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Land Use and Fiscal Competition

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Land Use and Fiscal Competition

Abstract

This paper explores the effects of fiscal competition on local land use. A theoretical analysis considers the tradeoff faced by a local government deciding about the amount of land made available for commercial or residential uses, when its expansion has adverse effects on the quality of life. The analysis shows that, in an environment with mobile tax bases, jurisdictions are subject to fiscal incentives to expand this land use. Fiscal redistribution through equalization grants, however, reduces these incentives. Based on the theoretical analysis, the effect of fiscal competition on commercial and residential land use is investigated empirically using a large dataset of German municipalities. In order to identify differences in the exposure to fiscal competition, I exploit institutional characteristics of the system of fiscal equalization to which these municipalities are subjected. This enables me to provide causal evidence using a regression discontinuity analysis. The results show that commercial and residential land use is expanded 2-3 times faster and agricultural land use declines more rapidly in municipalities exposed to fiscal competition.

JEL-Codes: H710, R140, R520, Q260.

Keywords: land use policy, natural amenities, urban sprawl, fiscal competition, fiscal equalization, regression discontinuity analysis.

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1 Introduction

Expanded land use for settlements, including residential and commercial land use, is often feared to eat up open space and to exert adverse effects on the environment (Nechyba and Walsh 2004, Nilsson et al. 2013). The urban economics literature has emphasized that land use is only one dimension of local economic development, and efficient land use will have to trade off environmental and other concerns against the economic benefits of urban expansion (e.g., Brueckner 2000). Since land use is typically regulated by local governments, this suggests that local governments need to find a balance between the conflicting interests in the electorate. On the one hand, local governments face demands to attract firms in order to enhance employment opportunities and generate more revenues to expand the provision of public services. On the other, residents seek to maintain natural amenities, and there is pressure by environmental groups to restrict the expansion of land use. Finding a balance between these different demands might prove difficult in practice, and political economy considerations may give rise to concerns that local land use might be inefficient. Yet such concerns apply at all levels of government. At the local level, one could argue that competition between governments might actually support the efficiency of public policy, as has been noted by many writers in the tradition of Tiebout (1956).

The urban public finance literature has emphasized that a precondition for efficient local policies is a proper set of policy instruments. This includes various tax instruments that allow local governments to provide an efficient level of public services without distorting locational efficiency (Wildasin 1986). In practice, local governments often face limitations in the set of available policy instruments. If jurisdictions rely on mobile tax bases, their policy decisions exert fiscal externalities and the tax competition equilibrium is generally inefficient (for a survey, see Wilson 1999). Though it is well

established that interjurisdictional competition need not be confined to taxes, the literature clearly focuses on fiscal instruments (Agrawal, Hoyt, and Wilson forthcoming). Against this backdrop, the current paper explores the implications of fiscal competition for local land-use policy.

The starting point for the analysis in this paper is a standard tax-competition model, where local governments can only determine the tax rate on mobile capital. The model is augmented by land which serves as an amenity or, if assigned to a commercial land use, is an input to production. In this model, I discuss the tradeoff faced by a local government when deciding on the share of land assigned to commercial land use. An extension discusses how much land is devoted to residential land use, if mobile residents contribute to tax revenues. The analysis shows that municipalities expand commercial and residential land use under fiscal competition. Under fiscal equalization however, the incentives to do so are reduced.

The empirical testing ground is land use among municipalities in Germany. These municipalities offer a promising case for studying fiscal competition, since their main revenue source is a business tax, which is a tax levied on profits of local firms and establishments. Moreover, municipalities decide on land-use patterns including residential and commercial land use. In order to identify differences in the competitive environment of jurisdictions, I exploit institutional characteristics of fiscal equalization among municipalities which shields municipalities from the tax-base effects associated with fiscal competition. The empirical analysis is based on a dataset of 2,056 Bavarian municipalities, where land use and the treatment by the fiscal equalization system are observed on an annual basis over the years from 2008 to 2013. The results show that the amount of land dedicated to commercial and residential land use expands faster and agricultural land use declines more rapidly in municipalities that are fully exposed to fiscal competition.

The contribution of this paper is threefold. The first contribution is to study the role of inter-jurisdictional fiscal competition as a driver of expanding commercial and residential land use. The urban economics literature has noted that decentral regulation may encourage excessive land use (Blöchliger et al. 2017). The main criticism is that the local property tax provides an incentive to reduce the capital intensity of housing and hence fosters spatial expansion of cities (e.g., Brueckner and Kim 2003, Song and Zenou 2006). The role of interjurisdictional competition for land use has mainly been discussed in the context of growth control regulations, where the negative population externality contributes to a proliferation of these restrictions of land use (e.g., Brueckner 1995; Brueckner 1998). In contrast, this paper shows that due to the incentives associated with fiscal competition, commercial and residential land use is expanded.

A second contribution is to provide empirical evidence on the incentive effects of fiscal redistribution and revenue sharing on local governments' policies. While those effects are discussed in the theoretical literature in local public finance and fiscal federalism (e.g., Bucovetsky and Smart 2006), empirical evidence has focused on fiscal instruments such as tax rates (e.g., Dahlby and Warren 2003, Buettner 2006, Egger, Koethenbueger, and Smart 2010, Dahlby and Ferde 2016, Ferde 2017) or public expenditures (e.g., Matheson 2005, Hindriks, Peralta, and Weber 2008). An exception is the paper by Han and Kung (2015), who find that an increase of revenue sharing has induced Chinese prefectures to devote less land to commercial use, which is in accordance with the findings in this paper.

The third contribution is to ascertain the role of fiscal competition as a driver of land use in Germany. The expansion of residential and commercial land use has been identified as a source of environmental damage and the federal government's sustainable development strategy is committed

to coordinate attempts to curtail its expansion (Federal Government (Bundesregierung) 2016). While it has been argued that the desire to raise tax revenues might fuel the expansion of commercial land use due a “fiscalization of land use” (Wassmer 2002, Langer and Korzhenevych 2018), empirical evidence is lacking. The results of this paper confirm the role of the fiscal incentives for the expansion of commercial as well as residential land use. However, the results also indicate that fiscal equalization substantially curtails this effect of fiscal competition in Germany.

The paper is organized as follows. The next section provides the theoretical background by augmenting a tax competition model with land, where the local government determines the amount of land available for commercial and residential uses. Section 3 discusses the empirical methodology. Section 4 describes the data and the institutional background. Section 5 discusses the empirical results. Section 6 summarizes the main findings and provides conclusions.

2 Theoretical Analysis

This section develops a model of the local economy that enables me to discuss public policies with regard to land use. First, I consider the use of land as a production factor and derive the primary equilibrium allocation. In a second step, I discuss the effects of an increase of the amount of land assigned to commercial use on equilibrium wage rate and capital demand. Equipped with the understanding of how a local government’s choices affect equilibrium outcomes, I discuss the optimal local policy. In a fourth step, I show how the optimal choice changes when fiscal competition is limited by fiscal equalization. To shed light on residential land use, in a last step, I provide a variant of the model which enables me to explore the fiscal incentive to attract mobile residents to

the local jurisdiction.

2.1 Commercial Land Use under Capital Mobility

Commercial land use generates a rent to the owner. This rent varies with the employment of labor and capital. Denoting land and capital with L_i and K_i and the number of immobile workers, each supplying one unit of labor, with N_i , the output is determined by a constant returns-to-scale production function $F(K_i, L_i, N_i)$. The land rent is determined by the excess of output over cost of capital and compensation of workers:

$$\pi_i = F(K_i, L_i, N_i) - w_i N_i - r_i K_i, \quad (1)$$

where r_i is the (before tax) return on capital and w_i is the wage rate. Maximization of the land rent requires:

$$\frac{\partial F_i}{\partial K_i} = r_i \quad (2)$$

$$\frac{\partial F_i}{\partial N_i} = w_i \quad (3)$$

Assuming, for simplicity, that labor supply is equal in all jurisdictions $N_i = N$, equation (2) can be rearranged as a capital demand function for jurisdiction i :

$$K_i = \varphi(L_i, r_i, N) \quad (4)$$

The properties of this function are governed by the production function. It decreases in r_i and, given input complementarity ($F_{iKL} > 0$), increases in L_i . Formally,

$$\frac{\partial \varphi_i}{\partial r_i} = \frac{1}{F_{iKK}} < 0$$

and

$$\frac{\partial \varphi_i}{\partial L_i} = \frac{-F_{iKL}}{F_{iKK}} > 0.$$

I assume that capital is mobile such that the (after tax) rate of return on capital is equal to the common rate ρ . Hence

$$r_i = \tau_i + \rho, \tag{5}$$

where τ_i is the local tax rate. The capital-market equilibrium condition requires that employment of capital in all M jurisdictions obeys

$$\sum_{j=1}^M K_j = K, \tag{6}$$

with K being the fixed capital supply in the economy. Equations (3), (4), (5) and (6) define a set of $3M + 1$ conditions which determine equilibrium levels of factor prices w_i, r_i , the employment of capital K_i and the rate of return on capital ρ for given L_j and τ_j in all jurisdictions.

2.2 Effects of Increasing Commercial Land

Holding constant the choices of other governments, a local government's decision regarding commercial land use affects the local demand for capital and the local wage rate. To determine the general-equilibrium effect of an increase in commercial land, I follow Wilson (1991) and consider

the equilibrium net rate of return on capital in jurisdiction i as a function of the policy parameters in all jurisdictions. The effect of an increase of land L_i in jurisdiction i is:¹

$$\frac{\partial \rho}{\partial L_i} = \frac{\frac{F_{iKL}}{F_{iKK}}}{\sum_j \frac{1}{F_{jKK}}} > 0$$

By taking a total differential of equation (4), holding constant labor and tax rate, and using (5) I obtain:

$$\frac{\partial K_i}{\partial L_i} = -\frac{F_{iKL}}{F_{iKK}} \left(1 - \frac{\frac{1}{F_{iKK}}}{\sum_j \frac{1}{F_{jKK}}} \right) > 0$$

From equation (3) the effect of an increase of commercial land on the wage rate is also positive:

$$\frac{\partial w_i}{\partial L_i} = F_{iNL} + F_{iNK} \frac{\partial K_i}{\partial L_i} > 0.$$

2.3 Optimal Amount of Commercial Land

Public policy aims at maximizing the utility of an immobile worker residing and working in jurisdiction i . Utility is defined by a quasi-linear function

$$\Omega_i = (1 - t) w_i + u(X_i) + v(A - L_i), \quad (7)$$

¹To derive the effect of commercial land on the equilibrium return on capital, I consider the total differential of the capital-market equilibrium condition (6) with $d\tau_i = 0$ to find

$$\sum_j \frac{\partial \varphi_j}{\partial r_j} d\rho + \frac{\partial \varphi_i}{\partial L_i} dL_i = 0.$$

where $(1 - t) w_i$ is the wage rate net of the income tax, u is utility from the consumption of a (pure) public good X_i and v captures the benefit from land as an amenity with total area A . This benefit increases in the volume of land not assigned to commercial use $A - L_i$ ($v' > 0$). Provision of the public good is financed by the tax on income as well as by the tax on capital. Note that in light of the institutional setting governing the data (see below), I assume that the tax rate on income t is fixed. The public budget constraint is

$$X_i = \tau_i K_i + t w_i N.$$

Optimization with regard to the amount of commercial land requires $\frac{\partial \Omega_i}{\partial L_i} = 0$. This implies:

$$v'(A - L_i) = (1 - t) \frac{\partial w_i}{\partial L_i} + u'(X_i) \left[tN \frac{\partial w_i}{\partial L_i} + \tau_i \frac{\partial K_i}{\partial L_i} \right] \quad (8)$$

This expression states that under optimal land use the marginal benefit from land as an amenity (on the left-hand side) is equal to its opportunity cost (on the right). The latter is determined by the increase of the wage rate and by the benefits from higher tax revenues if an additional unit of land is made available for commercial use.

The optimal choice taken by the local jurisdiction is socially inefficient, though, since expanding commercial land creates external effects on other jurisdictions. The utility of a worker residing in jurisdiction j is

$$\Omega_j = (1 - t) w_j + u(X_j) + v(A - L_j). \quad (9)$$

A marginal increase in commercial land in jurisdiction i affects utility of a worker in jurisdiction j through its effects on the wage rate and on tax revenues. Formally,

$$\frac{\partial \Omega_j}{\partial L_i} = (1-t) \frac{\partial w_j}{\partial L_i} + u'(X_j) \left[tN \frac{\partial w_j}{\partial L_i} + \tau_j \frac{\partial K_j}{\partial L_i} \right].$$

Since the equilibrium rate of return on capital rises, capital demand declines

$$\frac{\partial K_j}{\partial L_i} = \frac{1}{F_{jKK}} \frac{\partial \rho}{\partial L_i} < 0,$$

and the decline in capital demand is associated with a decline in the wage rate

$$\frac{\partial w_j}{\partial L_i} = F_{jKL} \frac{\partial K_j}{\partial L_i} < 0.$$

Hence $\frac{\partial \Omega_j}{\partial L_i}$ is unambiguously negative, indicating that the local decision in i to expand commercial land creates a negative externality on jurisdiction j as labor income and tax revenues decline. This is similar to the fiscal externality emerging from tax competition (Keen and Konrad 2013). However, though the externality from the land-use decision is driven by capital mobility, it is mixture of a labor-market effect and a fiscal externality.

2.4 Policy under Fiscal Equalization Grants

To highlight the role of fiscal competition and to lay the ground for the empirical identification strategy, I introduce fiscal equalization grants provided by an upper level government. More specifically, I assume that municipality i receives a grant reflecting a basic level of fiscal need b per capita.

At the same time, the local government has to pay a revenue sharing contribution proportional to its tax capacity. The latter is defined by

$$C_i = \vartheta K_i + \phi t w_i N.$$

Tax capacity has two components. The first captures standardized revenues from the local business tax, i.e. revenues that were collected when applying a standard tax rate to the local base of the business tax K_i . ϑ is similar to the representative tax rate known from provincial fiscal equalization in Canada (e.g., Smart 2007) and determines the marginal contribution to the equalization scheme. ϕ captures the extent to which income tax revenue is accounted for in the tax capacity. The municipality receives a grant

$$Z_i = bN - C_i, \quad \text{where } bN > C_i.$$

Optimal policy maximizes the above quasi-linear utility function (7), using the budget constraint

$$X_i = bN + (\tau_i - \vartheta) K_i + (1 - \phi) t w_i N.$$

The condition for the optimal amount of commercial land is:

$$v'(A - L_i) = (1 - t) \frac{\partial w_i}{\partial L_i} + u'(X_i) \left[(1 - \phi) t N \frac{\partial w_i}{\partial L_i} + (\tau_i - \vartheta) \frac{\partial K_i}{\partial L_i} \right] \quad (10)$$

Comparison with equation (8) reveals the effect of fiscal redistribution on commercial land use. More specifically, suppose the fiscal equalization grant is revenue neutral in the sense that the same

amount of public services X_i could be provided if the jurisdiction would choose the same tax rate and the same amount of commercial land as in the optimum without fiscal redistribution. Since part of the tax revenue generated from expanding commercial land is compensated for by lower grants, the opportunity cost of using land as an amenity decreases and the optimal amount of commercial land is reduced. Note however, that fiscal redistribution only reduces the fiscal incentive to expand commercial land. The incentive to increase the local wage rate is unaffected. Hence, equalization is unlikely to result in socially efficient policies.

Of course, if the fiscal equalization grant is not revenue neutral, the amount of public services that can be provided at the same tax rate and the same amount of commercial land would change. In particular, if the equalization grant exerts a positive income effect in the local public budget, the resulting expansion of public services would further contribute to a decline in the opportunity cost of land as an amenity.

2.5 A Model with Mobile Residents

Suppose land is not only used as an amenity and for commercial activities but can also be used to attract mobile residents. The advantage for the local community is that mobile residents would contribute to tax revenues and, hence, facilitate more public spending. A disadvantage is that the amount of land serving as an amenity diminishes. Depending on whether or not the mobile residents enter the local labor market, further effects may arise. However, I postpone the discussion of potential wage effects by assuming that mobile residents are commuters and do not add to the local labor supply. To keep matters simple, I also assume that there is no capital and the land rent (1) is a function only of labor and land. The key difference to the above model is that the local

government may decide to assign P_i units of land as private land to mobile residents in order to raise the attractiveness as a location for these residents.

The supply of the local public good is determined by the budget constraint:

$$X_i = tw_iN + tyR_i \quad (11)$$

ty denotes the local income tax paid by a mobile resident with income y . From equation (3) the local wage rate is a function of commercial land

$$w_i = w(L_i, N). \quad (12)$$

Whether an increase in P_i attracts mobile residents depends on the options available to them. In order to explore this further, I assume that the utility of a mobile resident is similar to the utility of an immobile worker, except that it includes the benefit from land assigned to the mobile residents:

$$\omega_i = (1 - t)ty + u(X_i) + v(A - L_i - P_i) + h\left(\frac{P_i}{R_i}\right) \quad (13)$$

The benefit from land P_i is assumed to be an increasing function ($h' > 0$) and to be declining with the number of mobile residents, since it is used privately. Due to mobility, the utility is equal across jurisdictions:

$$\omega_i = \omega \quad (14)$$

The equilibrium condition requires:

$$\sum_{j=1}^M R_j = R, \quad (15)$$

with R being the total number of mobile citizens in the economy. Equations (11), (12), (13), (14) and (15) define a set of $4M + 1$ conditions which determine equilibrium levels of public goods X_j , wage rates w_j , the number R_j and utility ω_j of mobile residents as well as the common utility level ω for given L_j and P_j in all jurisdictions.

Holding constant the choices of other governments, the local government's decision regarding the size of land given to mobile residents P_i exerts an effect on the number of mobile residents R_i . As shown in the Appendix (see A.1), if the marginal benefit from private land is sufficiently strong, an increase of land available for mobile residents is associated with an increase of mobile residents:

$$\frac{\partial R_i}{\partial P_i} > 0 \quad (16)$$

As above, public policy is assumed to aim at maximizing the utility of immobile workers. It is defined as:

$$\Omega_i = (1 - t) w_i + u(X_i) + v(A - L_i - P_i) \quad (17)$$

The main difference to the above case, is that the land given to mobile residents reduces the land which serves as an amenity.

The optimal choice $\frac{\partial \Omega_i}{\partial P_i} = 0$ obeys

$$u'(X_i) ty \frac{\partial R_i}{\partial P_i} = v'(A - L_i - P_i). \quad (18)$$

The left-hand side captures the advantage from mobile residents, which results from the increase of public good provision. The right-hand side reflects the opportunity cost of increasing the land given to mobile residents.

As above, the optimal policy is socially inefficient, since the land given to mobile residents results in a higher equilibrium level of utility of mobile residents in all jurisdictions. As a consequence, other jurisdictions are losing mobile residents and the associated income tax revenues (see section A.1 in the Appendix). Hence, expanding residential land use exerts a negative fiscal externality on other jurisdictions.

How does the incentive to provide mobile residents with land changes under fiscal redistribution?

Since the tax capacity accounts for revenues collected from mobile residents, I redefine C_i as

$$C_i = \phi tw_i N + \phi ty R_i,$$

and the budget constraint becomes

$$X_i = b(N + R_i) + (1 - \phi)(tw_i N + ty R_i).$$

Optimal provision of land for mobile residents requires

$$u'(X_i) (b + (1 - \phi) ty) \frac{\partial R_i}{\partial P_i} = v'(A - L_i - P_i) R_i. \quad (19)$$

Comparison with equation (18) reveals the effect of fiscal redistribution. If redistribution is revenue neutral in the above sense, the fiscal incentive to attract mobile residents is reduced under equalization if

$$b - \phi ty < 0.$$

This condition requires that the larger fiscal need due to more mobile residents is not sufficient to compensate for the decrease in transfers due to the increase in tax capacity.

If mobile residents would add to the local work force, a further disadvantage of mobile residents from the perspective of local policy is that the local wage rate declines with adverse effects on the income of immobile workers and on income tax revenues. The latter might partly be offset by higher revenues from the business tax. However, if the wage effect is strong enough, the utility of the local work force would decline. In this case, the jurisdiction has no incentive to attract mobile residents. Therefore, the above result on residential land use needs to be qualified. If mobile residents enter the local labor market and if the associated wage effect is strong, the jurisdiction will not expand residential land, regardless of fiscal redistribution.

3 Empirical Methodology

The empirical analysis examines determinants of land use using data for local jurisdictions. Based on the theoretical discussion, it aims to test whether the intensity of land use for commercial and residential purposes is higher by jurisdictions that operate under fiscal competition compared to jurisdictions where the revenue effects of expanding land use are neutralized by fiscal redistribution. The testing ground is German municipalities, for which data on land use is provided on an annual basis (see next section). To identify differences in the strength of fiscal competition faced by the individual jurisdictions, I rely on the specific fiscal institutions under which these municipalities operate. More specifically, I exploit the fact that equalization grants,² the key instrument for fiscal redistribution among German municipalities, are not paid to all municipalities. Municipalities which have high tax capacity or are deemed to have low fiscal need are exempt.

While the details vary, the basic set-up of equalization is the same in all German states except for the three urban states. Jurisdictions with low fiscal capacity relative to fiscal need receive equalization grants that are inversely related to fiscal capacity. The degree of fiscal redistribution is very high: An additional euro of tax revenues results in a decline of fiscal equalization grants by 80 cents on average (Buettner 2006).³ Consequently, the impact of an expansion of commercial and residential land use on net revenues is substantially reduced. Jurisdictions that have fiscal capacity above a certain level of fiscal need are considered “abundant” and do not receive equalization grants. Hence, these jurisdictions are exempt from fiscal redistribution. In terms of the above theoretical discussion, marginal contribution rates and fiscal need vary among municipalities: ϑ_i , ϕ_i , and b_i

²In German these grants are formally called *Schlüsselzuweisungen nach der mangelnden Steuerkraft*.

³While Buettner (2006) refers to the state of Baden-Wuerttemberg, Thöne, Rauch, and Hummel (2015) (in German) find a similar number for the municipalities in Bavaria.

are positive for municipalities that receive equalization grants and are zero or close to zero in municipalities that are “abundant”.⁴

The identification of the degree of fiscal redistribution faced by an individual jurisdiction utilizes the fact that equalization grants are formula based and determined by measures of tax capacity and fiscal need. Formally, the equalization grant scheme can be depicted by a function

$$Z_i = \max(G_i - C_i, 0),$$

where G_i is “fiscal need” and C_i is “tax capacity”.⁵ The latter includes standardized revenues from the local business tax as well as revenues from the local income tax. The distinction between high- and low tax-capacity jurisdictions implies that the function Z_i is discontinuous: the derivative of Z_i with regard to the tax bases differs substantially between jurisdictions that are below a threshold level of $G_i = C_i$ and those that are above. More specifically, jurisdictions receiving grants have fiscal need in excess of fiscal capacity $G_i > C_i$. These jurisdictions are subject to fiscal redistribution since any increase in the tax base is associated with a decline in grants. Jurisdictions that have tax capacity exceeding fiscal need $C_i \geq G_i$ are exempt from fiscal redistribution.

As outcome variables, I employ annual differences in the share of land assigned to commercial, residential or agricultural land use between periods $t + 1$ and t . Focusing on the change of land-use is useful, since the transformation of land into residential or commercial uses is not easily revertible.

⁴Abundant municipalities that are associated to a county face some fiscal redistribution associated with the contributions to the county in question.

⁵Note that this is a simplified exposition. In the context of German municipal fiscal equalization, for municipalities that receive fiscal equalization grants, the basic fiscal need $b_i N$ is equivalent to the “Hauptansatz”, divided by the rate of equalization (“Ausgleichssatz”). Similarly, the marginal contribution rate ϑ_i is equivalent to the standardized tax rate (“Nivellierungshebesatz”) divided by the rate of equalization. Also φ_i is scaled with the rate of equalization.

Once space is devoted to commercial or residential uses, the land-owner has a protected right to use it in this way, and hence, a reversal is only possible with the consent of both land-owner and municipality and even may require removal of existing structures.⁶

Given the institutional setting, the log of the relative tax capacity $c_i = \log \frac{C_i}{G_i}$ can be used as an assignment variable in a sharp regression discontinuity (*RD*) analysis. Hence, I use kernel regressions fitted to each side of the cutoff point $c_i = 0$ in order to provide estimates of the treatment effect at the cutoff point. Denoting the outcome variable with y , I estimate functions

$$y_i = \alpha_L + \beta_L c_i + \epsilon_i, \forall i \text{ with } -h \leq c_i < 0 \text{ and}$$

$$y_i = \alpha_R + \beta_R c_i + \epsilon_i, \forall i \text{ with } 0 \leq c_i \leq +h,$$

where h denotes the bandwidth around the cutoff point. The resulting estimate of the treatment effect is the difference in the intercept $\alpha_R - \alpha_L$. Estimations are carried out using kernel weights $K\left(\frac{c_i}{h}\right)$, which put more weight on observations close to the threshold. Estimates might become more precise, when the bandwidth is large. However, depending on the true underlying relationship between y_i and c_i , the difference in the intercept terms delivers a biased estimate of the local treatment effect (Lee and Lemieux 2010) and the bias increases with the bandwidth. To find the right balance between precision and bias, I implement the bandwidth selection procedure by Calonico, Cattaneo, and Titiunik (2014). To check for robustness I also employ squared and higher order terms of the right-hand side variable c_i , include total size as a control variable and explore the treatment effect estimates associated with placebo values of the cutoff point.

⁶Referring to the change of land use is also common practice by geographical indicators of “land consumption”, e.g., Melchiorri et al. (2019).

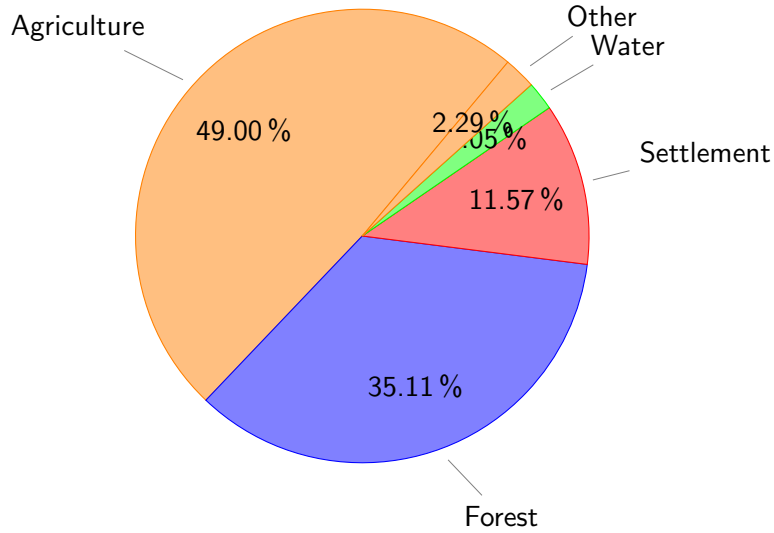
4 Data

German municipalities form the lowest tier of governments in the German federation. With the exception of three urban states, all states run systems of fiscal equalization that strongly redistribute local revenues. Preconditions to implement the sharp regression discontinuity design outlined above are that a sufficient number of municipalities are exempt from fiscal redistribution and that it is possible to measure the assignment into treatment precisely. In order to meet these requirements, the empirical analysis focuses on the state of Bavaria, where all municipalities operate under the same equalization system, a substantial fraction of municipalities are exempt from fiscal redistribution (abundant), and relative fiscal capacity is precisely reported in the official statistics.

The data refers to all 2,056 municipalities of Bavaria in the six years between 2008 and 2013. Data on land use refers to the entry in the official cadastral land register. Land uses are reported for each individual parcel and aggregated at municipal level.⁷ Figure 1 shows the fraction of basic types of land use in Bavaria. About half of all land is used for agriculture. About a third is covered by forests. The settlement area, captures only about 12% of total land. Figure 2 provides a breakdown of the settlement area. While the largest fraction of this area is used for transport, the fraction of residential use is second, amounting to roughly a quarter of all settlement area, or a total of 1,990 km². Residential land use includes buildings and areas predominantly used for housing. Commercially used land amounts to about 5% of the settlement area. This includes buildings and areas used for industrial production and other commercial purposes. The total size of commercial land is 435 km².

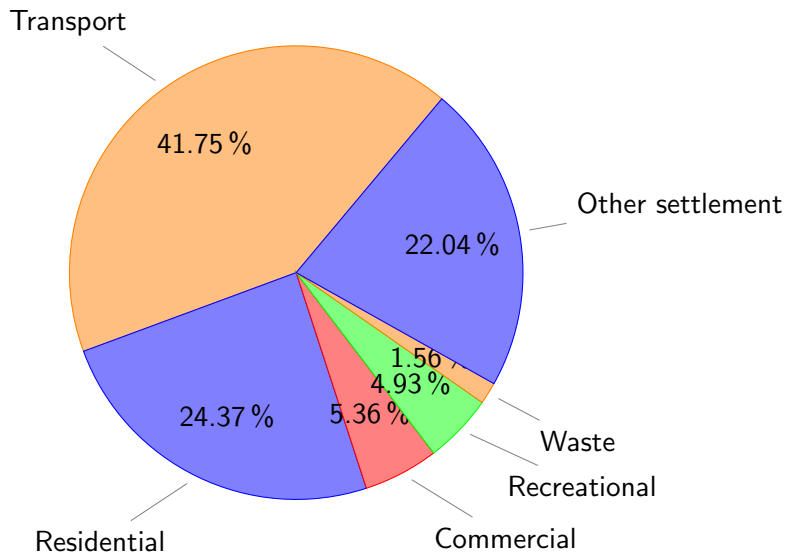
⁷Note that due to migration of the statistic from the digital land register towards a geographic information system, I exclude more recent years as well as observations for two counties in 2013, which first shifted to the new reporting standard.

Figure 1: General Types of Land Use



Fractions of land use in the state of Bavaria in 2013 based on official land registry information for its 2,056 municipalities.

Figure 2: Composition of Settlement Area



Fractions of land use within the settlement area in Bavaria in 2013 based on official land registry information for its 2,056 municipalities.

In the following, I focus on commercial and residential land use. As it is the biggest category of non-settlement land use, I also explore effects on agricultural land use for comparison. Since the size of municipalities differs, I consider the different categories of land use and their change over time relative to the total area of each municipality.

Descriptive statistics for the size of municipalities and their land use are provided by Table 1. The share of land assigned to commercial uses is rather small. In 2013, on average about 53.1% of total area is assigned to agricultural land use. In the years under consideration, from 2008 to 2013, the average share of land used commercially is about 0.6% of total area. The average annual change of this share of land is positive: on average, 0.01 % of total land is added to commercial land use every year. Putting this in relation to the fraction of land already devoted to commercial land, commercial land use increases on average by 1.8% every year. The minimum is negative indicating a decline of commercial land. However, declines are relatively infrequent – less than 20% of observations report a decline.

On average, residential land use also displays increases every year. The mean annual increase of residential land is around 1% every year. Declines are even less likely than in the case of commercial land – less than 8% of observations report a decline. The table also shows that the increases in commercial and residential land use are reflected in declining agricultural land use.

Figure 3 depicts the change in the commercial land use between 2008 and 2013. The map classifies the change in four groups with declining share, no or small increase, modest and strong increase. Figure 4 depicts the average change in residential land use. This map classifies the change in four groups with declining or constant shares, small, modest and sharp increases. In particular, residential land use shows stronger increases in the southern parts of Bavaria, close to the agglomeration

Table 1: Descriptive Statistics

Variable		N.Obs	Mean	Std.Dev.	Min	Max
Commercial land use ¹						
	(in 100 m^2)	12,238	20.3	50.5	0	1154.7
	(in % of area)	12,238	0.6126	0.9875	0	17.765
	(change)	10,182	0.0111	0.1179	-1.7119	9.2808
Residential land use ¹						
	(in 100 m^2)	12,238	94.4	213.3	3.7	7820.5
	(in % of area)	12,238	3.2809	3.5557	0.1234	46.370
	(change)	10,182	0.0316	0.0523	-1.6861	0.8542
Agricultural land use ¹						
	(in 100 m^2)	12,238	1679.4	1214.4	28.7	8407.8
	(in % of area)	12,238	53.102	16.106	2.0565	91.255
	(change)	10,182	-0.1492	0.9133	-55.333	1.5046
Total area ¹	(in 100 m^2)	12,238	3312.6	2550.9	138.9	31074.0
Population		12,336	6090.8	33537.2	238	1407836
Equalization grants	(euros per cap.)	12,336	166.8	115.9	0	1014.7
Zero grants	(binary)	12,336	0.1433	0.3498	0	1
Zero grants in no year	(binary)	2,056	0.7563	0.4294	0	1
Zero grants in one year	(binary)	2,056	0.0642	0.2452	0	1
Zero grants in two years	(binary)	2,056	0.0350	0.1839	0	1
Zero grants in three years	(binary)	2,056	0.0229	0.1495	0	1
Zero grants in four years	(binary)	2,056	0.0253	0.1570	0	1
Zero grants in five years	(binary)	2,056	0.0253	0.1570	0	1
Zero grants in six years	(binary)	2,056	0.0710	0.2569	0	1
Tax capacity ²	(euros per cap.)	12,088	586.2	253.7	223.4	2994.6
Fiscal need ²	(euros per cap.)	12,088	807.8	85.4	647.7	1758.8
Relative tax capacity ²		12,088	0.7311	0.3190	0.2921	2.6483

Sources: Own computations based on statistics provided by the Bavarian Office for Statistics and Data Processing. Annual observations if not otherwise indicated.

¹ Land use data based on official land register. Due to the changes in the reporting system some observations from 2013 are missing.

² Tax capacity, fiscal need and relative tax capacity after removing 1% and 99% percentile of the relative tax capacity.

around the city of Munich.

Table 1 also provides descriptive statistics on other characteristics of municipalities. The average population is a bit more than 6,000 residents, the largest city (Munich) has about 1.4 million residents. The average equalization grant in the sample is about 167 euros per capita with a maximum of about 1,015 euros. The table also reports a binary indicator for “abundant” jurisdictions receiving zero equalization grants. In the dataset, about 14% of municipalities fall in this category.

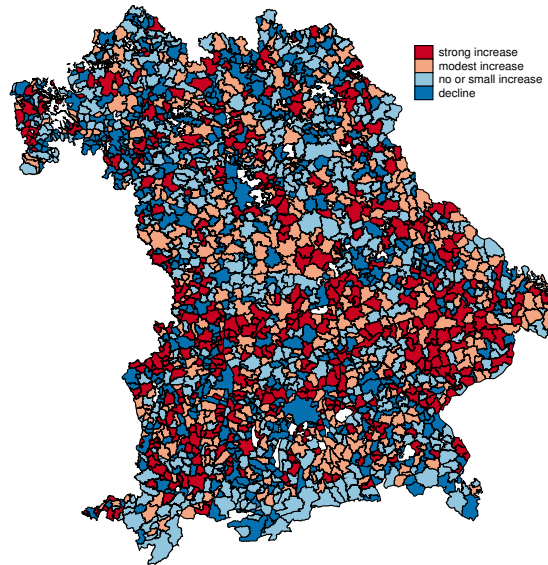
The tax capacity per-capita is on average 586 euros. The two most important revenue sources included are the municipal share of the income tax and the revenues from the local business tax, but the local property tax is also included.⁸ As there are single data points with negative or very high revenues typically reflecting legal disputes over the tax filings of large firms, municipalities with relative tax capacity below the 1% percentile and those with relative tax capacity above 99% are excluded. Nevertheless, the descriptive statistics point at relatively strong cross-sectional variation in tax capacity. For some jurisdictions, tax capacity only amounts to 223 euros per capita, while others report 1,759 euro per capita.

The fiscal need amounts to 808 euro per capita, on average. It shows much lower dispersion than tax capacity, which reflects the redistributive nature of the fiscal equalization system. Note that fiscal need includes a basic per-capita allowance, featured in the theoretical analysis, as well as some additional allowances capturing municipal spending obligations related to welfare aid and local unemployment.

Figure 5 provides a scatter plot of equalization grants against the assignment variable, i.e. tax

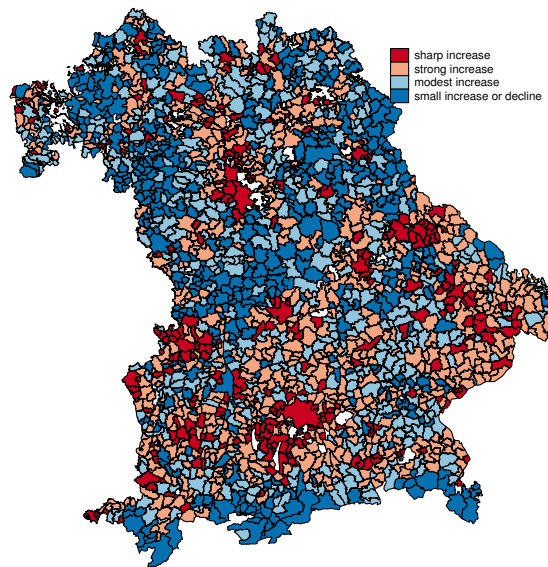
⁸Note that the German property tax is unimportant as a revenue source. This comes from the fact that assessment is held fixed since the 1960s.

Figure 3: Change in Commercial Land Use



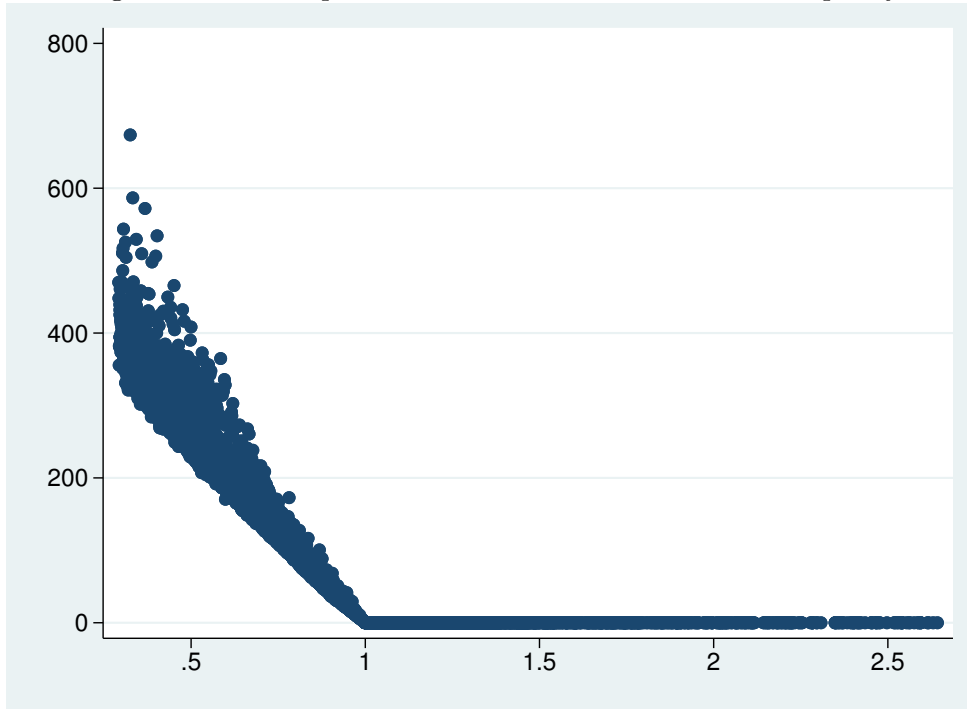
Note: The figure reports the average change in the share of land assigned to commercial use in the years from 2008 to 2013. The interval boundaries are as follows. “No or small increase” refers to an increase up to 0.005% of total area. “Modest increase” is an increase up to 0.015% of total area. “Strong increase” refers to an increase exceeding 0.015% of total area.

Figure 4: Change in Residential Land Use



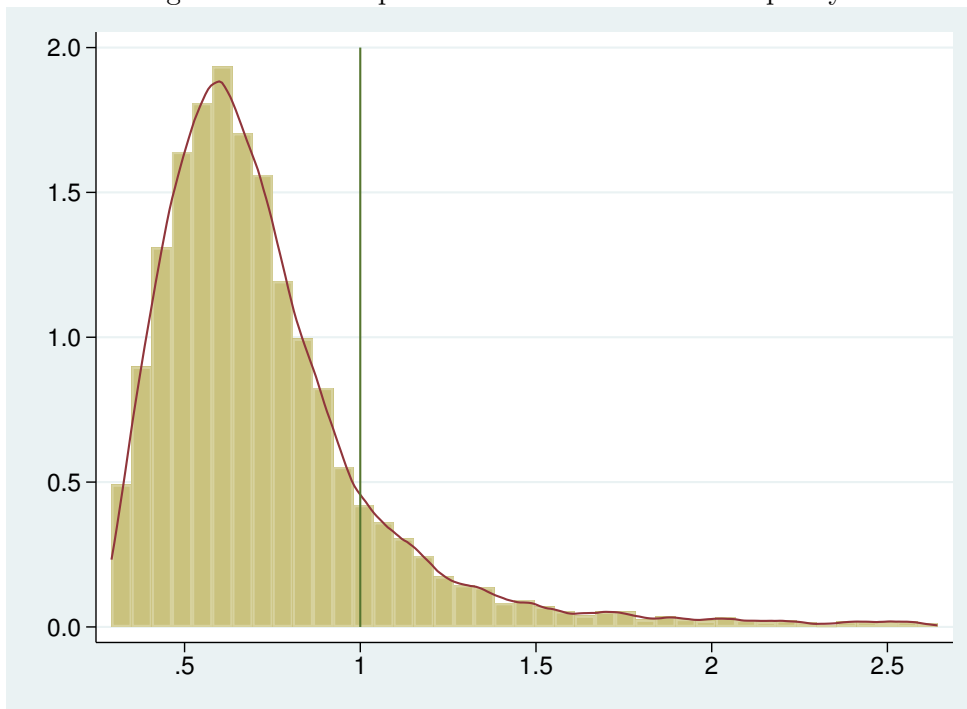
Note: The figure reports the average change in the share of land assigned to residential use in the years from 2008 to 2013. The interval boundaries are as follows. “Small increase or decline” denotes a decline or increases below 0.015% of total area. “Modest increase” refers to an increase up to 0.025% of total area. “Strong increase” is an increase up to 0.05% of total area. “Sharp increase” refers to an increase exceeding 0.05 % of total area.

Figure 5: Fiscal Equalization Grants and Relative Tax Capacity



Note: The figure reports equalization grants in per-capita terms for the municipalities in Bavaria. The horizontal axis reports tax capacity relative to fiscal need.

Figure 6: Fiscal Equalization Grants and Tax Capacity



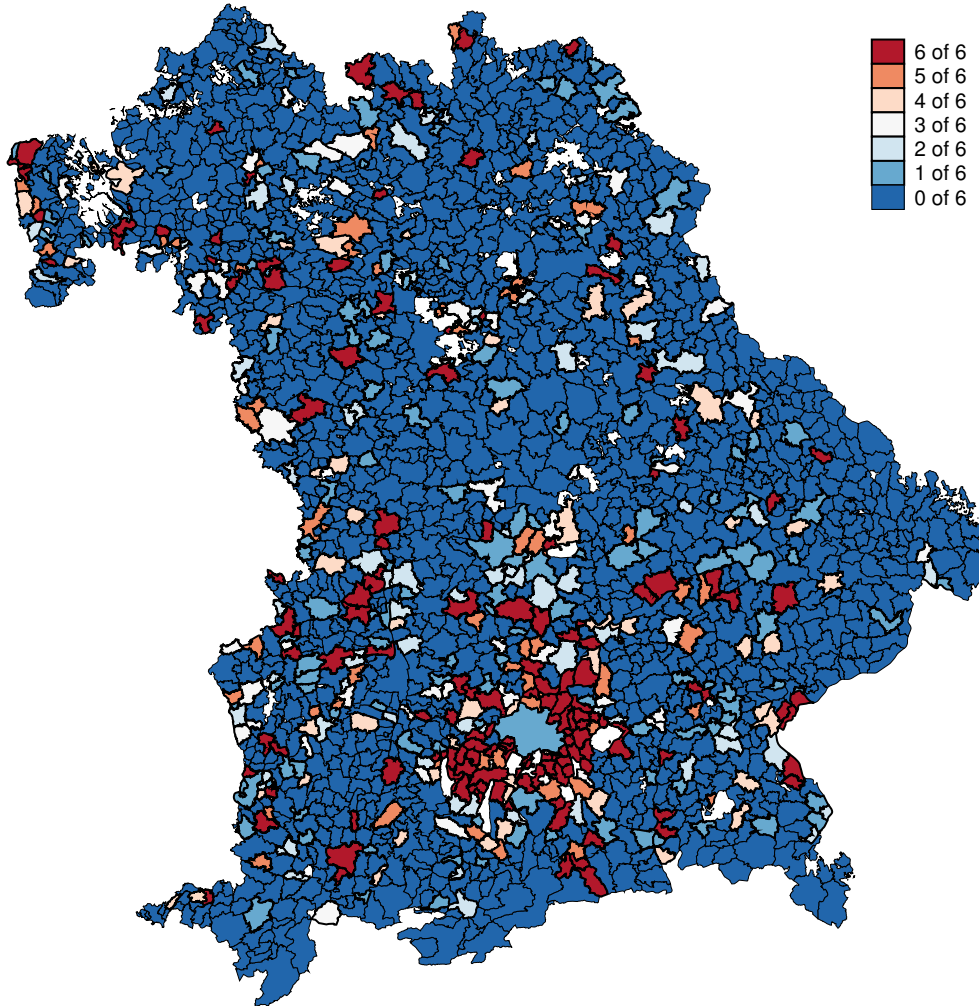
Note: The figure reports relative tax capacity and equalization grants both in per-capita terms for the estimation sample.

capacity relative to fiscal need. While there is some variation in the equalization grants paid at low levels of the assignment variable, the discontinuity at the threshold level of relative tax capacity of unity is obvious. Moreover, note that to the left of the threshold level the amount of grants received strongly declines with tax capacity. Close to the threshold, therefore, income effects in the local budget associated with fiscal equalization grants are unimportant.

The distribution of relative tax capacity is illustrated graphically by Figure 6 which provides a histogram of relative tax capacity together with a kernel estimate of the density. While the plot documents that most jurisdictions display relative tax capacity below unity, the cut-off point is clearly placed within the distribution.

Since the data refers to the six years between 2008 and 2013, the relative tax capacity of a municipality displays some variation over time. While most of the municipalities either display a relative tax capacity below or above unity in all years, some municipalities change their fiscal position and receive grants in some but not all years. Table 1 reports that 1,555 municipalities, i.e. about three quarters of all municipalities, have relative tax capacity below unity and receive grants in all years. 146 municipalities, i.e. about 7.1% of all municipalities, always report relative tax capacity above unity and receive no equalization grants. Figure 7 provides a map displaying the frequency of relative tax capacity at or above unity in the period under consideration.

Figure 7: No. of Years with Relative Tax Capacity at or above Unity



Note: The legend indicates the number of years in the six year period from 2008 to 2013 in which a municipality has relative tax capacity at or above unity.

5 Empirical Results

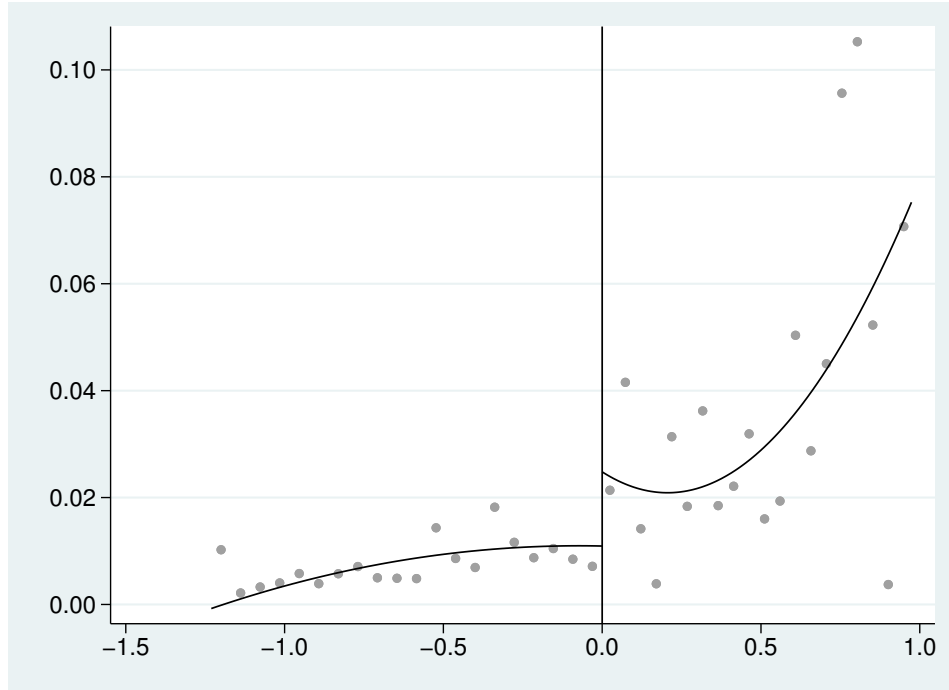
The discussion of the empirical results starts with three sets of plots showing the distribution of outcome variables around the cutoff point. Since the forcing variable is right skewed, all plots depict the forcing variable (relative tax capacity) in logs. As we noted above, if the relative capacity exceeds unity, or the log of the relative capacity exceeds zero, jurisdictions do not receive fiscal equalization grants. Hence, to the right of the threshold, jurisdictions are exempt from fiscal redistribution, and fiscal incentives to expand commercial and residential land use should be strong. All municipalities to the left of the cutoff point are subject to intense fiscal redistribution and, thus, face much weaker fiscal incentives to expand land use.

The upper plot in Figure 8 reports the means of annual changes in commercial land as a fraction of total land. Observations depict the means for an equal number of 20 bins on each side of the cutoff point.⁹ Whereas the change of commercial land use is close to zero to the left of the cutoff point, the means point at increases of commercial land use to the right. The lower plot is based on the same data and reports the means for a smaller number of bins, which minimizes the integrated mean squared error of the prediction as suggested by Calonico, Cattaneo, and Titiunik (2014). The plot also depicts the 95% confidence interval. The results are qualitatively similar. Note that the confidence intervals are larger to the right of the cutoff point, which reflects the smaller number of observations.

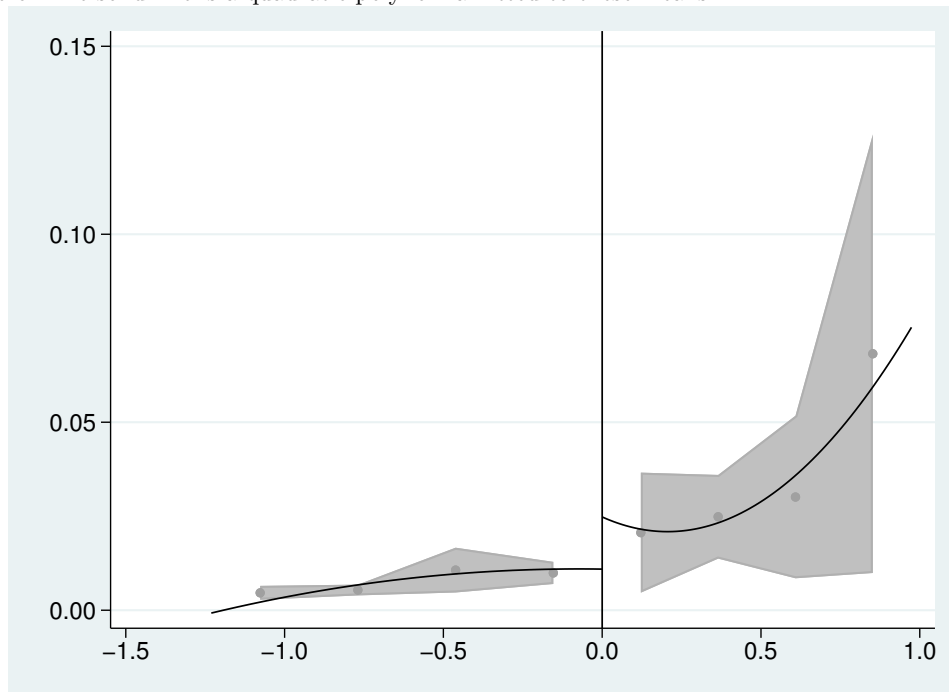
Figure 9 reports regression discontinuity plots for the annual changes in residential land as a fraction of total land. Again, the upper plot is based on 20 bins left and right of the cutoff point. The

⁹Plots were constructed using the `rdplot` command of stata's RD package.

Figure 8: Change in Commercial Land Use, w/ or w/o Fiscal Redistribution

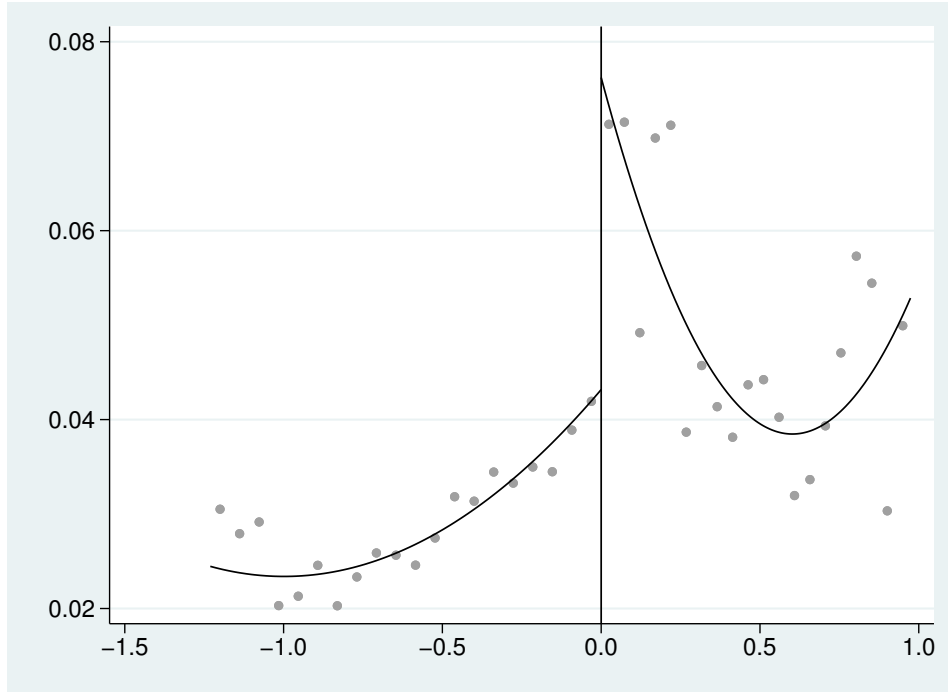


Means of annual changes in commercial land as a fraction of total area (in %) plotted against the log of relative tax capacity. 8244 observations. Based on 20 evenly spaced bins left and right of the cutoff point of log relative tax capacity of zero. The solid line is a quadratic polynomial fitted to these means.

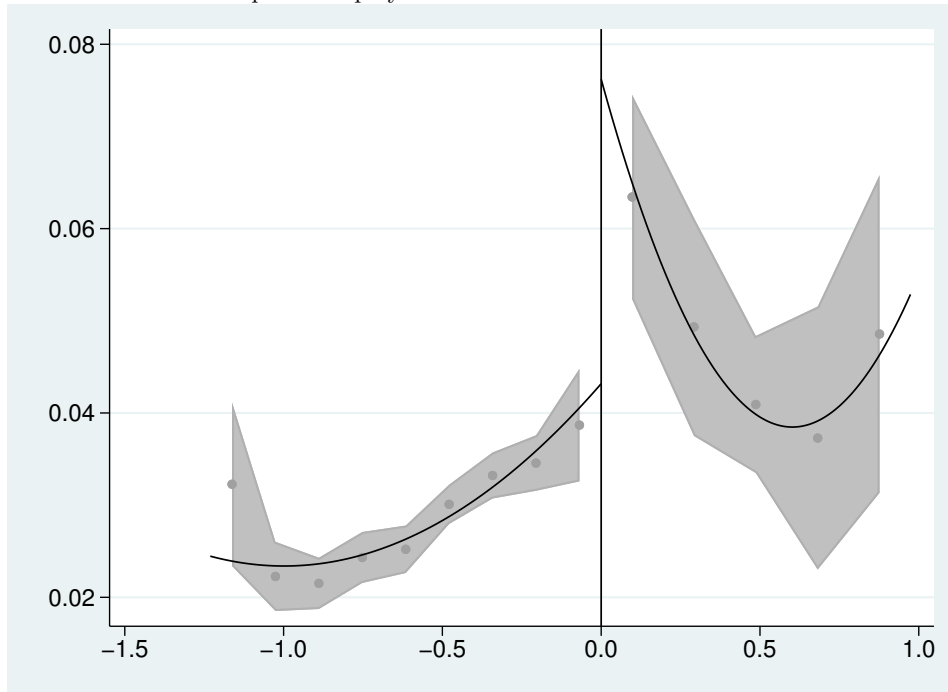


Means of annual changes in commercial land as a fraction of total area (in %) plotted against the log of relative tax capacity. 8244 observations. Evenly spaced bins left and right of the cutoff point of log relative tax capacity of zero. The number of bins left and right of the cutoff point is computed in order to minimize the integrated mean squared error (Calonico, Cattaneo, and Titiunik 2014). The solid line is a quadratic polynomial fitted to these means.

Figure 9: Change in Residential Land Use, w/ or w/o Fiscal Redistribution



Means of annual changes in residential land as a fraction of total area (in %) plotted against the log of relative tax capacity. 8244 observations. Based on 20 evenly spaced bins left and right of the cutoff point of log relative tax capacity of zero. The solid line is a quadratic polynomial fitted to these means.



Means of annual changes in residential land as a fraction of total area (in %) plotted against the log of relative tax capacity. 8244 observations. Evenly spaced bins left and right of the cutoff point of log relative tax capacity of zero. The number of bins left and right of the cutoff point is computed in order to minimize the integrated mean squared error (Calonico, Cattaneo, and Titiunik 2014). The solid line is a quadratic polynomial fitted to these means.

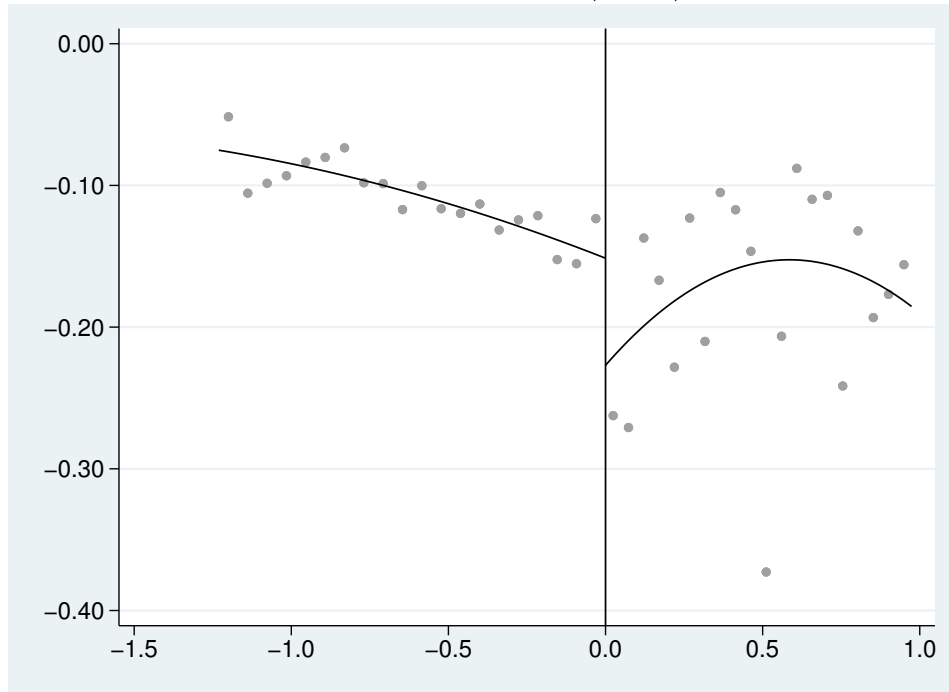
lower plot reports the means for the number of bins, which minimizes the integrated mean squared error of the prediction, together with the confidence interval. Both plots show that residential land increases stronger to the right of the cutoff point. Compared with commercial land use, the treatment seems slightly more local to the discontinuity.

Figure 10 turns to agricultural land. As there is no fiscal incentive to increase this type of land use, I do not expect to see increases to the right of the cutoff point. Instead, as the expansion of residential and commercial land use comes at the expense of other types of land uses, a decline of agricultural land seems likely. Again, the upper plot is based on 20 bins left and right of the cutoff point. The lower plot reports the means for the number of bins, which minimizes the integrated mean squared error of the prediction, together with the confidence interval. Both plots show a stronger decline of agricultural land to the right of the cutoff point, at least close to the cutoff point.

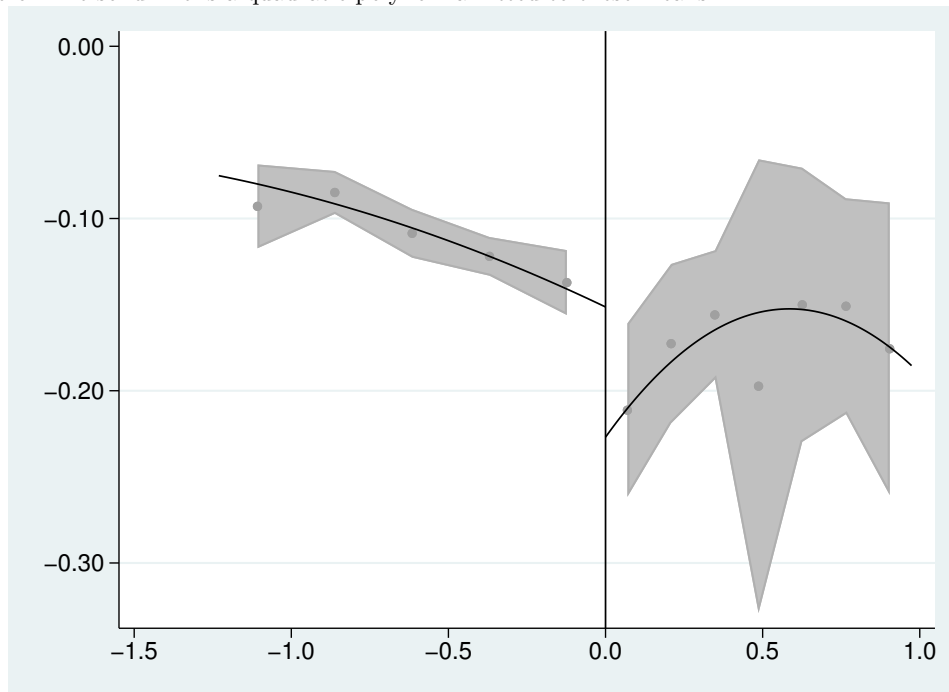
All plots support the view that jurisdictions operating under fiscal competition tend to expand the use of land used for commercial and residential purposes. To obtain estimates of the actual magnitude of these effects, I now turn to the regression analysis.

Table 2 reports point estimates for the treatment effect on the change in the share of land assigned to commercial use as well as related statistics. The table reports ten different estimates, all obtained by local regression discontinuity analysis but using different specifications. The first column reports results from a basic setting with bandwidth set to 25 log points. This restricts the analysis to a subsample comprising only around 18% of all observations. Since the modal point of the distribution is below the cut-off there are more observation to the left of the cut-off: 1,172 observations have fiscal need exceeding tax capacity and hence are subject to redistribution, 260

Figure 10: Change in Agricultural Land Use, w/ or w/o Fiscal Redistribution



Means of annual changes in agricultural land as a fraction of total area (in %) plotted against the log of relative tax capacity. 8244 observations. Based on 20 evenly spaced bins left and right of the cutoff point of log relative tax capacity of zero. The solid line is a quadratic polynomial fitted to these means.



Means of annual changes in agricultural land as a fraction of total area (in %) plotted against the log of relative tax capacity. 8244 observations. Evenly spaced bins left and right of the cutoff point of log relative tax capacity of zero. The number of bins left and right of the cutoff point is computed in order to minimize the integrated mean squared error (Calonico, Cattaneo, and Titiunik 2014). The solid line is a quadratic polynomial fitted to these means.

Table 2: RD Estimates for Commercial Land

	(1)	(2)	(3)	(4)	(5)
Coefficient	0.0275	0.0212	0.0260	0.0267	0.0270
Standard error	(0.0111)	(0.0120)	(0.0114)	(0.0110)	(0.0100)
z	2.231	2.340	2.172	2.299	2.565
$P(z)$	0.026	0.016	0.030	0.022	0.010
Covariate (log area)	no	no	no	no	no
Temporary assignment	no	no	no	no	no
Bandwith method	manual	manual	manual	opt.	opt.
Bandwidth	0.250	0.250	0.250	0.259	0.256
Polynomial	1	1	1	1	1
Kernel	trian.	rectan.	parabl.	triang.	triang.
Cluster	munic.	munic.	munic.	munic.	county
N.Obs left	1,172	1,172	1,172	1,237	1,213
N.Obs right	260	260	260	269	264
	(6)	(7)	(8)	(9)	(10)
Coefficient	0.0275	0.0329	0.0373	0.0242	0.0159
Standard error	(0.0131)	(0.0149)	(0.0154)	(0.0111)	(0.0061)
z	1.970	2.166	2.402	2.082	2.392
$P(z)$	0.049	0.030	0.016	0.026	0.017
Covariate (log area)	no	no	no	yes	no
Temporary assignment	no	no	no	no	yes
Bandwith method	opt.	opt.	opt.	opt.	opt.
Bandwidth	0.429	0.521	0.600	0.261	0.279
Polynomial	2	3	4	1	1
Kernel	triang.	triang.	triang.	triang.	triang.
Cluster	munic.	munic.	munic.	munic.	munic.
N.Obs left	3,072	4,106	4,939	1,253	2,198
N.Obs right	428	470	517	270	847

Dependent variable: change of the share of land available for commercial use. Basic estimation sample includes 8,394 municipality-year cells except in specification (10) where the sample includes 10,151 cells. Coefficients reflect the point estimates of the local treatment effect of the absence of fiscal redistribution. All specifications shown use the log of relative tax capacity with cutoff point zero as an assignment variable. The results are based on a specification of the local polynomials with bandwidth selection and degree of polynomial as indicated. Standard error estimates are clustered at the level of the municipality or county. z reports the robust bias corrected standardized test statistic following Calonico, Cattaneo, and Titiunik (2014).

observations are “abundant”, i.e. have tax capacity exceeding fiscal need and are thus exempt from fiscal redistribution. The local regressions use linear polynomials and a triangular kernel. The resulting point estimate of the treatment effect indicates that the expansion of commercial land use is faster in the abundant municipalities: annual expansion is found to exceed the control group by 0.0275 % of total area. Given that the average expansion of commercial land use in the dataset amounts to 0.01% of total area this is a sizeable effect indicating that the speed of expansion is 2 to 3 times higher. Based on the cluster-robust standard error the effect is significantly different from zero. I also report a bias-corrected standardized test statistic following Calonico, Cattaneo, and Titiunik (2014), which shows a P-value below 5%. Columns (2) and (3) report alternative specifications which use the same bandwidth and degree of polynomial but different kernels. Based on the rectangular kernel, as reported in (2), the point estimate is slightly reduced. If a parabolic kernel is used the point estimate is more similar. This suggests that the treatment effect is local to the discontinuity.

Column (4) reports results of specifications where the bandwidth is not fixed arbitrarily but chosen to strike an optimal balance in the bias-variance tradeoff that emerges under a first-order polynomial following Calonico, Cattaneo, and Farrell (2020). The procedure employs a slightly larger bandwidth and yields quite similar results as in column (1). Since land-use decisions of neighboring municipalities are correlated, column (5) reports results of a specification where the standard errors are clustered by county rather than municipality. This robustness check delivers smaller standard errors suggesting that spatial correlation, if present, does not create a risk of overrejecting the Null.

When higher-order polynomials are fitted, the optimal bandwidth is drastically enlarged. When quadratic functions are fitted to the left and to the right of the cutoff point (column 6), the optimal

bandwidth is set to 43 log points and the number of observations increases to almost 42% of the sample. When cubic (column 7) or quartic polynomials (column 8) are fitted, the majority of all municipalities are included. While qualitative results are similar, the higher data demand suggests a need to interpret the results obtained with higher-order polynomials with caution and to rely on local linear or quadratic polynomials (Gelman and Imbens 2019). Column (9) reports results based on first-order polynomials which include the (log) size of the municipality as a covariate. The treatment effect estimate proves robust, indicating that the information about the size of the municipality can safely be omitted.

Specifications (1) to (9) exclude all municipalities switching their status of abundance over time. If switching is temporary, given the difficulty to revert an expansion of land use, this seems reasonable. However, if the change in status is expected to be permanent, switching the status might well exert effects on land use. As a robustness check, therefore, column (10) reports results where also municipalities which change their status are included in the sample. While the number of observations increases, the treatment effect turns out to be smaller. This supports the view that at least some of the switching is temporary.

Note that regardless of whether switching municipalities are excluded or included, the data does not point at self selection into or out of the treatment. Defining bins of +/- 0.5 log points around the cutoff, in the sample excluding switching municipalities, 31 observations are at the left, 29 are right of the cutoff. If switching municipalities are included, the observation numbers are 38 and 34 respectively. The absence of manipulation is also indicated by formal tests whether the density of the assignment is continuous at the threshold.¹⁰

¹⁰The test statistic derived using the local polynomial density estimation method by Cattaneo, Jansson, and Ma (2020) with a quadratic polynomial and data driven choice of the bandwidth is $T = -0.2649$ with P-value of 0.7911

As a robustness check, I explored the estimation of treatment effects using placebo values of the cutoff point, where a higher value of the assignment variable is not associated with being exempt from fiscal redistribution. As expected, for cutoff points with relative tax capacity of -20 log points or -40 log points counterfactual treatments show no effects on commercial land use.¹¹

Table 3 turns to the treatment effect of fiscal competition on residential land use. As above, the table shows point estimates using regression discontinuity methods employing a set of different specifications. Column (1) shows the treatment effect obtained from a specification with bandwidth fixed to 25 log points using a triangular kernel and a first-order polynomial. The positive coefficient points to a stronger increase of residential land use under fiscal competition. More specifically, the average increase of residential land exceeds the control group by 0.0288 % of total area. Given the average expansion of residential land use among all municipalities by 0.0316 % of total area, this indicates that the speed of expansion doubles under fiscal competition. Based on the cluster-robust standard error as well as on the bias-corrected standardized test statistic following Calonico, Cattaneo, and Titiunik (2014), the effect is weakly significant with a P-level of about 10%. A rectangular kernel results in a smaller effect (see column (2)), while the parabolic kernel (see column (3)) yields a similar effect indicating that the treatment effect is local to the discontinuity. If an optimal bandwidth is chosen using the method of Calonico, Cattaneo, and Farrell (2020), the treatment is found to be larger and the P-level of significance declines (see column (4)). Based on the point estimate for the treatment effect of 0.0377 % of total area, the speed of expansion more than doubles. As above, results are robust when taking account of possible spatial correlation. Allowing for higher-order polynomials is associated with much larger optimal bandwidth. Nevertheless, if switching municipalities are excluded, and $T = 0.5090$ with P-value of 0.6107 if they are included.

¹¹Results are provided in columns (1) and (2) of Table A-1 in the Appendix.

Table 3: RD Estimates for Residential Land

	(1)	(2)	(3)	(4)	(5)
Coefficient	0.0288	0.0277	0.0264	0.0337	0.0333
Standard error	(0.0177)	(0.0158)	(0.0169)	(0.0113)	(0.0151)
z	1.650	1.264	1.623	2.846	2.264
$P(z)$	0.099	0.206	0.105	0.004	0.024
Covariate (log area)	no	no	no	no	no
Temporary assignment	no	no	no	no	no
Bandwith method	manual	manual	manual	opt.	opt.
Bandwidth	0.250	0.250	0.250	0.551	0.573
Polynomial	1	1	1	1	1
Kernel	trian.	rectan.	parabl.	triang.	triang.
Cluster	munic.	munic.	munic.	munic.	county
N.Obs left	1,172	1,172	1,172	4,460	4,673
N.Obs right	260	260	260	489	503
	(6)	(7)	(8)	(9)	(10)
Coefficient	0.0365	0.0350	0.0319	0.0318	0.0046
Standard error	(0.0139)	(0.0149)	(0.0194)	(0.0113)	(0.0049)
z	2.218	1.523	1.301	2.479	0.639
$P(z)$	0.027	0.128	0.193	0.013	0.523
Covariate (log area)	no	no	no	yes	no
Temporary assignment	no	no	no	no	yes
Bandwith method	opt.	opt.	opt.	opt.	opt.
Bandwidth	0.848	1.007	1.323	0.506	0.416
Polynomial	2	3	4	1	1
Kernel	triang.	triang.	triang.	triang.	triang.
Cluster	munic.	munic.	munic.	munic.	munic.
N.Obs left	6,722	7,299	7,636	3,945	3,817
N.Obs right	604	650	690	462	1,038

Dependent variable: change of the share of land available for residential use. Basic estimation sample includes 8,394 municipality-year cells except in specification (10) where the sample includes 10,151 cells. Coefficients reflect the point estimates of the local treatment effect of the absence of fiscal redistribution. All specifications shown use the log of relative tax capacity with cutoff point zero as an assignment variable. The results are based on a specification of the local polynomials with bandwidth selection and degree of polynomial as indicated. Standard error estimates are clustered at the level of the municipality or county. z reports the robust bias corrected standardized test statistic following Calonico, Cattaneo, and Titiunik (2014).

treatment effects are similar though estimated with lower precision. Column (9) reports an estimate including the total size of a municipality (in logs) as a control. Point estimate and inference are not much affected. The specification reported in column (10) includes municipalities that are only exempt from fiscal redistribution in some but not all years. As above, the treatment effect is much smaller and no longer statistically significant. Also for residential land use estimates of treatment effects using placebo values of the cutoff point do not show any effects.¹²

Table 4 shows treatment effects on agricultural land use. The table uses the same specifications, that are used above. Column (1) shows that a basic regression-discontinuity estimate based on a bandwidth of 0.25 log points, a local linear polynomial and triangular kernel delivers a negative treatment effect pointing to a decline of agricultural land use. Given the average decline in agricultural land use of -0.15% of total area, the point estimate suggests that the speed of decline increases by a factor of two thirds if a municipality operates under fiscal competition. Across different specifications, the quantitative estimates of the treatment effect vary but the qualitative results prove robust. The qualitative differences across specifications are similar to the analysis of commercial and residential land. The treatment effect is local to the discontinuity, robust against potential spatial correlation, and is estimated with less precision when higher-order polynomials are used. The treatment effect is robust against inclusion of total size (in logs) as a control and disappears if the sample is extended to include municipalities that are exempt from fiscal redistribution in some but not all years. Moreover, robustness checks conducted using placebo values of the cutoff point do not show any effects on agricultural land use.¹³

¹²Results are provided in columns (3) and (4) of Table A-1 in the Appendix.

¹³Results are provided in columns (5) and (6) of Table A-1 in the Appendix.

Table 4: RD Estimates for Agricultural Land

	(1)	(2)	(3)	(4)	(5)
Coefficient	-0.1442	-0.1017	-0.1321	-0.1011	-0.1001
Standard error	(0.0681)	(0.0559)	(0.0636)	(0.0458)	(0.0511)
z	-2.027	-2.162	-2.200	-2.146	-1.940
$P(z)$	0.043	0.031	0.028	0.032	0.052
Covariate (log area)	no	no	no	no	no
Temporary assignment	no	no	no	no	no
Bandwith method	manual	manual	manual	opt.	opt.
Bandwidth	0.250	0.250	0.250	0.419	0.420
Polynomial	1	1	1	1	1
Kernel	trian.	rectan.	parabl.	triang.	triang.
Cluster	munic.	munic.	munic.	munic.	county
N.Obs left	1,172	1,172	1,172	2,940	2,968
N.Obs right	260	260	260	418	423
	(6)	(7)	(8)	(9)	(10)
Coefficient	-0.1249	-0.1575	-0.1781	-0.0960	0.0032
Standard error	(0.0561)	(0.0754)	(0.1064)	(0.0456)	(0.0223)
z	-2.154	-2.025	-1.622	-2.041	0.181
$P(z)$	0.031	0.034	0.105	0.041	0.856
Covariate (log area)	no	no	no	yes	no
Temporary assignment	no	no	no	no	yes
Bandwith method	opt.	opt.	opt.	opt.	opt.
Bandwidth	0.702	0.829	1.040	0.421	0.365
Polynomial	2	3	4	1	1
Kernel	triang.	triang.	triang.	triang.	triang.
Cluster	munic.	munic.	munic.	munic.	munic.
N.Obs left	5,803	6,625	5,864	2,971	3,219
N.Obs right	558	601	562	423	976

Dependent variable: change of the share of land available for agricultural use. Basic estimation sample includes 8,394 municipality-year cells except in specification (10) where the sample includes 10,151 cells. Coefficients reflect the point estimates of the local treatment effect of the absence of fiscal redistribution. All specifications shown use the log of relative tax capacity with cutoff point zero as an assignment variable. The results are based on a specification of the local polynomials with bandwidth selection and degree of polynomial as indicated. Standard error estimates are clustered at the level of the municipality or county. z reports the robust bias corrected standardized test statistic following Calonico, Cattaneo, and Titiunik (2014).

6 Conclusions

The theoretical analysis in this paper considers the land-use policy of a local government that aims at maximizing the utility of immobile workers. Optimal land use equates the marginal benefit from land that serves as an amenity with its opportunity cost. This cost is determined by the wage increase that results from an increase of commercial land use as well as by fiscal incentives. The latter stem from the taxation of labor income and of mobile capital. In particular, expansion of commercial land use attracts mobile capital, tax revenue increases and the supply of public services is expanded. This link between land use and taxation fuels concerns about an inefficient expansion of commercial land use by jurisdictions competing for mobile capital. The theoretical analysis also shows that fiscal equalization among local governments tends to mitigate the fiscal incentive to expand commercial land use. An extension shows that there is also a fiscal incentive to expand residential land in order to attract mobile residents as tax payers, at least if the mobile residents do not enter the local labor market.

As an empirical testing ground for the analysis of the fiscal incentives to expand commercial and residential land use, the paper considers the land use among municipalities in Germany. In order to identify differences in the competitive environment faced by the municipalities, I exploit institutional characteristics of the fiscal equalization system. In particular, I make use of the discontinuity in the system that involves heavy redistribution among the majority of municipalities, but at the same time, exempts municipalities with higher levels of tax capacity from fiscal redistribution. This causes strong institutional variation in the degree of fiscal redistribution which enables me to base the empirical analysis on a sharp regression discontinuity design.

The empirical analysis utilizes a large dataset comprising the development of land use between 2008 and 2013 in the 2,056 municipalities of Bavaria, a major German state. The results confirm a significant effect of fiscal competition on commercial and residential land use. More specifically, I find that commercial land use expands 2-3 times faster in municipalities exempt from fiscal redistribution compared to municipalities that receive equalization transfers. Regarding residential land use, the results indicate that municipalities that are exempt from fiscal redistribution also expand this land use about 2 times faster than those municipalities that receive these transfers. At the same time, agricultural land is found to decline more rapidly in municipalities that are exempt from fiscal redistribution. These findings confirm that fiscal competition is an important driver of land use.

However, the majority of the municipalities are not exempt from fiscal equalization and, thus, are subject to the heavy degree of fiscal redistribution that is characteristic for German municipalities. Therefore, while the results point to the general importance of fiscal incentives as drivers behind expansion of land use, my findings also suggest that municipal fiscal equalization severely curtails the fiscal incentive to expanding land use in Germany.

Since the empirical results on the effects of fiscal competition on land use are derived from German data, the question arises whether similar effects hold in other settings as well. Regarding commercial land use, the strong effects may reflect the heavy reliance of German municipalities on the business tax. In more conventional tax settings, where the property tax is the main source of municipal tax revenue, the fiscal incentive to expand commercial land might be smaller. A similar point can be made with regard to the fiscal incentive to expand residential land use.

That the strength of the fiscal incentives hinges on a country's tax system is in accordance with the

tax competition literature, which has pointed out that inefficiencies are primarily driven by the lack of suitable tax instruments. However, the theoretical analysis has shown that externalities from land use policies are not only the result of fiscal incentives. If local policy aims at increasing wages of immobile workers, expanding commercial land use might be a way to attract investments which result in higher wages or employment. Since the identification strategy in this paper exploited fiscal redistribution, the empirical analysis is silent on whether this incentive is empirically relevant. But if this is the case, even with fiscal equalization, socially inefficient policies would result.

From a broader perspective, the findings in this paper strengthen the view that lack of harmonization of land use regulation can be an important driver of sprawl (Burchfield et al. 2006). In fact, it is tempting to relate the finding of a strong sensitivity of land use policy to local competition to the size of the municipalities under consideration. The vast majority of municipalities in the data are very small with average population size of about 6,000 inhabitants. Hence, the empirical setting is characterized by a heavily decentralized land-use policy, which is prone to socially inefficient outcomes because of externalities.

A Appendix

A.1 Residential Land Use and Number of Mobile Residents

If the amount of land assigned to mobile residents P_i increases, the general-equilibrium effects involve changes in the utility of mobile residents in all jurisdictions:

$$d\omega_i = \frac{\partial\omega_i}{\partial P_i} dP_i + \frac{\partial\omega_i}{\partial R_i} dR_i \quad (\text{A.1})$$

$$d\omega_j = \frac{\partial\omega_j}{\partial R_j} dR_j \quad \forall j \neq i \quad (\text{A.2})$$

The partial derivatives of utility are

$$\frac{\partial\omega_i}{\partial P_i} = \left[h' \left(\frac{P_i}{R_i} \right) \frac{1}{R_i} - v' (A - L_i - P_i) \right]$$

and

$$\frac{\partial\omega_j}{\partial R_j} = \left[u' (X_j) ty - h' \left(\frac{P_i}{R_i} \right) \frac{P_i}{R_i^2} \right] \quad \forall j.$$

A positive effect of P_i on the number of mobile residents R_i arises, if the marginal benefit from private land $h' \left(\frac{P_i}{R_i} \right)$ is sufficiently strong. More specifically, two requirements need to be met:

1. First, from the perspective of a mobile resident the land assigned to private use has higher value than the opportunity cost of using this land as an amenity:

$$\frac{P_i}{R_i} h' \left(\frac{P_i}{R_i} \right) > P_i v' (A - L_i - P_i)$$

This ensures that $\frac{\partial\omega_i}{\partial P_i} > 0$.

2. The second requirement is that the value of private land from the perspective of a mobile resident exceeds the value of income tax revenues from mobile residents:

$$\frac{P_i}{R_i} h' \left(\frac{P_i}{R_i} \right) > u' (X_i) ty R_i$$

This condition ensures that an increase of mobile residents is associated with a decline of utility of mobile residents $\frac{\partial \omega_i}{\partial R_i} < 0$.

Solving equations (A.1) and (A.1) for dR_i or dR_j and noting that $d\omega_i = d\omega_j = d\omega$ yields:

$$dR_i = \frac{1}{\frac{\partial \omega_i}{\partial R_i}} d\omega - \frac{\frac{\partial \omega_i}{\partial P_i}}{\frac{\partial \omega_i}{\partial R_i}} dP_i \quad (\text{A.3})$$

$$dR_j = \frac{1}{\frac{\partial \omega_j}{\partial R_j}} d\omega \quad \forall j \neq i \quad (\text{A.4})$$

Noting that $\sum dR_j = 0$, we have

$$0 = \sum_j \frac{1}{\frac{\partial \omega_j}{\partial R_j}} d\omega - \frac{\frac{\partial \omega_i}{\partial P_i}}{\frac{\partial \omega_i}{\partial R_i}} dP_i$$

Solving for $\frac{d\omega}{dP_i}$ gives:

$$\frac{d\omega}{dP_i} = \frac{\partial \omega_i}{\partial P_i} \left(\frac{\frac{1}{\frac{\partial \omega_i}{\partial R_i}}}{\sum_j \frac{1}{\frac{\partial \omega_j}{\partial R_j}}} \right) \quad (\text{A.5})$$

With $\frac{\partial \omega_i}{\partial P_i} > 0$ and $\frac{\partial \omega_j}{\partial R_j} < 0$, this term is positive. Thus, increasing the amount of land given to mobile residents in jurisdiction i raises the equilibrium level of utility of mobile residents in all jurisdictions. From equation (A.4), as a consequence, the number of mobile residents in all other jurisdictions declines.

To derive the effect on the number of mobile residents in jurisdiction i , I note that equation (A.3) implies:

$$\frac{dR_i}{dP_i} = \left(\frac{1}{\frac{\partial \omega_i}{\partial R_i}} \right) \frac{d\omega}{dP_i} - \frac{\frac{\partial \omega_i}{\partial P_i}}{\frac{\partial \omega_i}{\partial R_i}}$$

Inserting from (A.5) this term can be rearranged to prove inequality (16):

$$\frac{dR_i}{dP_i} = -\frac{\frac{\partial \omega_i}{\partial P_i}}{\frac{\partial \omega_i}{\partial R_i}} \left(1 - \frac{\frac{1}{\frac{\partial \omega_i}{\partial R_i}}}{\sum_j \frac{1}{\frac{\partial \omega_j}{\partial R_j}}} \right) > 0 \quad (\text{A.6})$$

■

A.2 Data Sources and Definitions

Municipalities: Units of observation are all 2,056 municipalities in the state of Bavaria. The set of municipalities has not changed between 2008 and 2013. Each municipality has an identifier (“Allgemeiner Gemeindeschlüssel”) which includes information about whether it is an urban county or associated to a county and if so, to which county. GIS data for producing maps are provided by the Federal Agency for Cartography and Geodesy (www.bkg.bund.de/EN/Home/home.html).

Land Use Data: Data on land use in all municipalities of Bavaria are obtained from the official land use statistics provided by the Bavarian Office for Statistics and Data Processing (www.statistik.bayern.de). The statistics are based on the electronic register ALB (“Automatisches Liegenschaftsbuch”). It reports the use for each individual parcel and the statistics aggregates these uses at the level of the municipality. Due to the migration of the statistics from the digital land register towards a geographic information system, observations for the year 2013 referring to the counties of Bayreuth and Amberg-Sulzbach and the urban counties of Bayreuth and Amberg are based on the new ALKIS reporting system and are removed from the basic sample. The land-use statistics reports land use at the level of the municipality in units 100 m^2 based on the ALB classification in eight broad and eight selected sub-categories. The data refers to the 31st. of December of the respective year.

Total area: The 2,056 municipalities cover almost all area of Bavaria. However, some small fraction of land is not assigned to a municipality but to the state of Bavaria (“Gemeindefreie Gebiete”). In some rare instances, this land has been assigned to individual municipalities. In these cases, the total size of a municipality has increased. To avoid

any biases, all observations where the total size increased by more than 5% are removed from the estimation sample.

Commercial land: Commercial land is a subcategory in the land-use statistics. It refers to land predominantly used for commercial and industrial use (“Gebäude- und Freiflächen, die vorherrschend gewerblichen und industriellen Zwecken dienen”).

Residential land: Residential land is a subcategory in the land-use statistics. It refers to land predominantly used for housing (“Gebäude- und Freiflächen, die vorherrschend Wohnzwecken dienen”).

Agricultural land: Agricultural land is another subcategory and refers to land predominantly used for mixed farming, market gardening including orcharding and tree nursery and winegrowing. Abandoned agricultural land is included, moorland and heithland are excluded.

Population: Population numbers are provided by Bavarian Office for Statistics and Data Processing (www.statistik.bayern.de). They refer to the 31st. December of each year. In the data preparation, per-capita numbers are computed using the observations from the preceding year.

Fiscal Equalization Grants: Data are provided by Bavarian Office for Statistics and Data Processing (www.statistik.bayern.de). The data refers to the year of disbursement.

Fiscal Need: Data for fiscal need (“Finanzbedarf”) are obtained from Bavarian Office for Statistics and Data Processing (www.statistik.bayern.de). They include the basic fiscal need (“Hauptansatz”) as well as additional allowances to cover expenses associated with welfare aid and local unemployment. The data refers to the year of the fiscal equalization grant.

Tax Capacity: Data for tax capacity (“Steuerkraft”) are obtained from Bavarian Office for Statistics and Data Processing (www.statistik.bayern.de). They reflect standardized revenues from the local business tax and the local property taxes. In addition they include the municipal share (15%) of the income taxes of the residents. The data refers to the year of the fiscal equalization grant.

Table A-1: Results using Placebo Cutoffs

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	commercial land use		residential land use		agricultural land use	
Cutoff	$c(-0.2)$	$c(-0.4)$	$c(-0.2)$	$c(-0.4)$	$c(-0.2)$	$c(-0.4)$
Coefficient	0.000	0.006	0.005	-0.002	-0.023	0.008
Standard error	(0.006)	(0.012)	(0.005)	(0.003)	(0.027)	(0.019)
z	0.113	0.599	1.321	-0.847	-0.861	0.459
$P(z)$	0.910	0.305	0.186	0.397	0.285	0.646
Covariate (log area)	no	no	no	no	no	no
Temporary assignment	no	no	no	no	no	no
Bandwidth method	manual	manual	manual	opt.	opt.	opt.
Bandwidth	0.198	0.341	0.175	0.222	0.285	0.251
Polynomial	1	1	1	1	1	1
Kernel	triang.	triang.	triang.	triang.	triang.	triang.
Cluster	munic.	munic.	munic.	munic.	munic.	munic.
N.Obs left	1,935	3,347	1,693	2,413	2,939	2,677
N.Obs right	764	2,623	730	2,113	836	2,273

Dependent variable: change of the share of land assigned to the type of use indicated. Basic estimation sample includes 8,394 municipality-year cells. Coefficients reflect the point estimates of placebo treatment effects at cutoff points of log relative fiscal capacity of -0.2 or -0.4 as indicated. The results are based on a specification of the local polynomials with bandwidth selection and degree of polynomial as indicated. Standard error estimates are clustered at the level of the municipality or county. z reports the robust bias corrected standardized test statistic following Calonico, Cattaneo, and Titiunik (2014).

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