Expectations about Future Tax Rates and Firm Entry*

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Abstract

Firms should use all available information to anticipate future tax rates. Firm mobility is one source of such information. We first show theoretically that governments increase tax rates on profits if average firm mobility decreases, and that the potential entry of immobile firms in the future deters firms from entering today. Building on prior evidence that German municipalities increase tax rates after the entry of immobile firms (wind power plants), we confirm that firms use this information to anticipate future tax rates. In the jurisdictions with the largest expected future tax rate increases, 10% fewer firms enter.

Keywords: corporate taxation, firm mobility, commitment

JEL Classification: H25, H71, D84

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1 Introduction

Corporate tax rates are an important determinant of firms' entry and (re-)location decisions: If the corporate tax rate is one percent higher, the number of new firms decreases by about 1–3% (Becker et al., 2012; Brülhart et al., 2012; Suárez Serrato/Zidar, 2016; Riedel et al., 2020).

This literature has focussed on the effects of *current* tax rates. However, as relocating in response to tax rate changes is costly, both *current and future* tax rates should matter. Consider, for example, a firm that decided in 2000 to invest in either the U.S. or Canada and is indifferent between the two locations regarding non-tax factors. In that year, the U.S. and Canada had a corporate tax rate (including average state tax rates) of around 40%. Over the next ten years, Canada lowered its tax rate by more than 10%-points, while the U.S. tax rate remained constant. If our hypothetical firm foresaw these changes, it would have preferred to invest in Canada.

In this paper, we first provide a stylized model of how firms can use changes in average firm mobility to foresee tax rate changes. We then empirically show that firms anticipate future tax rates in their location decisions. Our model focuses on a local government whose only policy instrument is the corporate tax rate.[1] The corporate sector in this jurisdiction consists of mobile firms (who can relocate to a low-tax jurisdiction) and immobile firms (who cannot relocate). We show that the local government sets a higher tax rate after an immobile firm entered and that mobile firms anticipate this behavior in their entry decisions.

Thus, our model implies that fewer mobile firms enter when the expected tax base share of immobile firms is high because they use this information to form expectations about future tax rates. To test this prediction empirically, we build on the results of Langenmayr/Simmler (2021), where we show that municipalities in Germany increase their local business tax rates (a profit tax) after the entry of one type of immobile firm: wind turbines. This paper provides evidence that (non-wind turbine) firms indeed anticipate these tax increases.

The setting in Germany provides ample variation for our study. First, Germany has about 11,000 municipalities, each imposing a local business tax rate that constitutes about half of the tax burden on corporate profits. Second, the tax base share of wind turbines varies substantially: across municipalities (due to differences in wind strength)

[1] This assumption reflects the institutional setting in most countries, including our empirical testing ground Germany. In the model, we ignore public good provision directed to firms, another economic policy tool available to governments, as recent evidence suggests little impact of local government spending on firm entry (Riedel et al., 2020). In the empirical analysis, we control for local authority expenditures.

and over time (due to changes in federal subsidies). Following the introduction of these subsidies, the number of wind turbines increased from roughly 5,000 in 2000 to over 23,000 in 2012. Their tax base share increased from 0.5% in 2000 to 5% in 2012. In Langenmayr/Simmler (2021) we show that municipalities experiencing an increase in the tax base share of immobile firms from 0 to 100% increased their local business tax rate by on average 3%-points (or around 20%). Furthermore, as wind turbine investors reached out to local officials and landowners to find potential locations, the (local) public often expected wind turbines to enter soon.

We estimate a Poisson model of (non-wind-turbine) firm entry at the municipal level. As a proxy for future tax rates, we use the expected tax base share of immobile firms, which we predict for each jurisdiction based on (time-series variation in) subsidies for wind turbines in combination with (cross-sectional variation in) the potential number of wind turbines. We estimate the potential number of turbines based on the actual turbines in 2011, wind strength, and the tax base of mobile firms. Our results suggest that an increase in the expected tax base share of immobile firms deters (non-wind turbine) firms from entering a particular jurisdiction. Quantitatively, the effect is substantial: Jurisdictions with the largest expected future tax rate increase had around 10% fewer firms entering. Wind turbines require almost no labor input while running, so this effect is not caused by higher local wages.

Our paper relates to three lines of literature. First, we contribute to the literature studying the effect of taxation on firms' location decisions. Higher profit tax rates or less generous depreciation rules deter firms from locating in a particular jurisdiction (Buettner, 2003; de Mooij/Ederveen, 2008; Feld/Heckemeyer, 2011; Rohlin et al., 2014). Some forces, such as agglomeration benefits, affect how sensitively firms react to tax rates (Baldwin/Krugman, 2004; Borck/Pflüger, 2006; Brülhart et al., 2012). We contribute to this literature by showing that firms also consider future tax rates in their location decisions.

Second, we add to the literature that studies the role of expectations for firm investment. Overall investor sentiment (Arif/Lee, 2014) and the expectations of analysts (Cummins et al., 2006) or Chief Financial Officers (Gennaioli et al., 2016) have high predictive power for firm investment. Greenwood/Hanson (2015) highlight the importance of expectations for investment in the shipping industry. In contrast to these studies, which rely on surveys, analyst forecasts, or current profits to measure expectations, we explicitly model expectations about future circumstances.

Last, our paper relates to the literature that points out a time-consistency problem in capital taxation. Kydland/Prescott (1980) show that the anticipation of future high tax rates imposes an excess burden today. Ex-post optimal taxation implies an excessively high tax rate in the first period. Kehoe (1989) adds tax competition to the analysis and shows that its tendency to lower tax rates may thus be beneficial. Janeba (2000) shows that firms can over-invest in capacity to induce tax competition between two countries, alleviating the time-inconsistency problem. We contribute to this literature by showing that a sufficiently large share of highly mobile firms in a jurisdiction also alleviates the commitment problem. Further, our empirical work confirms that the costs of the commitment problem can be substantial and highlights that they should be taken into account when designing optimal taxes or subsidies for location-sensitive industries such as renewable energies.[2]

2 Model

To clarify the expected effects, we extend the model in Langenmayr/Simmler (2021) to include firm entry. We consider a local government (e.g., a municipality) that chooses a tax rate on profits, τ. There are two types of firms: Mobile firms, which can relocate to a low-tax country (with tax rate τ_{low}) at a cost; and immobile firms, which cannot relocate. Local governments must tax both mobile and immobile firms at the same rate. This assumption captures the empirical reality, especially for small- and medium-sized firms.

Mobile firms realize a fixed profit of π^M. A mass of potential entrants (normalized to one) can enter the municipality. Firms only decide whether to enter or not ("latent start-up model").[3] They can relocate to the low-tax country at a later stage. To enter, each firm has to pay a firm-specific fixed cost, $f_i \pi^M$, which it draws from a uniform distribution in $[0, 1]$ before deciding about entry. If a firm relocates, it has to pay the same fixed cost $f_i \pi^M$ to build a new plant there.

Immobile firms use a different technology, which makes them unable to relocate. This may be the case because they are using resources that exist only in the specific jurisdiction (e.g., mining companies), or because the cost of relocation is prohibitively high (e.g., wind turbines). We denote an immobile firm's profit by π^I. Immobile firms have a set-up cost of c_j, with c_j uniformly distributed in $[0, 1]$. They, too, learn about this cost before deciding to enter. We assume that only one immobile firm is active in each

[2]Further papers studying the dynamic effects of capital taxes assume that existing capital and new capital can be taxed at different rates. Doyle/Van Wijnbergen (1994) show that tax holidays may result from sequential bargaining between a multinational firm and a host country government. Bond/Samuelson (1986) point out that host countries may offer tax holidays to signal their productivity to multinational firms.

[3]In other words, potential entrepreneurs are immobile, in line with the empirical evidence: most entrepreneurs start firms in their home district (Figueiredo et al., 2002).

jurisdiction. This normalization enables us to focus on the share of mobile vs. immobile firms, abstracting from the size of the jurisdiction.

Stages of the game. The model proceeds in three stages. First, firms decide whether to enter. Second, the local government chooses its profit tax rate.[4] In the third stage, mobile firms can relocate to the (exogenous) low-tax country. Firms then produce and pay taxes. We solve the model backward.

Stage 3: Relocation decision of mobile firms. Mobile firms relocate if their profit when relocating to the low-tax country, $(1-\tau_{low})\pi^M - f_i\pi^M$, is higher than the after-tax profit in the local jurisdiction, $(1-\tau^j)\pi^M$.[5] $\tau^j \in \left\{\tau^I; \tau^0\right\}$ denotes the tax rate that the government chooses in the second stage (τ^I with and τ^0 without an immobile firm). Comparing profits when relocating and not relocating shows that mobile firms with

$$f_i < \tau^j - \tau_{low} \tag{1}$$

relocate in response to the tax differential.

Stage 2: Tax rate choice. We assume that the jurisdiction maximizes tax revenue, T:

$$T = \begin{cases} \tau^0 \left[\mu\pi^M - \left(\tau^0 - \tau_{low}\right)\pi^M\right], & \text{if no immobile firm entered,} \\ \tau^I \left[\pi^I + \mu\pi^M - \left(\tau^I - \tau_{low}\right)\pi^M\right], & \text{if an immobile firm entered,} \end{cases} \tag{2}$$

where μ is the mass of mobile firms that entered in stage 1, and the last term in the brackets describes the mass of mobile firms that relocates in stage 3 according to eq. (1), using that f_i is uniformly distributed in $[0,1]$.

The revenue-maximizing tax rates are

$$\begin{aligned} \tau^0 &= \frac{\mu + \tau_{low}}{2} \\ \tau^I &= \frac{\pi^I + \pi^M\left(\mu + \tau_{low}\right)}{2\pi^M} = \frac{\eta}{2} + \tau^0. \end{aligned} \tag{3}$$

[4] Thus, the government can set the tax rate knowing the mobility of its tax base, similarly to Haupt/Krieger (2020).

[5] As common in the literature on firms' location choices and their response to taxation, we assume that the incidence of the profit tax is (at least partially) born by the firm (Haufler/Wooton, 2010; Haufler/Mittermaier, 2011). This assumption is consistent with the prior empirical literature. Although firms can pass on some of the burden of taxation to employees (Fuest et al., 2018), taxes matter for firms' location choices and investment decisions (de Mooij/Ederveen, 2008; Feld/Heckemeyer, 2011; Zwick/Mahon, 2017). In Langenmayr/Simmler (2021), we discuss the role of tax incidence in more detail.

τ^I depends on the potential tax base share of immobile firms, $\eta = \frac{\pi^I}{\pi^M}$.[6] The tax rate rises in the tax base: τ^0 increases with μ, i.e. the number of active firms; τ^I rises in both μ and the potential tax base share of immobile firms, η. Thus, we observe the classical trade-off when increasing the tax rate: A higher tax rate raises additional revenue from active firms but also implies more firms relocating. If an immobile firm is present, a smaller share of the tax base can relocate. The government thus always chooses a higher tax rate if an immobile firm is active. The higher the tax base share of the immobile firm, the higher the revenue-maximizing tax rate.

Lemma 1 (Tax Rates Choice) *A local jurisdiction sets a higher tax rate if an immobile firm is active.*

Proof. Follows directly from eq. (3). ■

Stage 1: Firm entry. The immobile firm anticipates that if it enters, the jurisdiction will set the higher tax rate τ^I. Hence, the immobile firm enters if $\pi^I(1 - \tau^I) \geq c_i \pi^I$.

Mobile firms do not know whether an immobile firm will enter the jurisdiction. They thus base their entry decision on an expected tax rate, $E(\tau) = p\tau^I + (1-p)\tau^0$. Given that c_i is uniformly distributed, the probability p that an immobile firm enters is

$$p = 1 - \tau^I = 1 - \frac{\mu + \eta + \tau_{low}}{2}. \tag{4}$$

Mobile firms compare their expected after-tax profit with the fixed cost of entry, f_i. The mass of firms entering is $\mu = 1 - E(\tau)$.[7] Using eq. (3), we find that

$$\mu = 1 - \tau_0 - p\frac{\eta}{2}. \tag{5}$$

Thus, mobile firm entry depends on the expected tax base of immobile firms, $p\eta$. Mobile firms anticipate that with a certain probability p an immobile firm will enter (and then has a tax base share of η), inducing the government to increase the tax rate to τ^I. Thus, fewer mobile firms enter if the expected tax base of immobile firms is high.

Since p is a function of the tax base share of immobile firms, η, we re-write eq. (5) using eq. (3) and (4),[8]

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[6] As the mass of potential mobile firms is 1, π^M corresponds to total profits of mobile firms.

[7] We assume that η is sufficiently small that not all mobile firms relocate after immobile firm entry. After solving for the equilibrium, we can show that this implies $4\eta - \eta^2 < 2(1 - \tau_{low})$.

[8] To link the model to the empirical test, we do not fully solve for the equilibrium here. Appendix 1 shows the equilibrium values of all variables.

$$\mu = 1 - \tau_0 \left(1 - \frac{\eta}{2}\right) - \frac{\eta}{2} \left(1 - \frac{\eta}{2}\right). \tag{6}$$

This highlights two aspects. First, a high initial tax rate affects the number of mobile firms less if the potential tax base share of immobile firms is high, as it is then less likely that an immobile firm enters. Second, the tax base share of immobile firms has a non-linear impact on the number of mobile firms for the same reason: If the tax base share of immobile firms is higher, the tax rate increases more when an immobile firm enters, which in turn decreases the likelihood of immobile firm entry.

We now test this relationship empirically.

3 Empirical Strategy and Data

3.1 Empirical Strategy

In Langenmayr/Simmler (2021), we showed that municipalities in Germany increased their local business tax rates after the entry of immobile firms (wind turbines).[9] After wind turbines entered, municipalities increased their local business tax rate by on average 3%-points (or around 20%). We now build on this result and analyze whether other (non-wind turbine) firms take the potential entry of wind turbines, and thus the potential increase in future tax rates, into account when making their location choice.

The setting in Germany provides ample variation for this empirical analysis. First, each of the over 11,000 municipalities in Germany ($\sim 9,600$ in the eleven federal states we study) decides annually about its local business tax rate (see also Link et al., 2022). In our sample, about 10% of municipalities change their tax rate each year. The mean tax rate was 14%.[10]

In addition, the expansion of wind energy in Germany was salient. First, already in 2000, roughly 5,000 (onshore) wind turbines existed; their number had more than quadrupled by 2011. Second, since wind turbine investors reached out to local officials and the owners of agricultural land to find suitable locations (and to strengthen their bargaining position by having several options), the public knew about potential investors and expected the entry of wind turbines. Lastly, company owners in Germany undoubtedly know about the link between tax base mobility and tax rates. The local

[9]Carlsen et al. (2005); Devereux et al. (2008) and Slemrod (2004) also show a negative relationship between (capital) mobility and tax rates.

[10]Municipalities set a "tax multiplier", which has to be multiplied by 5% (before 2008) to calculate the tax rate.

business tax poses a substantial tax burden and rates differ substantially among jurisdictions (usually between 9% and 15%). Thus, the potential shift in the tax base due to the entry of wind turbines and the resulting impact on jurisdictions' tax rate choices could reasonably be foreseen by potential entrepreneurs.

We analyze firm entry in all municipalities with a positive tax base of mobile firms in 1998. We observe 82,769 municipality-years between 1998 and 2006. Following Brülhart et al. (2012), we estimate a Poisson model at the municipality level. Guimarães et al. (2003) and Becker/Henderson (2000) show that the Poisson model is appropriate to estimate the determinants of the location decision based on the footloose start-up as well as of the latent start-up model.[11] Our estimation equation, which follows from eq. (6), is

$$N_{i,t} = exp\left(\alpha_1 \tau_{i,t} + \alpha_2 \left\{ E\left(\frac{T^E_{I,i,t}}{T_{0,i,t}}\right) \cdot \left(1 - E\left(\frac{T^P_{I,i,t}}{T_{0,i,t}}\right)\right)\right\} + \beta' X_{i,t} + \delta_i + \rho_t + \epsilon_{i,t}\right). \tag{7}$$

The dependent variable $N_{i,t}$ in our main specification is the number of new firms in municipality i in year t.[12] Our two main explanatory variables are the current tax rate $\tau_{i,t}$—which corresponds to τ^0 in the model—and the corrected expected tax base share of immobile firms $E\left(\frac{T^E_{I,i,t}}{T_{0,i,t}}\right) \cdot \left(1 - E\left(\frac{T^E_{I,i,t}}{T_{0,i,t}}\right)\right)$—which corresponds to $\frac{\eta}{2}\left(1 - \frac{\eta}{2}\right)$ from eq. (6) of the model.

The corrected expected tax base share of immobile firms takes the impact on the expected tax base share of immobile firms ($\frac{T^E_{I,i,t}}{T_{0,i,t}}$) on the entry decision of immobile firms into account. We calculate the expected tax base share by multiplying the potential tax base share of immobile firms by its realization probability.[13] We describe its calculation in detail in Section 3.2, but to summarize, it depends on local wind conditions, the area available for building wind turbines, the size of the tax base of non-wind-turbine firms, and the average share of jurisdictions in the particular state that has wind turbines (in

[11] In footloose start-up models, a company decides where to locate among several jurisdictions. In latent start-up models, the company faces only the choice between starting a business in a particular jurisdiction or not starting. The model presented in Section 2 is a latent start-up model.

[12] In principle, estimation at the municipality-industry level would be preferable as it allows to control for industry-wide shocks. However, this would result in a large share of zero firm entries (overdispersion). We thus prefer the municipality level as it ensures a more reasonable distribution of firm entries. Furthermore, it allows us to interpret the estimated coefficients as average semi-elasticities.

[13] In the model, η is the expected tax base share of immobile firms. Since wind turbines' entry probability is 1/2 (due to uniform fixed costs between 0 and 1), $\frac{\eta}{2}$ is the expected tax base share.

2011).[14]

To ensure that our estimates do not suffer from omitted variable bias and to increase the efficiency of our estimates, we include several municipality characteristics and fixed effects. In all specifications, we include municipality fixed effects (δ_i) and control for the variables used to calculate the (corrected) expected tax base share, namely the tax base in 1998, agricultural land, and wind strength 10m above ground. We always include these baseline control variables directly and squared, and interacted with year dummies.

In some specifications, we control for additional municipality characteristics (public good provision measured by municipality spending and market potential measured by population) and regional characteristics (average tax rates and public good provision in neighboring jurisdictions, measured by inverse distance–weighted average tax rate and spending in municipalities within a 20km radius).[15] In addition, we control for common unobserved shocks by including state-year or county-year fixed effects.

3.2 Data

The data on firm entry stems from the *Gewerbeanzeigenstatistik*, the registry of firms. It covers all firm entries and exits (including new establishments) in a particular municipality per year, discloses whether firms relocated or are newly founded, and includes industry information. The data covers the years 1998–2006 for almost all German states (all except Saarland, Baden Württemberg, and the city-states Berlin, Hamburg, and Bremen). The coverage only starts in 1998 for Lower Saxony, 1999 for Schleswig-Holstein, and 2001 for Hesse. We focus on the years up to 2006 as the first years after the introduction of wind turbine subsidies in 2000 provide the cleanest set-up for our analysis. In addition, major corporate tax reform was announced in 2007 and implemented in 2008.

In our main tests, we will consider only "real" firm births. That is, we do not include relocating firms, as the impact of municipality characteristics on new and already existing firms' location decisions may differ. We also exclude self-employment.

To calculate the (corrected) expected tax base share of immobile firms, we proceed in four steps.

[14] We use this proxy approach and do not include the (observed) future tax rate as the explanatory variable (an IV strategy) as we believe that the proxy approach requires less challenging assumptions, in particular regarding the link between the expected and the realized tax rate.

[15] Controlling for public good provision absorbs the 'positive side' of higher tax rates, namely higher tax revenues and thus potentially more spending, which could increase firm entry.

1. Determine the expected profitability of turbine for each municipality/year.
2. Estimate the potential number of wind turbines in each municipality.
3. Divide this potential tax base of wind turbines by the overall tax base.
4. Multiply the potential tax base share of turbines with a realization probability.

In the first step, we simulate the tax base of wind turbines using data on wind turbines from the operator database, a private database collected by consultants in the renewable energy industry and the Schleswig-Holstein Chamber of Agriculture. We use the location, technology, and construction date for all wind turbines in Germany and simulate wind turbines' profitability by using information on the average wind strength in a municipality and the feed-in tariff that applied in the respective year (see Haan/Simmler, 2018, for details of this calculation). We then take the average profit over the life cycle of a turbine with the median technology.

In the second step, we predict the number of wind turbines to be built in a jurisdiction. As we cannot observe expectations, we use the sample of jurisdictions with turbines in 2011 and regress (ln) number of turbines (in 2011) on the economic and legal factors determining wind turbines' location choice. These factors are wind strength (10m above ground), agricultural land, tax base in 1998, tax rate in 1998) and state dummies to account for differences in building regulations. We then use the estimated coefficients for wind strength, agricultural land, and state dummies to predict the number of turbines. This aims to remove the impact of the expected tax base share on the expected number of turbines. We then multiply the simulated wind turbine profits (from the first step) with the predicted number of turbines in a particular jurisdiction to calculate the potential wind turbine tax base.

In the third step, we scale this potential wind turbine tax base by the tax base of mobile firms in 1998 plus the simulated potential turbine tax base.

Lastly, to derive the expected tax base share of immobile firms, we multiply the potential tax base share by the fraction of municipalities within a state that have at least one turbine in 2011. We see this as a proxy for the fixed entry costs in the model ($\bar{c}$). The underlying idea is that planning regulation—set by the federal states—largely determines how many wind turbines will be built. In a robustness check, we use the share of municipalities with turbines in 2011 for wind strength quintiles as a proxy for the realization probability. The variation in the expected tax base share thus stems from time-series variation in the feed-in tariff and the technological development of wind turbines and from cross-sectional variation in jurisdictions' wind strength, number of potential turbines, and 1998 tax base of mobile firms.

As discussed in Section 3.1, we use several municipality characteristics as control variables. Table A1 in the appendix lists the data sources and describe these variables in detail.

Descriptively, the average local business tax rate in our sample is 14%. On average, a municipality has 6,470 inhabitants and about 14 new firms per year. The realized tax base share of wind turbines is around 2%, their potential tax base share is 42%, and the expected tax base share based on state variation in realization is 7%. The sample of municipalities without turbines in 2011 has similar local business tax rates, inhabitants and potential and expected tax base shares. The number of new firms (9 per municipality) is lower, however. Table A2 in the appendix provides the full descriptive statistics.

4 Results

4.1 Graphical Evidence

First, we illustrate the sources of variation in the corrected expected tax base share of immobile firms. Fig. 1a plots the evolution of the average expected tax base share of immobile firms for the 5th, 50th, and 95th percentiles of the tax base of mobile firms in 1998. We observe the strongest reaction to the introduction of subsidies for the 5th and 50th percentile of the tax base of mobile firms. This is not surprising: In municipalities with many mobile firms, the tax base share of immobile firms will always remain small.

The profitability of wind turbines is the second main determinant of the expected tax base share of immobile firms. Fig. 1b confirms that the evolution of the corrected expected tax base share has some variation for all levels of the mobile firm tax base, although the variation at the lower end of the distribution is largest.

Second, we inspect some descriptive evidence of how the corrected expected tax base share relates to the entry of new (mobile) firms. As we cannot control for the realized tax base share (which triggers an increase in tax rates), we include only jurisdictions without wind turbines in 2011.

Fig. 1c shows the evolution of entering firms relative to 1997, split into jurisdictions with an above-median change in the corrected expected tax base share ("treatment group") and below the median ("control group").[16] Although mapping changes in the corrected expected tax base share into a binary indicator discards some information,

[16] We use data from 1997 as it allows a better inspection of the common trend, although we do not observe the number of new firms for 1997 for Schleswig-Holstein, Lower Saxony, and Hesse.

Figure 1: Graphical Evidence

Figure 1a: Evolution for Different Percentiles of Mobile Firms' Tax Base

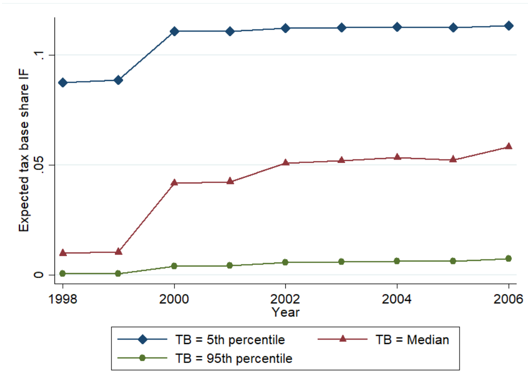


Figure 1b: Distribution of Changes across Mobile Firms' Tax Base

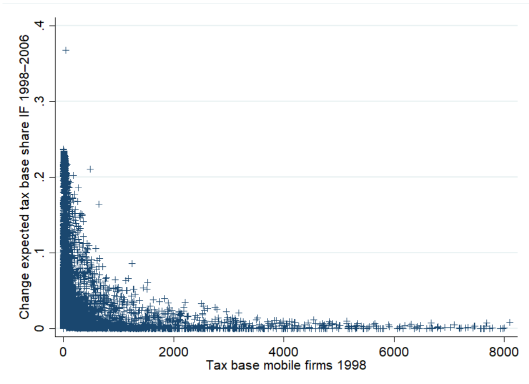
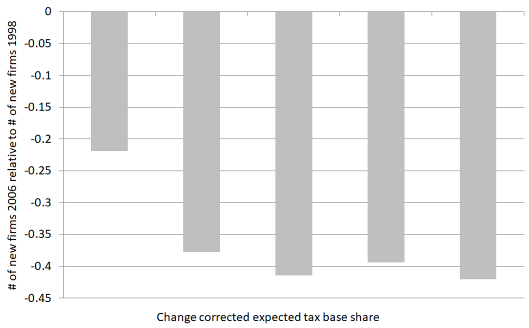


Figure 1c: Firm Entry for Above/Below Median Tax Base Share

Figure 1d: Firm Entry for Δ Tax Base Share Quintiles



Notes: Fig. 1a shows the evolution of the expected tax base share of immobile firms for the 5th, the 50th and the 95th percentile of the 1998 tax base of mobile firms. Fig. 1b shows the change in the expected tax base share of immobile firms between 1998 and 2008 for different levels of the 1998 tax base of mobile firms. Fig. 1c shows the evolution of firm entry (relative to new firms in 1997) for treatment and control group based on above/below median change in the corrected expected tax base share of immobile firms between 1997 and 2006. Fig. 1d shows relative changes in the number of new firms between 1998 and 2006 for quintiles of the change in the corrected expected tax base share of immobile firms between 1998 and 2006.
Source: Authors' calculation based on Statistik Lokal, 1997–2011, and data from the operator database, 1990–2011, and the German Weather Service.

it allows us to inspect whether treatment and control groups followed a common trend before the subsidies for wind energy. As expected, fewer firms enter jurisdictions with a larger change in immobile firms' corrected expected tax base share.

In Fig. 1d, we exploit more variation in the corrected expected tax base share by studying quintiles of its changes between 1998 and 2006. Again, we see that larger changes in the corrected expected tax base share are associated with larger reductions in the number of firms entering the jurisdiction.

4.2 Regression Evidence

Before reporting our main regression results, we show that the expected tax base share of immobile firms (as well as the realized tax base share of immobile firms, which we used in Langenmayr/Simmler, 2021) is a reasonable predictor of (expected) future tax rates. Table 1 shows the results using 1998 and 2006 only, i.e., a long difference. In col. (1) we regress the tax rate on the expected tax base share of immobile firms, using state variation for the realization probability, and in col. (3) on the expected tax rate using wind strength variation. In both specifications, we find a positive and statistically significant point estimate, suggesting that a higher expected tax base share of immobile firms is associated with higher future tax rates. In col. (2) and (4) we instrument the realized tax base share of immobile firms. Our excluded instrument is the expected tax base share using realization probabilities based on states (col. 2) or wind strength (col. 4). To assess the validity of the instrument(s), we use in both specifications also the binary triple DiD estimator as in Langenmayr/Simmler (2021) and report the results of the Sargan-Hansen test of overidentifying restrictions.

We obtain similar results in both specifications as in Langenmayr/Simmler (2021). In particular, we find that the local business tax rate increases by 3 %-points if the realized tax base share of immobile firms increases from 0 to 1. In addition, in both specifications, the instruments are sufficiently strong and the exogeneity of one instrument cannot be rejected conditional on the exogeneity of the other instrument.[17] Thus, our expected tax base share of immobile firms captures the variation we want to capture.

In Table 2 Panel A, we present our main results based on eq. (7). Col. (1) shows that the expected tax base share has a negative and significant impact on the number of new firms. To assess whether the expected tax base share also affects the entry of immobile firms and thus has a non-linear impact, we also include the expected tax base share

[17] The instrument using realization probabilities based on states is stronger than the one based on wind strength. This could reflect the relative importance of building regulations (which differ by state) and wind strength for wind turbines' location choice; or that our wind strength measure (which is on the municipality level) comes with some measurement error.

Table 1: Expected and Realized Tax Base Share of Immobile Firms and Tax Rates

Dependent variable	Local business tax rate			
	OLS	IV	OLS	IV
Realization Prob.:	States		Wind strength	
	(1)	(2)	(3)	(4)
Exp. Tax Base Share IF	0.010***		0.009*	
	(0.004)		(0.005)	
Real. Tax Base Share IF		0.034***		0.033*
		(0.012)		(0.017)
Municipality FE	x	x	x	x
State-year FE	x	x	x	x
IV Variables	x	x	x	x
Tax base quintile–year FE	x	x	x	x
Observations	16,360	16,360	16,360	16,360
First Stage Point Estimate		0.287***		0.260***
		(0.053)		(0.075)
Hansen p-value		0.725		0.738
F-Statistics		20		9

Notes: Table shows reduced form estimates for the expected tax base share of immobile firms on the local business tax rate and IV estimates where the realized tax base share of immobile firms is instrumented using the expected tax base share of immobile firms. The realization probability for the expected tax base share in cols. (1) and (2) is based on the share of municipalities with turbines in 2011 on the state level and in cols. (3) and (4) on the wind strength quintile level. Robust standard errors, clustered at the county level, in parentheses. ***, **, * indicate significance at the 1%, 5%, 10% levels. *Source:* Authors' calculations based on Statistik Lokal, 1998–2006, data from the operator database, 1990–2006, and the German Weather Service.

squaredly in col. (2). The point estimates for the linear and the squared terms are almost identical, but less precisely estimated. Since the marginal effect in a Poisson model depends on all variables included, we also estimate the same specification using a log-linear model (see col. (1) and (2) of Panel B of Table 2) and obtain similar results. These results support the use of the corrected expected tax base share of immobile firms.[18]

In col. (3) of Panel A, we include the additional control variables, which increases the point estimate somewhat. In col. (4), we use a control function approach for the tax rate to assess whether endogeneity in the tax rate (and/or measurement error) is the reason the expected tax base share of immobile firms is significant. The instrument exploits (similarly to Riedel et al., 2020) variation in state-specific fiscal equalization schemes. The point estimate for the tax rate decreases substantially and suggests an elasticity of the number of new firms regarding the local business tax of around -3 in line with prior literature (e.g., Riedel et al. (2020) or Becker et al. (2012) for Germany or Suárez Serrato/Zidar (2016) for the US). The point estimate for the expected tax base share of immobile firms is unchanged.[19] To further hedge against concerns that the entry of wind turbines drives the expected tax base share, we restrict the sample to jurisdictions without turbines in 2011 in cols. (5) and (6). Restricting the sample also addresses the concern that we count some wind turbines as new firms. Both worries are unjustified as the point estimate for the expected tax base share in col. (5) is almost unchanged. When we include county-year fixed effects (col. 6), precision decreases but the point estimate is again unchanged. In the log-linear model (see col. (3) of Panel B), neither point estimate nor precision changes when we control for county-year fixed effects.

Sensitivity. We assess the sensitivity of our results in five robustness checks.[20] First, we use firms that relocated from another jurisdiction as the dependent variable. The results (col. (4) of Panel B) are similar to our baseline results.

Second, we change the definition of the expected tax base share of immobile firms. In col. (5)–(6) we use the potential tax base share of immobile firms. In col. (5) we also

[18]We also assess whether the expected tax base share has a negative impact on the location decision of wind turbines (see Table A3) and find some support for that. However, when we account for the endogeneity of local business taxes using an instrumental variable strategy, the point estimate for the tax rate is negative but insignificant. Given this, we do not interact the expected tax base share of immobile firms with the local business tax as suggested by eq. (6).

[19]The elasticity of -3 follows from the point estimate for the local business tax rate shown in col. (4), and the average tax rate of 14% in our sample (0.14%*21.4 = 3.0).

[20]We use the sample excluding jurisdictions with turbines in 2011. Results are similar in the full sample.

Table 2: Estimation of Firms' Location Choice

Panel A: Main Results

Dependent variable	Number of new firms					
Sample	All jurisdictions				Jurisdictions w/o turbines 2011	
				CF		
	(1)	(2)	(3)	(4)	(5)	(6)
LBT	-2.030**	-2.032**	-0.823	-21.391*	-0.540	-1.359
	(1.012)	(1.012)	(1.033)	(12.459)	(1.075)	(1.069)
Exp. TBS * (1-Exp. TBS)	-0.665**		-0.759**	-0.768**	-0.873**	-0.702
	(0.315)		(0.298)	(0.299)	(0.379)	(0.431)
Real. TBS IF	-0.068	-0.070	-0.076	-0.069		
	(0.075)	(0.076)	(0.075)	(0.075)		
Exp. TBS		-0.710				
		(0.437)				
Exp. TBS, squared		0.882				
		(1.120)				
Municipality FE + Baseline controls	x	x	x	x	x	x
State-year FE	x	x	x	x	x	
County-year FE						x
Additional controls		x	x	x	x	x
Observations	84,214	84,214	84,214	84,214	69,807	69,807

Panel B: Sensitivity Analysis

Model	OLS			Poisson			
Dependent variable	IHS(# of new firms)			Relocated firms	# of new firms		
Realization probability	States						Wind
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LBT	-1.066	-1.068	-0.497	-1.324	-1.135	-0.551	-0.541
	(0.746)	(0.747)	(0.752)	(2.198)	(1.251)	(1.066)	(1.074)
Exp. TBS	-1.288***						
	(0.381)						
Exp. TBS, squared	1.949**						
	(0.927)						
Exp. TBS * (1-Exp. TBS)		-1.086***	-1.320***	-0.776			-0.884**
		(0.269)	(0.358)	(0.982)			(0.381)
Pot. TBS					-0.264**		
					(0.109)		
Pot. TBS, squared					0.142		
					(0.089)		
Pot. TBS * (1-Pot. TBS)						-0.184**	
						(0.089)	
Municipality FE + Controls	x	x	x	x	x	x	x
State-year FE	x	x		x	x	x	x
County-year FE			x				
Observations	84,214	84,214	69,807	69,807	69,807	69,807	69,807

Notes: Panel A shows results of the Poisson model (eq. 7) for the corrected (except col. (2)) expected tax base share of immobile firms on the number of total firm entries per municipality and year. The sample in col. (1) to (4) includes jurisdictions with positive tax base of mobile firms in 1998, in col. (5) and (6) only those without turbines in 2011. In col. (2) we split the corrected expected tax base share into the linear and the squared expected tax base share of immobile firms. From col. (3) onward we include add. control variables. In col. (4) we use a control function approach to counter the potential endogeneity of the local business tax rate. The excluded instrument is the interaction of the positive difference between tax rate and reference multiplier in 1998 interacted with the reference multiplier. In col. (6) we include county-year fixed effects. Panel B shows sensitivity analyses based on OLS (cols. (1)–(3)) and Poisson estimations (col. (4)–(7)). The sample in col. (1) and (2) includes jurisdictions with positive tax base of mobile firms in 1998, and in col. (3)–(7) only those without turbines in 2011. Main explanatory variables are the (linear and squared) expected tax base share (col. (1)), the corrected expected tax base share (cols.(2)–(4), (7)), the (linear and squared) potential tax base share (col. (5)) or the corrected potential tax base share of immobile firms (col. (6)). The realization probabilities for the expected tax base share of immobile firms are based on the share of municipalities with turbines in 2011 on the state level, except in col. (7) where they are based on the wind strength quintiles. Robust standard errors, clustered at the county level, in parentheses. ***, **, * indicate significance at the 1%, 5%, 10% levels.
Source: Authors' calculations based on Statistik Lokal, 1998–2006, data from the operator database, 1990–2006, and the German Weather Service.

include the squared potential tax base share, finding that using the corrected potential tax base share is again supported. In col. (6) we use the corrected potential tax base share of immobile firms, obtaining a negative and significant point estimate. The size of the point estimate is reasonable; on average around 25% of the jurisdictions in 2011 had turbines. Lastly, col. (7) uses the realization probability for wind strength quintiles based on the share of municipalities with turbines in 2011. Again, the results are similar to the baseline results.

Third, we account for a potential non-monotonic relationship by re-running the regression with dummies for each quintile of immobile firms' corrected expected tax base share. Fig. 2a shows the results, using an otherwise identical specification as in cols. (3) and (5) of Table 2, Panel A. The results are similar to the more restrictive specification for both samples.

Fourth, we assess the timing of the impact. More precisely, we calculate the change in immobile firms' corrected expected tax base share between 1998 and 2006 and interact it with year dummies. As many turbines were erected in the early 2000, we focus on the sample that excludes jurisdictions with turbines in 2011. Figure 2b suggests that before introducing the subsidies for renewable energy, the change in the expected tax base share of immobile firms had no predictive power for the location decision of mobile firms.

Since we have only two years of pre-reform data for most jurisdictions, we use an alternative dependent variable in the last robustness test: (ln) number of employees, based on data by the Federal Employment Agency available from 1996 for West Germany. We use a log-linear specification and control for state-year or county-year fixed effects and the baseline control variables. The results (Figure 2c) are qualitatively similar.

Effect Size How large is the estimated effect? In absolute terms, Figure 2a suggests that in the most affected jurisdictions (top quintile), the number of new firms decreased by around 10%. This is a substantial effect, particularly as it is based purely on expectations and independent of wind turbines actually entering at some point.

In Langenmayr/Simmler (2021) and in this paper (see col. (3)–(4) in Table 1), we estimate that municipalities in which the tax base share of immobile firms changed from 0 to 0.3 increased the tax rate by about 1%-point ($0.3 \cdot 0.033$). Based on the control function specification (col. (4) of Table 2, Panel A), a tax rate change of this size implies about 21% fewer entering firms ($-21.39 \cdot 0.01$). This is consistent with the impact of the corrected expected tax base share on firm entry, which we estimate at -0.77 (also col. 4). If the expected tax base share of immobile firms increases from 0 to

Figure 2: Sensitivity Tests

Figure 2a: Estimated Coefficients for Quintiles Dummies Expected Tax Base Share of Immobile Firms

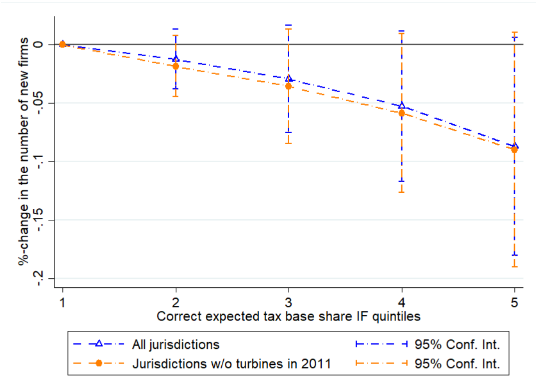


Figure 2b: Yearly Estimated Coefficients for Change Expected Tax Base Share IF 1998–2006

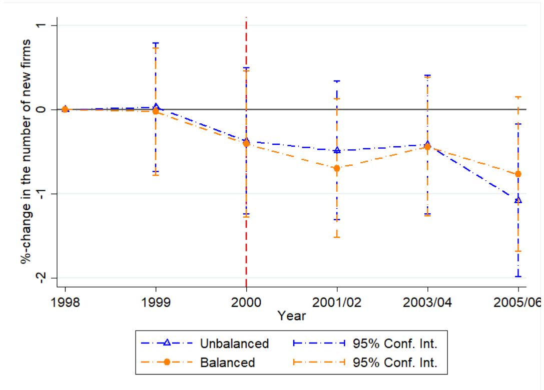
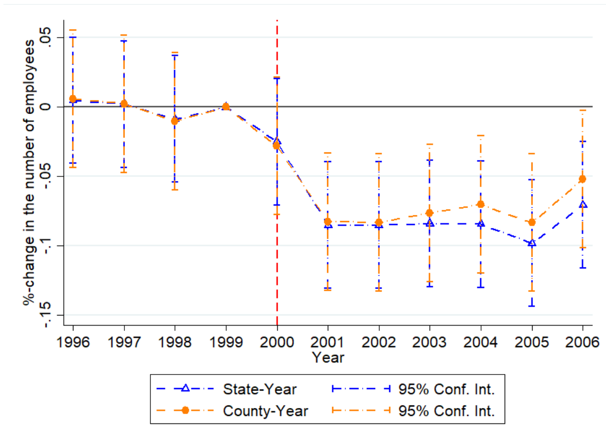


Figure 2c: Yearly Estimated Coefficients for Change Corrected Expected Tax Base Share IF 1996–2006: Employment



Notes: Notes: Fig. 2a shows estimated coefficients for the corrected expected tax base share quintile dummies based on an otherwise identical specification as in col. (3) (blue) and col. (5) (orange) of Table 2, Panel A. Fig. 2b shows estimated coefficients for the change in expected tax base share deciles between 1998 and 2005 interacted with year dummies based on an otherwise identical specification as in col. (5) of Table 2, Panel A. The sample includes only jurisdictions with no turbines in 2011. Fig. 2c shows estimated coefficients for the change in corrected expected tax base share between 1998 and 2006 interacted with year dummies using (ln) number of employees as dependent variable and OLS estimations for 1996–2006. The sample includes only jurisdictions with no turbines in 2011, that are located in West Germany and observed for all years. There are 7,125 of these jurisdictions and the total number of jurisdiction-year observations is therefore 78,375. All graphs include 95% confidence intervals.

Source: Authors' calculation based on Statistik Lokal, 1997–2011, and data from the operator database, 1990–2011, and the German Weather Service.

0.3, the corrected expected tax base share increases from 0 to 0.21 (around 16% fewer new firms, $-0.77 \cdot 0.21$).[21]

As a second plausibility check, we compare the estimated employment effects (see Figure 2c) with prior literature. We estimate that employment decreases by 8% when the corrected expected tax base share increases from 0 to 1. Assuming again that the expected tax base share of immobile firms changes from 0 to 0.3, and thus the corrected expected tax base of immobile firms from 0 to 0.21, this suggests a reduction in employment by 1.7% ($0.21 \cdot 0.08$). This is similar to prior literature: Misra (2019) estimates for Germany a long-run tax semi-elasticity of employment of about 2.25[22], i.e. an increase in the tax rate by 1% (upon realization) predicts a decrease in employment by 2.25%. Again, our estimated effect is plausible.

Effect Heterogeneity. Last, we assess the evidence for effect heterogeneity using the same criteria as in Langenmayr/Simmler (2021) (see Table A4). We find little effect heterogeneity, consistent with the results for the increase in the local business tax rates and the realized tax base share in Langenmayr/Simmler (2021).

5 Conclusion

Our paper points to the commitment problem of governments: Low tax rates attract firms with low and high relocation costs. In the presence of relatively immobile firms, governments face an incentive to increase tax rates. We show that firms react to the current and expected future tax rate in their location decisions. Our empirical approach exploits that firms use average mobility to predict future tax rates, but other information as, for example, spending needs or agglomeration benefits (Koh et al., 2013) matter certainly as well.

Our results suggest that prior empirical estimates underestimated the role of taxation by focusing only on the current tax rates. In addition, they highlight the relevance of government credibility for effective tax policy for less mobile firms and how the presence of highly mobile firms mitigates the commitment problem, as these firms continue to pressure the government for a low tax rate in the future.

[21] The effect of the expected tax base share on firm entry is non-linear. For an average jurisdiction with an expected tax base share of 7%, the difference between the impact of expected and current tax rates is much smaller.

[22] Misra (2019) estimates the impact of tax rate changes on employment growth at the firm level, finding a short-run semi-elasticity of -1 and a long-run semi-elasticity of 4.5, but also that small and medium-sized firms drive the response. Assuming that large and non-large firms each account for $\tilde{5}0$% of employment, the long-run semi-elasticity on the jurisdiction level is around 2.25.

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Online Appendixes

Appendix 1: Equilibrium

Solving the equation system given by (3), (4), and (5) yields the equilibrium values for all endogenous variables. The equilibrium tax rates of the local governments are

$$\tau^{0*} = \frac{\frac{1}{2}\eta^2 - \eta + 2(1 + \tau_{low})}{6 - \eta}$$
$$\tau^{I*} = \frac{2(\eta + 1 + \tau_{low})}{6 - \eta}. \tag{A1}$$

Firm entry in equilibrium is described by

$$p^* = \frac{2(2 - \tau_{low}) - 3\eta}{6 - \eta},$$
$$\mu^* = \frac{\eta^2 + (2 - \eta)(2 - \tau_{low})}{6 - \eta}. \tag{A2}$$

Appendix 2: Additional Tables and Figures

Table A1: Variable Definitions and Sources: Firm Entry Decisions (1997–2006)

Variable	Definition	Source
Number of new firms	All newly founded firms, excluding self-employed.	Gewerbeanzeigenstatistik
Number of firm entries due to relocation	Entries of firms relocating from another municipality.	Gewerbeanzeigenstatistik
Local business tax rate (LBTR)	Local business tax multiplier multiplied by 5% to yield local business tax rate and taking into account that the local business tax was deductible from its own tax base.	Statistik Lokal
Potential tax base share immobile firms (IF)	Ratio of potential wind turbines' tax base to tax base in 1998 plus potential wind turbines' tax base. The number of turbines is estimated using jurisdictions with turbines in 2011 and wind strength, amount of agricultural land, the tax base in 1998, the tax rate in 1998 and state dummies.	Simulation using data from Operator Database, German Weather Service and financial statements database DAFNE

Expected tax base share IF	Potential tax base share IF multiplied with the share of municipalities that have turbines in 2011 based on states or based on wind strength quintiles	German Weather Service
Corrected expected tax base share IF	Expected tax base share IF multiplied with 1 less expected tax base share of immobile firms.	German Weather Service
Realized tax base share IF	Ratio of built wind turbines' tax base to total tax base (= mobile firms tax base in 1998 plus built wind turbines' tax base).	Simulation using data from Operator Database, German Weather Service and financial statements database DAFNE
Spending in million euros	Overall municipality and pro-rata county spending excluding spending for social services.	Jahresrechnungsstatistik
Population	Population	Statistik Lokal
Neighbor spending in million euros	Average spending of neighboring municipalities within 20 km radius, inverse distance weighted.	Calculation based on Statistik Lokal
Neighbor LBTR	Average local business tax rate of neighboring municipalities within 20 km radius, inverse distance weighted.	Calculation based on Statistik Lokal
Neighbor population (in 1,000)	Average population of neighboring municipalities within 20 km radius, inverse distance weighted.	Calculation based on Statistik Lokal

All variables are at the municipality level.

Table A2: Descriptive Statistics Mobile Firms

	Mean	P25	P50	P75	SD
All municipalities, N= 84,214					
Number of new firms	13.72	1.00	2.00	8.00	72.88
Number of firms that relocated	1.52	0.00	0.00	1.00	6.60
Local business tax (LBT)	0.14	0.13	0.14	0.15	0.01
Pot. tax base share IF (rel.)	0.42	0.07	0.34	0.79	0.36
Expected tax base share IF (states)	0.07	0.01	0.04	0.10	0.07
Expected tax base share IF(wind strength)	0.08	0.01	0.05	0.15	0.08
Real. tax base share IF	0.02	0.00	0.00	0.00	0.10
Spending in million euro	12.83	1.10	2.44	7.24	73.25
Population in thd.	6.47	0.69	1.54	4.35	28.65
Neighbor $<$ 20km spending in mil.	580.32	263.16	396.23	623.83	757.03
Neighbor $<$ 20km LBT	0.13	0.14	0.15	0.01	
Municipalities without turbines in 2011, N= 69,807					
Number of new firms	9.45	0.00	2.00	6.00	44.89
Number of firms that relocated	1.23	0.00	0.00	1.00	5.28
LBT	0.14	0.13	0.14	0.15	0.01
Pot. tax base share IF (rel.)	0.44	0.08	0.39	0.81	0.36
Expected tax base share IF (states)	0.06	0.01	0.04	0.10	0.07
Expected tax base share IF (wind strength)	0.08	0.01	0.06	0.15	0.08
Real. tax base share IF	0.00	0.00	0.00	0.00	0.00
Spending in million euro	8.63	1.00	2.11	5.42	46.60
Population in thd.	4.48	0.63	1.34	3.37	18.73
Neighbor $<$ 20km spending in mil.	568.79	263.21	393.64	615.15	744.09
Neighbor $<$ 20km LBT	0.14	0.13	0.14	0.15	0.01

Source: Authors' calculations based on Statistik Lokal, 1998–2006, data from the operator database, 1990–2006, and the German Weather Service. IF: Immobile firms.

Table A3: Impact of Expected Tax Base Share of Immobile Firms on Wind Turbines Location Choice

Dependent variable	Number of turbines			Installed Power		
			CF			CF
	(1)	(2)	(3)	(4)	(5)	(6)
LBT	3.008	7.961	-20.484	8.410	14.981	-13.134
	(6.122)	(5.704)	(37.228)	(8.378)	(9.275)	(48.361)
Exp. TBS	-1.668*	-0.513	-0.206	-3.404**	-2.449	-2.156
	(1.011)	(0.897)	(0.921)	(1.595)	(1.527)	(1.555)
CF residuals			29.137			28.718
			(37.973)			(49.638)
Municipality FE	x	x	x	x	x	x
Year FE	x			x		
State-year FE		x	x		x	x
Observations	16,360	16,360	16,360	16,360	16,360	16,360

Notes: Table shows the estimated coefficients for the impact of the expected tax base share of immobile firms on the number of wind turbines in two periods (up to 1998; and built between 1999 and 2006) in cols. (1) to (3) and on installed power of wind turbines in two periods (up to 1998 and between 1999 and 2006). Cols. (1) and (3) include only local business tax, expected tax base share of immobile firms and year and municipality fixed effects. In col. (2), (3), (5) and (6) we additionally include state-year fixed effects. In col. (3) and (6) we use a control function approach to account for the potential endogeneity of the local business tax rate. The excluded instrument is the interaction of the positive difference of the tax rate to the reference multiplier in 1998 interacted with the reference multiplier. Robust standard errors, clustered at the county level, in parentheses. ***, **, * indicate significance at the 1%, 5%, 10% levels. *Source:* Authors' calculations based on Statistik Lokal, 1998–2006, data from the operator database, 1990–2006, and the German Weather Service.

Table A4: Heterogeneity Analysis

Dependent variable	Number of new firms or IHS(Number of new firms)									
	Within County Variation		Fiscal Equalization Scheme				North	South	West	East
	Core	Periphery	LBT < Ref	LBT > Ref	High Replacement	Low Replacement	Germany			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
LBT	-0.495	-0.373	0.871	-0.860	-1.515	0.366	0.336	-1.072	0.855	-0.952
	(1.262)	(1.588)	(2.155)	(1.231)	(1.905)	(1.188)	(1.408)	(1.515)	(1.494)	(1.325)
Exp. TBS * (1- Exp. TBS)	-0.378	-0.403	-0.929	-0.845**	-1.493***	0.179	-0.967**	-1.365**	-1.525***	-0.813
	(0.571)	(0.520)	(1.491)	(0.402)	(0.436)	(0.712)	(0.480)	(0.669)	(0.563)	(0.546)
Municipality FE	x	x	x	x	x	x	x	x	x	x
Baseline control variables	x	x	x	x	x	x	x	x	x	x
State-year FE	x	x	x	x	x	x	x	x	x	x
Additional control variables	x	x	x	x	x	x	x	x	x	x
Observations	34,841	34,966	29,871	39,936	33,252	36,555	26,421	43,386	47,505	22,302

Notes: Table shows the results of heterogeneity analyses for the impact of corrected expected tax base share of immobile firms on the number of new firms entries in a municipality and year using a Poisson model. The sample includes includes jurisdictions with positive tax base of mobile firms in 1998 and without turbines in 2011. In col. (1) only jurisdictions with a share of agricultural land below the county-average are included (core), and in col. (2) only jurisdictions with a share above (periphery). In col. (3) we only include jurisdictions that had in 1995 a tax multiplier below the reference tax multiplier and in col. (4) only jurisdictions that had a tax multiplier above. In col. (5) we include only jurisdictions in states with above median replacement rates in 1995 and in col. (6) only jurisdictions in states with below median replacement rates. Finally, in col. (7), (8), (9) and (10) we use only jurisdictions in north, south, east and west Germany respectively. Standard errors, shown in parentheses, are robust to heteroscedasticity and clustered at the commuting-zone level. ***, **, * indicate significance at the 1%, 5%, 10% levels. *Source:* Authors' calculations based on Statistik Lokal, 1997–2011, the operator database, 1990–2011, and the German Weather Service.