# The Effects of Beijing's Urban Growth Boundaries on Urban Development

Shihe Fu[a], Yizhen Gu[b*], Ying Long[c]

[a] *Southwestern University of Finance and Economics*

[b] *Jinan University*

[c] *Tsinghua University*

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**Abstract**

We examine the effects of Beijing's urban growth boundaries (UGBs) on urban development. Using data on land use permits issued between 2003 and 2010, we find that this policy have to some extent curtailed urban development outside UGBs. The development probability of parcels located just outside UGBs was one to six times smaller than those just inside UGBs. Our identification strategy that combines both a difference in differences (DID) approach and a regression discontinuity design (RDD) approach can well address two challenging issues in the empirical work: the existence of confounding policies and the endogeneity of the UGB's location. Using only a DID approach fails to exclude the effects of policies implemented along with UGBs, while using only an RDD approach cannot exclude the influence of factors that happen to have a spatial discontinuity at the boundaries. Furthermore, there have been lots of doubts about the effectiveness of urban plans in China, which sometimes are described as "Drawn on the map, and Hung on the wall." Our finding shows that, at least in Beijing, urban planning plays a significant role in shaping a city.

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*Corresponding author. E-mail: yizhengu@jnu.edu.cn.

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## 1 Introduction

The urban growth boundary (UGB), as one type of urban containment policy to curtail urban sprawl, 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. Since the establishment of land markets in China, urban growth boundaries have now been imposed in some Chinese cities as part of the urban master plan and are updated when the urban master plan is revisited. This study uses data on land use permits issued between 2003 and 2010 to examine the effects of Beijing's UGBs on urban development.

There are a few theoretical studies on the effects of the UGB on housing and land market. Using a standard 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. 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.

In these studies, the counterfactual is assumed to be the same city without a UGB. However, due to difficulties in constructing the ideal counterfactual, most empirical studies such as Knaap (1985) and Jun (2006) investigate the effects of UGBs on housing/land prices and the development rates of parcels outside UGBs with those inside UGBs as the benchmark.[2] Though this may cause upward bias from a general equilibrium perspective, the bias would not be substantial if the UGB were not highly binding.[3]

However, there are still two challenging issues to be addressed when using such counterfactuals:

[2]Another strategy is to examine the effect of growth management on urban growth by using the cross-county variation in its implementation (e.g., Boarnet, McLaughlin and Carruthers, 2011).

[3]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. If this holds in the context of urban growth boundary, it implies an underestimate of the effect.

i) the existence of confounding policies, and ii) the endogeneity of the UGB's place. First, 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 rents, e.g., tax incentives that attract businesses to the downtown. Second, the UGB is usually specified according to factors such as the current land use and the provision of infrastructure or public facilities. Earlier studies that use hedonic price models, e.g., Knaap (1985), fail to address either of the two issues and tend to give biased estimates of the UGB's effects. A few recent studies have used an instrumental variable approach (e.g., Boarnet, McLaughlin and Carruthers, 2011; McMillen and McDonald, 2002; Zhou, McMillen and McDonald, 2008) or a matching method (Lynch, Gray and Geoghegan, 2007) to address the endogeneity issue. Dempsey and Plantinga (2013) present a difference in differences (DID) estimator of the UGB's effect on land development, which lowers the endogeneity-related bias by exploiting a panel dataset. Nonetheless, the DID approach could not exclude the effects of confounding policies if they were implemented around the same time. In contrast, the regression discontinuity design (RDD) approach (e.g., Grout, Jaeger and Plantinga, 2011) can well address this issue by looking at the local effects at the boundaries, on the premise that these policies don't have the same boundaries as the UGB. Nevertheless, if there is any factor that happens to have a discontinuity at the UGB's location–possibly due to the endogeneity of the UGB–it will be difficult to identify only the UGB's effects using an RDD approach.

This study applies a methodology that combines both a DID approach and an RDD approach to evaluate the effects of Beijing's urban growth boundaries on urban development using a panel dataset of land development. If an UGB were 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, unless this factor begins to show its discontinuity at about the same time when the UGB is imposed, which is unlikely even under the rapid urbanization of Chinese cities. The same methodology has been used in Fu and Gu (2014) to test the effects of highway toll on air pollution.

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 (*Yongdi Kongzhi Bianjie* in Chinese) were imposed separately for the central city and eleven new towns. This study focuses on only seven new towns, each of which has its planned built land concentrated in one or two clusters. The UGB in each new town is set primarily based on the forecast population (conservative in most cases) and the per capita built land quota given by the City Planning Law of China. Land development outside UGBs usually is not allowed, and there would be a more demanding approval process if a development proposal were submitted.

This study uses the issuance of land use permits as the indicator of land development rather than the change in satellite images (see e.g., Dempsey and Plantinga, 2013). It facilitates the use of the DID approach because the time lag between the issuance of land use permits and the completion of construction projects is no longer an issue here. All land use permits issued between 2003 and 2010 are obtained from web crawling at the web site of the Beijing Planning Commission.[4] 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, respectively. Here only one-year pre-treatment samples are available because land use permits data before 2003 cover just the Beijing central city.

We first present a DID estimator of the effects of Beijing's UGBs on land development. After the UGBs were imposed, 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. However, if we move the original UGBs 1km inwards or outwards, the estimates of the placebo UGBs' effects are still significantly positive. It indicates that the results of the DID approach may also be explained by other policies that cause the increase in bid rent gradients and thus are only suggestive.

[4]The original dataset is crawled by Dong Li and Jianghao Wang and released at `http://beijingcitylab.org/data-released`.

We then apply an RDD approach to land use permits data in 2003 and from 2005 to 2010, respectively. Before the UGBs were imposed, there was no significant difference in the development probability between parcels just outside UGBs and those just inside UGBs. While after that, the development likelihood for the former was one to six times smaller (or 1.4-7.9 percentage points lower) than the latter. As a 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. We also apply a multi-dimensional RDD approach that visualizes the identified discontinuity on a surface rather than a line, as in Dell (2010). Last, using a DID+RDD methodology, we find that after the UGBs were imposed, the gap in the development probability between parcels just inside and outside the boundaries increased by 1.4-7.7 percentage points compared to that before the imposition of the UGBs. Our results show that urban planning, at least in Beijing, did play a role in shaping the city and may more or less remove the doubt about the enforcement of urban planning in Chinese cities.

This study contributes to the literature on UGB's effects by using an identification strategy that can deal with both confounding policies and the UGB's endogeneity, which has not been well addressed in earlier studies. The rest of this article is organized as follows. Section 2 summarizes Beijing's urban growth boundaries. Section 3 introduces data. In Section 4, we explore a DID approach and show why it is not persuasive using two placebo tests. In Section 5, we present our identification strategy, estimation results, and robustness checks. Section 6 concludes.

## 2 Beijing's urban growth boundaries

In 2004, the Beijing municipal government started to draft 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. 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 standards 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 drafting the urban master plan is to specify the overall built land quota. This in turn depends on the forecast population and the per capita built land quota given by the City Planning Law. Under a strict national farmland protection system, the forecast population and thus the overall built land quota are in general underestimated.

The State Council approved the 2020 Plan in Jan 2005. In this plan, the population of the Beijing City in 2020 is set as 18 million and the built land quota is 1,650 $km^2$, which are then allocated to the central city and eleven new towns. On the basis of this, planners specify the development boundaries for the central city and each new town separately as well as the land use type for each land parcel. Due to the pressure from new town governments, these boundaries usually cover more than the assigned built land quota, to allow certain planning adjustments in the future.

Though these boundaries have not been explicitly named as urban growth boundaries, their functions are similar to the UGBs implemented in U.S. cities like Portland, Oregon. The issuance of land use permits depends on whether the proposed development project lies within the built land boundary.[5] Land development outside the boundaries generally is not allowed. Additionally, there is a more demanding approval process if a development proposal is submitted. Otherwise, these new town governments would not make so much effort in expanding the plan-given boundaries.

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). There is one major UGB that includes nearly all planned built land respectively in Tongzhou, Fangshan, and Miyun. 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

[5]More precisely, planning officials make decisions according to the detailed planning that is similar to the zoning in U.S., and planners even don't draft the detailed planning for land parcels outside the boundaries.

land is relatively scattered and thus it is hard to draw an urban growth boundary for any of them. Gu, Zheng and Cao (2009) show that there have been multiple job centers in the Beijing central city using the 2004 Beijing Economic Census data.

[Figure 1 about here.]

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 (Figure 1).

With the rapid expansion of the Beijing City, the development boundaries given in the last urban master plan are much smaller than those in the 2020 Plan. Since we use an RDD approach with UGBs as the threshold, the old boundaries that lie 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 need not consider the time span of a construction project when a DID approach is applied. All land use permits issued by the Beijing Planning Commission from 2003 to 2010, with their locations and issuance dates, are obtained from web crawling at its web site.

All 40,540 land parcels within $5km$ 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 $km^2$. Of them, about 1/4 are located within UGBs. The parcels in two key towns, Tongzhou and Yizhuang, account for more than half of the sample parcels since the UGBs in these two towns are relatively large.

[Table 1 about here.]

We then overlay the land parcel layer with the land use permit layer using GIS software. In so doing, we construct a panel dataset that records whether a parcel was approved for development (or redevelopment) in each year between 2003 and 2010 for all sample parcels. Within the study area, the number of land use permits issued per year ranges from 148 to 418.[6] We use 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. 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 parcels outside UGBs, but since 2005, more than 50% of permits were issued to parcels inside UGBs annually (Figure 2). This is suggestive evidence of UGBs' effects on urban development.

[Figure 2 about here.]

The air distance from each parcel's centroid to the corresponding UGB is used as the running variable when using an RDD approach. Recent studies that also use geographic distance as the running variable include, e.g., Pence (2006), Lavy (2010), Dell (2010), and Gibbons, Machin and Silva (2013).

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. The estimates of this dummy variable show the difference in the approval likelihood between 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 were issued to parcels that had been developed in 2003–a result of inefficient development in the old planned economy. We also control for the land use status of each land parcel given in

[6] Overall, 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.

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.

We calculate three location variables for each 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 $30km$ away from the city center and $1km$ 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+RDD 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, there were only four lines in operation, but after that, nine more lines had been added into the system till Dec 2010. As a result, the average distance to the subway station decreased from $19km$ in 2003 to 7km in 2010. We try also a time-invariant distance variable on the basis of the planned 2015 subway system in Section 5.

## 4 A difference-in-differences approach

This section uses a 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 were imposed based on the following regressions:

$$Approve_{i,t} = \alpha + x_{i,t}\beta + UGB_i\gamma + After_t\lambda + (UGB_i * After_t)\theta + \epsilon_{i,t}, \tag{4.1}$$

where $Approve_{i,t}$ is the outcome, which equals 1 if parcel $i$ was issued a land use permit in period $t$; $x_{i,t}$ is a vector of control variables of parcel $i$ in period $t$; $UGB_i$ is a location dummy, which equals 1 if parcel $i$ is inside the corresponding UGB; $After_t = \{0, 1\}$ indicates the period before (2003) and after (2005-2010) the UGB policy was implemented. The main coefficient of interest, $\theta$, shows UGBs' effects on urban development.

We estimate six equations. Equation I and II include only the location dummy, the period dummy, and an interactive term of the location dummy and the period dummy. Equation III and IV add a vector of control variables that include two land use status dummies and three location variables. Equation V and VI add further new town fixed effects. Equations I, III, and V include samples in two periods: 2003 and 2005-2010. Here we take land use permits data between 2005 and 2010 as cross-sectional, i.e., whether a parcel was approved for development during this period. In Equations II, IV, and VI, we use only samples of year 2003 and 2005 as a robustness check. In all equations, standard errors are clustered by new town, since planning officials make approval decisions separately for each new town on the basis of its built land quota.

The estimation results of Model 4.1 are presented in Table 2. 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 10km away from the city center, and decreases by 0.5-1.9 percentage points with every 10km away from major roads, though not significant across all specifications. The estimates of the subway variable are mixed. As suggested by Equation V, a 10km 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 equations are significantly positive. This indicates that the UGBs in these new towns had the intended effects in restricting development. Before the UGBs were imposed, there was 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 I, III and V in Table 2.

[Table 2 about here.]

However, the identified UGBs' effects may be attributed to other policies implemented along with the UGB program. To show this, we design two sets of placebo UGBs by moving the original UGBs 1$km$ inwards or outwards. The estimation results of Model 4.1 using these placebo UGBs are presented in Table 3. Here we use still land parcels within 5$km$ distance to each of the original UGBs.[7] The estimates of placebo UGBs' effects are still significantly positive in all specifications, though the magnitude is less than that when using the true UGBs. Therefore, the identified UGBs' effects may simply arise from other policies that caused 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 a DID approach and an RDD approach in Section 5.

[Table 3 about 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 A DID+RDD methodology

### RDD

An RDD approach is used where treatment depends on whether an running variable exceeds a known cutoff point (Lee and Lemieux, 2010). Thus, its use can effectively exclude the effects of confounding policies as long as these policies don't 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 regressions:

$$Approve_i = \alpha + x_i\beta + UGB_i\gamma + D_i\theta + \epsilon_i, \tag{5.2}$$

[7] Using parcels within 5$km$ distance to each of the placebo UGBs does not change the results much.

where $D_i$ is the distance to the corresponding UGB (negative when outside boundaries) and used as the running variable. The main coefficient of interest, $\gamma$, shows local effects of UGBs on urban development. The period subscript is omitted here because we estimate Model 5.2 using pre-treatment and post-treatment samples separately.

Table 4 presents the estimation results. All equations include the five control variables and new town fixed effects but only the coefficient on $UGB$ is presented. In 2003 when the UGBs were not implemented, the estimates of the location dummy in Panel 1 are all insignificant except the negative one in Column III. In contrast, the estimates using the 2005-2010 samples in Panel 2 are significantly positive up to the seventh-order polynomial. This shows evidence of a discontinuity in the development probability at the plan-given boundaries. On average, parcels just inside UGBs were 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 $100m$ 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 was one to six times larger than that of parcels just outside UGBs. The estimates using only the 2005 samples in Panel 3 are also significantly positive up to the fifth order polynomial.[8] The difference in the estimates using pre-treatment and post-treatment samples suggests that UGBs specified in the 2020 Plan did restrict land development outside UGBs.

[Table 4 about here.]

We should be cautious about the above findings. When standard errors are clustered at the new town, the estimates of the location dummy using the 2005-2010 samples in Panel 5 are all positive but significant in only Columns I and III, though the estimates using the pre-treatment samples in Panel 4 are still insignificant in all specifications.

Nonetheless, graphing the data lends support to the identified UGBs' effects on land development.

[8] As a robustness check, we estimate Model 5.2 for samples in each year between 2006 and 2010. The estimation results confirm the jump in the development likelihood at the boundaries.

For a better illustration, we use only parcels within $2km$ distance to UGBs.[9] The average ratio of parcels that were issued a land use permit in different periods is computed by $100m$ bins and graphed against the mid-point of the bins (Figures 3, 4 and 5). We choose the $100m$ bins rather than smaller ones considering that the average size of parcels is $0.053km^2$ (Table 1). Also, a standard $F$-test comparing the fit of a regression model with $100m$ bin dummies to one with $50m$ bin dummies, as suggested by Lee and Lemieux (2010), confirm that we are not oversmoothing the data by using $100m$ bins ($F$-statistic 1.11).

Figures 4 and 5 show clear evidence of a discontinuity in the development likelihood at the boundaries after the UGBs were implemented in Beijing. Note the difference in y-axis scale, which may conceal the fact that the local gap using the 2005 samples is smaller than that using the 2005-2010 samples. In contrast, the jump at the boundaries is almost negligible when the UGBs had not been 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 by new town. Our findings holds up to a cubic polynomial, though the relative magnitude differs.

[Figure 3 about here.]

[Figure 4 about here.]

[Figure 5 about here.]

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

[9] The following findings hold using parcels within $5km$ 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 samples (Column VII 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.[10] This difference is especially pronounced in key towns like Tongzhou and Yizhuang.

[Figure 6 about here.]

In addition, we apply a multi-dimensional RDD approach as in Dell (2010). This approach is different from the traditional RDD setup 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.[11] We estimate Model 5.2 up to the cubic polynomial of parcels' centroid coordinates, with standard errors clustered at the new town. The estimates of the location dummy, whether a parcel is located within UGBs or not, using the 2005-2010 samples are significantly positive in all specifications, while those using the 2003 samples are all negative, either significant or insignificant (not reported here).[12] 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 were implemented are imputed using quadratic polynomial model and graphed in

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

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

[12]The estimates of the location dummy using the 2005 samples are all positive, though insignificant.

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).

[Figure 7 about here.]

[Figure 8 about here.]

[Figure 9 about here.]

**DID+RDD**

Using the RDD approach can exclude the influence of confounding policies by looking at local effects at the boundaries. However, the results of the RDD model using the post-treatment samples are only 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. Therefore, we compare the discontinuity in the development likelihood identified using pre-treatment samples and that using post-treatment samples based on the following DID+RDD regressions:

$$Approve_{i,t} = \alpha + x_{i,t}\beta + UGB_i\gamma + D_i\rho + After_t\lambda + (UGB_i * After_t)\theta + (D_i * After_t)\tau + \epsilon_{i,t}, \quad (5.3)$$

where $\lambda$ and $\tau$ 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, $\theta$, shows local 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.

[Table 5 about here.]

Table 5 presents the estimation results. All equations include the five control variables and new town fixed effects but only the coefficients on $UGB$ and the interactive term $UGB * After$ are presented. We use the 2003 samples and the 2005-2010 samples in Panels 1 and 3, and the 2003 and 2005 samples in Panels 2 and 4. The estimates in Panel 1 confirm that UGBs in new towns had a significant effect on land development only after the 2020 Plan had 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 is added. Panel 2 shows qualitatively the same results.

Again, when standard errors are clustered by new town, the estimates of the interactive term are still positive in all columns of Panels 3 and 4, though significant in only Columns I, III, and VI of Panel 3.

**Robustness check**

In addition to adding polynomials of the running variable, we do a series of robustness checks. 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 $100m$ 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".

[Figure 10 about 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).[13] 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 by simply the spatial correlation of development activities. Nonetheless, the DID+RDD method we use, in particular the estimation results using the pre-treatment samples,

[13]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.

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.

[Figure 11 about here.]

We test the sensitivity of results to a range of symmetric windows: $2km$, $1km$, and $0.5km$. Tables 6 and 7 present the estimation results of Models 5.2 and 5.3 using the $2km$ and $1km$ windows, respectively. As for the $2km$ window, the insignificant estimates of the location dummy using pre-treatment samples (Panel 1) and the significant estimates using post-treatment samples (Columns I to V in Panel 2, and Columns I to III in Panel 3) validate the effects of UGBs on development. Note that when standard errors are clustered by new town, the estimates are significant in only the linear model using the 2005-2010 samples and insignificant in all equations using the 2005 samples, though all positive. Panels 4 and 5 present qualitatively the same results using the DID+RDD model. The estimates of the location dummy using post-treatment samples within the $1km$ window lose their significance in specifications such as Columns III and IV in Panel 2 and Column III in Panel 3, compared to those using the $2km$ window. Furthermore, the estimates, not reported here, are significant in even fewer specifications when the $0.5km$ 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).

[Table 6 about here.]

[Table 7 about 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 cutting point, by adding interactive terms of the location dummy and polynomials of the running variable in Model 5.2. As seen in Table 8, the estimation results using pre-treatment and post-treatment samples are quite similar to those in Table 4. The estimates of interactive terms, not reported here, confirm the different spatial trends.

[Table 8 about here.]

Other robustness tests not reported here include: i) allowing UGBs' effects to be different between plan-given key towns and other towns; ii) allowing the spatial trends different between key towns and other towns, or different across each town; iii) using a time-invariant subway variable on the basis of the planned 2015 subway system; and iv) adding the lags of the dependent variable when appropriate.[14] 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 location dummy and the year dummy on the basis of Model 5.2.

## 6 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.[15] Our findings show that this policy to some extent have curtailed urban development outside UGBs. After the imposition of UGBs, the development probability of parcels located just outside UGBs was lower by 1.4-7.7 percentage points than those just inside UGBs.[16] This effect is economically large since the

[14]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.

[15]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.

[16]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.

probability that a parcel within 100$m$ to the boundaries from outwards was issued a land use permit between 2005 and 2010 was only 1.3%.

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 DID approach cannot attribute the identified effects to simply the UGB program, which is illustrated by two placebo tests. An RDD approach overcomes this issue by looking at local effects at the boundaries. However, there is another challenging question if only a cross-sectional dataset is 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, as shown in this paper. The methodology used here, which combines both a DID approach and an RDD approach, can exclude the influence of not only confounding policies but also such "discontinuity" factors.

The National Development and Reform Commission of China recently proposed that the focus of urban planning be on specifying urban growth boundaries as well as redevelopment rather than urban expansion.[17] However, there have been lots 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, and Hung on the wall." Our study shows that, at least in Beijing, urban planning plays a significant role in shaping a city.

[17] `http://www.yicai.com/news/2014/07/3997750.html` (*in Chinese*), accessed on Jul 25, 2014.

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

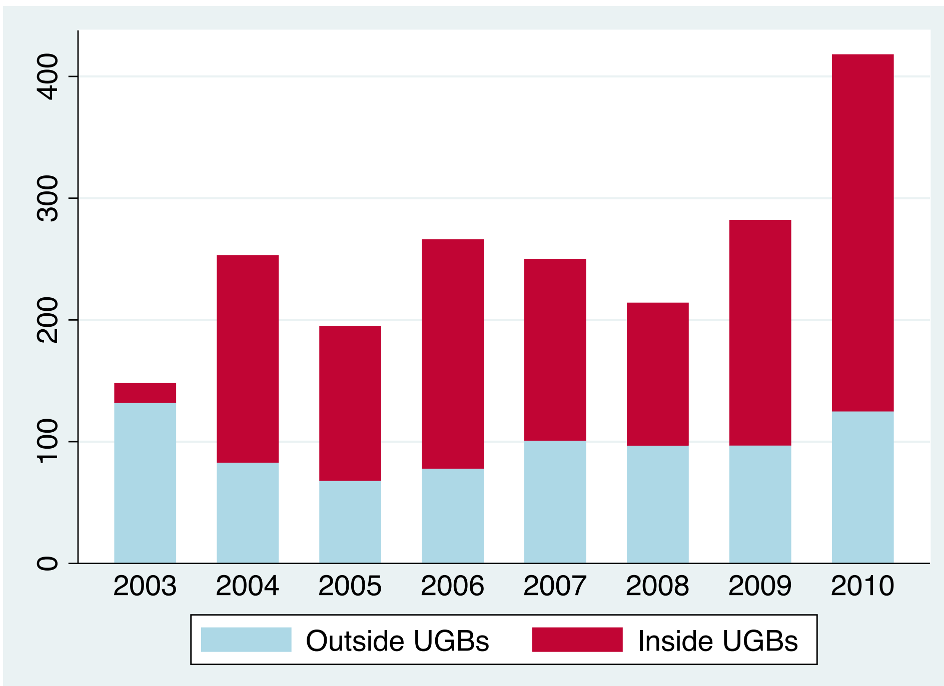
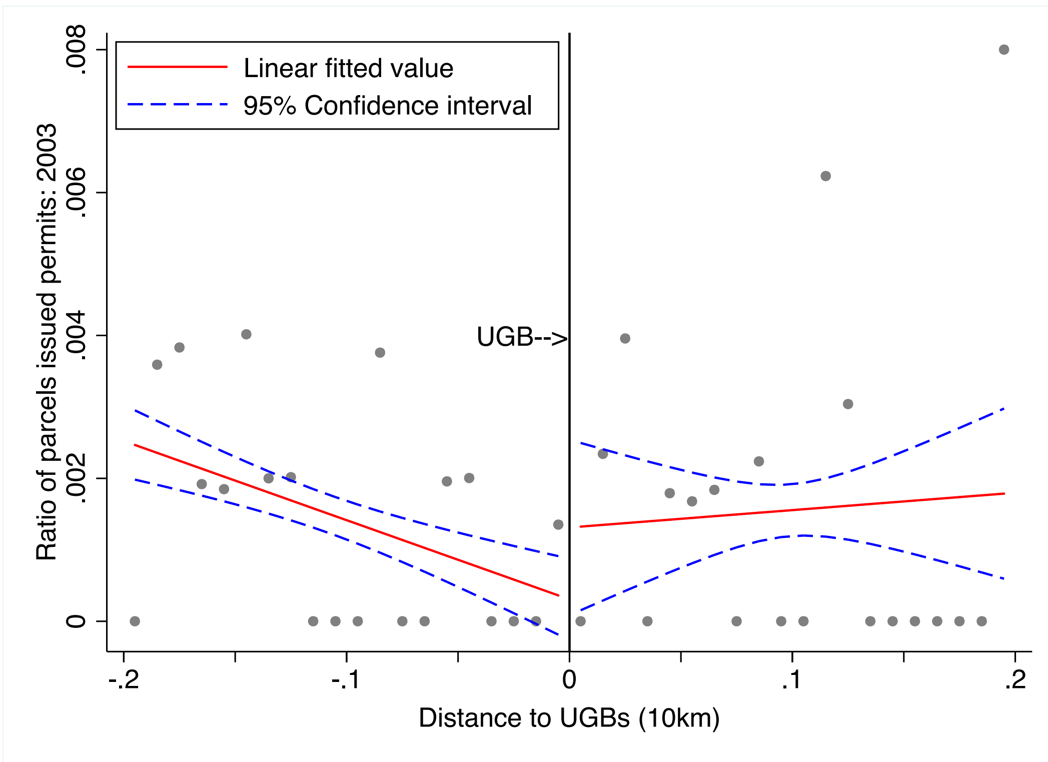
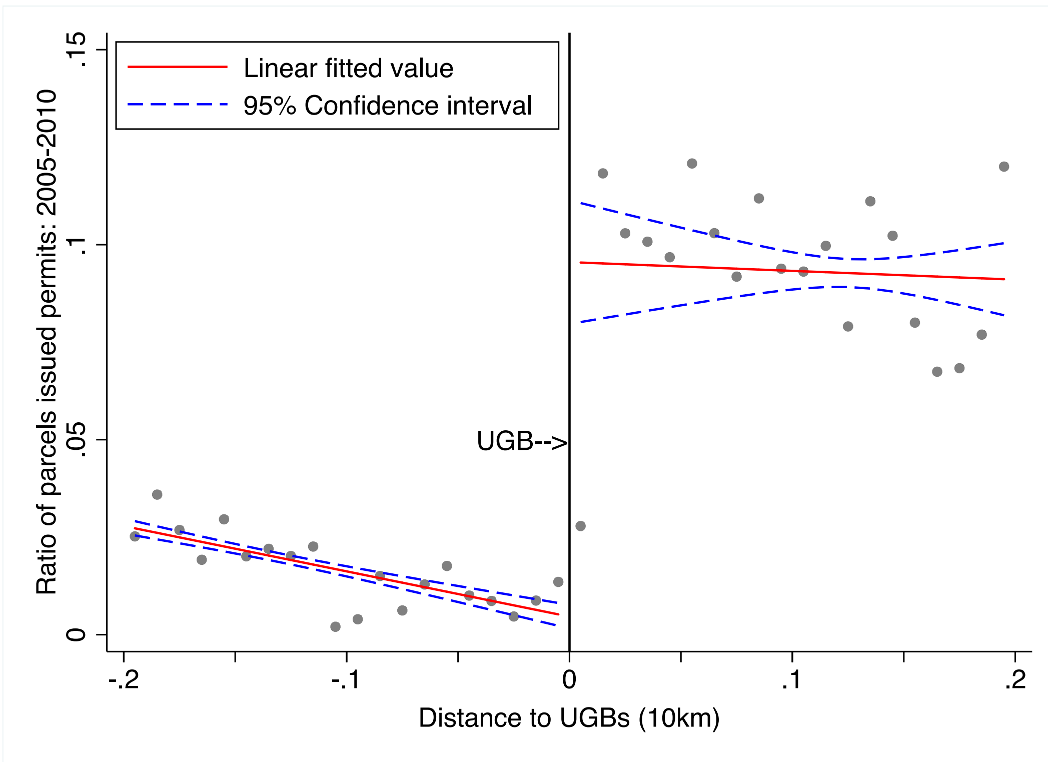



Figure 2: The number of land use permits issued from 2003 to 2010 within the study area



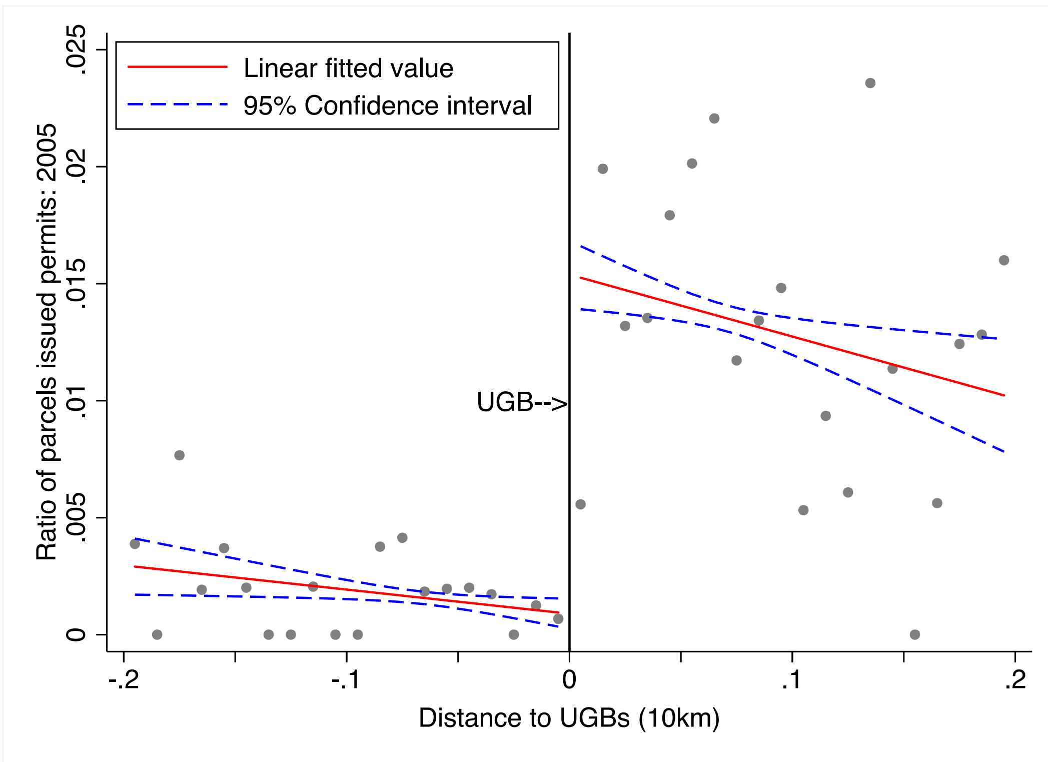

Note: Standard errors clustered by new town. Different spatial trends allowed.

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

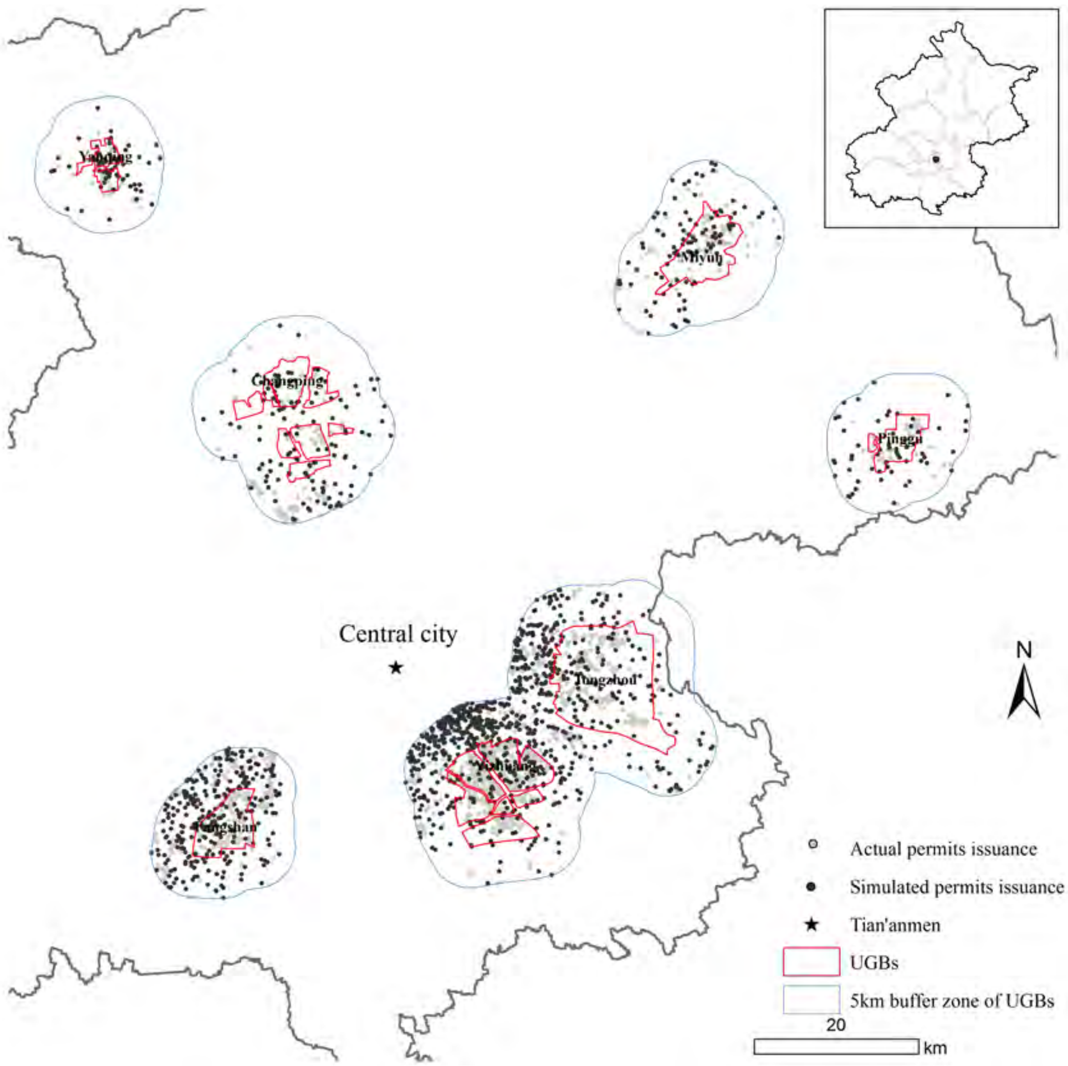
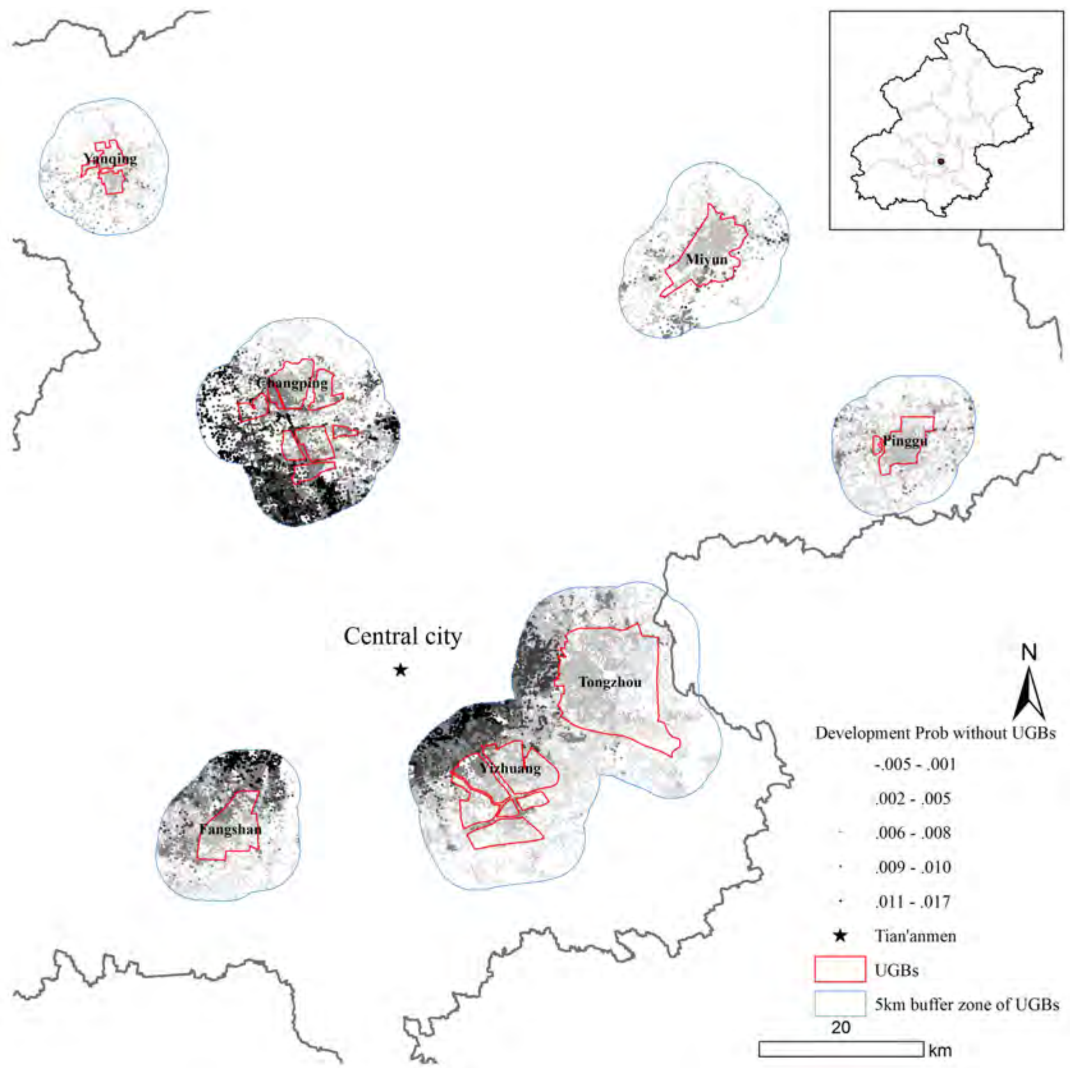
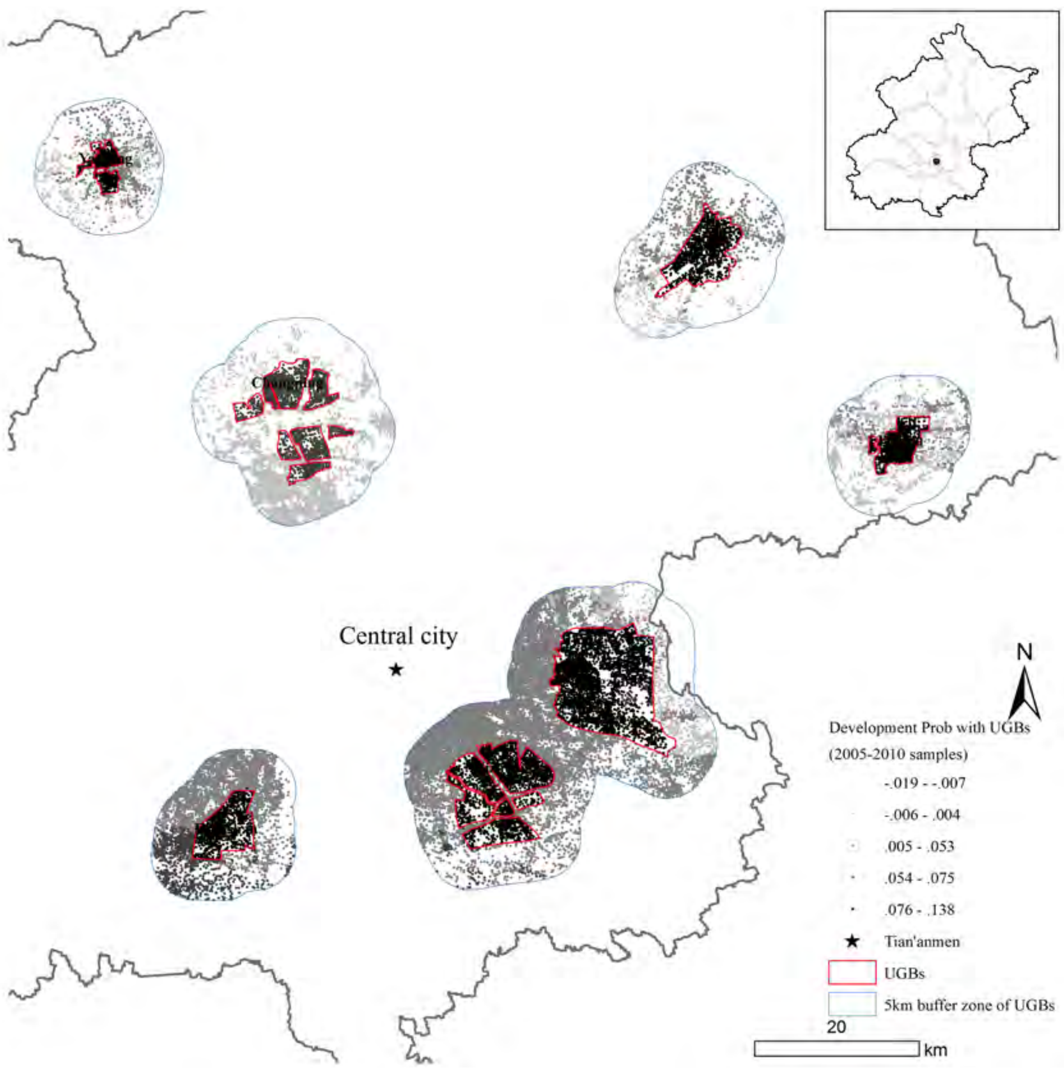



Figure 6: The spatial distribution of land use permits issued from 2005 to 2010
Actual (with UGBs) vs. Simulated (without UGBs)



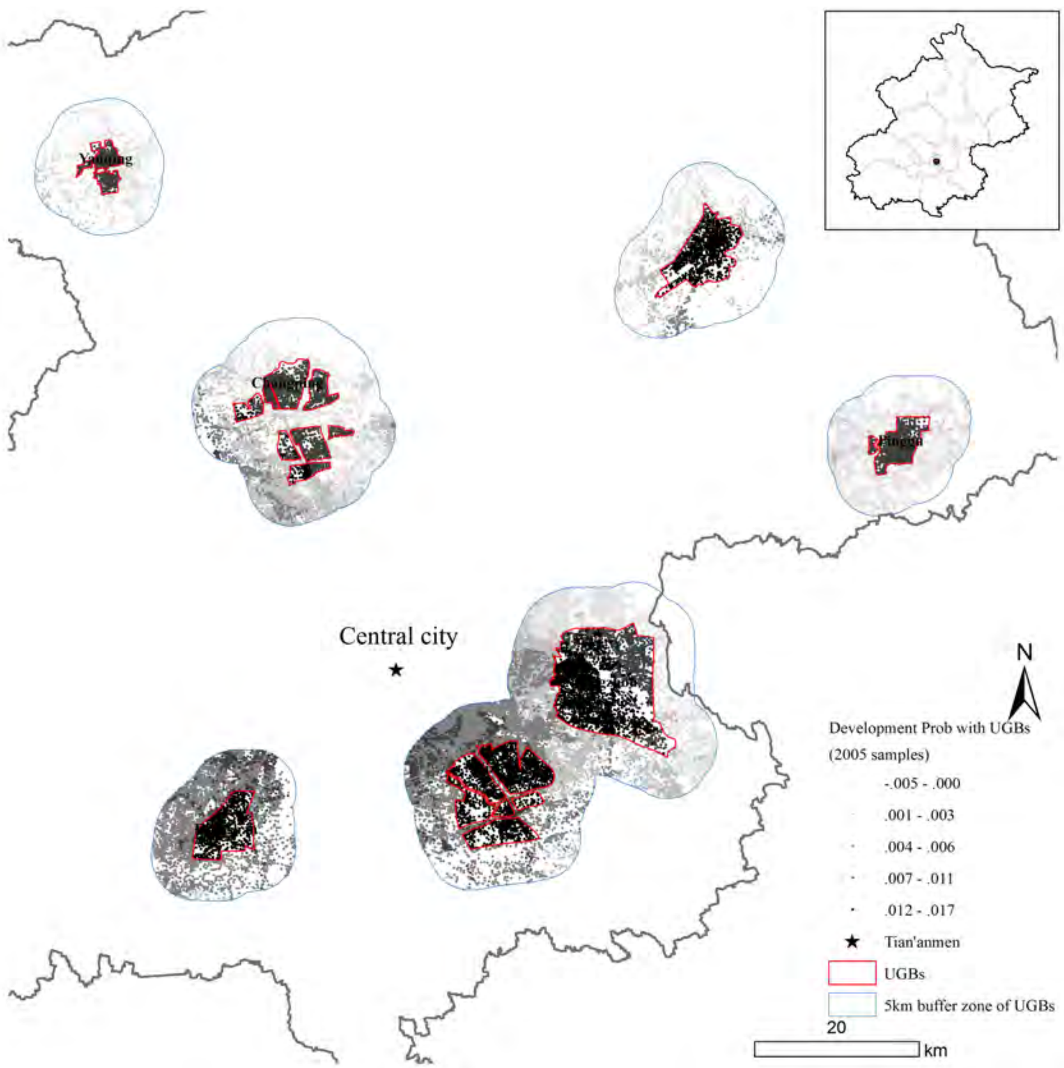

Note: Quadratic fit of a multi-dimensional RDD model. Standard errors clustered by new town.

Figure 7: The predicted development probability of parcels in 2003



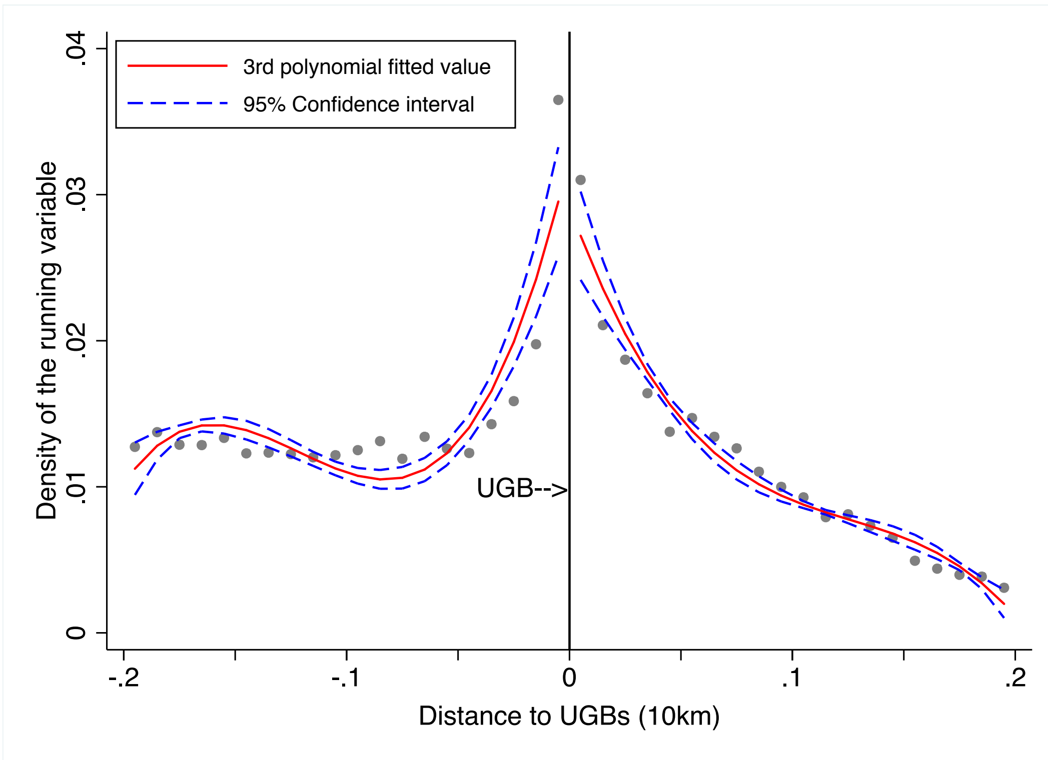

Note: Quadratic fit of a multi-dimensional RDD model. Standard errors clustered by new town.

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



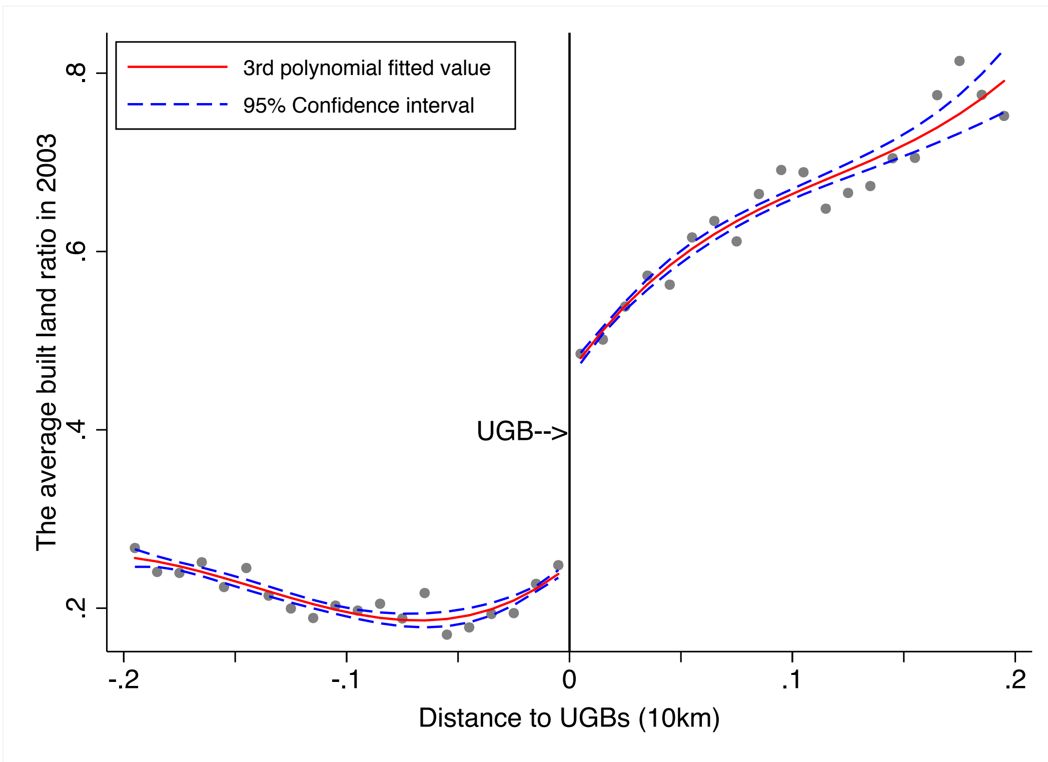

Note: Quadratic fit of a multi-dimensional RDD model. Standard errors clustered by new town.

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 5.2: 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 5.3: 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 5.2 and 5.3: $2km$ 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 5.2 and 5.3: $1km$ 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 5.2: 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.