we use only parcels within 2 kilometers distance to the UGBs.[8] The average ratio of parcels that were issued a land use permit in different periods is computed by 100 meter bins and graphed against the mid-point of the bins (Figures 3, 4, and 5). We choose the 100 meter bins rather than smaller ones considering that the average size of parcels is 0.053 square kilometers (Table 1). Also, a standard F-test comparing the fit of a regression model with 100 meter bin dummies to one with 50 meter bin dummies, as suggested by Lee and Lemieux (2010), confirm that we are not oversmoothing the data by using 100 meter bins (F-statistic is 1.11).

Figures 4 and 5 show clear evidence of a discontinuity in the development likelihood at the boundaries after the UGBs are implemented in those new towns. Note the difference in y-axis scale, which may conceal the fact that the local gap using the 2005 subsample is smaller than that using the 2005-2010 subsamples. In contrast, the jump at the boundaries is almost negligible when the UGBs are not implemented (Figure 3). Here we present only the linear fitted value, with different spatial trends to the left and to the right of the cutting point allowed, as well as the 95% confidence interval calculated with standard errors clustered at the town level. Our findings holds up to a cubic polynomial term of distance, although the relative magnitude differs.

[Insert Figures 3, 4, and 5 here.]

Inspecting Figures 4 and 5, we find that the discontinuity is actually located 100 meters inwards relative to the plan-specified UGBs. This is not surprising because planning officials may be conservative when approving development projects, given that the plan-specified boundaries cover more than the assigned built land area. There is no other policy that takes this very place (100 meters inwards) as cutting point, which is the advantage of using the RDD method.

[7] As a robustness check, we estimate Model (5.1) for subsamples in each year between 2006 and 2010. The estimation results confirm the jump in the development likelihood at the boundaries.
[8] The following findings hold using parcels within 5 kilometers distance to the boundaries.

As a further visual assessment of the results, we compare the spatial distribution of land use permits issued between 2005 and 2010 to what it would have been in the absence of UGBs. Assuming that each new town gets the same number of land use permits, we simulate the development probability of each parcel between 2005 and 2010 by adding a random number (normal distribution $N(0, 1)$) to the fitted probability using the 2003 subsamples (Column (7) of Panel 1 in Table 4). We then allocate land use permits to parcels in each new town by order of the simulated development probability. Figure 6 presents this rough counterfactual as well as the actual distribution of land use permits. In the absence of UGBs, more land use permits would have been allocated to parcels outside boundaries between 2005 and 2010 compared to the actual distribution with UGBs.[9] This difference is especially pronounced in key towns like Tongzhou and Yizhuang.

[Insert Figure 6 here.]

In addition, we apply a multi-dimensional RDD approach as in Dell (2010). This approach is different from the traditional RDD setting in terms of using geographic coordinates rather than the distance to the boundary. Its advantage is to visualize the results on a surface rather than on a line.[10] We estimate Model (5.1) up to the cubic polynomial of parcels' centroid coordinates, with standard errors clustered at the town level. The estimates of the UGB dummy, using the 2005-2010 subsamples, are significantly positive in all specifications, while those using the 2003 subsamples are all negative, either significant or in- significant (not reported here).[11] These results again confirm UGBs' effects on land development in Beijing. Based on the AICs, the predicted development probabilities of each parcel before and after the UGBs are implemented are imputed using quadratic polynomial model and graphed in Figures 7 to 9. We find a discontinuous change in the predicted development probability across the boundaries only after the implementation of UGBs (Figures 8 and 9).

[Insert Figures 7, 8, and 9 here.]

Although the above analysis taken together provide consistent support that the UGB policy have delayed the development of land outside the boundaries, the results of the RDD model using the post-treatment subsamples are still suggestive because there may be other factors that happen to show a discontinuity at the UGB's location—probably due to the endogeneity of the UGB. A model combining both the DID and RDD can effectively deal with both the time-varying and spatially-varying confounding factors.

6. Combining both the DID and RDD methods

[9] Here we graph the results of only one realization of the unobserved term. As expected, our findings hold in most simulations.

10 This, however, is essentially just a DID approach because it is not easy to control for the location of boundaries in the model.

11 The estimates of the location dummy using the 2005 subsamples are all positive but insignificant.

We propose a method of combining both the DID and RDD and compare the discontinuity in the development likelihood identified using pre-treatment subsamples and that using post-treatment subsamples. The model is specified as follows:

$$Approve_{itc} = \alpha_c + \beta X_{it} + \gamma UGB_{ic} + f(D_{ic}) + \lambda After_t + \theta(UGB_{ic} \times After_t) + \tau(f(D_{ic}) \times After_t) + \varepsilon_{itc}, \quad (6.1)$$

where λ and τ capture the overall change in development probability and the change in the spatial trend after the UGBs were imposed, respectively. The main coefficient of interest, θ, shows local treatment effects of UGBs on urban development relative to the absence of the UGB program, i.e., the difference in the local effects before and after the policy was imposed. The benefit of Model (6.1) is, as we discussed before, that any unobserved confounding factors must have a discontinuity that coincides both the urban growth boundary and the timing when the UGB policy is implemented, which is very unlikely.

Table 5 presents the estimation results. All models include the five control variables and new town fixed effects but only the coefficients of UGB and the interactive term *UGB*After* are reported. We use the 2003 subsamples and the 2005-2010 subsamples in Panels 1 and 3, and the 2003 and 2005 subsamples in Panels 2 and 4. The estimates in Panel 1 confirm that UGBs in new towns have a significant effect on land development only after the 2020 Plan has been approved. The development likelihood of parcels just inside UGBs is higher by 1.4-7.7 percentage points than those just outside UGBs relative to the absence of UGBs. The estimates lose their significance when the seventh-order polynomial terms of distance is added. Panel 2 shows qualitatively the same results.

Again, when standard errors are clustered at the town level, the estimates of the interactive term are still positive in all columns of Panels 3 and 4, though significant in only Columns (1), (3), and (6) of Panel 3.

[Insert Table 5 here.]

More robustness checks

In addition to adding polynomials of the running variable, we do a series of robustness checks to show the running variable is not manipulated. First, the density of the running variable, along with a third-order polynomial fitted line (different spatial trends allowed), is presented in Figure 10. Moving outwards from town center, the density first increases and then decreases, mainly because both the number and the size of parcels increase with distance to town center. The graph shows no evidence of discontinuity at the boundaries. A formal McCrary sorting test using 100 meter bins also fails to reject the null hypothesis of no discontinuity (log difference in height -0.013, with standard error 0.013) (McCrary, 2008). This is not surprising since land parcels could hardly be spatially "manipulated".

[Insert Figure 10 here.]

We then check whether there is any discontinuity in the covariates, i.e., the potential endogeneity of UGBs. Of all five covariates, we find a discontinuity at the boundaries for just the 2003 land use status dummy (Figure 11).[12] Thus, it is possible that UGBs in the 2020 Plan were specified based on the actual land use at that time. This will cast doubt on our estimation results if we use only post-treatment samples. For example, the identified UGBs' effects on land development could be explained simply by the spatial correlation of development activities. Nonetheless, the DID+RDD method we use, in particular the estimation results using the pre-treatment samples as the comparison (control group) excludes such an explanation. We should have found evidence of spatial discontinuity in the issuance of land use permits in 2003 if the alternative explanation holds, but this is not true according to the estimates in Tables 4 and 5.

[Insert Figure 11 here.]

We test the sensitivity of results to a range of symmetric windows: 2, 1, and 0.5 kilometers. Tables 6 and 7 present the estimation results of Models (5.1) and (6.1) using the 2 and 1 kilometer windows, respectively. As for the 2 kilometer window, the insignificant estimates of the UGB dummy using pre-treatment subsamples (Panel 1) and the significant estimates using post-treatment subsamples (Columns (1) to (5) in Panel 2, and Columns (1) to (3) in Panel 3) validate the effects of UGBs on development. Note that when standard errors are clustered at the town level, the estimates are significant in only the linear model using the 2005-2010 subsamples and insignificant in all models using the 2005 subsamples, although all positive. Panels 4 and 5 present qualitatively the same results using the DID+RDD model. The estimates of the UGB dummy using post-treatment samples within the 1 kilometer window lose their significance in specifications such as Columns (3) and (4) in Panel 2 and Column (3) in Panel 3, compared to those using the 2 kilometer window. Furthermore, the estimates, not reported here, are significant in even fewer specifications when the 0.5 kilometer window is used. This probably arises from the fact that planning officials act conservatively when approving development projects inside UGBs but close to the boundaries, i.e., the actual control group being larger than it seems to be (see Figures 4 and 5).

[Insert Tables 6 and 7 here.]

As suggested by Figures 3 to 5, we allow different spatial trends of development probabilities to the left and to the right of the UGB, by adding interactive terms of the UGB dummy and polynomials of the running variable in Model (5.1). As seen in Table 8, the estimation results using pre-treatment and post-treatment subsamples are quite similar to those in Table 4. The estimates of interactive terms, not reported here, confirm the different spatial trends.

[12] A spatial discontinuity is also found for the planned land use dummy in 2020, since it was given by the 2020 Plan. As discussed below, this would not invalidate our results given the method we use.

[Insert Table 8 here.]

Other robustness tests not reported here include: (1) allowing UGBs' effects to be different between plan-specified key towns and other towns; (2) allowing the spatial trends to be different between key towns and other towns, or different across each town; (3) using a time-invariant subway variable on the basis of the planned 2015 subway system; (4) adding the lags of the dependent variable when appropriate.[13] Using the panel data of year 2005 to 2010, we also find no evidence of diminishing effects of UGBs with time by adding an interactive term of the UGB dummy and the year dummy on the basis of Model (5.1).

7. Conclusions

This study examines the effects of Beijing's urban growth boundaries on land development using the dataset of land use permits issued between 2003 and 2010.14 Our findings show that this policy to some extent have curtailed urban development outside UGBs. After the imposition of UGBs, the development probability of land parcels located just outside UGBs is lower by 1.4-7.7 percentage points than those just inside UGBs. This effect is economically large since the probability that a parcel within 100 meter to the boundaries from outwards was issued a land use permit between 2005 and 2010 was only 1.3%. The identified effects are due to either the strict enforcement on the government side or the postpone of development on the developer side given the potential increase in land prices within the boundaries. However, we cannot distinguish between these two interpretations since we have no data on projects denied permits.

Our identification strategy can well address two issues in the empirical work: the existence of confounding policies and the endogeneity of the UGB's location. First, there may be other policies implemented along with the UGB program that also restrict urban sprawl. In this case, researchers who use a differences-in-differences approach cannot simply attribute the identified effects to the UGB program. The regression discontinuity design approach overcomes this issue by looking at local effects near the boundaries. However, there is another challenge if only cross-sectional data are used. Since a UGB is usually specified according to the current land use and the provision of infrastructure or public facilities, it is possible that one of these factors have a spatial discontinuity at the UGB's location. The methodology we propose combines both the DID approach and the RDD approach and can exclude the influence of not only confounding policies but also such "discontinuity" factors.

[13] Sometimes a land parcel were issued multiple land use permits in different years. The main reason is that a parcel may have been subdivided into several lots but remains as a complete parcel in the geographic database. In this case, for each lot its developer need apply for a separate land use permit. Usually planning officials would not deny the application if land use permits had been assigned to other lots in the same parcel.

14 We do not investigate UGBs' effects on land price because in China the non-built land specified as in urban plan is not available for leasehold sales. We examine UGBs' effects on population density using public transit passenger in 2010 as proxy but do not find any discontinuity, probably due to the relatively small number of permits issued

The National Development and Reform Commission of China proposed in 2014 that the focus of urban planning be on specifying urban growth boundaries as well as redevelopment rather than urban expansion. However, there have been a lot of doubts about the effectiveness of urban planning in China, and in particular whether or not plans have been effectively implemented. These plans are often described as being merely "Drawn on the map, hung on the wall." Our study shows that, at least in Beijing, urban planning plays a significant role in shaping a city's spatial structure.

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Figure 1: UGBs in seven new towns and parcels within the 5km window

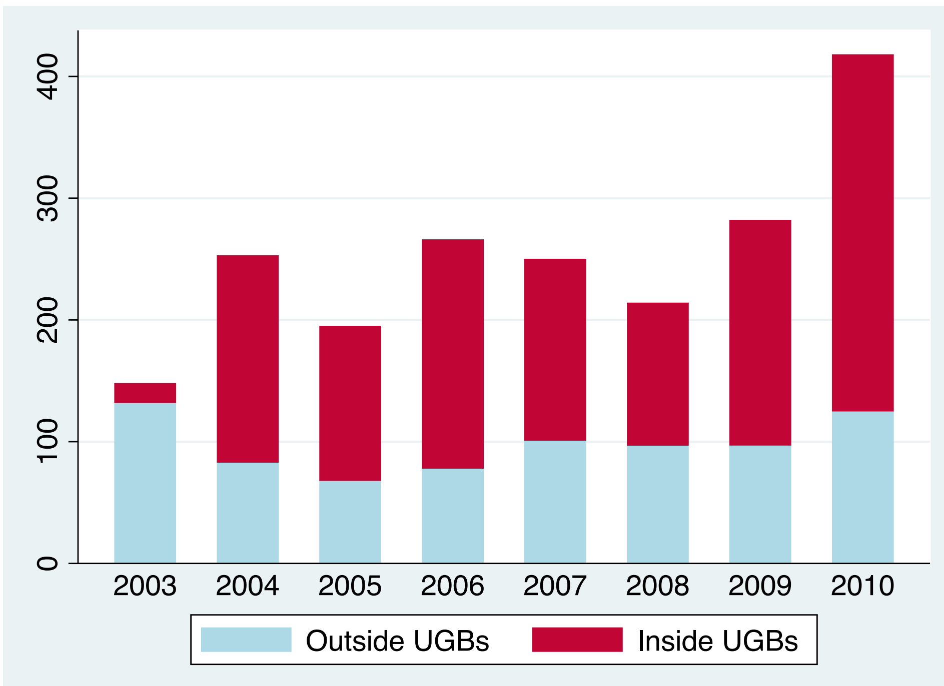
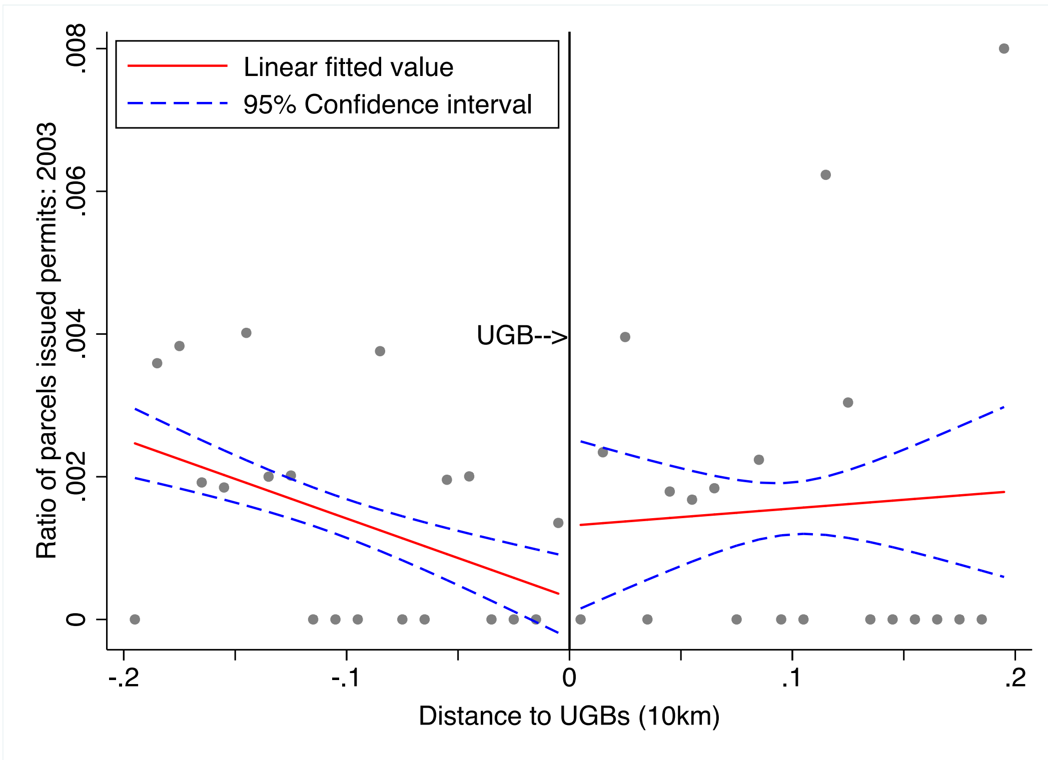
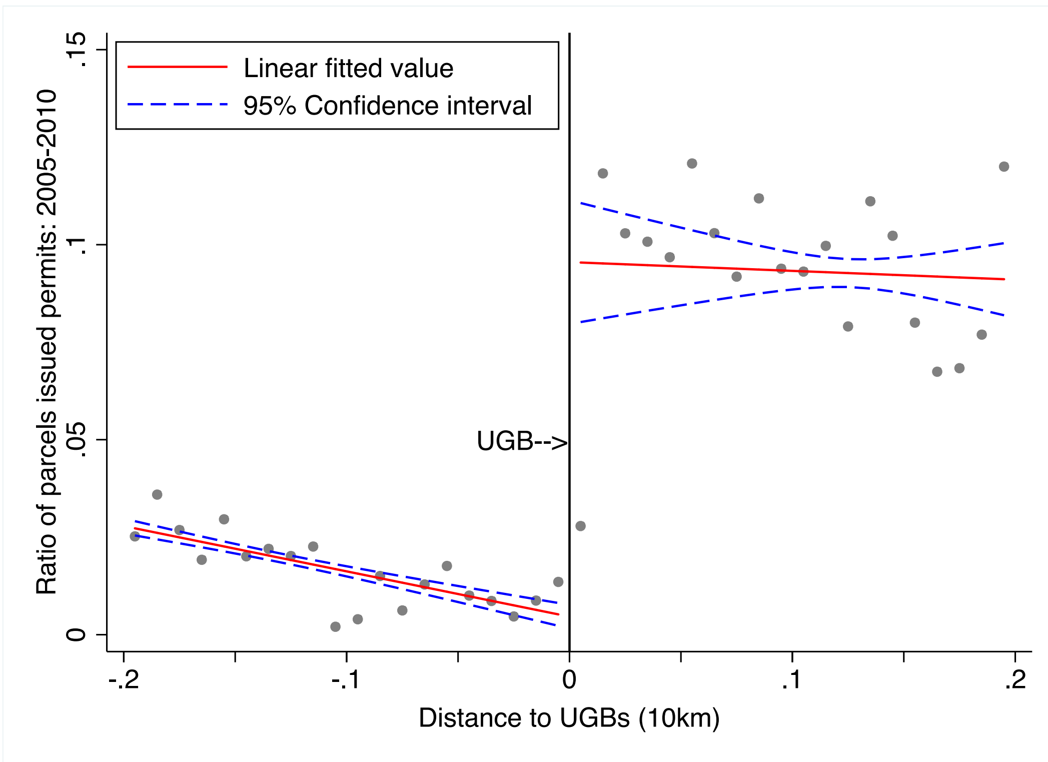


Figure 2: The number of land use permits issued from 2003 to 2010 within the study area



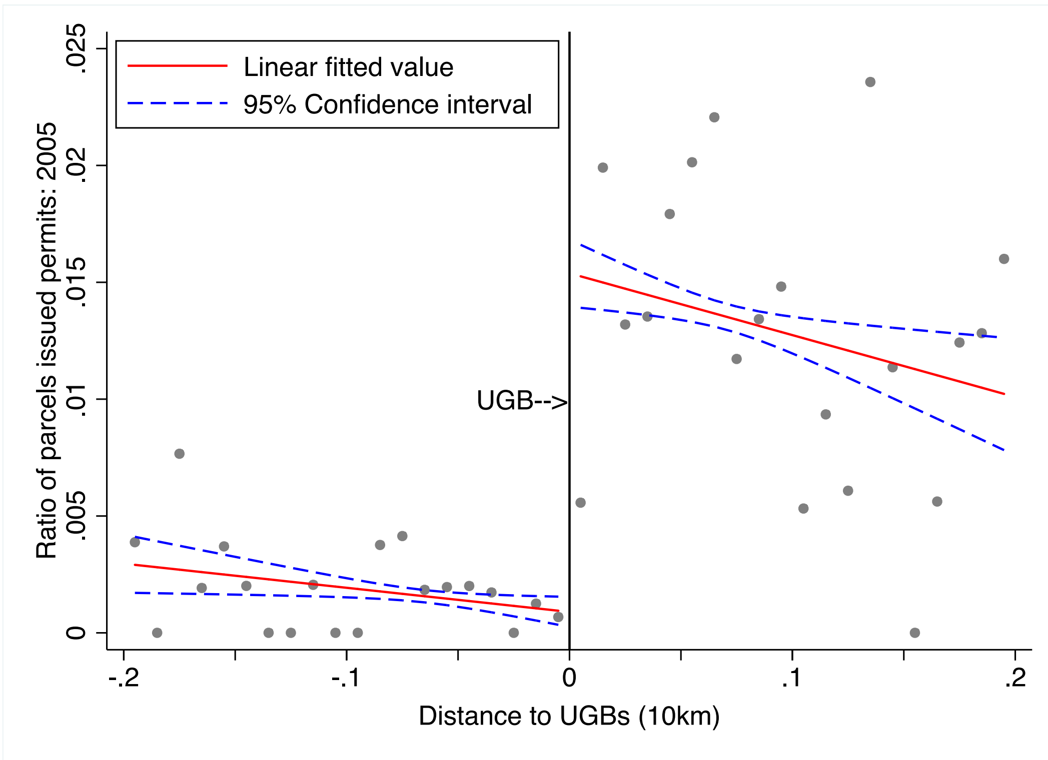
Note: Standard errors clustered by new town. Different spatial trends allowed.

Figure 3: The average ratio of parcels issued a land use permit in 2003



Note: Standard errors clustered by new town. Different spatial trends allowed.

Figure 4: The average ratio of parcels issued a land use permit from 2005 to 2010



Note: Standard errors clustered by new town. Different spatial trends allowed.

Figure 5: The average ratio of parcels issued a land use permit in 2005

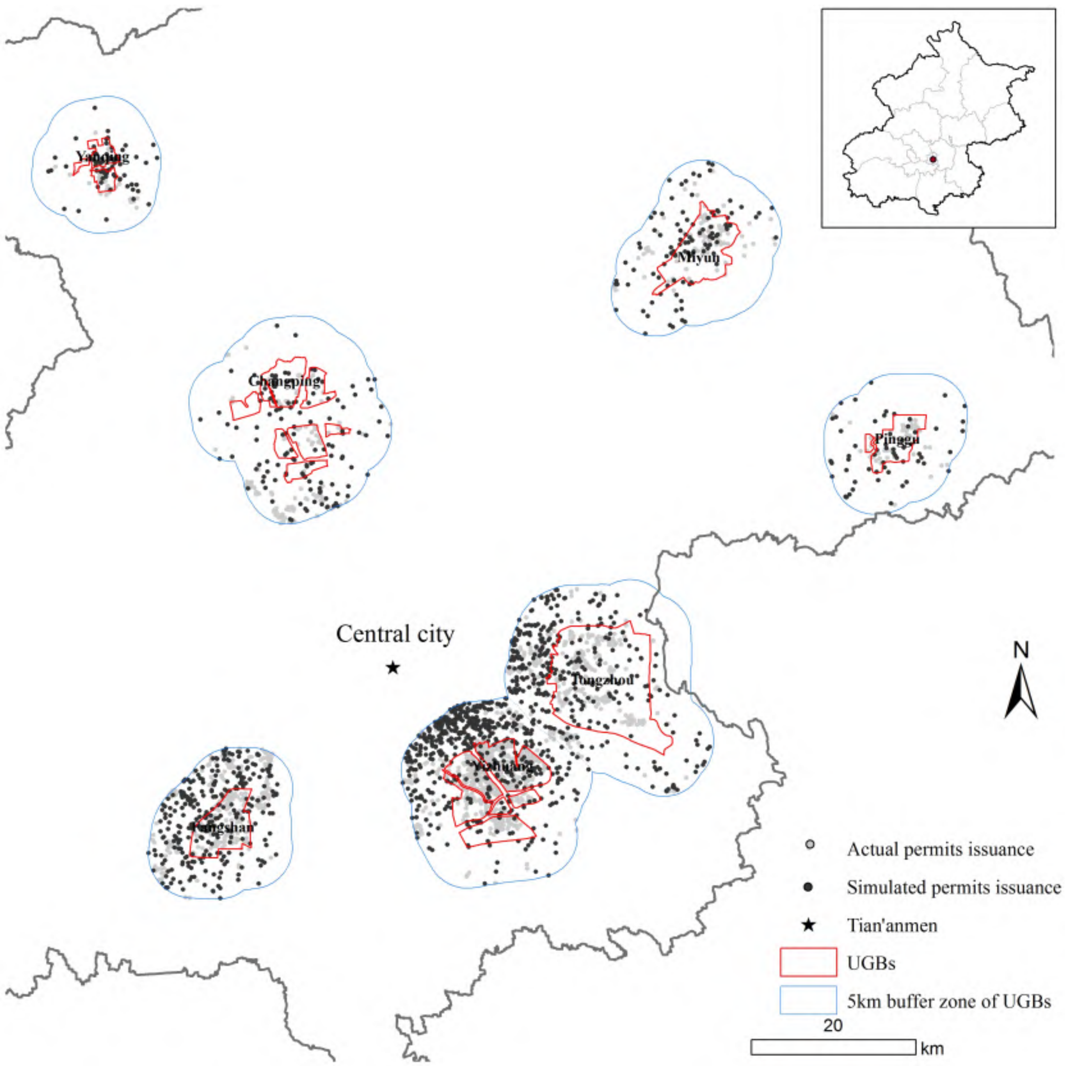
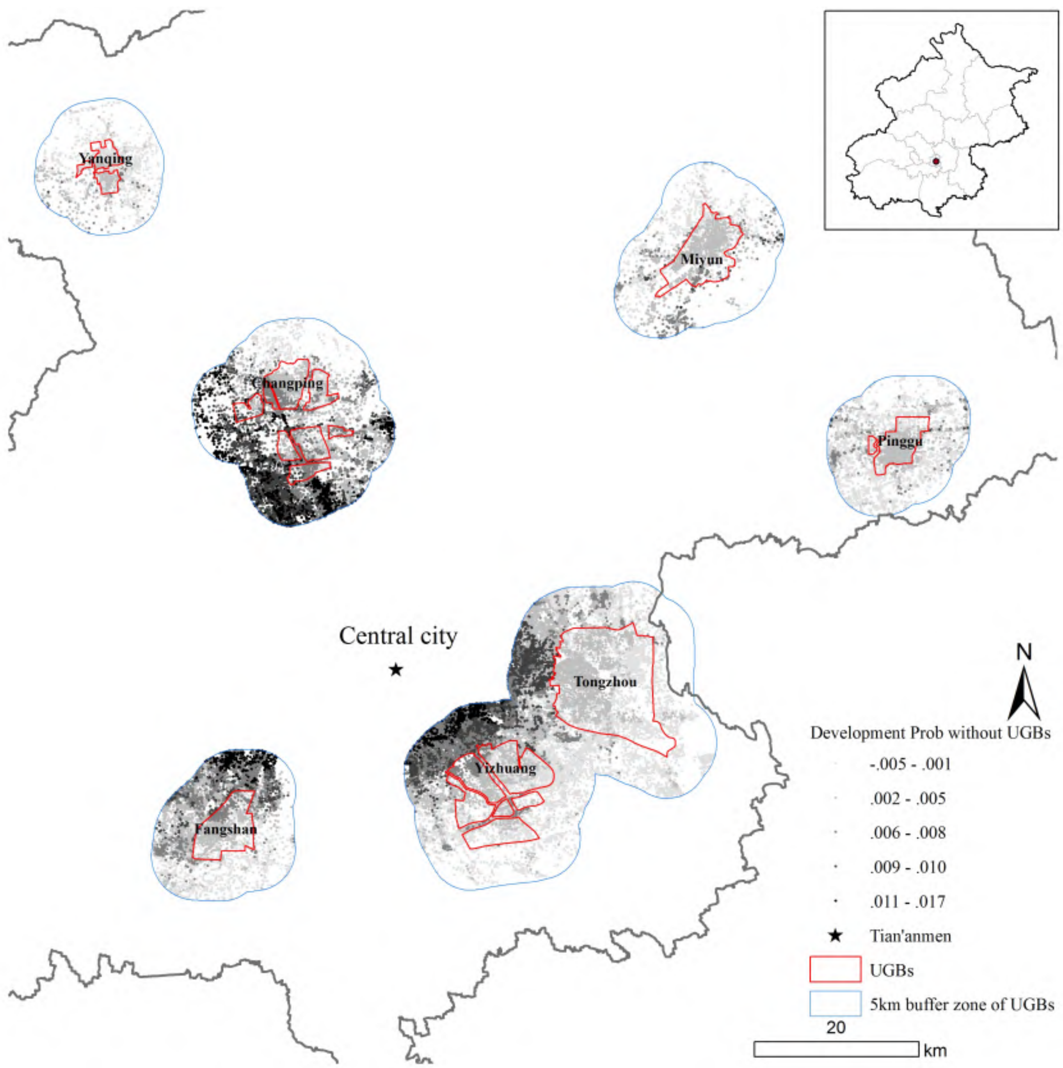
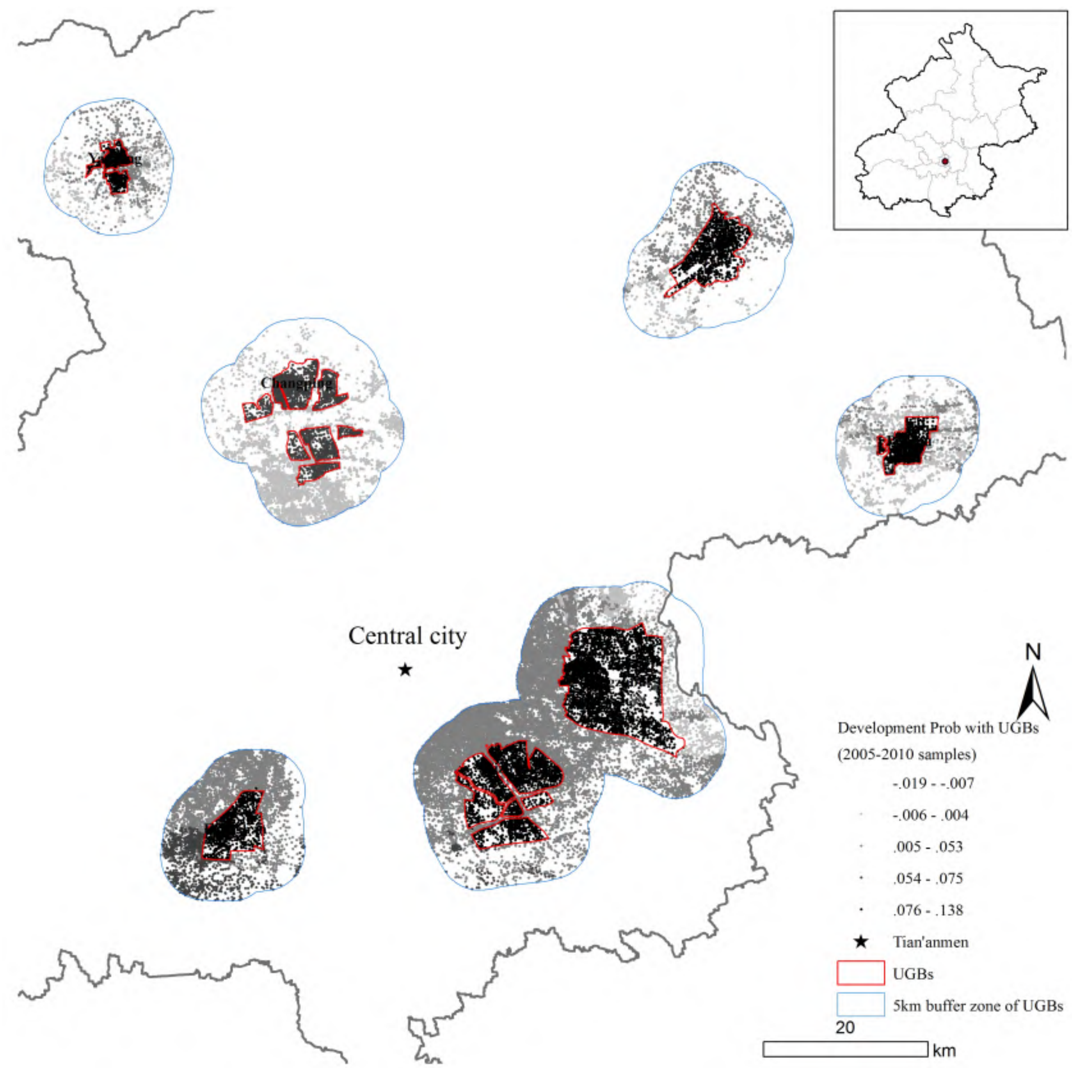


Figure 6: The spatial distribution of land use permits issued from 2005 to 2010
Actual (with UGBs) vs. Simulated (without UGBs)



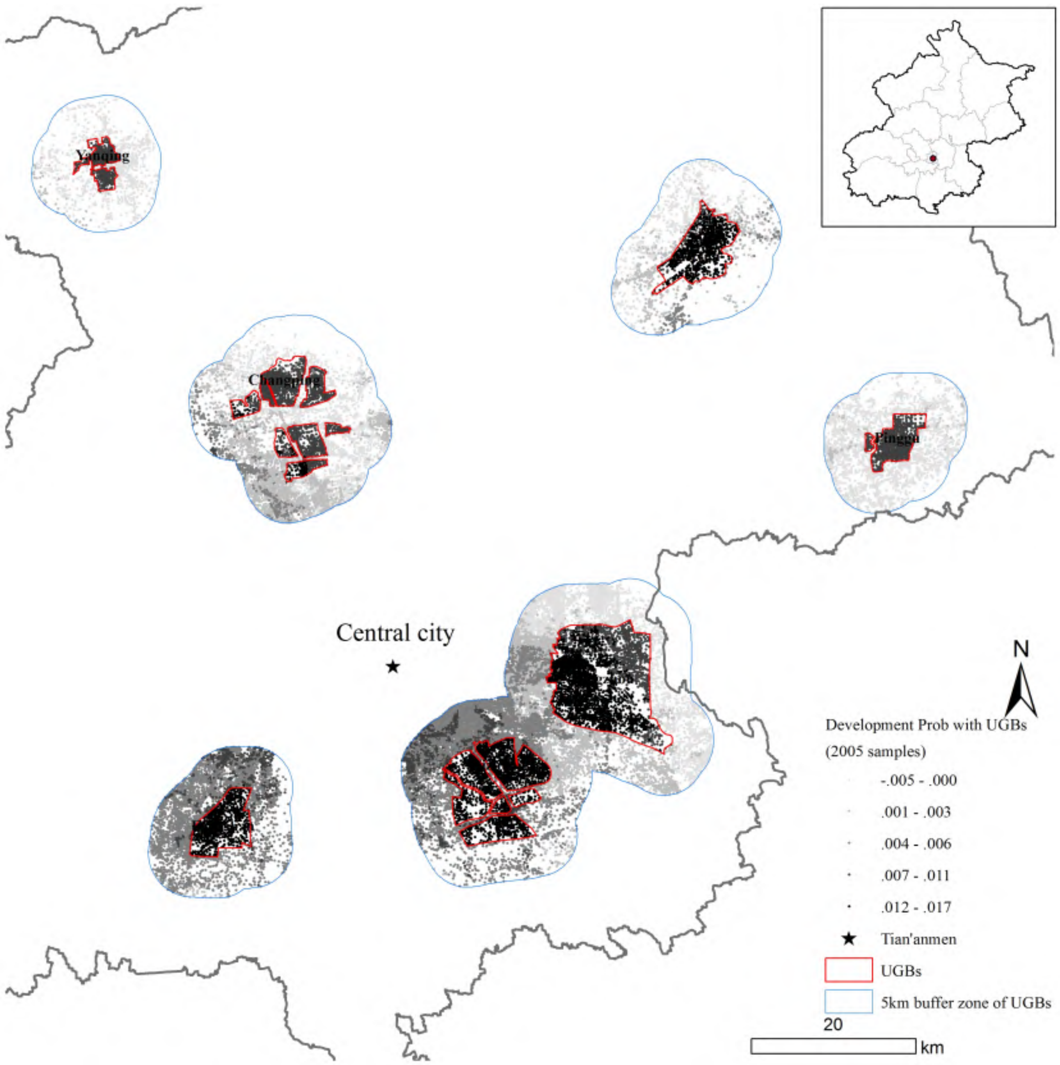
Note: Quadratic fit of a multi-dimensional RDD model. Standard errors clustered by new town.

Figure 7: The predicted development probability of parcels in 2003



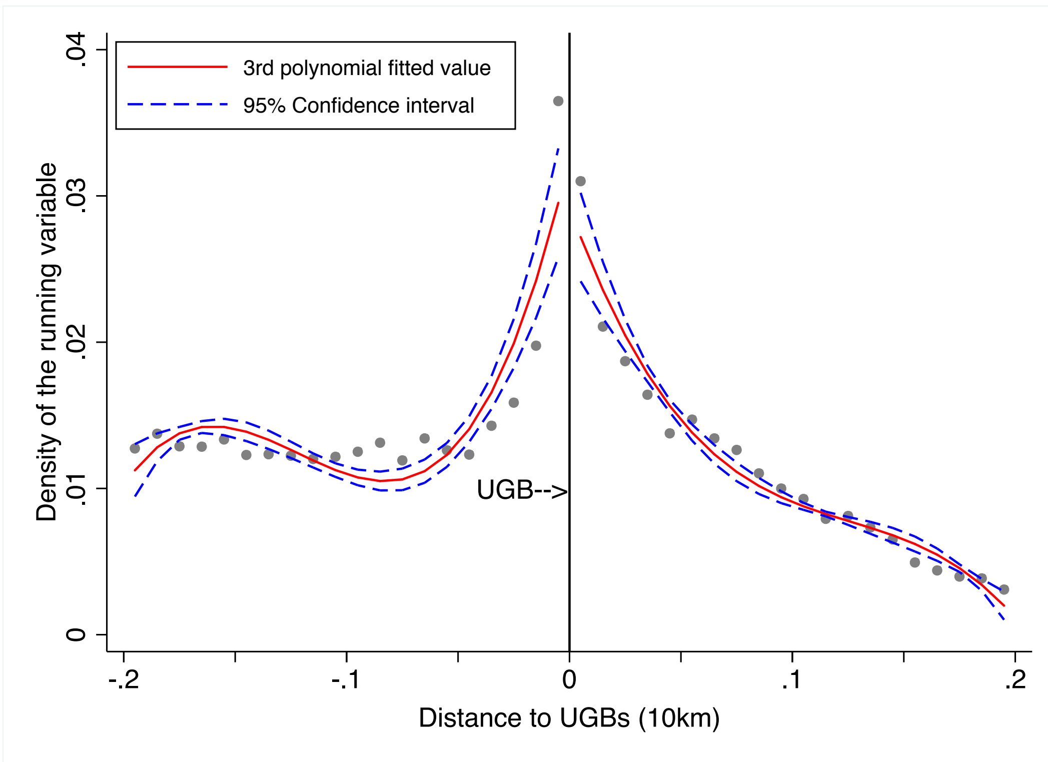
Note: Quadratic fit of a multi-dimensional RDD model. Standard errors clustered by new town.

Figure 8: The predicted development probability of parcels between 2005 and 2010



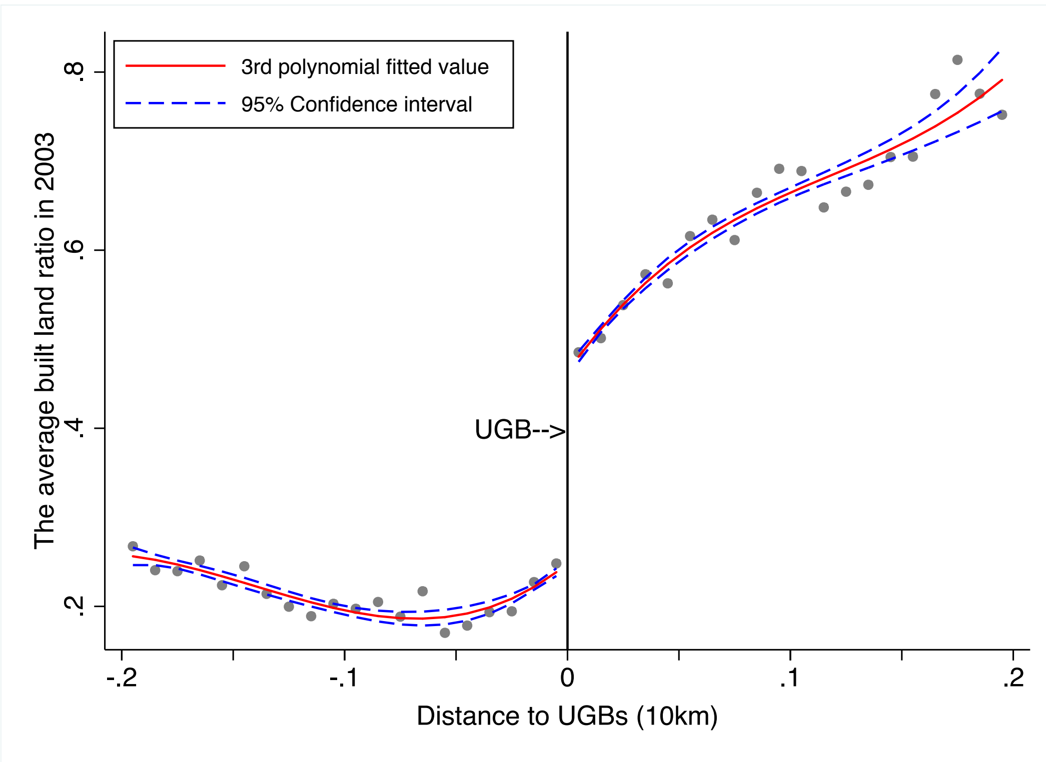
Note: Quadratic fit of a multi-dimensional RDD model. Standard errors clustered by new town.

Figure 9: The predicted development probability of parcels in 2005



Note: Standard errors clustered by new town. Different spatial trends allowed.

Figure 10: The density of the running variable



Note: Standard errors clustered by new town. Different spatial trends allowed.

Figure 11: The average built land ratio in 2003

Table 1: Summary statistics of all 40,540 parcels

Variable	**Definition**	**Year**	**Mean**	**SD**	**Min**	**Max**
Approve	Whether being issued a land use permit	2003	0.004	0.060	0	1
		2005-2010	0.037	0.188	0	1
Area	km^2		0.053	0.288	0.000	24.283
UGB	Inside UGBs or not		0.259	0.438	0	1
D	Air distance to the corresponding UGB (10km), negative when outside UGBs		-0.160	0.209	-0.500	0.499
Built03	Built land as of 2003 or not		0.353	0.478	0	1
Plan20	Built land as in the 2020 Plan or not		0.815	0.388	0	1
TAM	Air distance to Tian'anmen (10km)		2.951	1.753	0.826	7.865
Road	Air distance to the closest major road in 2006 (10km)		0.101	0.101	0.000	0.765
Subway	Air distance to the closest subway station in 2003 or in 2010 (10km)	2003	1.878	1.000	0.005	4.352
		2005-2010	0.697	0.621	0.000	3.421
NewTown	Tongzhou 28.0%, Yizhuang 26.9%, Miyun 4.9%, Pinggu 7.0%, Changping 17.9%, Fangshan 11.5%, Yanqing 3.8%					

Table 2: Estimation results of Model 4.1: a DID approach

Regressand	*Approve*: whether being issued a land use permit					
N = 81,080	**(I)**	**(II)**	**(III)**	**(IV)**	**(V)**	**(VI)**
UGB	-0.003	-0.003	-0.003	-0.004	-0.001	-0.003
	(0.002)	(0.002)	(0.004)	(0.003)	(0.004)	(0.002)
After	0.013**	-0.002**	0.016**	-0.002**	0.003	-0.002**
	(0.005)	(0.001)	(0.005)	(0.001)	(0.005)	(0.001)
UGB*After	0.076**	0.013*	0.075**	0.013*	0.076**	0.013*
	(0.030)	(0.006)	(0.030)	(0.006)	(0.029)	(0.006)
Built03			0.001	0.003**	0.001	0.003**
			(0.003)	(0.001)	(0.003)	(0.001)
Plan20			0.005	0.002	0.004	0.002
			(0.003)	(0.001)	(0.003)	(0.001)
TAM			-0.002*	-0.001***	-0.003	-0.005*
			(0.001)	(0.000)	(0.003)	(0.002)
Subway			0.002	0.001	-0.008**	0.005
			(0.001)	(0.000)	(0.003)	(0.003)
Road			-0.019	-0.008*	-0.006	-0.005
			(0.013)	(0.004)	(0.011)	(0.004)
Constant	0.004**	0.004**	0.005	0.004**	0.007	0.017**
	(0.001)	(0.001)	(0.004)	(0.002)	(0.013)	(0.006)
Fixed effect: by new town	No	No	No	No	Yes	Yes
R-squared	0.039	0.002	0.041	0.004	0.045	0.006

Equation I, III, and V: samples in 2003 and 2005-2010; Equation II, IV, and VI: samples in 2003 and 2005.
Standard errors clustered by new town in parenthesis. * = 10% significance, ** = 5% significance, *** = 1% significance.

Table 3: Estimation results of Model 4.1: a DID approach with placebo UGBs

Regressand	*Approve*: whether being issued a permit			
Placebo UGBs	Moving the original UGBs			
	1km inwards		1km outwards	
N = 81,080	**(I)**	**(II)**	**(III)**	**(IV)**
UGB	-0.006***	-0.003*	-0.006**	-0.004**
	(0.001)	(0.001)	(0.002)	(0.002)
After	0.019***	0.001	0.006	-0.003*
	(0.004)	(0.002)	(0.004)	(0.001)
UGB*After	0.062***	0.006**	0.044**	0.010**
	(0.009)	(0.002)	(0.016)	(0.003)
Built03	0.006**	0.004**	0.007***	0.004**
	(0.002)	(0.001)	(0.001)	(0.001)
Plan20	0.013**	0.003***	0.011***	0.003***
	(0.004)	(0.001)	(0.002)	(0.000)
TAM	0.004	-0.005	0.002	-0.005*
	(0.008)	(0.002)	(0.005)	(0.002)
Subway	-0.007**	0.005	-0.007*	0.005
	(0.002)	(0.003)	(0.003)	(0.003)
Road	-0.015	-0.007*	-0.011	-0.006
	(0.008)	(0.003)	(0.011)	(0.004)
Constant	-0.020	0.013	-0.012	0.016**
	(0.031)	(0.007)	(0.020)	(0.006)
R-squared	0.027	0.004	0.029	0.005

Equation I and III: samples in 2003 and 2005-2010; Equation II and IV: samples in 2003 and 2005.
New town fixed effects added. Standard errors clustered by new town in parenthesis. * = 10% significance, ** = 5% significance, *** = 1% significance.

Table 4: Estimation results of Model 5.1: RDD by period

Regressand	*Approve*: whether being issued a land use permit						
N = 40,540	**(I)**	**(II)**	**(III)**	**(IV)**	**(V)**	**(VI)**	**(VII)**
Polynomial	1st order	2nd order	3rd order	4th order	5th order	6th order	7th order
Panel 1: 2003 samples							
UGB	0.000	0.001	-0.004**	0.001	0.000	-0.004	-0.001
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
R-squared	0.008	0.008	0.009	0.009	0.009	0.010	0.010
AIC	-112964.2	-112965.2	-112988.3	-113003.1	-113001.2	-113011.3	-113015.6
Panel 2: 2005-2010 samples							
UGB	0.079***	0.078***	0.074***	0.057***	0.034***	0.023***	0.014*
	(0.003)	(0.004)	(0.005)	(0.006)	(0.007)	(0.008)	(0.008)
R-squared	0.039	0.039	0.039	0.039	0.040	0.041	0.041
AIC	-22076.9	-22074.9	-22074.6	-22101.7	-22147.6	-22157.3	-22161.1
Panel 3: 2005 samples							
UGB	0.012***	0.013***	0.012***	0.011***	0.008***	0.004	0.004
	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
R-squared	0.006	0.006	0.006	0.006	0.006	0.007	0.007
AIC	-101744.8	-101743.4	-101742.1	-101741.1	-101744.0	-101751.8	-101749.8
Panel 4: 2003 samples; Robust standard errors							
UGB	0.000	0.001	-0.004	0.001	0.000	-0.004	-0.001
	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)	(0.003)	(0.003)
R-squared	0.008	0.008	0.009	0.009	0.009	0.010	0.010
AIC	-112968.2	-112971.2	-112996.3	-113013.1	-113011.2	-113025.3	-113033.6
Panel 5: 2005-2010 samples; Robust standard errors							
UGB	0.079*	0.078	0.074*	0.057	0.034	0.023	0.014
	(0.040)	(0.042)	(0.038)	(0.031)	(0.023)	(0.014)	(0.009)
R-squared	0.039	0.039	0.039	0.039	0.040	0.041	0.041
AIC	-22080.7	-22080.9	-22082.6	-22109.7	-22159.6	-22167.3	-22175.1
Panel 6: 2005 samples; Robust standard errors							
UGB	0.012	0.013	0.012	0.011	0.008	0.004	0.004
	(0.007)	(0.008)	(0.010)	(0.009)	(0.006)	(0.006)	(0.005)
R-squared	0.006	0.006	0.006	0.006	0.006	0.007	0.007
AIC	-101748.8	-101749.4	-101750.1	-101749.1	-101756.0	-101763.8	-101761.8

Land use dummies, location variables, and new town fixed effects included in all equations. Columns I to VII include polynomial terms of the running variable up to the seventh order. Standard errors in parenthesis (clustered by new town in Panels 4-6). * = 10% significance, ** = 5% significance, *** = 1% significance.

Table 5: Estimation results of Model 6.1: A DID+RDD approach

Regressand	*Approve*: whether being issued a land use permit						
N = 81,080	**(I)**	**(II)**	**(III)**	**(IV)**	**(V)**	**(VI)**	**(VII)**
Polynomial	1st order	2nd order	3rd order	4th order	5th order	6th order	7th order
	Panel 1: 2003 and 2005-2010 samples						
UGB	0.001	0.003	-0.002	0.002	0.001	-0.002	0.000
	(0.002)	(0.003)	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)
UGB*After	0.077***	0.072***	0.073***	0.053***	0.032***	0.024***	0.014
	(0.003)	(0.004)	(0.005)	(0.006)	(0.007)	(0.008)	(0.009)
R-squared	0.045	0.045	0.045	0.045	0.046	0.047	0.047
AIC	-91812.2	-91810.4	-91815.8	-91862.6	-91939.6	-91957.3	-91963.2
	Panel 2: 2003 and 2005 samples						
UGB	0.001	0.002	-0.003	0.001	0.001	-0.003	-0.001
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
UGB*After	0.010***	0.010***	0.014***	0.009***	0.007*	0.007*	0.004
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
R-squared	0.006	0.006	0.006	0.006	0.006	0.007	0.007
AIC	-213842.5	-213841.8	-213861.7	-213872.1	-213873.9	-213891.4	-213891.6
	Panel 3: 2003 and 2005-2010 samples; Robust standard errors						
UGB	0.001	0.003	-0.002	0.002	0.001	-0.002	0.000
	(0.002)	(0.002)	(0.004)	(0.001)	(0.001)	(0.003)	(0.002)
UGB*After	0.077*	0.072	0.073*	0.053	0.032	0.024*	0.014
	(0.038)	(0.041)	(0.034)	(0.030)	(0.022)	(0.012)	(0.008)
R-squared	0.045	0.045	0.045	0.045	0.046	0.047	0.047
AIC	-91822.2	-91824.4	-91833.8	-91884.6	-91963.6	-91983.3	-91995.2
	Panel 4: 2003 and 2005 samples; Robust standard errors						
UGB	0.001	0.002*	-0.003	0.001*	0.001	-0.003	-0.001
	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)	(0.002)
UGB*After	0.010	0.010	0.014	0.009	0.007	0.007	0.004
	(0.008)	(0.008)	(0.008)	(0.009)	(0.007)	(0.004)	(0.004)
R-squared	0.006	0.006	0.006	0.006	0.006	0.007	0.007
AIC	-213852.5	-213855.8	-213879.7	-213892.1	-213897.9	-213921.4	-213923.6

The period dummy, land use dummies, location variables, and new town fixed effects included in all equations. Columns I to VII include polynomial terms of the running variable up to the seventh order. Different pre-treatment and post-treatment spatial trends allowed. Standard errors in parenthesis (clustered by new town in Panels 3 and 4). * = 10% significance, ** = 5% significance, *** = 1% significance.

Table 6: Estimation results of Models 5.1 and 6.1: $2km$ symmetric window

Regressand	*Approve*: whether being issued a land use permit							
	(I)	**(II)**	**(III)**	**(IV)**	**(V)**	**(VI)**	**(VII)**	**(VIII)**
Polynomial	1st order	2nd order	3rd order	4th order	1st order	2nd order	3rd order	4th order
N = 20,712	Panel 1: RDD; 2003 samples							
UGB	0.000	0.000	-0.001	0.000	0.000	0.000	-0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)
R-squared	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
AIC	-77389.3	77387.4	77387.8	-77386.5	-77393.3	-77393.4	-77395.8	-77396.5
	Panel 2: RDD; 2005-2010 samples							
UGB	0.085***	0.061***	0.034***	0.018*	0.085*	0.061	0.034	0.018
	(0.005)	(0.007)	(0.008)	(0.009)	(0.042)	(0.033)	(0.021)	(0.011)
R-squared	0.050	0.052	0.053	0.054	0.050	0.052	0.053	0.054
AIC	-6032.5	-6062.3	-6093.2	-6102.2	-6036.5	-6068.3	-6101.2	-6108.2
	Panel 3: RDD; 2005 samples							
UGB	0.013***	0.011***	0.007**	0.004	0.013	0.011	0.007	0.004
	(0.002)	(0.003)	(0.003)	(0.004)	(0.009)	(0.008)	(0.007)	(0.004)
R-squared	0.010	0.010	0.011	0.011	0.010	0.010	0.011	0.011
AIC	-45054.5	-45053.5	-45058.0	-45057.7	-45058.5	-45059.5	-45066.0	-45067.7
N = 41,424	Panel 4: DID+RDD; 2003 and 2005-2010 samples							
UGB	0.003	0.003	0.001	0.000	0.003	0.003	0.001	0.000
	(0.004)	(0.005)	(0.006)	(0.007)	(0.003)	(0.002)	(0.002)	(0.002)
UGB*After	0.079***	0.055***	0.031***	0.017*	0.079*	0.055	0.031	0.017
	(0.005)	(0.007)	(0.008)	(0.010)	(0.038)	(0.030)	(0.019)	(0.010)
R-squared	0.064	0.066	0.067	0.067	0.064	0.066	0.067	0.067
AIC	-39214.0	-39270.5	-39325.2	-39339.5	-39224.0	-39284.5	-39341.2	-39359.5
	Panel 5: DID+RDD; 2003 and 2005 samples							
UGB	0.001	0.001	-0.001	0.000	0.001	0.001	-0.001	0.000
	(0.002)	(0.002)	(0.002)	(0.003)	(0.001)	(0.001)	(0.001)	(0.002)
UGB*After	0.012***	0.010***	0.007**	0.005	0.012	0.010	0.007	0.005
	(0.002)	(0.003)	(0.003)	(0.004)	(0.009)	(0.008)	(0.006)	(0.004)
R-squared	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
AIC	-110863.2	-110861.4	-110868.0	-110866.0	-110873.2	-110875.4	-110886.0	-110888.0
Standard errors					Robust	Robust	Robust	Robust

Land use dummies, location variables, and new town fixed effects included in all equations. The period dummy included in Panels 4 and 5. Columns I to IV and V to VIII include polynomial terms of the running variable up to the fourth order. Different pre-treatment and post-treatment spatial trends allowed in Panels 4 and 5. Standard errors in parenthesis (clustered by new town in Panels 4 and 5). * = 10% significance, ** = 5% significance, *** = 1% significance.

Table 7: Estimation results of Models 5.1 and 6.1: $1km$ symmetric window

Regressand	*Approve*: whether being issued a land use permit							
	(I)	**(II)**	**(III)**	**(IV)**	**(V)**	**(VI)**	**(VII)**	**(VIII)**
Polynomial	1st order	2nd order	3rd order	4th order	1st order	2nd order	3rd order	4th order
N = 13,174	Panel 1: RDD; 2003 samples							
UGB	0.000	0.000	-0.002	-0.003	0.000	0.000	-0.002	-0.003
	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.001)	(0.002)	(0.003)
R-squared	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
AIC	-51958.1	-51957.2	-51958	-51956.9	-51952.1	-51963.2	-51966	-51964.9
	Panel 2: RDD; 2005-2010 samples							
UGB	0.067***	0.035***	0.001	-0.016	0.067	0.035*	0.001	-0.016
	(0.006)	(0.008)	(0.010)	(0.012)	(0.036)	(0.018)	(0.006)	(0.011)
R-squared	0.067	0.069	0.071	0.072	0.067	0.069	0.071	0.072
AIC	-3494.4	-3525.2	-3554.6	-3559.9	-3498.4	-3531.2	-3562.6	-3567.9
	Panel 3: RDD; 2005 samples							
UGB	0.012***	0.006*	0.003	0.001	0.012	0.006	0.003	0.001
	(0.003)	(0.004)	(0.004)	(0.005)	(0.008)	(0.005)	(0.003)	(0.002)
R-squared	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
AIC	-26541.6	-26544.7	-26544.7	-26543	-26545.6	-26550.7	-26552.7	-26551
N = 26,348	Panel 4: DID+RDD; 2003 and 2005-2010 samples							
UGB	0.004	0.002	-0.001	-0.002	0.004*	0.002	-0.001	-0.002
	(0.005)	(0.006)	(0.007)	(0.009)	(0.002)	(0.002)	(0.002)	(0.002)
UGB*After	0.060***	0.032***	0.002	-0.013	0.06	0.032	0.002	-0.013
	(0.006)	(0.009)	(0.011)	(0.012)	(0.032)	(0.017)	(0.005)	(0.012)
R-squared	0.080	0.082	0.084	0.085	0.080	0.082	0.084	0.085
AIC	-24382.7	-24436.5	-24487.2	-24496.1	-24392.7	-24450.5	-24503.2	-24514.1
	Panel 5: DID+RDD; 2003 and 2005 samples							
UGB	0.001	0.000	-0.003	-0.004	0.001	0.000	-0.003	-0.004
	(0.002)	(0.003)	(0.003)	(0.004)	(0.001)	(0.001)	(0.002)	(0.002)
UGB*After	0.010***	0.007*	0.006	0.006	0.010	0.007	0.006	0.006**
	(0.003)	(0.004)	(0.005)	(0.005)	(0.008)	(0.005)	(0.003)	(0.002)
R-squared	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
AIC	-67701.3	-67705.3	-67705.2	-67701.8	-67711.3	-67719.3	-67723.2	-67719.8
Standard errors					Robust	Robust	Robust	Robust

Land use dummies, location variables, and new town fixed effects included in all equations. The period dummy included in Panels 4 and 5. Columns I to IV and V to VIII include polynomial terms of the running variable up to the fourthth order. Different pre-treatment and post-treatment spatial trends allowed in Panels 4 and 5. Standard errors in parenthesis (clustered by new town in Panels 4 and 5). * = 10% significance, ** = 5% significance, *** = 1% significance.

Table 8: Estimation results of Model 5.1: RDD with different spatial trends allowed

Regressand	*Approve*: whether being issued a land use permit						
N = 40,540	**(I)**	**(II)**	**(III)**	**(IV)**	**(V)**	**(VI)**	**(VII)**
Polynomial	1st order	2nd order	3rd order	4th order	5th order	6th order	7th order
	Panel 1: 2003 samples						
UGB	-0.001	0.000	-0.003*	0.000	0.000	-0.003	-0.002
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
R-squared	0.008	0.008	0.009	0.009	0.009	0.010	0.010
AIC	-112964.2	-112967.8	-112987.5	-112999.3	-112995.3	-113004.6	-113008.0
	Panel 2: 2005-2010 samples						
UGB	0.076***	0.073***	0.066***	0.048***	0.027***	0.014*	0.005
	(0.003)	(0.004)	(0.005)	(0.006)	(0.007)	(0.008)	(0.009)
R-squared	0.039	0.039	0.040	0.041	0.042	0.042	0.043
AIC	-22079.2	-22084.4	-22110.7	-22153.7	-22192.1	-22215.9	-22227.3
	Panel 3: 2005 samples						
UGB	0.013***	0.013***	0.011***	0.009***	0.006**	0.003	0.003
	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
R-squared	0.006	0.006	0.006	0.007	0.007	0.007	0.007
AIC	-101753.1	-101750.4	-101749.4	-101756.1	-101763.2	-101764.0	-101763.3
	Panel 4: 2003 samples; Robust standard errors						
UGB	-0.001	0.000	-0.003	0.000	0.000	-0.003	-0.002
	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)	(0.002)
R-squared	0.008	0.008	0.009	0.009	0.009	0.010	0.010
AIC	-112970.2	-112977.8	-113001.5	-113017.3	-113013.3	-113026.6	-113036.0
	Panel 5: 2005-2010 samples; Robust standard errors						
UGB	0.076	0.073	0.066*	0.048*	0.027	0.014	0.005
	(0.044)	(0.043)	(0.033)	(0.024)	(0.018)	(0.014)	(0.009)
R-squared	0.039	0.039	0.040	0.041	0.042	0.042	0.043
AIC	-22085.2	-22094.4	-22124.7	-22169.7	-22212.1	-22237.9	-22253.3
	Panel 6: 2005 samples; Robust standard errors						
UGB	0.013	0.013	0.011	0.009	0.006	0.003	0.003
	(0.009)	(0.009)	(0.009)	(0.008)	(0.006)	(0.006)	(0.004)
R-squared	0.006	0.006	0.006	0.007	0.007	0.007	0.007
AIC	-101759.1	-101760.4	-101763.4	-101774.1	-101785.2	-101788.0	-101789.3

Land use dummies, location variables, and new town fixed effects included in all equations. Columns I to VII include polynomial terms of the running variable up to the seventh order. Different spatial trends to the left and to the right of the cutting point allowed. Standard errors in parenthesis (clustered by new town in Panels 4 to 6). * = 10% significance, ** = 5% significance, *** = 1% significance.