Taxation, Fiscal Redistribution and Local Land Use Regulation

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July 2022

Abstract

This paper explores the role of fiscal institutions for local land use. The paper argues that tax base mobility results in an incentive to expand commercial and residential land use, which is mitigated by fiscal redistribution. These predictions are investigated empirically using a dataset of German municipalities. To identify differences in the exposure to fiscal redistribution, I exploit institutional characteristics of fiscal equalization grants using a regression discontinuity analysis. The results support an important role of fiscal incentives for local land use policy, as commercial and residential land use is expanded much faster, and agricultural land use declines more rapidly in municipalities exempted from fiscal redistribution.

JEL-Classifications: H71; R52; Q26

Keywords: *Fiscal Competition; Fiscal Redistribution; Land Use Policy; Natural Amenities; Urban Sprawl; Fiscal Equalization Grants; Regression Discontinuity Analysis*

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Acknowledgements: For data support I thank Martin Bürner from the Bavarian Office for Statistics and Data Processing. For helpful comments and discussions I thank David Agrawal, Calin Arcalean, Martin Altemeyer-Bartscher, Jan Brueckner, Wolfgang Buchholz, Bill Hoyt, Jay Wilson and participants on various seminars and conferences including the ZEW Public Finance conference, Mannheim, the conference on Fiscal Competition and Fiscal Federalism at the University of Kentucky, Meeting of the Verein fuer Socialpolitik in Augsburg, and Seminars at the University of Regensburg and the IWH Research Seminar.

1 Introduction

Expanded land use for settlements, including commercial and residential land use, is often criticized as it reduces open space and exerts adverse effects on the environment (Nechyba and Walsh 2004, Nilsson et al. 2013). The economic 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 generate more revenues to expand the provision of public services and to attract firms in order to enhance employment opportunities. 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 literature in public finance has emphasized, however, 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 face limitations in the set of available policy instruments and, in particular, often rely on mobile tax bases. Policy decisions then exert fiscal externalities and the equilibrium is generally inefficient (for a survey, see Wilson 1999). This creates a role for a system of fiscal redistribution that mitigates or even cancels fiscal externalities (e.g., Köthenbürger 2002, Bucovetsky and Smart 2006). Against this backdrop, the current paper explores the implications of fiscal competition and redistribution for local land-use policy.

The starting point for the analysis in this paper is the standard model of fiscal competition, where local governments attempt to attract 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 a local government faces when deciding on the fraction of land devoted to commercial land use. The analysis shows that under fiscal competition the local jurisdiction is subject to a fiscal incentive to expand commercial land use. An extension shows that a similar incentive may exist with regard to residential land use. However, when fiscal competition is mitigated by fiscal equalization grants, the fiscal incentive to expand land use is reduced or absent.

The empirical testing ground is land use among municipalities in Germany. These municipalities offer a promising case for studying fiscal incentives, since their main revenue source is a tax on a mobile base: the local business tax is levied on profits of local firms and establishments. Moreover, municipalities decide on land-use patterns including residential and commercial land use. To identify differences in fiscal redistribution among municipalities, I exploit institutional details of a system of fiscal equalization grants, which strongly redistribute revenues of receiving municipalities while others are exempted. The results show that the amount of land dedicated to commercial and residential land use expands faster and agricultural land use declines more rapidly if municipalities are exempted from fiscal equalization.

The contribution of this paper is threefold. The first contribution is to study the role of local public finances as a driver of expanding commercial and residential land use. 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). The urban economics literature has noted that decentral regulation may encourage excessive land use (for a survey see Blöchliger et al. 2017). The main criticism is that the local property tax provides an incentive to reducing 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 population externality contributes to a proliferation of these restrictions of land use (e.g., Brueckner 1995; Brueckner 1998). In contrast, this paper focuses on the role of fiscal competition for expanding and restricting commercial and residential land use.

A second contribution is to provide empirical evidence on the incentive effects of fiscal redistribution 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, Koethenbuerger, and Smart 2010, Dahlby and Ferede 2016, Ferede 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 and equalization as drivers 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), the role of fiscal redistribution has not been explored. The results of this paper confirm that this redistribution tends to mitigate the expansion of commercial as well as residential land use in Germany.

The paper is organized as follows. The next section provides the theoretical background by augmenting a model of fiscal competition with land and discussing the implications of fiscal equalization grants on local land use. 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 Land-use policy and fiscal redistribution

This section provides a brief theoretical discussion of the choice of local land-use restrictions. To do so, I augment a simple model of fiscal competition with land. In a first step, I characterize the spatial equilibrium allocation treating policies as given including the amount of land assigned to commercial use. This enables me to determine the amount of capital employed by local firms. In a second step, I discuss the effects of local policy. More specifically, I consider the effect of an increase of commercial land in a single jurisdiction on the capital market equilibrium. Equipped with the understanding of how local governments' choices affect equilibrium outcomes, I discuss the local policy choice. The goal of this section is to make empirical predictions about how the decision of a jurisdiction might change, when it is subject to fiscal redistribution. An analysis of the competitive equilibrium strategies of all jurisdictions, which would be required to make strong welfare statements, is beyond the scope of this paper, however.

2.1 Locational choice

Commercial land use generates a profit (rent) to the owner. This profit varies with the input of labor and capital. Denoting land and capital employed in jurisdiction i with L_i and K_i and the number of immobile workers in this jurisdiction, each supplying one unit of labor, with N_i, the output is determined by a constant returns-to-scale production function $F(K_i, L_i, N_i)$. Setting the output price to unity, the profit from commercial land use in jurisdiction i is determined by the excess of output over cost of capital and compensation of workers (expressed in units of the output):

$$\pi_i = F(K_i, L_i, N_i) - w_i N_i - r_i K_i, \tag{1}$$

where r_i is the (before tax) return on capital and w_i is the wage rate. Profit maximization requires:

$$\frac{\partial F_i}{\partial K_i} = r_i \tag{2}$$

$$\frac{\partial F_i}{\partial N_i} = w_i \tag{3}$$

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

$$K_i = \varphi(L_i, r_i, N) \tag{4}$$

The properties of this function are governed by the production function. It decreases in r_i, $\frac{\partial \varphi_i}{\partial r_i} = \frac{1}{F_{iKK}} < 0$, and, given input complementarity,[1] increases in L_i, $\frac{\partial \varphi_i}{\partial L_i} = \frac{-F_{iKL}}{F_{iKK}} > 0$.

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

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

where τ is the tax rate. The capital-market equilibrium condition requires that input 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 input of capital K_i and the rate of return on capital $\tau + \rho$ for given L_j and in all jurisdictions. Using equation (1) also the profit of the land-owner is determined, which equals the marginal product of land. While the effects of a change in the local tax rate have been discussed at length in the literature (e.g., Wilson 1999), the next subsection focuses on a change in commercial land.

2.2 Effects of increasing commercial land

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

[1] Formally, $F_{iKL} > 0, F_{iKN} > 0, F_{iNL} > 0$.

i as a function of the policy parameters in all jurisdictions. The effect of an increase of land L_i in jurisdiction i on the net rate of return is positive, $\frac{\partial \rho}{\partial L_i} > 0$.[2] Hence, by taking a total differential of equation (4) 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:

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

Note that the effect on the wage rate has two components. The first reflects the direct productivity gain from employing more commercial land. The second is an indirect effect which results from the increased input of capital.

2.3 Local policy with respect to commercial land

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

$$\Omega_i = w_i + u(X_i) + v(A - L_i), \tag{7}$$

[2] To derive the effect of commercial land on the equilibrium return on capital, I consider the total differential of the capital-market equilibrium condition (6)

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

and find

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

where w_i is the wage rate, 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, which is assumed to be the same across jurisdictions in line with the above symmetry assumption. This benefit increases in the volume of land not assigned to commercial use, $v' > 0$. Provision of the public good is financed by the tax on capital, and the public budget constraint is:

$$X_i = \tau K_i \tag{8}$$

Optimization with regard to the amount of land assigned to commercial use requires $\frac{\partial \Omega_i}{\partial L_i} = 0$. Using the above decomposition of the wage effect, the first-order condition becomes:

$$v'(A - L_i) = F_{iNL} + F_{iNK} \frac{\partial K_i}{\partial L_i} + u'(X_i) \tau \frac{\partial K_i}{\partial L_i} \tag{9}$$

This expression states that land use is optimal if the marginal benefit from land as an amenity (on the left-hand side) is equal to its opportunity cost (on the right). The latter consist of three terms: These are positive direct and indirect effects of commercial land on the marginal product of labor as well as the benefit from higher tax revenues as the local tax base increases. The latter effect is absent if the tax rate is zero and increases in the tax rate. This is intuitive as an increase in the tax base exerts stronger revenue effects the larger the tax rate is. The first term on the right-hand side reflects the basic opportunity cost of using land as an amenity. The other terms on the right-hand side are both caused by relocation of capital. While these terms add to the opportunity cost of using land as an amenity, they reflect a decline of the capital input in other jurisdictions and, hence, constitute negative externalities.

For each jurisdiction the first-order condition defines a best response of the land-use restriction given the choices of all other jurisdictions. The Nash equilibrium is characterized by the intersection of these response functions. Assuming that this equilibrium exists and is unique,[3] it is socially inefficient, since expanding commercial land by any local jurisdiction creates negative external effects on other jurisdictions (see section A.1 in the Appendix.)

The notion of externalities of local land-use restrictions is useful for interpreting the optimality condition (9). The direct productivity effect of assigning more land to commercial use reflects the social opportunity cost of using land as an amenity. The indirect effects associated with mobility indicate that the private opportunity cost from the perspective of the local jurisdiction is higher than the social opportunity cost. Hence, from a social perspective, jurisdictions assign too much land to commercial use. Note that the inefficiency of the land use restriction is similar to the distortion of environmental policies discussed in Oates and Schwab (1988), although, in their analysis, inefficiencies only arise from a fiscal externality.

2.4 Fiscal equalization

The above discussion of the fiscal incentive to expand commercial land use assumes that the local budget is exclusively financed by a tax on a mobile base. In practice, local jurisdictions often receive a substantial amount of intergovernmental revenue by grants from upper-level governments. Depending on how grants are determined, fiscal incentives change. In particular, Bucovetsky and Smart (2006) note that equalization grants would limit externalities from tax base mobility.

[3] The literature on capital tax competition has discussed sufficient conditions under which the intersection of the response functions will gives rise to a unique Nash-equilibrium, e.g. Taugourdeau and Ziad (2011).

Fiscal equalization can be introduced into the model, by assuming that municipality i receives a grant equal to the difference between “fiscal need” and “tax capacity”, Formally, the equalization grant amounts to $Z_i = G_i - C_i$, where G_i represents the fiscal need, i.e. a politically determined figure of what is considered a reasonable level of public expenditure per resident. Fiscal capacity is defined by $C_i = \vartheta K_i$ and determines the extent by which revenues from the capital tax are taken into account. In a way, ϑ is similar to the representative tax rate known from provincial fiscal equalization in Canada (e.g., Smart 2007) and determines the implicit marginal contribution to the equalization scheme. Taking the grant into account, the local public budget constraint is

$$X_i = G_i + (\tau - \vartheta) K_i.$$

Depending on the magnitudes of G_i and ϑ, at a given level of the tax base K_i, total revenues need not be different under equalization grants. However, changes in the local tax base K_i exert weaker effects on local revenue. This mitigates the fiscal incentive to expand commercial land use and with full equalization, the fiscal incentive is absent.

To derive the effect of fiscal equalization on the incentive to extend commercial land use, I assume that optimal policy maximizes the quasi-linear utility function (7) subject the budget constraint including grants. The condition for the optimal amount of commercial land is:

$$v'(A - L_i) = \frac{\partial w_i}{\partial L_i} + u'(X_i)(\tau - \vartheta)\frac{\partial K_i}{\partial L_i} \tag{10}$$

Comparison with equation (9) 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 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.[4]

Note however, that fiscal redistribution only reduces the fiscal incentive to expand commercial land. The incentive to attract mobile capital in order to increase the local wage rate is unaffected. Hence if this effect is strong, even full 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 amount of commercial land use would change. In particular, if the equalization grant exerts a positive revenue effect in the local public budget, the expansion of public services would further contribute to a decline in the opportunity cost of land as an amenity. However, note that the empirical analysis is concerned with a local treatment effect at levels of tax capacity, where fiscal equalization does not exert net-revenue or income effects.

While the discussion has focused on the regulation of commercial land use, there are many other types of land-use restrictions,[5] including restrictions on the total amount of land available for residential developments partly also motivated by environmental objectives (Anas and Rhee 2006). In this case, similar trade-offs may emerge as in the case of the commercial land use. In particular, revenues from taxing capital would benefit if local labor supply increases with new residents. Under capital tax competition, therefore, jurisdictions may also have an incentive to devote land for

[4]If the local jurisdictions has discretion in setting the local tax rate, fiscal equalization grants may also exert an effect on the local tax rate. In fact, they provide an incentive to increase the local tax rate (Bucovetsky and Smart 2006), which may partly offset the effect a higher marginal contribution rate.

[5]For a taxonomy of land use restrictions in the US see Quigley and Rosenthal (2005).

residential developments in order to attract mobile residents and, indirectly, capital. A formal derivation of this incentive is discussed in an extension with mobile residents in the Appendix (see Section A.2).

3 Empirical methodology

The empirical analysis examines determinants of land use regulation using data for local jurisdictions. Based on the theoretical discussion, it aims to test whether the intensity of land use is affected by fiscal redistribution. In order to answer this question, I explore local land use policies in a setting where local jurisdictions are subject to a system of fiscal equalization and compare the outcome with land use policies if revenues are determined under conditions of local fiscal autonomy. This distinction is characteristic of municipalities in Germany, which therefore serve as this paper's empirical testing ground for the relationship between fiscal redistribution and land use.

While the details vary, the basic set-up of fiscal redistribution is the same in all major German states.[6] Jurisdictions that have tax capacity above a certain level of fiscal need are considered "abundant" and do not receive equalization grants. Jurisdictions with low tax capacity relative to fiscal need receive equalization grants that are inversely related to tax capacity. For municipalities receiving those grants, the degree of fiscal redistribution is usually very high: An additional euro of tax revenues results in a decline of fiscal equalization grants by 80 cents on average (Buettner 2006).[7] Hence, the impact of an expansion of commercial and residential land use on net revenues is substantially reduced.

[6]The system differs in the three urban states.

[7]In terms of the above notation, the degree of redistribution is determined by $\frac{\vartheta}{\tau}$. If $\vartheta = \tau$, there is full redistribution implying that revenues are equalized except for differences in fiscal need.

Since the grants are not paid to abundant municipalities, the fiscal equalization formula is indeed nonlinear. Actually, employing the above notation, the equalization grant is determined by a function[8]

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

This function has two properties that are important for the empirical analysis. First, tax capacity is a linear function of the tax base $C_i = \vartheta K_i$, and, hence, grants are a function of the tax base as well.[9]

Importantly, this function is continuous. While this is obvious for $G_i > C_i$ or $G_i < C_i$ it also holds at the threshold level of the tax capacity. Formally, this level is defined by a tax base

$$K_i = \Gamma_i, \text{ where } 0 = G_i - \vartheta\Gamma_i.$$

Hence, at the threshold level of the tax base the left and the right limit of the function are identical

$$\lim_{K_i \uparrow \Gamma_i} Z_i = \lim_{K_i \downarrow \Gamma_i} Z_i = 0.$$

Second, however, the first-order derivative of the grant function with respect to the tax base is

[8] In the context of German municipal fiscal equalization, for municipalities that receive fiscal equalization grants, the basic fiscal need G_i is equivalent to the "Hauptansatz", divided by the rate of equalization ("Ausgleichssatz").

[9] In German municipal equalization, the marginal contribution rate ϑ_i is equivalent to the standardized tax rate ("Nivellierungshebesatz") for the business tax divided by the rate of equalization.

discontinuous at the threshold level, and the left and the right limit of the function differ:

$$\begin{aligned}\lim_{K_i \uparrow \Gamma_i} \frac{\partial Z_i}{\partial K_i} &= -\vartheta \\ \lim_{K_i \downarrow \Gamma_i} \frac{\partial Z_i}{\partial K_i} &= 0\end{aligned}$$

As jurisdictions with tax capacity close to the threshold level have about the same amount of net-revenues, the discontinuity is not associated with an income effect. However, the effect of a change in the tax base on net revenues differs strongly to the left and the right of the threshold, i.e. it depends on whether or not tax capacity exceeds fiscal need.

Thus, 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 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

$$\begin{aligned}y_i &= \alpha_L + \beta_L c_i + \epsilon_i, \; \forall i \text{ with } -h \leq c_i < 0 \text{ and} \\ y_i &= \alpha_R + \beta_R c_i + \epsilon_i, \; \forall i \text{ with } 0 \leq c_i \leq +h,\end{aligned}$$

where h denotes the bandwidth around the cutoff point. The resulting estimate of the treatment effect is the difference in the intercept $\alpha_R - \alpha_L$.

Using an RD design enables me to identify the local average treatment effect of being subject to fiscal equalization. The estimate indicates a change in the outcome variable which results when the municipality is subject to strong fiscal redistribution. However, in the application below, it does not directly provide a semi-elasticity. Although the degree of fiscal redistribution is low for the municipalities not receiving equalization grants, it is not zero. At the same time, the degree of redistribution among municipalities included in fiscal equalization is very high but not complete. Actually, the degree of redistribution is roughly halved for the municipalities that are exempt from fiscal equalization.[10]

When specifying the RD estimator, an appropriate choice of bandwidth must be made. The estimate can become more precise if 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 jurisdiction size as a control variable and explore the treatment effect estimates associated with placebo values of the cutoff point. Estimation is carried out using different specification of kernel weights $K\left(\frac{c_i}{h}\right)$ based on the relative tax capacity.

If local governments seek to avoid or perhaps purposefully induce inclusion in fiscal redistribution, the number of observations would be systematically higher on one side of the threshold. In this case, a key identification assumption of the regression discontinuity estimator would be violated (McCrary 2008). To check this, I follow Cattaneo, Jansson, and Ma (2020) and provide tests, whether the density of the assignment is continuous at the threshold.

[10]For a municipality with median tax rate receiving equalization grants the degree of redistribution is about 80%. If the municipality is considered abundant and does not receive equalization grants, the degree of redistribution is about 40%. For details on the Bavarian equalization system see Ministry of Finance of Bavaria (Bayerisches Staatsministerium der Finanzen) 2022.

As outcome variables, I employ 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 a change of the assignment of land into commercial or residential uses is not easily revertible. 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.[11]

The decision on land use is made by the municipal or city council. In contrast to budget planning, these decisions can also be made during the year. With regard to the annual collection of data on land use as well as data for public budgets, however, the empirical analysis employs annual data. Major regulatory changes, such as the development of a new land-use plan for the municipality as a whole, may also have a longer lead time. When using annual data, this can lead to a temporal correlation in the residuals, suggesting to use clustering at the level of the municipality.

The above research approach uses the ability to precisely determine whether a jurisdiction is subject to fiscal equalization grants. However, this assignment into the institutional treatment is based on annual data. This raises the question of how to deal with cases where the assignment varies from year to year. In particular, the tax capacity changes with the evolution of tax revenues. If the year used to determine the fiscal status shows relatively high revenues, a jurisdiction may be temporarily exempt from equalization even if it is included in all other years. Conversely, a jurisdiction might be subject to an adverse revenue shock. As a consequence, it may switch status and receive fiscal equalization grants temporarily, even if is exempt in the other years. In these cases, a forward looking jurisdiction may not change its land use policy. Therefore, in the empirical analysis, I

[11]Referring to the change of land use is also common practice by geographical indicators of "land consumption", e.g., Melchiorri et al. (2019).

use data for several years (2008 to 2013) and focus on municipalities that are either subject to redistribution in all years considered or exempt from equalization in all years. For robustness testing purposes only, I include all municipalities.

4 Data

German municipalities form the lowest tier of governments in the German federation. They have a constitutionally guaranteed fiscal autonomy. This includes an own budget, which is financed by tax revenues from the local business tax, a property tax and shares in federal taxes. Since the municipalities decide about the local rate of the business tax, they are traditionally engaged in local tax competition (e.g., Buettner 2001).[12] Besides fiscal autonomy, municipalities are responsible for building permits and setting up of zoning plans (e.g., Gunlicks 2003). This raises the question of the relationship between fiscal autonomy with mobile tax bases and land use policy (Götze and Hartmann 2021). However, with the exception of three urban states, the German states run systems of fiscal equalization that strongly redistribute revenues among municipalities.

Preconditions for using the sharp regression discontinuity design outlined above are that a sufficient number of municipalities are exempt from fiscal equalization 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 equalization (abundant), and relative tax capacity is precisely reported in the official statistics.

[12]Recently, however, federal policy has implemented measures to reduce tax competition. In the year 2004, a minimum tax rate of 7% was introduced. Since 2008, up to a tax rate of 13,3%, business tax payments can be credited against the income tax liability (Buettner, Scheffler, and Schwerin 2014).

Details about the data sources and the definitions are provided in the Appendix B. 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. This implies that the data directly reflects the regulation of the land use. For example, if the municipality decides that a plot of land, that was previously assigned to agricultural use, is devoted to commercial or residential purposes, this will be reflected in the data accordingly as a commercial or residential land use. This holds regardless of whether the buildings required for a corresponding use have been erected and whether new businesses or households have moved in. Any change of the land use in the data, therefore, reflects a policy decision. This facilitates the empirical analysis of land use policy.

Land use is reported for each individual parcel and aggregated at municipal level.[13] 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.

While the largest fraction of this area (about 42%) is used for transport, the fraction of residential use is second, amounting to roughly a quarter of all settlement area (about 24%). 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. A relatively large fraction (about 22%) is characterized as a residual category (other settlement area). However, a more detailed breakdown is not available at municipal level.[14]

[13] Note 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.

[14] This refers to space used for buildings and open space but not primarily to residential or commercial land. This includes space used for public institutions, including public services, churches, cemetries. This heterogenous category also includes land used for commercial activies such as fairgrounds, exhibition sites.

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.[15] 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 of municipalities 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. Declines of commercial land use are relatively infrequent – less than 20% of observations report a decline. Putting the change of land use in relation to the fraction of land already devoted to commercial land, commercial land use increases on average by 1.8% every year.

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 1 provides a map of the changes in 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. The increase in commercial land use is a bit more intense in the southern part of

[15] The results for this non-settlement land use are qualitatively and quantitatively similar if forest land is included. However, since the proportion of forested areas tends to be particularly high in peripheral regions, where the incentive to increase commercial or residential land may be particular small, the results below focuses explicitly on agricultural land use.

Table 1: Descriptive Statistics

Variable	Unit	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[2)]	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[2)]	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[2)]	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[3)]	euros per cap.	12,088	586.2	253.7	223.4	2994.6
Fiscal need[3)]	euros per cap.	12,088	807.8	85.4	647.7	1758.8
Relative tax capacity[3)]		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) Change refers to the annual change of the fraction of commercial land in % of total land.

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

Bavaria, but stronger increases are also found in other regions. Figure 2 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. Also residential land use shows stronger increases in the southern parts of Bavaria, in particular, close to the agglomeration around the city of Munich.

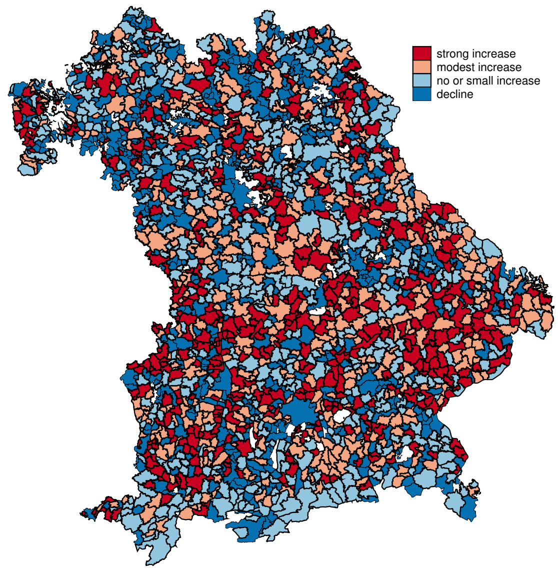
Table 1 also provides descriptive statistics on other characteristics of municipalities. The average population size slightly exceeds 6,000 residents, the largest city (Munich) has about 1.4 million residents. The average equalization grant in the sample is about 167 euros per capita with a maximum of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

The tax capacity per-capita is on average 586 euros. This includes revenues from the local business tax but also the municipal shares of income and value-added taxes as well as the local property tax.[16] As there are single data points with negative or very high revenues, typically reflecting legal disputes over the business 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

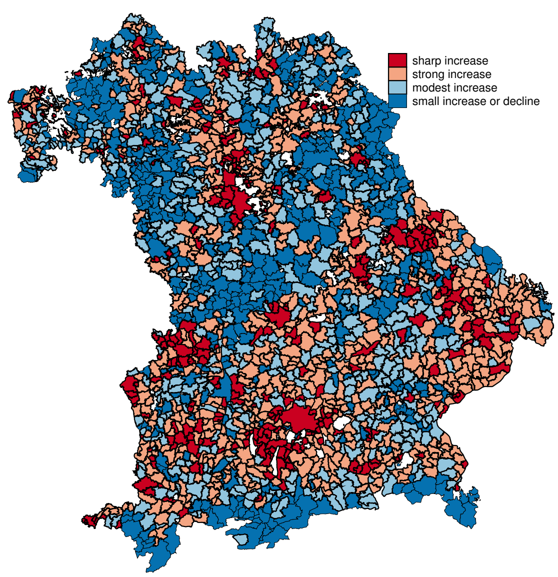
[16]Table C.1 in the Appendix provides figures for the revenue shares of the main taxes. Note that the German property tax is unimportant as a revenue source. This comes from the fact that assessment is held fixed since the 1960s.

Figure 1: Change in Commercial Land Use



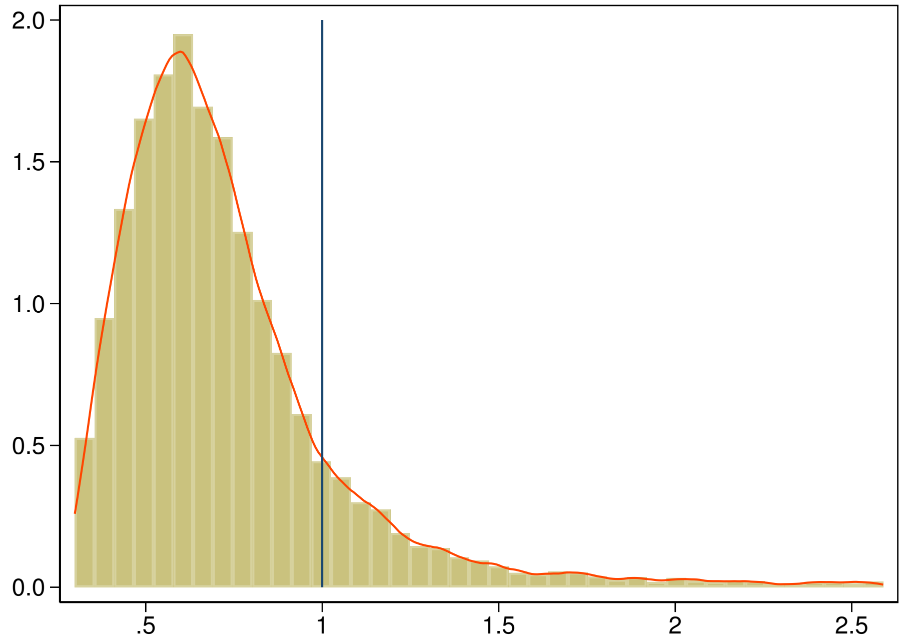
Note: The figure reports the average change in the share of land assigned to commercial use in the years from 2008 to 2013. The interval boundaries are as follows. “No or small increase” refers to an increase up to 0.005% of total area. “Modest increase” is an increase up to 0.015% of total area. “Strong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

Figure 2: 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 3: Relative Tax Capacity



Note: The figure reports the distribution of relative tax capacity for the estimation sample.

fiscal need includes a basic allowance, featured in the theoretical analysis, as well as some additional allowances capturing municipal spending obligations related to welfare aid and local unemployment.

The distribution of relative tax capacity is illustrated graphically by Figure 3 which provides a histogram 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 still placed well 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 4 provides a map displaying the frequency of relative tax capacity at or above unity in the period under consideration.

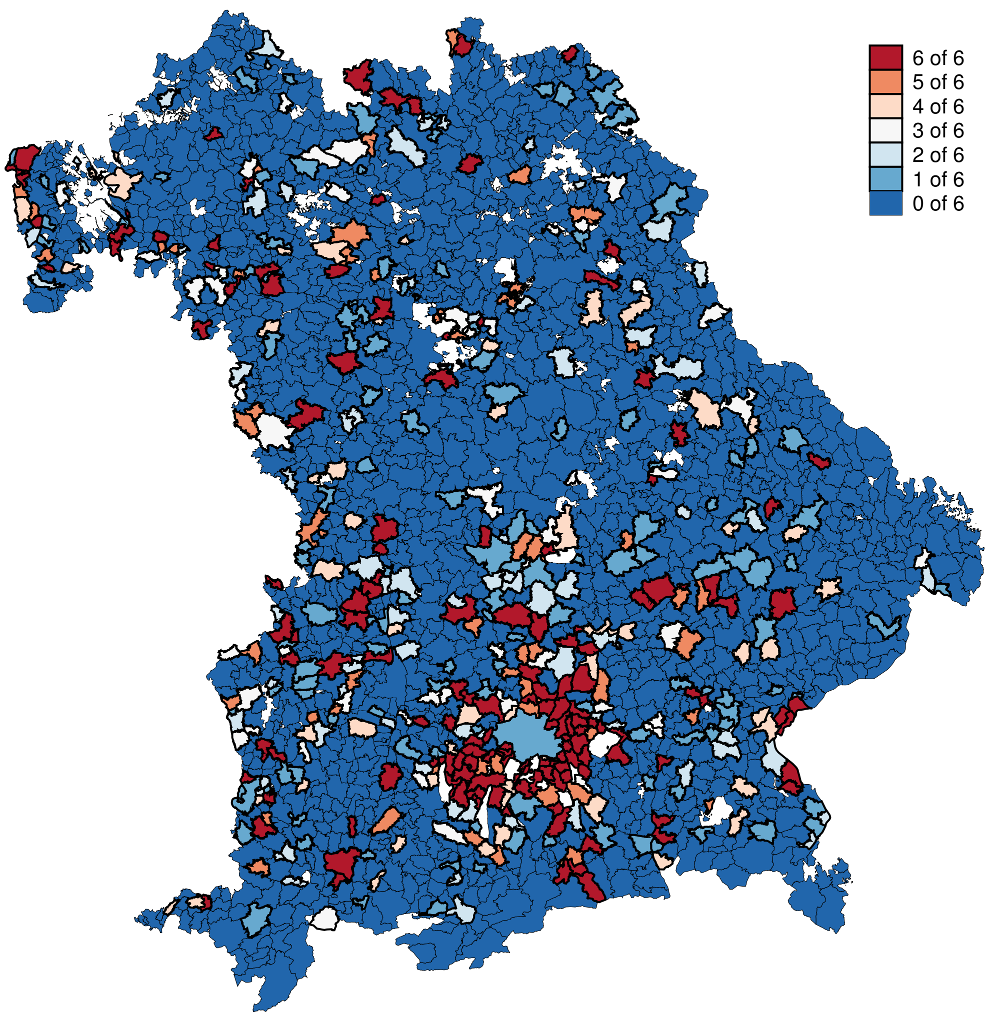
5 Empirical results

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 tax capacity exceeds unity, or the log of the relative tax capacity exceeds zero, jurisdictions do not receive fiscal equalization grants. Hence, to the left of the threshold, jurisdictions are subject to fiscal equalization. Therefore, fiscal incentives to expand commercial and residential land use should be weak. Municipalities to the right of the cutoff point are exempt from fiscal equalization and face a stronger fiscal incentive to expand land use.

The upper plot in Figure 5 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.[17] 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

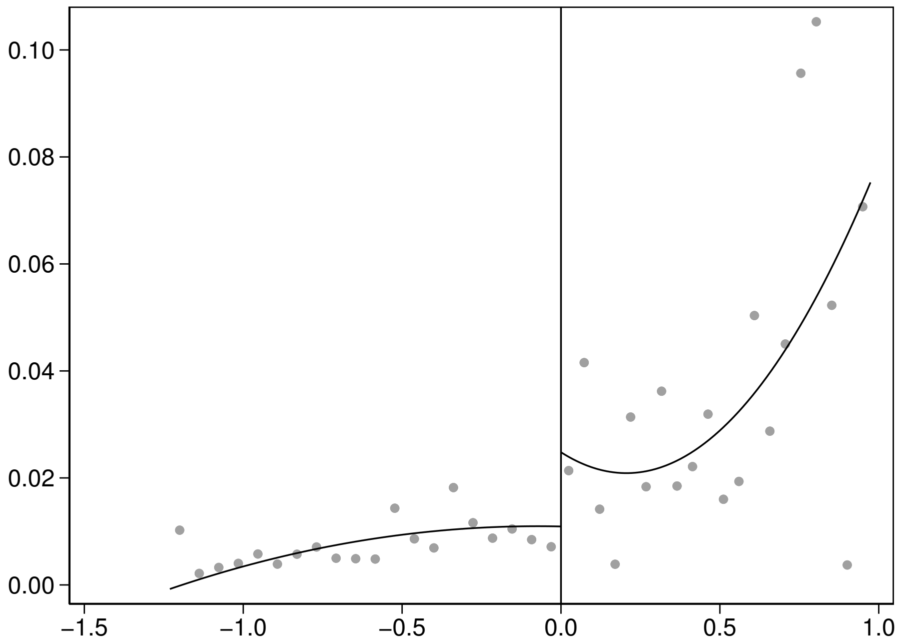
[17]Plots were constructed using the rdplot command of stata's RD package.

Figure 4: No. of Years with Relative Tax Capacity at or above Unity

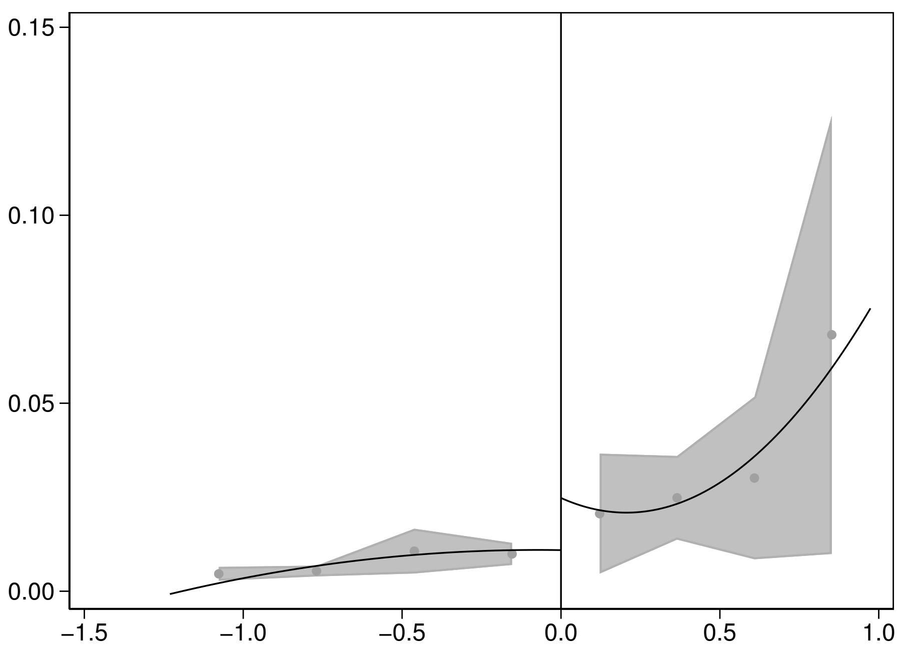


Note: The legend indicates the number of years in the six year period from 2008 to 2013 in which a municipality has relative tax capacity at or above unity.

Figure 5: 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.

confidence intervals are larger to the right of the cutoff point, which reflects the smaller number of observations.

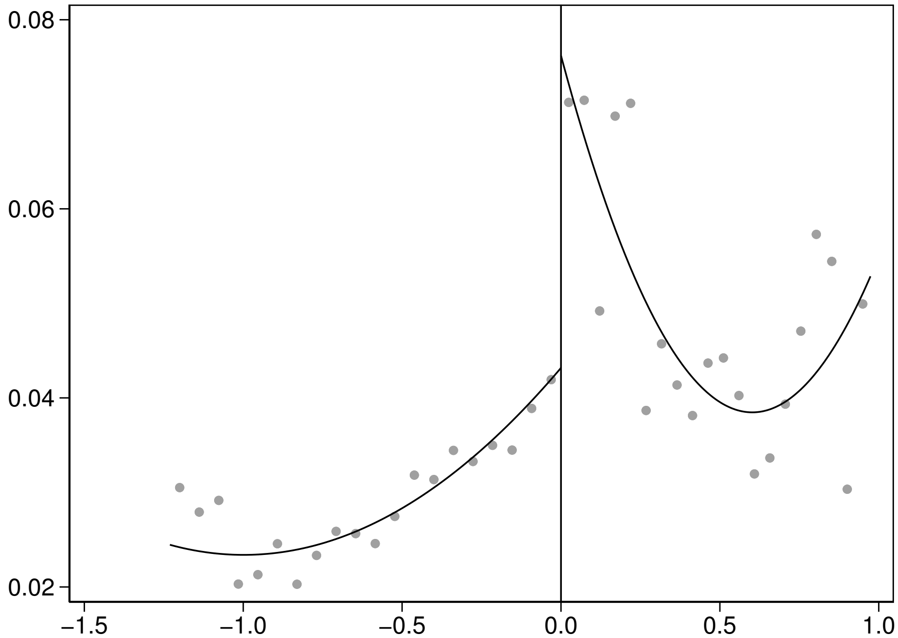
Figure 6 reports regression discontinuity plots for the annual changes in residential land as a fraction of total land. Again, the upper plot is based on 20 bins left and right of the cutoff point. The lower plot reports the means for the number of bins, which minimizes the integrated mean squared error 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 7 turns to agricultural land. As there is no fiscal incentive to increase this type of land use, I do not expect to observe 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.

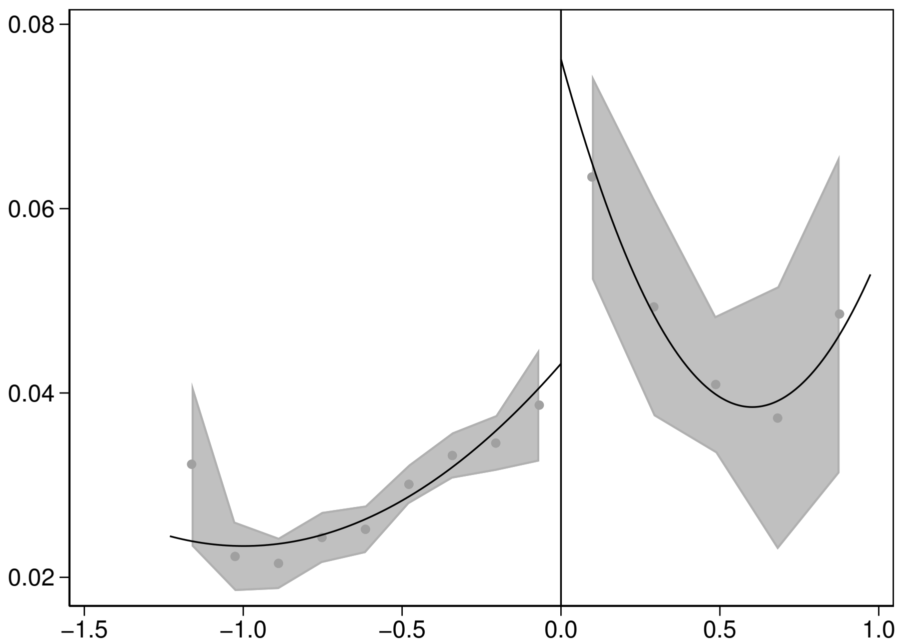
All plots support the view that jurisdictions exempt from fiscal equalization tend to expand the use of land used for commercial and residential purposes more than the others. To obtain estimates of the actual magnitude of these effects, and to provide specification tests, I now turn to the regression analysis.

Table 2 reports point estimates for the treatment effect on the change in the share of land assigned

Figure 6: Change in Residential Land Use, w/ or w/o Fiscal Redistribution

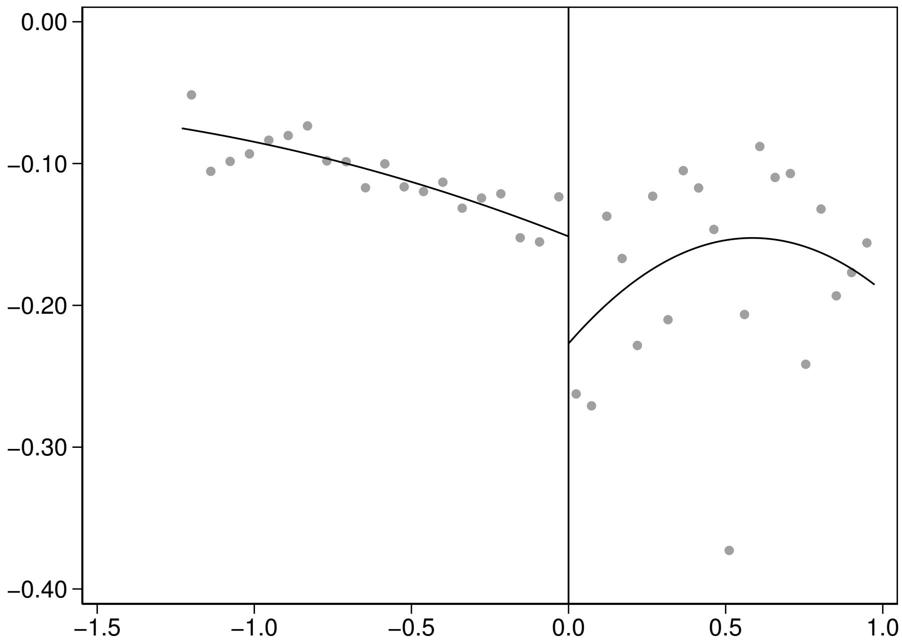


Means of annual changes in residential land as a fraction of total area (in %) plotted against the log of relative tax capacity. 8244 observations. Based on 20 evenly spaced bins left and right of the cutoff point of log relative tax capacity of zero. The solid line is a quadratic polynomial fitted to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

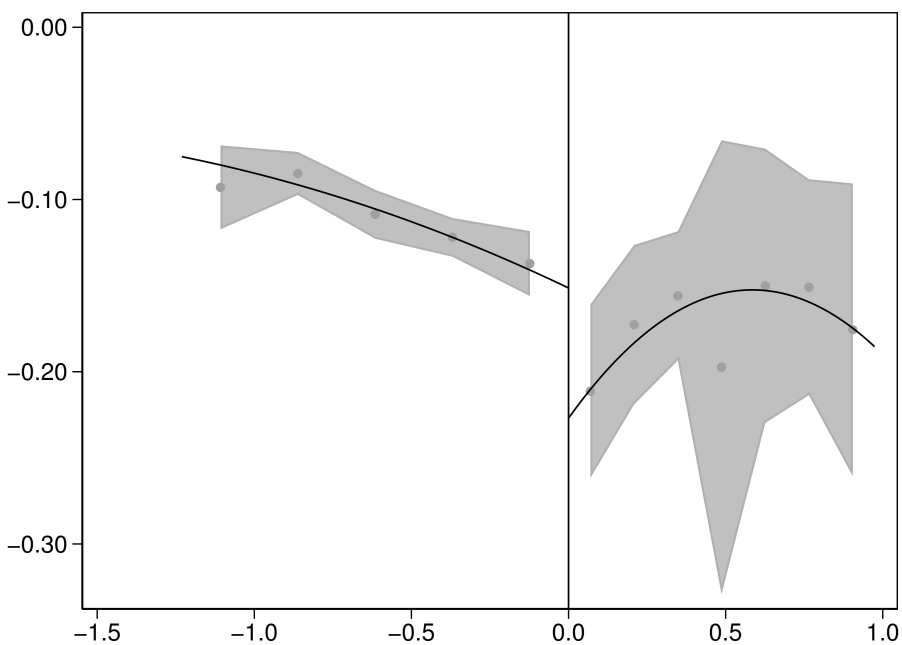


Means of annual changes in residential land as a fraction of total area (in %) plotted against the log of relative tax capacity. 8244 observations. Evenly spaced bins left and right of the cutoff point of log relative tax capacity of zero. The number of bins left and right of the cutoff point is computed 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.

Figure 7: 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
Bandwidth 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
T manipulation test	0.157	1.119	0.325	-0.927	-0.927
$P(T)$	0.876	0.263	0.745	0.354	0.354
	(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
Bandwidth 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
T manipulation test	-0.265	-1.170	-0.754	-0.927	0.270
$P(T)$	0.791	0.242	0.451	0.354	0.787

Dependent variable: change of the share of land available for commercial use. Basic estimation sample includes 8,394 municipality-year cells; specification (10) includes 10,151 cells. All specifications use the log of relative tax capacity with cutoff point zero as assignment variable. The coefficient reports the local treatment effect. 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). For specifications where the p-value is below 5% the coefficient is marked with a star. The test statistics for the manipulation test is obtain from the local polynomial density estimation method by Cattaneo, Jansson, and Ma (2020).

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. If local governments seek to avoid or perhaps purposefully induce inclusion in fiscal redistribution, many observations would systematically be found on one side of the threshold. For each specification, therefore, the table reports a test statistic for the continuity of the density of the assignment variable at the threshold.

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. 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 observations are "abundant", i.e. have tax capacity exceeding fiscal need and are thus exempt from fiscal redistribution. However, the manipulation test statistic proves insignificant indicating that the continuity of the density of the assignment cannot be rejected. 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, due to the higher data demands the results obtained with higher-order polynomials should be interpreted with caution; Gelman and Imbens (2019) suggest relying in general on local linear or quadratic polynomials. 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 abundancy over time. As discussed above, 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 expected to be 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 the formal tests whether the density of the assignment is continuous at the threshold.

As a robustness check, I explore the estimation of treatment effects using placebo values of the cutoff point. 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.[18]

The above results suggest that if municipalities are exempt from fiscal redistribution, they intensify land use. This confirms the theoretical view that the expansion of commercial land use by municipalities is advantageous in a setting with fiscal competition because it attracts mobile capital. Now, the expansion of commercial land use is only one means of improving locational attractiveness. Another means, emphasized in the fiscal competition literature, would be to reduce the tax rate on mobile capital. Indeed, also the municipalities under consideration here have discretion in adjusting the local business tax rate. The existing empirical literature for German municipalities has confirmed a negative impact of the exposure to fiscal competition on the local tax rate (e.g., Buettner 2006, Egger, Koethenbuerger, and Smart 2010). It might therefore be interesting to see

[18] Results are provided in columns (1) and (2) of Table C.2 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
Bandwidth 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
Bandwidth 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; specification (10) includes 10,151 cells. All specifications use the log of relative tax capacity with cutoff point zero as assignment variable. The coefficient reports the local treatment effect. 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). For specifications where the p-value is below 5% the coefficient is marked with a star.

if the data used here confirms this finding. However, due to a tax reform that was implemented in 2008, right at the beginning of the period under study, this is not clear. This reform introduced a substantial income tax credit for local business tax payments. For the vast majority of municipalities, this created an opportunity to raise the tax rate without increasing the tax burden on businesses which are subject to the income tax (Buettner, Scheffler, and Schwerin 2014).[19] At any rate, estimates reported in the appendix show that the preferred RD specification indeed supports a smaller adjustment in tax rates of those municipalities that are exempt from redistribution.[20]

Table 3 turns to the treatment effect of fiscal competition on residential land use. As above, the table shows point-estimates using the regression-discontinuity method 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 slower expansion of residential land use under fiscal equalization. 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 almost doubles if municipalities are exempted from fiscal equalization. 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

[19] The tax credit applies to business taxes paid up to a tax rate of 13.3% (equivalent to a collection rate (Hebesatz) of 380%). This corresponds to the 95 percentile of the tax rate distribution in 2008, implying that this regulation applies to almost all Bavarian municipalities.

[20] If an optimal bandwidth is chosen using the method of Calonico, Cattaneo, and Farrell (2020), with linear polynomials and a triangular kernel the treatment effect points at a decline in the business tax rate by about 0.5 log points, see Table C.3 in the appendix.

effect is local to the discontinuity. If an optimal bandwidth is chosen using the method of Calonico, Cattaneo, and Farrell (2020), the treatment effect 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, 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.[21]

Table 4 shows treatment effects on agricultural land use. The table uses the same specifications, as in the above analyse. 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 is exempted from fiscal equalization. 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

[21]Results are provided in columns (3) and (4) of Table C.2 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
Bandwidth 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
Bandwidth 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; specification (10) includes 10,151 cells. All specifications use the log of relative tax capacity with cutoff point zero as assignment variable. The coefficient reports the local treatment effect. 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). For specifications where the p-value is below 5% the coefficient is marked with a star.

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.[22]

6 Conclusions

The theoretical analysis in this paper considers the land-use policy of a local government, relying on revenues from a tax on mobile capital. 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 expansion of land use as well as by a fiscal incentive. The latter stems from the taxation of mobile capital. In particular, an expansion of commercial land use attracts mobile capital, tax revenue increases and the supply of public services is expanded. The link between land use and tax revenues fuels concerns about an inefficient expansion of land use by jurisdictions competing for mobile capital. Under fiscal redistribution, however, the incentive for land expansion is reduced. An extension shows that there is also a fiscal incentive to expand residential land use in order to attract mobile residents.

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 policy among municipalities in Germany. In order to identify differences in the environment faced by the municipalities, I exploit institutional characteristics of the fiscal equalization system. In particular, I make use of the discontinuity in

[22] Results are provided in columns (5) and (6) of Table C.2 in the Appendix.

the system of fiscal equalization which involves strong fiscal redistribution among the majority of municipalities, but at the same time, exempts municipalities with higher levels of tax capacity from 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 uses a dataset covering the evolution of official land use between 2008 and 2013 in the 2,056 municipalities of Bavaria, a large German state. The results confirm a significant effect of fiscal equalization on the land assigned for commercial and residential use. More specifically, I find that land assigned to commercial use increases 2-3 times faster in municipalities exempted from fiscal equalization than in municipalities that are receiving equalization grants. As for residential land, the results show that municipalities exempt from fiscal equalization also expand this form of land use about 2 times faster than other municipalities. At the same time, land allocated to agriculture is found to decrease faster in municipalities exempt from fiscal equalization. These results suggest that municipal fiscal equalization severely curtails the fiscal incentives to expanding land use in Germany.

By relying on official land use data, the analysis reveals the effects of fiscal redistribution on municipal land policy. The effect on actual land use may be different, however, because, once land is formally assigned to a given use, private sector action is usually required to enable the actual land use. Whether such action actually occurs in a timely manner or whether the policy decision to expand commercial or residential land is ineffective cannot be examined in the context of this analysis and is left to further research.

Since the empirical results on the effects of fiscal redistribution 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 settings, where the property tax is the main source of local tax revenue, the fiscal incentive to expand commercial land might be smaller, and perhaps a stronger incentive emerges with regard to residential land. If local sales taxes are important, the fiscal incentive to increase land for shopping opportunities may be strong in particular. At any rate, the analysis in this paper supports the view that the "fiscalization" of land use is a relevant concern.

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 has focused on a fiscal incentive, our analysis is silent on whether this incentive is empirically relevant. If this is the case, socially inefficient policies would result even in the absence of fiscal competition.

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 inefficient land use (Burchfield et al. 2006). In fact, it is tempting to relate the finding of a strong sensitivity of land use policy to local fiscal 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.

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Appendix

Taxation, Fiscal Redistribution and Local Land Use

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July 2022

Contents

A Extensions of the theoretical analysis

A.1 External effects of the local land use

Externalities of local policy choices are a familiar result in the tax competition literature (Keen and Konrad 2013). In our case, the externalities are negative, i.e. increasing commercial land lowers the utility of immobile workers in other jurisdictions. More specifically, expanding commercial land exerts a fiscal externality on the budget of other jurisdictions as well as a labor market externality on other jurisdictions. Formally, the utility of a worker residing in jurisdiction j is

$$\Omega_j = w_j + u\left(X_j\right) + v\left(A - L_j\right). \tag{A.1}$$

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

$$\frac{\partial \Omega_j}{\partial L_i} = F_{jNK}\frac{\partial K_j}{\partial L_i} + u'\left(X_j\right)\tau\frac{\partial K_j}{\partial L_i}.$$

Since the equilibrium rate of return on capital rises, input of capital declines $\frac{\partial K_j}{\partial L_i} = \frac{1}{F_{jKK}}\frac{\partial \rho}{\partial L_i} < 0$, and the decline of the capital input is associated with a decline in the wage rate $\frac{\partial w_j}{\partial L_i} = F_{jNK}\frac{\partial K_j}{\partial L_i} < 0$. Hence $\frac{\partial \Omega_j}{\partial L_i}$ is unambiguously negative, indicating that the local decision in i to expand commercial land creates negative externalities on jurisdiction j as labor income and tax revenues decline.

A.2 A model with mobile residents

To discuss whether land-use policy has an incentive to attract mobile residents under fiscal competition I augment the above theoretical analysis. More specifically, I assume that local production uses two types of labor. One type is provided by local immobile population the other type is provided by mobile residents R_i. Hence, there are two dimensions of location choice: not only capital but also mobile residents determine in which jurisdiction they locate.

A.2.1 Spatial equilibrium

With mobile residents the production is $F(K_i, L_i, N_i, R_i)$ and profit maximization of the land owner requires not only the first-order conditions (2) and (3) to hold, but also that the condition for optimal employment of mobile residents is met

$$\frac{\partial F_i}{\partial R_i} = y_i, \tag{A.2}$$

where y_i denotes the wage rate of mobile residents. To model the location choice of mobile residents, I assume that their utility is similar to that of immobile workers, except that it includes the benefit from land P_i assigned by the government to mobile residents:

$$\omega_i = y_i + u(X_i) + v(A - L_i - P_i) + h\left(\frac{P_i}{R_i}\right) \tag{A.3}$$

Since land assigned to mobile residents is used privately, the benefit is assumed to be an increasing function of the ratio of residential land P_i to the number of mobile residents. Assigning land to mobile residents, however, reduces the amount of open land which serves as an amenity.

Due to their mobility, spatial equilibrium requires the utility of mobile residents to be equal across jurisdictions:

$$\omega_i = \omega \tag{A.4}$$

With R being the total number of mobile residents in the economy, there is another resource constraint:

$$\sum_{j=1}^{M} R_j = R \tag{A.5}$$

As above, equations (2), (3), (5), (6) are 3M+1 equations that help to determine the wage rate of immobile labor w_i, the gross rate of return to capital r_i, the input of capital K_i and the equilibrium rate of return on capital ρ at given values of the exogenous variables L_j, τ and P_j. In the augmented model, in order to characterize the equilibrium allocation, I also need to determine $y_i, \omega_i, \omega, R_i$, as well as public expenditures X_i. These 4M+1 variables can be determined with the help of the budget constraint (8) and the additional equations (A.2), (A.3), (A.4) and (A.5).

A.2.2 Effects of increasing residential land

Holding constant the choices of other governments, the local government's decision regarding the size of land given to mobile residents P_i exerts effects on the number of mobile residents R_i, on capital demand as well as on factor prices and tax revenues. To derive these effects, it is useful to consider first the effects of a change of mobile residents on the rate of return to capital and on capital input.

Proposition 1:

In a symmetric setting, with equal supply of immobile workers N and total area A in all jurisdictions, a marginal increase of mobile residents in jurisdiction i does not affect the equilibrium rate of return to capital and leads to an increase of the capital input

$$\frac{dK_i}{dR_i} > 0.$$

For a proof see Subsection A.2.4.

In the next step, I consider the effect of an increase of residential land P_i on the number of mobile residents in jurisdiction i.

Proposition 2:

In a symmetric setting, with equal supply of immobile workers N and total area A in all jurisdictions, if the marginal benefit from privately used residential land is sufficiently strong, a marginal increase of land available for mobile residents is associated with an increase of mobile residents

$$\frac{dR_i}{dP_i} > 0.$$

For a proof see Subsection A.2.5.

A.2.3 Optimal policy with respect to residential land

Equipped with an understanding of the effects of increased residential land P_i on the number of mobile residents and on capital input, I explore the optimal land use policy of the government. As above, public policy is assumed to aim at maximizing the utility of immobile workers. It is defined as:

$$\Omega_i = w_i + u\left(X_i\right) + v\left(A - L_i - P_i\right) \tag{A.6}$$

Note that the land given to mobile residents reduces the land which serves as an amenity.

The first-order condition for optimal land use policy, $\frac{\partial \Omega_i}{\partial P_i} = 0$, implies:

$$v'\left(A - L_i - P_i\right) = F_{iNR}\frac{\partial R_i}{\partial P_i} + F_{iNK}\frac{\partial K_i}{\partial P_i} + u'\left(X_i\right)\tau\frac{\partial K_i}{\partial P_i} \tag{A.7}$$

The left-hand side reflects the marginal benefit of using land as an amenity. The right-hand side captures the opportunity cost determined by the marginal benefits from assigning more land to mobile residents. As in the case of commercial land use, there are three components. Two components reflect effects on the wages of immobile workers. The third components reflects an increase of public good provision.

Though mobile residents add to the local work force, under strict complementarity, $F_{iNR} > 0$, wages of immobile workers increase. Even if mobile and immobile workers are substitutes and the local wage rate of immobile workers declines, the government may still consider to attract mobile residents, if the other components of the opportunity cost of using land as an amenity are large enough.

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. Hence, expanding residential land use exerts negative labor market and fiscal externalities on other jurisdictions.

While the analysis has abstracted from fiscal equalization grants, it is possible to extend the analysis and introduce this additional source of revenue as in section **??**. Under revenue neutrality, it is straightforward to show that the fiscal incentive for attracting mobile residents is reduced under fiscal equalization.

A.2.4 Proof of proposition 1

A total differential of equation (2), holding commercial land constant, gives

$$dK_i = \frac{1}{F_{iKK}} d\rho - \frac{F_{iKR}}{F_{iKK}} dR_i.$$

Noting that the total supply of capital is fixed

$$\sum_j dK_j = \sum_j \frac{1}{F_{jKK}} d\rho - \sum_j \frac{F_{jRK}}{F_{jKK}} dR_j = 0.$$

In a symmetric equilibrium, $\frac{F_{iRK}}{F_{iKK}} = \frac{F_{jRK}}{F_{jKK}}$, and the expression can be rearranged:

$$d\rho \sum_j \frac{1}{F_{jKK}} - \frac{F_{iRK}}{F_{iKK}} \sum_j dR_j = 0$$

Since the total supply of mobile residents is fixed, $\sum_j dR_j = 0$, and the rate of return to capital is unchanged, $d\rho = 0$. As a consequence, the effect of mobile residents on the capital input simplifies to

$$\frac{\partial K_i}{\partial R_i} = -\frac{F_{iKR}}{F_{iKK}} > 0, \tag{A.8}$$

which is positive.

A.2.5 Proof of proposition 2

After inserting for the wage rate from equations (A.3) and (A.4) and for the budget from equation (8), a total differential of equation (A.3) yields

$$\begin{aligned} d\omega &= F_{iRK}dK_i + F_{iRR}dR_i + u'(X_i)\tau dK_i \\ &+ \left[h'\left(\frac{P_i}{R_i}\right)\frac{1}{R_i} - v'(A - L_i - P_i)\right]dP_i - h'\left(\frac{P_i}{R_i}\right)\frac{P_i}{R_i^2}dR_i. \end{aligned} \tag{A.9}$$

Inserting from equation (A.8) and rearranging terms, I obtain:

$$dR_i = -\alpha_i d\omega + \alpha_i\left[h'\left(\frac{P_i}{R_i}\right)\frac{1}{R_i} - v'(A - L_i - P_i)\right]dP_i, \tag{A.10}$$

where

$$\alpha_i = \left[\left(\frac{F_{iKR}^2 - F_{iRR}F_{iKK}}{F_{iKK}}\right) + \left(h'\left(\frac{P_i}{R_i}\right)\frac{P_i}{R_i^2} + u'(X_i)\tau\frac{F_{iRK}}{F_{iKK}}\right)\right]^{-1}.$$

Note that the expression for α_i contains two bracketed terms. The first is positive due to the properties of the production function. The second is positive if an inflow of mobile residents lowers the locational attractiveness for mobile residents, which is required for a interior equilibrium. Hence, $a_i > 0$.

Summing across jurisdictions and noting that

$$\sum_j dR_j = 0,$$

I can determine the effect on the equilibrium utility of mobile residents

$$\frac{\partial\omega}{\partial P_i} = \frac{\alpha_i}{\sum_j \alpha_j}\left[h'\left(\frac{P_i}{R_i}\right)\frac{1}{R_i} - v'(A - L_i - P_i)\right]dP_i.$$

If the marginal benefit from privately used residential land is sufficiently strong, an increase in mobile residents increases the equilibrium level of utility of these residents $\frac{\partial\omega}{\partial R_i} > 0$.

Replacing the change in the equilibrium level of utility in eq. (A.10) gives:

$$\frac{dR_i}{\partial P_i} = \alpha_i \left(1 - \frac{\alpha_i}{\sum_j \alpha_j}\right) \left[h'\left(\frac{P_i}{R_i}\right)\frac{1}{R_i} - v'\left(A - L_i - P_i\right)\right],$$

which is positive if the marginal benefit from privately used residential land is sufficiently strong.

■

B 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.

Tax rate: Data for the tax rate of the local business tax ("Hebesatz der Gewerbesteuer") are obtained from Bavarian Office for Statistics and Data Processing (www.statistik.bayern.de). The data refers to the actual year.

C Additional tables

Table C.1: Municipal Tax Revenues

Year	2008	2009	2010	2011	2012	2013
Total tax revenues (in Bill. euros)	13,2	11,9	12,2	13,5	14,1	15,1
Share by tax source						
Business tax	0,434	0,390	0,412	0,449	0,437	0,444
Property tax	0,111	0,125	0,127	0,116	0,114	0,108
Income tax (revenue share)	0,406	0,429	0,406	0,382	0,396	0,399
VAT (revenue share)	0,039	0,045	0,045	0,043	0,043	0,041
Other	0,010	0,011	0,011	0,010	0,010	0,009

Sources: Tax revenues and revenue shares of individual taxes of Bavarian municipalities by year. Own computations based on statistics provided in the Statistical Yearbook for 2011, 2012, and 2014 published by the Bavarian Office for Statistics and Data Processing. Business tax refers to tax revenues from the local business tax net of direct revenue sharing with state and federal governments. Property tax refers to the tax on housing and commercial property (Grundsteuer B).

Table C.2: 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 tax 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).

Table C.3: RD Estimates for the Business Tax Rate

	(1)	(2)	(3)	(4)	(5)
Coefficient	-0.0027	-0.0068	-0.0038	-0.0049*	-0.0047
Standard error	(0.0047)	(0.0038)	(0.0043)	(0.0022)	(0.0025)
z	0.574	0.517	0.435	-2.004	-1.693
$P(z)$	0.566	0.605	0.664	0.045	0.090
Covariate (log area)	no	no	no	no	no
Temporary assignment	no	no	no	no	no
Bandwidth method	manual	manual	manual	opt.	opt.
Bandwidth	0.250	0.250	0.250	0.635	0.764
Polynomial	1	1	1	1	1
Kernel	trian.	rectan.	parabl.	triang.	triang.
Cluster	munic.	munic.	munic.	munic.	county
N.Obs left	1,351	1,351	1,351	6,179	7,417
N.Obs right	312	312	312	641	699
T manipulation test	-0.090	0.910	0.089	-1.111	-1.111
$P(T)$	0.928	0.363	0.930	0.267	0.267

	(6)	(7)	(8)	(9)	(10)
Coefficient	-0.0049	-0.0024	-0.0017	-0.0050*	0.0002
Standard error	(0.0043)	(0.0062)	(0.0068)	(0.0020)	(0.0018)
z	-0.764	-0.165	-0.134	-2.165	0.329
$P(z)$	0.445	0.869	0.893	0.030	0.742
Covariate (log area)	no	no	no	yes	no
Temporary assignment	no	no	no	no	yes
Bandwidth method	opt.	opt.	opt.	opt.	opt.
Bandwidth	0.582	0.662	0.907	0.683	0.381
Polynomial	2	3	4	1	1
Kernel	triang.	triang.	triang.	triang.	triang.
Cluster	munic.	munic.	munic.	munic.	munic.
N.Obs left	5,560	6,465	8,376	6,692	3,968
N.Obs right	615	653	755	661	1217
T manipulation test	-1.354	-0.864	-0.530	-1.111	-0.520
$P(T)$	0.176	0.387	0.596	0.267	0.603

Dependent variable: annual change of the log business tax rate. Basic estimation sample includes 10,206 municipality-year cells; specification (10) includes 12,333 cells. All specifications use the log of relative tax capacity with cutoff point zero as assignment variable. The coefficient reports the local treatment effect. 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). For specifications where the p-value is below 5% the coefficient is marked with a star. The test statistics for the manipulation test is obtain from the local polynomial density estimation method by Cattaneo, Jansson, and Ma (2020).