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Firm mobility and jurisdictions' tax rate choices: Evidence from immobile firm entry ☆

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ABSTRACT

Capital mobility is one of the key determinants of corporate tax rates. We first show theoretically that governments will set higher tax rates on firm profits after an immobile firm has entered. We then test this prediction in a well-identified setting, using the rapid growth of wind power plants (a very immobile industry) and the large variation in local business taxes across Germany for identification. We confirm that municipalities increase corporate tax rates by up to 24% after immobile firm entry. The effect is stronger when immobile firms make up a larger share of the overall tax base.

1. Introduction

Governments cannot tax highly mobile firms at high rates. If a government tries to do so, mobile firms will move to other jurisdictions. While economic theory has long argued along these lines, there is little direct empirical evidence for this fundamental relationship.[1] In this paper, we contribute to filling this gap. We exploit the evolution of a new, immobile industry (wind turbines) in Germany and provide direct evidence for the effect of capital mobility on corporate tax rates. As we will argue below, wind turbines provide an ideal testing ground, as their relocation costs are prohibitively high, and exogenous, observable factors such as wind speed mostly determine their location decision. Thus, the contribution of our paper is to show in a well-identified setting that corporate tax rates increase in response to declining capital mobility.

In more detail, our paper starts by setting up a model in which local governments compete for mobile and immobile firms (i.e. firms with very low or very high relocation costs, respectively). We assume that all firms are taxed at the same rate.[2] Thus, govern-

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[1] As exogenous variation in capital mobility is rare, empirical tests have used various proxies, such as industry-specific location rents, measured e.g. by geographic profit variability (Carlsen et al., 2005), or indicators of globalization, measured e.g. by the relaxation of capital controls (Devereux et al., 2008) or trade openness (Slemrod, 2004).

[2] This assumption corresponds to common real-world policies, especially for small and medium-sized firms. Large multinational firms may be able to bargain for specific subsidies or tax holidays, or lower their effective tax burden via profit shifting. In the context of the small, local jurisdictions studied in this paper, however, all firms are usually subject to the same statutory rate.

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ments cannot target policies to specific firms, but must base their tax rate decisions on the overall mobility mix of the tax base. The model shows that governments set a higher tax rate if immobile firms constitute a larger share of the tax base.

To test the theoretical predictions of our model, we exploit variation in tax base mobility among German municipalities which arose after the introduction of federal subsidies for wind power plants in Germany after 2000. Following the introduction of these subsidies, the number of wind turbines increased from roughly 5,000 in the year 2000 to over 23,000 in 2012. This development considerably changed the mobility of the tax base for the local business tax, which is an important tax on profits in Germany. As the over 11,000 municipalities decide individually about the local business tax rate, there is substantial variation in tax rates. In the empirical analysis, we use the variation from wind turbine entry to assess the impact of a jurisdiction's tax base mobility on its tax rate choice.

We measure tax base mobility by the tax base share of immobile firms and use two sources of variation: (i) time-series variation from the entry of very immobile firms (wind turbines), combined with (ii) cross-sectional variation from the size of the tax base of mobile firms. As tax rates also affect (immobile) firms' entry decisions (and thus the mobility of the tax base), we employ an instrumental variable estimator to address this reverse causality problem.

We instrument both the numerator and denominator of the tax base share of immobile firms. For the numerator (the tax base of wind turbines), we use the interaction of wind strength, agricultural land and a dummy indicating subsidies for wind energy as our instrument. For the denominator (the total tax base), we use the sum of urban and industrial land. We control for each part of the instrument in our regressions, and can thus exclude that differential trends in tax rates across jurisdictions (depending on their share of agricultural land or wind speed) or the capitalization of wind turbine profits into agricultural land prices drive our results. In addition, we include agricultural land quintile–year and tax base quintile–year fixed effects to account for potential correlations between agricultural land or the size of the tax base and jurisdictions' tax rate choices. We also control for time-constant municipality and time-varying state or county characteristics by adding municipality and state-year fixed effects.

Using panel data from 1995 to 2011, our results suggest that municipalities increase the tax rate on immobile and mobile firms' profits by on average three percentage points, which is around 20%. This is consistent with evidence from case studies: the municipality of Ellhöft, for example, had not changed its local business tax rate for nine years, but increased it by 25% after four wind turbines were built there in 2007 (and building permits had been issued for three additional turbines).[3]

Our paper adds to the literature on tax competition, which is based on the idea that increasing capital mobility has led to lower corporate tax rates (for a review of the theoretical literature see Keen and Konrad, 2013). In most of this literature, all firms have the same mobility. An exception is Haupt and Krieger (2020), who show that while higher relocation mobility intensifies tax competition, it alleviates competition in subsidies to attract firms. Becker and Schneider (2018) consider a situation where the share of mobile firms is unknown, and the government use tax-induced firm migration to learn about the true number of mobile firms. The empirical literature on tax competition has focused on estimating reaction functions to other countries' tax rates (see Devereux and Loretz, 2013, for a review). In the absence of direct shocks to firm mobility, some papers use trade openness as a proxy (e.g. Slemrod, 2004; Haufler et al., 2009), finding correlations between openness and lower tax rates. More directly, Carlsen et al. (2005) show a negative relation between mobility (measured by profit variability of industrial sectors) and fees for infrastructure services across Norwegian municipalities. In contrast, we use a direct shock to average firm mobility and provide causal evidence on the relationship between firm mobility and tax rates.[4]

Our paper is also related to literature discussing the dynamic effects of tax rate increases. Here, the key trade-off is between generating more revenue from the existing tax base, or attracting a larger stock of capital, which can be taxed in the future (Wildasin, 2003). Marceau et al. (2010) show that countries with relatively little immobile capital will lower their tax rates to attract new, mobile capital, while such a strategy is too costly for countries with high stocks of immobile capital. Similarly, our paper studies the revenue-maximizing taxation of firms with different mobility, but we focus on ex-post optimal tax rates.

This paper proceeds as follows. Section 2 provides a theoretical model of firms' location decisions and governments' tax rate choices. Section 3 introduces our identification strategy and provides some background information on the renewable energy sector in Germany. Section 4 analyses how municipalities react to an increase in the tax base share of immobile firms. Section 5 concludes.

2. Model

To clarify the effects at work, we first provide a stylized model. There are two countries in the model. The home country is a federation with N local governments (e.g. provinces or municipalities), and each local government chooses its own tax rate, τ. The other country has a low, uniform tax rate, τ_{low}. The situation we want to capture with this set-up is that of a large federation and a nearby low-tax country to which firms can relocate.[5] There are two types of firms, mobile firms (which can relocate to the low-tax country at a cost), and immobile firms (which cannot relocate). There are no immobile firms in the low-tax country. We assume that each local jurisdiction has to tax both mobile and immobile firms at the same rate. This assumption captures the empirical reality, especially for small and medium-sized firms.[6]

Mobile firms realize a fixed profit of π^M. At the beginning of the model, an exogenously given mass M of mobile firms is active. Later on, each firm can decide to relocate to the foreign low-tax country. To do so, it has to pay a fixed cost, $f_i\pi^M$, where f_i is uniformly distributed in $[0, s]$.

[3] Ellhöft, a village of 113 inhabitants at the German-Danish border, receives several hundred thousand Euros in tax revenues from those wind turbines each year. Major German newspapers reported on the financial gains of wind turbines for small municipalities (see e.g. www.spiegel.de/wirtschaft/soziales/energiewende-wie-wind-kraft-ein-113-seelen-dorf-reich-machte-a-1078759.html for Ellhöft or www.mz-web.de/merseburg/windpark-farnstaedt-dank-wind-soll-s-in-der-kasse-klingeln-3329750 for Farnstädt, a village of 1,648 inhabitants in Saxony-Anhalt).

[4] The empirical literature also shows the importance of further determinants of tax rates, e.g. agglomeration and urbanization rents or budget needs (e.g. Jofre-Monseny, 2013; Koh et al., 2013).

[5] The inclusion of the low-tax country in addition to the federation simplifies the model substantially. If mobile firms relocated within the federation, the resulting game would be a many-country tax competition model with asymmetric jurisdictions (due to the presence of immobile firms in some municipalities). The empirical predictions from such a model should not differ systematically from those derived below.

[6] Preferential rates for mobile firms are difficult to implement. While some very large firms can negotiate special treatment, this route is not available to small and medium sized firms. The European Union even prohibits preferential rates for individual firms as a form of illegal state aid.

Immobile firms use different technologies, which makes them unable to relocate (because they are bound to resources that only exist in the specific jurisdiction, or because the cost of relocation is prohibitively high). Examples are mining companies, other resource extractors, or wind turbines. An immobile firm realizes a profit of π^I. Immobile firms have a fixed set-up cost of c_j when they become active, with c_j uniformly distributed in $[0, \zeta]$. They can only decide whether to enter or not; they cannot decide to enter in a different jurisdiction ("latent start-up model").[7] Only one immobile firm may be active in each jurisdiction. This normalization enables us to focus on the share of mobile vs. immobile firms later on and allows us to abstract from jurisdiction size.

Firms do not bear the complete burden of corporate taxation, but pass on some of it to employees, landowners, or consumers. For the U.S., Suárez Serrato and Zidar (2016) find that while firm owners bear roughly 40% of the tax burden, a substantial part is passed on to workers (30–35%) and landowners (25–30%). For Germany, Fuest et al. (2018) show that workers bear about half of the tax burden. We capture this issue in our model in stylized form by introducing parameters α and $\beta \in [0, 1]$, which measure how much of the incidence is borne by immobile and mobile firms (or their owners), respectively.

The model proceeds in five stages (see Fig. 1). In the first stage, immobile firms decide whether to enter the market. In the second stage, the local governments set their tax rates, observing which firms are active in each jurisdiction. This ordering of the stages of the game reflects that governments can adjust the tax rate after an immobile firm has entered: for example, in the empirical study presented below, a municipality is able to change its tax rate after a wind turbine has become active. In the third stage, the low-tax country observes the tax rates chosen by all jurisdictions in the federation, and then chooses its own tax rate. The low-tax country, as the smaller country, is more flexible than other jurisdictions and thus moves later.[8] In the fourth stage, mobile firms may relocate after observing the tax rate. In the last stage, firms produce and pay taxes.

We solve the model backwards and start with the relocation decision of mobile firms. Mobile firms relocate if the after-tax profit in the local jurisdiction, $(1 - \beta\tau^j)\pi^M$, is lower than the profit they would realize when relocating to the low-tax country, $(1 - \beta\tau_{low})\pi^M - f_i\pi^M$. Here, $\tau^j \in \{\tau^I; \tau^0\}$ denotes the tax rate that the government chooses in the second stage (τ^I if an immobile firm is active, τ^0 if not). Those mobile firms with

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

relocate. Thus, the larger the tax rate differential relative to the low-tax jurisdiction, and the higher the share of the tax burden that firm owners bear, the more firms relocate. The immobile firm cannot relocate by definition.

As there are many local jurisdictions within the federation, they do not take into account the effect they have on the low-tax country's tax rate choice. We thus postpone the discussion of the low-tax country and continue by studying the tax rate decisions of the local governments. Each local government observes whether an immobile firm has entered, and anticipates the relocation decisions of mobile firms.

We assume that local governments set their tax rates to maximize tax revenues.[9] Tax revenues depend on whether an immobile firm entered in the first stage:

$$T = \begin{cases} \tau^0\left[1 - \frac{\beta(\tau^0 - \tau_{low})}{s}\right]\pi^M M, & \text{if no immobile firm entered,} \\ \tau^I\pi^I + \tau^I\left[1 - \frac{\beta(\tau^I - \tau_{low})}{s}\right]\pi^M M, & \text{if an immobile firm entered,} \end{cases} \tag{2}$$

where the fraction describes the share of mobile firms that relocates in stage 4 according to Eq. (1), using that f_i is uniformly distributed in $[0, s]$. When the dispersion of mobility costs, s, is larger, tax revenue is higher because there are more firms with relatively high costs and thus fewer firms relocate. If there is less incidence on firm owners (lower β), tax revenue is also higher as firms react less to taxation.

The revenue-maximizing tax rates are

$$\begin{aligned} \tau^0 &= \frac{s + \beta\tau_{low}}{2\beta}, \\ \tau^I &= \frac{s\pi^I + \pi^M M(s + \beta\tau_{low})}{2\beta\pi^M M} = \frac{s\eta}{2\beta} + \tau^0, \end{aligned} \tag{3}$$

where τ^I depends on the potential tax base share of immobile firms, $\eta = \frac{\pi^I}{\pi^M M}, \eta < 1$. τ^I is higher if the tax base share of immobile firms, η, is higher. The optimal tax rate trades off the additional tax revenue of a higher tax rate (for a fixed number of firms) and the revenue loss from a larger number of firms relocating in response to the tax rate increase. The second effect is smaller if mobile firms bear less of the tax incidence (lower β). As the second effect is also smaller if an immobile firm is present, the government always chooses a higher tax rate if an immobile firm is active. Correspondingly, the mark-up in the tax rate if an immobile firm enters is higher when the tax base share of the immobile firm is higher. A larger dispersion of mobility costs (higher s) implies higher tax rates as there are more relatively immobile firms.

The immobile firm anticipates that if it enters, the jurisdiction will increase the tax rate to τ^I for sure. Therefore, the immobile firm only enters if $\pi^I(1 - \alpha\tau^I) \geqslant c_i\pi^I$. Given that c_i is uniformly distributed, p is

$$p = \frac{(1 - \alpha\tau^I)}{\zeta} = \frac{1}{\zeta} - \frac{\alpha}{\zeta}\left[\frac{\eta s}{2\beta} + \tau_{low}\right]. \tag{4}$$

If the variance of possible fixed costs of immobile firms is larger (higher ζ), it is less likely that a firm has sufficiently low cost and enters. More taxes born by the immobile firm (higher α) also decrease the entry probability.

Let us now turn to the low-tax country. It observes the tax rates chosen by the N local governments and anticipates the relocation decisions of mobile firms. It sets its tax rate to maximize its tax revenues, T_{low}. For simplicity, we assume that there are no other firms in the low-tax country. Tax revenues in the low-tax country then are

$$T_{low} = \tau_{low}N\pi^M M\left[p\beta\frac{(\tau^I - \tau_{low})}{s} + (1 - p)\beta\frac{(\tau^0 - \tau_{low})}{s}\right]. \tag{5}$$

[7] In other words, potential entrepreneurs are immobile. Entrepreneurs then sell a successful firm to an investor, who can decide to move the firm to the low-tax country (see e.g. Becker and Henderson, 2000; Brülhart et al., 2012). Using a sample of Portuguese firms, Figueiredo et al. (2002) show that most entrepreneurs (72%) start firms in their home district.

[8] With this assumption we follow the literature on Stackelberg tax competition, see e.g. Gordon (1992), Wang (1999) or Altshuler and Goodspeed (2015).

[9] We believe that this assumption is realistic for German municipalities, whose spending is to a substantial degree determined by federal law. As a consequence, many German municipalities are heavily indebted and have to raise as much tax revenue as they can. Nevertheless, some municipalities have financial leeway, and in Appendix A we sketch a model where municipalities use tax revenues to finance a public good. We find that while equilibrium tax rates are lower, the pattern between τ^0 and τ^I may be even more pronounced because of a "tax exporting" effect: for immobile firms, a larger share of the incidence is likely borne by non-local factors, thus providing an additional incentive to increase tax rates after such a firm enters.

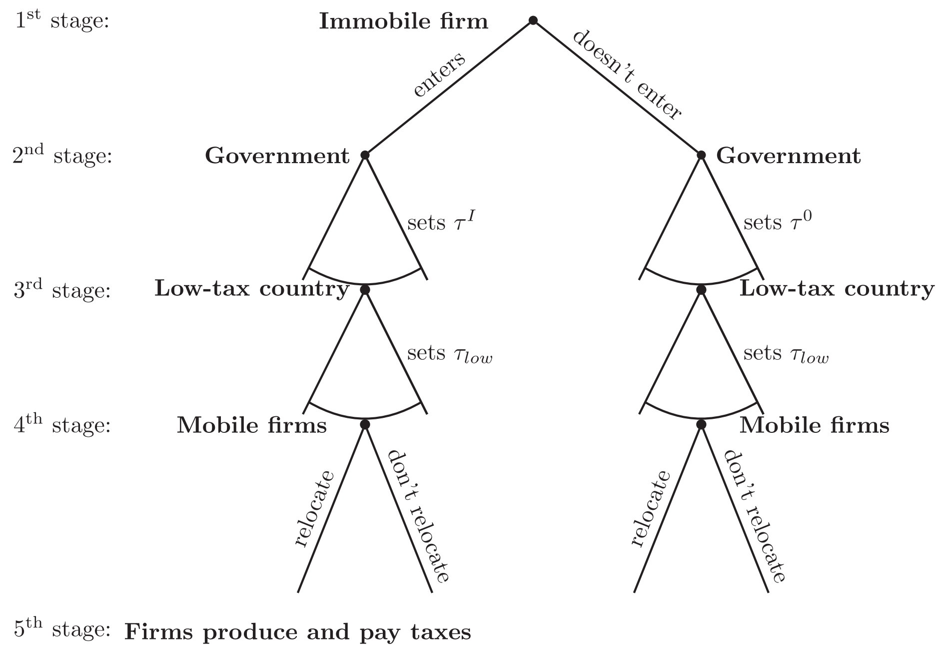

Fig. 1. Game Tree.

Maximizing Eq. (5) yields the revenue-maximizing tax rate of the low-tax country,

$$\tau_{low} = \frac{p\tau^I + (1-p)\tau^0}{2}. \quad (6)$$

The low-tax country thus sets a lower tax rate if the average tax rate in the home country is lower. The tax rates of the low-tax country and of the small jurisdictions of the home country are strategic complements, as common in models of tax competition.

Using Eqs. (4) and (6) in Eq. (3) allows us to formulate the following proposition.

Proposition 1 (*Equilibrium Tax Rates*). A jurisdiction sets a higher tax rate $\left(\tau^{I*} = \frac{s(\eta+3\zeta\eta+4\zeta)}{s\alpha\eta+6\beta\zeta}\right)$ if an immobile firm has entered, compared to an identical jurisdiction without an immobile firm $\left(\tau^{0*} = \frac{2\beta s(\eta+4\zeta)-s^2\alpha\eta^2}{2\beta(s\alpha\eta+6\beta\zeta)}\right)$. The difference between the tax rates increases in the tax base share of the immobile firm, η.

Proof. τ^{I*}, τ^{0*} follow from using Eqs. (4) and (6) in Eq. (3) and simplifying. $\tau^{I*} > \tau^{0*}$ as $\tau^{I*} - \tau^{0*} = \frac{s\eta}{2\beta}$. Lastly, $\frac{\partial \tau^{I*} - \tau^{0*}}{\partial \eta} = \frac{s}{2\beta} > 0$. □

Thus, the main implication of our model is that governments increase tax rates when an immobile firm enters a jurisdiction. We now test this hypothesis empirically.

3. Empirical Strategy

3.1. Setting

To empirically test whether immobile firm entry leads to higher tax rates, we exploit the evolution of a new and highly immobile industry within Germany. The setting within Germany is particularly suited for our research question, as it provides ample variation in tax rates without regulatory or tax base differences that could be problematic in a cross-country setting. In Germany, municipalities have the right to tax business profits. This local business tax accounts for roughly 50% of the tax burden on profits. In most of the over 11,000 municipalities, the tax rate was between 9% and 15% in 2008–2011, with a mean of 12%.[10] Tax rates change annually in about 10% of municipalities. Firms pay the tax in the municipality where the plant is located.[11] While the municipalities set the tax rate, the federal government defines the tax base.

Our identification strategy relies on changes in the mobility of the tax base. To identify such changes, we consider the market entry of very immobile firms: wind turbines. At the beginning of our sample period in 1995, few wind turbines existed in Germany, but capacity more than quadrupled until 2011 (see Fig. 2). Since wind turbine profits are taxed in the municipality where the turbine is located, wind turbine profit became a significant source of tax revenue for many rural municipalities. Thus, municipalities with favorable conditions for wind turbines have seen a substantial increase in tax revenue. In municipalities with at least one wind turbine, on average about 20% of the local business tax revenue came from wind power generation between 1997 and 2011 (see Table 1 in Section 4.2). Thus, the entry of these firms substantially changed the composition of the tax base.

Germany saw such strong growth in the number of wind turbines because it actively promoted them. In 2000, the federal government passed the Renewable Energy Act. This law introduced a price guarantee for green electricity to promote investment in renewable energies (as agreed in the Kyoto Protocol and in the Lisbon Treaty). This feed-in tariff guarantees a minimum wholesale

[10] Municipalities do not choose the tax rate, but a "tax multiplier". To calculate the tax rate, one has to multiply the tax multiplier by 5% (before 2008) or 3.5% (from 2008 onwards). The 2008 reform also changed how the tax base is calculated; in particular, the local business tax was deductible from its own tax base before the reform.

[11] If a firm is active in several municipalities, usually the wage bill determines how much local business tax the firm pays in each municipality. However, for wind turbines, where most plants have zero employees, the tax base was usually allocated to the municipality where the turbine is located. From 2007 on, the law required that 70% of the tax base are allocated to the municipality of the turbine; and the remaining 30% go to the headquarter's municipality (§29 Local Business Tax Law).

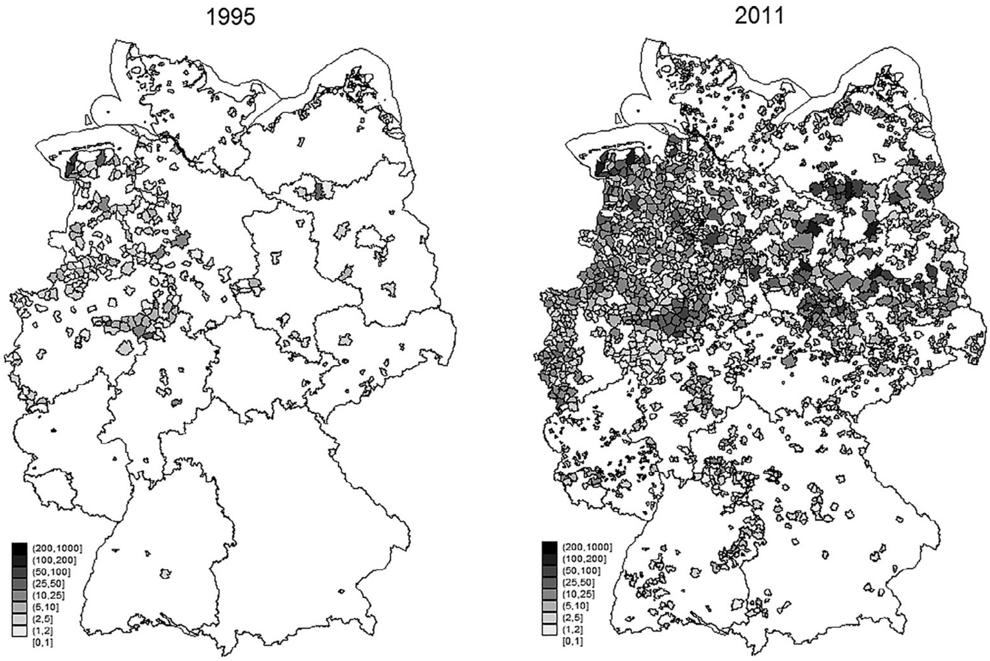

Fig. 2. Number of Wind Turbines, 1995 and 2011. *Notes:* Number of wind turbines per municipality in 1995 (left hand side) and 2011 (right hand side). *Source:* Authors' calculation based on data from the operator database, 1990–2011.

Table 1
Descriptive Statistics.

	All municipalities			Municipalities with at least 1 wind turbine		
	Mean	P50	SD	Mean	P50	SD
Local business tax multiplier	331.73	330.00	35.21	348.09	340.00	43.84
Local business tax rate in %	13.51	13.68	1.60	13.82	13.79	1.93
Tax base share IF in %	2.58	0.00	12.29	19.91	4.77	28.63
Wind strength 10 m above ground	3.46	3.34	0.63	3.70	3.60	0.55
Agricultural land	1,768	1,104	2,137	3,947	2,936	3,494
Population	7,382	2,147	28,656	17,994	6875	56,931
Share population $<$ 6 years	0.06	0.06	0.01	0.05	0.05	0.01
Share population $>$ 65 years	0.22	0.23	0.06	0.21	0.23	0.07
Share CDU or CSU	0.26	0.27	0.24	0.35	0.38	0.22
Share SPD	0.16	0.10	0.18	0.23	0.23	0.18
Share Greens	0.01	0.00	0.03	0.02	0.00	0.04
Share Liberals	0.02	0.00	0.05	0.03	0.00	0.06
Share Left Party	0.02	0.00	0.06	0.02	0.00	0.06
Observations	149,235			19,357		

Notes: Mean, median (P50) and standard deviation (SD) for municipality characteristics. IF stands for immobile firms. *Source:* Authors' calculation based on Statistik Lokal, 1997–2011, data from the operator data base, 1990–2011, and data from the German Weather Service.

price for wind energy for 20 years after the installation of the plant and thus made investments into wind power much more attractive. The average guaranteed price is about 8 cents per kWh, which substantially exceeds the average market price for electricity of about 3 cents per kWh (see Haan and Simmler, 2018).[12] Although the generosity of the feed-in tariff decreased over time, the profitability of newly built turbines stayed relatively constant or even increased due to technological progress (see Fig. A.1 in Appendix B). Moreover, the Renewable Energy Act obliges grid operators to buy all green electricity on offer. Grid operators do not bear the burden of the subsidy: all electricity consumers pay a fixed share of their electricity bill into a fund which reimburses grid operators. There is no link between the regional production of green electricity and the cost to consumers.[13]

The quick evolution of this new firm type is well-suited to our analysis: wind turbines are very immobile, and their location decisions are relatively simple. First, consider their immobility. It is extremely costly for wind turbines to relocate. Firms would face costs for dismantling the wind turbines, their transport and re-assembly as well as possible contractual penalties if they terminate the often long-term contract with the land owner. In addition, local wind conditions strongly influence which turbine technologies are suitable for which location.

[12] A subsidized feed-in tariff has existed in Germany since 1992, but while the tariff was only slightly smaller than the one introduced after 1999, its duration was uncertain, as it was only paid for as long as the law was in effect. We assume for the simulation later that investors expected it to be paid for three years.

[13] Although the contribution to the subsidy fund is constant, network charges may vary locally. Wind energy production varies substantially over time, making it costlier to maintain networks, so that network charges may be somewhat higher in regions with more wind energy. However, in course with the liberalization of the energy market, network charges decreased on average until 2009, despite the substantial increase in wind energy production.

Second, consider the location decision. By far the most important location-specific factor is wind strength. In addition, agricultural land prices and local business taxes matter (Ross and Carley, 2016).[14] Differences in wage costs are not important as wind electricity generation requires almost no labor. As the electricity grid in Germany is well developed, distances to the main power lines play little role. Given the limited number of determinants for wind turbines' location decision, municipalities have few options to attract wind turbines, except for the local business tax rate. In particular, municipalities may not pay specific subsidies for wind power generation and states (not municipalities) regulate where wind turbines may be built.[15] Wind turbine operators are private firms (e.g. utility companies) or local cooperatives. These firms choose among the large number of possible wind turbine locations based on expected wind turbine profitability.

3.2. Data

In our empirical analysis, we use panel data at the municipality level. The data set includes information on the local business tax rate and tax base, information on firm entries, as well as several municipal and regional characteristics. Our sample includes the years 1995–2011.[16] We end our sample period in 2011, as in 2012 the German government introduced a premium for directly sold green electricity. As we do not observe to whom electricity was sold, we cannot model this premium.

Our model points out that the tax base *share* of wind turbines matters. To calculate the tax base share of immobile firms, we divide the tax base of built wind turbines by the tax base of mobile firms in 1998 plus the tax base of wind turbines. The tax base of mobile firms in 1998 is proxied by deducting the tax base of wind turbines in 1998 from the observed local business tax base in that year.[17] We will show in sensitivity analyses that our results are not sensitive to the way of measuring the immobile firms' tax base share.

Since we do not observe the tax base of built wind turbines we simulate this variable using data on wind turbines from the operator database. This is a private database, collected by consultants in the renewable energy industry and the Chamber of Agriculture of the state Schleswig–Holstein. The data set includes information on the location, technology and construction date for all wind turbines in Germany. We 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 and Simmler, 2018, for details of this calculation). The simulated tax base varies over time as new turbines are built and their taxable profits change due to changes in the feed-in tariff, capital allowances, or bank financing. We assess the predictive power of the simulation by regressing the observed total local business tax base on our simulated wind turbine tax base. The results, shown in Table A.1 in Appendix B, suggest that the estimated coefficient is close to one and significant.[18]

Table A.2 in Appendix B describes all variables and data sources used in Section 4.

4. Tax Rate Choice and Immobile Firm Entry

4.1. Estimation Strategy

To provide evidence that municipalities increase the tax rate on firm profits when the tax base in the municipality becomes less mobile (i.e., when the tax base share of immobile firms rises), we estimate

$$\tau_{i,t} = \alpha \frac{T^I_{i,t}}{T^0_{i,t}} + \beta' X_{i,t} + \delta_i + \epsilon_{i,t}. \quad (7)$$

The dependent variable $\tau_{i,t}$ is the local business tax rate in municipality i at time t.[19] Our main explanatory variable is the tax base share of immobile firms $\left(\frac{T^I_{i,t}}{T^0_{i,t}}\right)$.

If the arrival of wind turbines was fully exogenous, OLS would be unbiased. However, as we sketch out in Section 3.1, the location decision of wind turbines not only depends on wind strength but (at least) also on the tax rate. Since higher taxes reduce the likelihood that a wind turbine locates in a particular jurisdiction, the OLS estimator suffers from reverse causality and is downward biased. Moreover, our measure assumes that all non-immobile firms have similar mobility, although substantial evidence exists that firm mobility depends on firm size, industry, agglomeration, urbanization etc. Thus, there is measurement error in the tax base share, which also biases our estimates (most likely) downward.[20] In addition, the OLS estimator could suffer from omitted variable bias if the characteristics of jurisdictions with wind turbines (e.g. the agricultural land area) are correlated with its local business tax rate. Such a correlation could exist in levels as, for example, jurisdictions with a lot of agricultural land are more rural and have lower business tax rates. It could also arise over time as there is a clear urbanization trend in Germany and thus a population decline in rural areas. Lastly, the heterogeneous mobility of mobile firms may also lead to omitted variable bias (and not just measurement error). Since wind turbines are more likely to enter in jurisdictions with relatively mobile mobile firms (conditional on the total size of the tax base of mobile firms), and tax rate increases are less likely if firm mobility is high, this also implies a downward bias of the OLS estimate.[21]

While we could in theory mitigate the omitted variable bias (except for the firm mobility part) by either adding a large set of control variables or by employing a matching strategy to reweight the sample, we can only address the omitted variable bias due to firm mobility heterogeneity, and reverse causality, by using

[14] Wind turbines are usually on agricultural land as regulation requires a minimum distance from populated areas.

[15] The federal states designate land on which wind turbines may be built (*Wind-Vorranggebiete*). In addition, wind turbines may be built on all agricultural land at a specified minimum distance from buildings unless environmental protection laws forbid it. Building outside the Wind-Vorranggebiete requires additional permits.

[16] In all states in former East Germany, administrative reforms took place after 1990 to reduce the number of municipalities. In our sample, 7% of all municipalities partake at least once in a municipality merger. To increase comparability over time, we treat changes in administrative borders during our sample period as if they had occurred at the beginning of the sample period. We construct the pre-merger tax rate in these cases as a population weighted average of the tax rates. When we exclude the two states with the most mergers (Brandenburg and Saxony-Anhalt) from the analysis, we find very similar results.

[17] We add the tax base of wind turbines built to the denominator so that our measure is always between zero and one, reducing noise in the ratio. We use the tax base of mobile firms in 1998 as this is the earliest year for which data on the local business tax base is available.

[18] The estimated coefficient is slightly larger than one when using the full sample and significant at the 5% level. When excluding municipalities with a very high (top 1%) or very low (bottom 1%) local business tax base, the coefficient decreases to 0.9 (col. 2).

[19] We calculate the local business tax rate by multiplying the local business tax multiplier, which is set by the municipalities, with the federally set local business tax factor ("Steuermesszahl"; 0.05 until 2007 and 0.035 afterwards) and by taking the deductibility of the local business tax until 2008 into account. The time dummies included in the regression pick up any effects arising from the change in the calculation of the local business tax. Results are quantitatively unchanged when using the local business tax multiplier as the dependent variable.

[20] Additionally, as the tax base of wind turbines is simulated, measurement error could also arise in the numerator of the tax base share.

[21] There is empirical support for this argument: Our tax base share is negatively and significantly correlated with the municipality-specific average investment elasticity with respect to taxes (as estimated by Riedel and Simmler, 2021), conditional on our set of fixed effects (except municipality fixed effects). This confirms that more wind turbines locate in municipalities with a large tax base elasticity.

an instrumental variable (IV) approach. Since the IV strategy also addresses the omitted variable bias (to the extent that the selection—conditional on our control variables—is uncorrelated with the excluded instrument), we will employ an IV estimator.

The Achilles' heel of any IV approach is the choice of the excluded instrument, which has to be relevant and, conditional on the control variables, uncorrelated with the error term. To ensure this, we use a triple DiD estimator defined as

$$\mathrm{REA}_t \cdot D(\text{wind strength}_i > \text{P50}) \cdot D(\text{agric. land}_i > \text{P50}) \cdot D\left(\frac{1}{\text{urban \& industrial land}_i} > \text{P50}\right), \quad (8)$$

where "REA" is a reform indicator for the introduction of wind turbine subsidies by the Renewable Energy Act, i denotes municipalities, and t years. The instrument is relevant as the tax base share of immobile firms should increase the most in areas in which many highly profitable wind turbines can be built (i.e. high wind strength and lots of agricultural land) and which have only a low tax base share of mobile firms (i.e. little urban and industrial land). By including the underlying DiD estimators in the second stage (REA·D(high wind)·D(large agricultural land area), REA·D(small urban and industrial land area), REA·D(high wind strength), and REA·D(large agricultural land area)), our approach takes into account that tax rates may be very different in jurisdictions depending on the tax base composition before and after the introduction of the subsidies for renewable energy.

In addition, we account for a non-linear relationship between tax rates, a jurisdiction's tax base of mobile firms, and the agricultural land area by including 1998 tax base quintile–year fixed effects and agricultural land quintile–year fixed effects. Further, to absorb time-invariant differences between jurisdictions as well as shocks common to municipalities in the same state, we include municipality as well as state-year fixed effects. In a robustness test we add further determinants of jurisdictions' tax rate choice, namely the (ln) population, the share of population under 6 and above 65, and the shares of the political parties in the local council. The latter ensures (in addition to the state-year fixed effects) that local politics (including the timing of tax rate changes as analyzed in Foremny and Riedel, 2014) do not bias our estimates. Since all variables are potentially endogenous, we use lagged values.

Given our control variables and the construction of the instrument, we believe the exclusion restriction to be fulfilled. Reverse causality of the instrument is ruled our by construction. Moreover, since we rely on land use variables to construct our instrument, the instrument should be uncorrelated with any potential measurement error in mobile and immobile firms' tax bases as well as uncorrelated with (unobserved) mobile firm mobility. While this triple DiD instrument is intuitive, it removes part of the variation in wind strength, agricultural land and the tax base of mobile firms. Thus, in the Online Appendix we employ a continuous version of this instrument, which allows us to control in addition for county-year fixed effects. The results are very similar to the ones presented in the following.

Table 1 shows descriptive statistics for our main variables. The average local business tax multiplier between 1997 and 2011 is 332 points, which corresponds to a tax rate of approximately 13.5% (14% before 2008 and 12% after 2008). The average population in a municipality in our sample is 7,382. The average tax base share of immobile firms is 3%, and for the subset of municipalities with at least one wind turbine, it is 20%.

4.2. Descriptive Evidence

Before turning to the regression results, we provide descriptive evidence on the relationship between the local business tax rate and the tax base share of immobile firms.

We first plot the kernel density for changes in the local business tax rate between 1995 and 2011 (left panel of Fig. 3). It suggests that municipalities with at least one wind turbine in 2011 were less likely to decrease their tax rate between 1995 and 2011 compared to municipalities with no wind turbines in 2011.[22] The right panel of Fig. 3 shows the average change in the local business tax rate between 1995 and 2011 for five different groups of municipalities defined according to the change in the tax base share of immobile firms. The figure suggests that municipalities with larger changes in the tax base share experienced a larger increase in the local business tax rate (relative to municipalities with no wind turbines).

All of the evidence presented so far has to be interpreted with caution as the treatment status as well as the change in tax base share of immobile firms are endogenous, which is why we implement the IV strategy. To highlight the validity of our IV strategy, we present in the following the results of a reduced form regression, in which we regress (i) the local business tax rate and (ii) the tax base share of immobile firms on our instrument (without the reform indicator), interacted with year dummies, and our set of control variables. This test allows us to assess pre-reform trends and the dynamics after the introduction of wind energy subsidies.

Fig. 4 shows the yearly point estimates. Their evolution over time supports the validity of our instrument: Before the introduction of the subsidies, the point estimates are close to zero and insignificant. After the Renewable Energy Act took effect in 2000, the point estimates increase over time and are significantly different from zero. Somewhat surprisingly, the tax rates do not increase immediately after the reform. One potential explanation for this finding is that municipalities kept tax rates constant to attract additional wind turbines.

While Fig. 4 largely supports a common trend in tax rates before the introduction of the subsidies, this does not rule out that confounding events may bias our IV estimates. Thus, we next inspect the correlation of our excluded instrument with municipality characteristics before the reform, conditional on our set of control variables (except for municipality fixed effects). Table A.3 in Appendix B reports the results, considering both the full sample, and a sample limited to municipalities in the bottom and top quartiles of exposure to our instrument (continuously defined). We assess the correlation between both the level and the changes in various municipality characteristics with our excluded instrument.

We find a significant correlation of the triple DiD estimator with the *levels*, but not the 1998–1999 *changes*, of the tax base and of tax revenues. The pattern is largely similar when we focus on jurisdictions in the top and bottom quartile: While significant correlations in levels exist, they vanish when considering changes in the municipality characteristics. Since we include municipality fixed effects, which absorb a potential correlation of our excluded instruments with the levels of the municipality characteristics in all specifications, this analysis suggests that the triple DiD estimator is a valid instrument.

Which variation in the endogenous variable (the tax base share of immobile firms) does our excluded instrument capture? To answer this question, Fig. 5 shows the spatial distribution of the change in the tax base share of immobile firms between 1995 and 2011 and the spatial distribution of our excluded instrument. The figure suggest that our instrument captures quite well the jurisdictions with the largest increase in the tax base share of immobile firms. Lastly, we assess how well our first stage equation predicts the variation in the change in the tax base share (see Fig. A.2 in Appendix B) and find a reasonably fitting relationship.

[22] The fact that local business tax rates declined on average is an artefact from the corporate tax reform in 2008. Local business tax rates increased on average between 1995 and 2011.

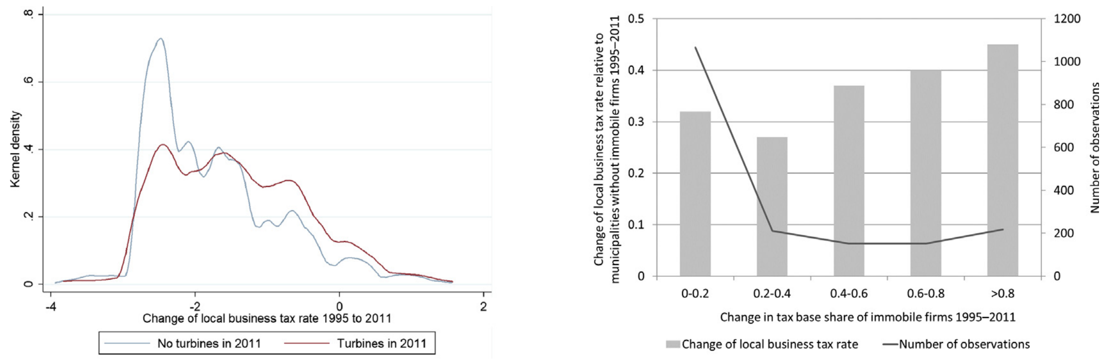

Fig. 3. Descriptive Evidence on Municipalities' Reaction to Immobile Firms. *Notes:* The left panel of Fig. 3 shows the kernel densities for the local business tax rate between 1995 and 2011 for municipalities with no turbines in 2011 and for municipalities with turbines in 2011. The right panel of Fig. 3 depicts changes in the local business tax rate for different intervals of changes in the tax base share of immobile firms between 1995 and 2011 (bars). The line shows the number of municipalities within the respective group. *Source:* Authors' calculation based on Statistik Lokal, 1995–2011, and data from the operator database, 1990–2011, and the German Weather Service.

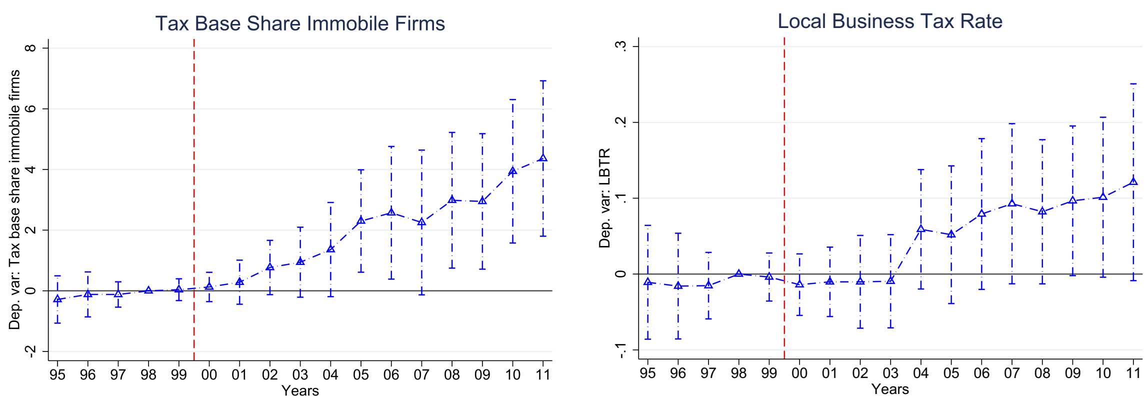

Fig. 4. Reduced Form Estimates for Triple DiD Estimator. *Notes:* Fig. 4 shows estimated coefficients and 95% confidence intervals for a reduced form regression of the tax base share of immobile firms (left hand side) and the local business tax rate (right hand side) on the triple DiD estimator. The control variables include the two simple DiD estimators interacted with year dummies and fixed effects by municipality, state-year, tax base quintile–year and agricultural land quintile–year. The triple DiD estimator is the interaction between indicator variables for high wind strength, large agricultural land area and low urban and industrial land area. The two simple DiD estimators are the interaction of the indicator variables for high wind strength and large agricultural land area, and high wind strength and low urban and industrial land area. Moreover, we include indicator variables for high wind strength and large agricultural land area, both interacted with year dummies. The indicator variables are constructed using the median as cut-off. *Source:* Authors' calculation based on Statistik Lokal, 1995–2011, and data from the operator database, 1990–2011, and the German Weather Service.

4.3. Regression Evidence

Table 2 presents results from estimating Eq. (7). In col. (1), we report the results from an OLS regression. The estimated coefficient for the tax base share of immobile firms is 0.001, which suggests that an increase in the tax base share from 0 to 1 increases the tax rate by 0.1%-points. Since the OLS estimate is likely biased downward (as discussed in Section 4.1), we next report the IV results.

First, consider the test statistics for our excluded instruments. They are comforting as the F-statistic is (except in col. 2) above 10 and the p-value for the underidentification test is less than 0.01. Moreover, the excluded instrument has the expected sign.

In the first IV specification (col. 2), the point estimate increases substantially to 0.03, but is not statistically different from zero. In col. (3), we do not control for D(Wind)·D(Agri)·REA, as its p-value in col. (2) is close to 1. This step increases the precision of our estimate of interest, but leaves it quantitatively unchanged. In col. (4), we additionally control for a set of municipality characteristics. Since these data are not available for 1995 and 1996, the sample in col. (4) covers only the years 1997–2011. The point estimate as well as the precision decreases slightly, but confidence intervals overlap with the point estimate reported in col. (3).

Since the reduced form estimates using the local business tax rate as dependent variable (see right hand side of Fig. 4) suggests that jurisdictions did not increase their tax rate right after the introduction of the subsidiaries for wind energy, col. (5) excludes the years 2000–03 and col. (6) 2000–07. While the point estimate increases in size and precision from col. (4) to col. (5), it changes little when additionally excluding 2004–07, showing that jurisdictions postponed raising tax rates only in the first years after the reform.

Based on the IV estimates in our preferred specifications shown in col. (5) and (6), our results suggest that municipalities increase the local business tax rate by 3.3%-points, or 24%, if the tax base share of immobile firms increases from 0 to 1.[23] This is not as substantial as one would expect given that wind turbines cannot relocate. One potential explanation for the relatively small effect is that governments care not only about tax revenues but also about employment, and wind turbines do not generate employment. They thus keep the tax rate relatively low to stay attractive for other firms.

[23] If we cluster standard errors by county (instead of commuting zones), the significance of results does not change. The standard errors with county clustering for the main coefficient of interest in col. (5) and (6) are 0.14 and 0.13, respectively.

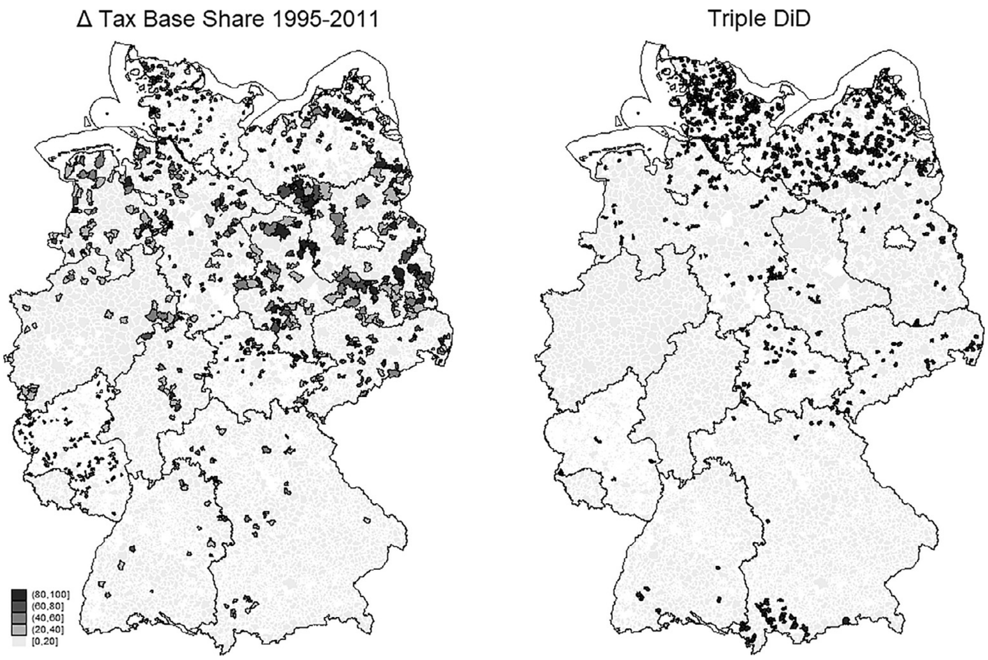

Fig. 5. Spatial Distribution of the Change of the Tax Base Share of Immobile Firms and the Excluded Instrument. *Notes:* The left hand side of Fig. 5 shows the spatial distribution of the change in the tax base share of immobile firms between 1995 and 2011 and the right hand side of Fig. 5 plots the distribution of the triple DiD instrument. *Source:* Authors' calculation based on Statistik Lokal, 1995–2011, and data from the operator database, 1990–2011, and the German Weather Service.

Table 2
Estimation Results: Municipalities' Tax Rate Choices.

Dependent Variable	Local Business Tax Rate (LBTR)					
Method	OLS	IV with Triple DiD				
Time Span	1995–2011			1997–2011	1995–1999 and 2004–2011	2008–2011
	(1)	(2)	(3)	(4)	(5)	(6)
Tax base share IF	0.001**	0.029	0.029**	0.026*	0.033**	0.034**
	(0.000)	(0.019)	(0.014)	(0.014)	(0.014)	(0.013)
D(Wind) · REA	0.073***	0.042	0.042	0.043	0.040	0.038
	(0.026)	(0.032)	(0.033)	(0.030)	(0.042)	(0.049)
D(Agr.) · REA	0.026	0.045	0.046	0.038	0.068*	0.092*
	(0.030)	(0.037)	(0.032)	(0.030)	(0.041)	(0.047)
D(Wind) ·D(Agr.) · REA	0.046	0.001				
	(0.031)	(0.044)				
$D\left(\frac{1}{U+I}\right)$ · REA	0.005	0.014	0.014	0.009	0.020	0.017
	(0.021)	(0.025)	(0.024)	(0.022)	(0.031)	(0.037)
Municipality FE	x	x	x	x	x	x
Tax base quintile–year FE	x	x	x	x	x	x
Agr. land quintile–year FE	x	x	x	x	x	x
State-year FE	x	x	x	x	x	x
Control variables				x		
Implied semi-elasticity in %	0.7	20.7	20.7	18.6	23.6	24.3
Observations	169,133	169,133	169,133	149,235	129,337	89,541
F-statistic IV: tax base		9	11	10	11	13
p-value: Underidentification		0.004	0.001	0.003	0.002	0.001
First stage for tax base:						
REA · $\frac{D(Wind) \cdot D(Agr.)}{D(U+I)}$		2.168***	2.634***	2.438***	3.474***	3.589***
		(0.743)	(0.782)	(0.754)	(1.043)	(1.179)

Notes: Table shows estimated coefficients for the impact of the tax base share of immobile firms on municipalities' tax rate choice. The dependent variable is the municipality-specific local business tax rate. IF stands for immobile firms, agr. for agricultural land area, and U + I for urban and industrial land area. In cols. (1)–(3), the sample spans 1995–2011, in col. (4) 1997–2011, in col. (5) 1995–1999 and 2004–2011 and in col. (6) 1995–1999 and 2008–2011. Column (1) reports OLS estimates, and cols. (2) to (6) IV estimates. We instrument the tax base share of immobile firms with the interaction between an indicator variable for high wind strength (above median), an indicator variable for large agricultural land area (above median), an indicator variable for 1 over urban and industrial land (above median), and a dummy for the introduction of the subsidies (REA) that is one for years after 1999. In all specifications, we control for municipality, agricultural land quintile-year, (1998) tax base quintile–year and state-year fixed effects. In col. (4) we additionally include our set of municipality-characteristics as control variables, described in Section 4.1. The implied semi-elasticity is based on an average tax rate of 14%. 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, 1995–2011, data from the operator database, 1990–2011, and the German Weather Service.

Robustness tests. To assess the sensitivity of our results, we run several robustness checks. First, we assess whether the estimated effects increase over time by estimating reduced-form regressions for three post-reform sub-periods (2000–03, 2004–07, 2008–11) separately. Table A.4 shows the results (using the same specification as in col. (3) of Table 2). The estimated effect of our instrument on the tax base share of immobile firms is three times higher in 2004–07 compared to 2000–03 and almost twice as high in 2008–11 compared to 2004–07. The estimated impact on the tax rate, in contrast, is zero for 2000–03, but positive and statistically significant in 2004–07; in 2008–11 it is almost twice as high as 2004–07. The ratios of the estimated coefficients for the local business tax rate and the tax base share of immobile firms (which equal the IV estimator) are very similar for the two later periods (as already suggested by the specifications in cols. (5) and (6) in Table 2).

Second, we account for fiscal interactions between neighboring jurisdictions.[24] To do so, we include the inverse distance–weighted average local business tax rate in jurisdictions within a 20 km (12.4 m) radius (see col. (1) of Table A.5 in Appendix B). The point estimate for the tax base share of immobile firms decreases somewhat, but confidence intervals overlap with the results of our preferred specifications. Moreover, we find—consistent with prior literature—a substantial correlation of a jurisdiction's tax rate with that of its neighbors (e.g. Devereux et al., 2008; Koh et al., 2013).[25]

Third, we assess whether the definition of the tax base share of immobile firms drives our findings: In col. (2) of Table A.5, we use the ratio of wind turbines' tax base to the observed tax base; in col. (3) the ratio of the wind turbines' tax base to the observed tax base in 1998, and in col. (4) the ratio of the number of wind turbines to the number of firms in 1998. In all three robustness checks, we find a positive and statistically significant effect.

Sources of Bias in OLS. Next, we aim to explain the substantial downward bias in the OLS estimate (of around 96%, OLS estimate of 0.001 and IV estimate of 0.029, see col. (1)–(3) in Table 2).[26] In Section 4.1, we discuss three potential reasons for bias: (i) measurement error, (ii) reverse causality and (iii) omitted variables. In addition, the estimated relationship changes over time, as the results in Table A.4 show. To address the latter aspect, we use an OLS estimator and include only 1995 and 2011 into the sample. This gives us an OLS estimate of 0.0022, which suggests that a potentially mis-specified timing is not a key driver of the bias.

We can quantify—under some simplifying assumptions—the reverse causality bias. Let α denote the impact of the tax base share on the tax rate (0.03, according to col. (3) of Table 2) and γ the impact of the tax rate on the tax base share. Then, the reverse causality bias (for a regression without control variables) is $\frac{\gamma}{1-\alpha\gamma}\frac{\sigma_\epsilon^2}{V\left(\frac{T_I}{T_O}\right)}$, where σ_ϵ^2 is the variance of the error term of our estimation equation and $V(T_I/T_O)$ the variance of the tax base share.

To assess the magnitude of reverse causality bias, we can use estimates from the literature to approximate γ. Fossen and Steiner (2018) find a tax elasticity of profits of -0.45. Applying this estimate to the components of the tax base share of immobile firms (evaluated at its mean) yields -3.1 for γ. Calculating $\frac{\sigma_\epsilon^2}{V\left(\frac{T_I}{T_O}\right)}$ from the data returns $\frac{\sigma_\epsilon^2}{V\left(\frac{T_I}{T_O}\right)} = 0.003$.[27] Taken together, the reverse causality bias is about 0.01, or about one third of the total bias. If wind turbine profits would be twice as elastic, reverse causality would explain two thirds of the downward bias.

Thus, while reverse causality explains a large share of the downward bias, it does not explain all of it. Measurement error in the tax base share and omitting the mobility of mobile firms are also important factors. Since we do not have a measure for mobile firms' mobility, we are not able to disentangle these aspects further.

Effect Heterogeneity. In Table 3 we explore whether effects vary across municipalities. First, we assess whether the effect is stronger in peripheral or non-peripheral (or core) jurisdictions, defined as jurisdictions with a larger (smaller) than median share of agricultural land in the county. The results, shown in col. (1) and (2), suggest that the effect is stronger in core jurisdictions, although these results should be interpreted with caution: when splitting the sample in this way, our instrument looses strength.

Second, we test if the relative position of a municipality within the (state-specific) fiscal equalization scheme matters (see Buettner and Holm-Hadulla, 2008, for details on German inter-municipality fiscal equalization). Col. (3) (col. (4)) shows the results when analyzing only those municipalities with a local business tax multiplier below (above) the reference multiplier, which influences fiscal capacity of a municipality. The fiscal capacity determines whether a municipality obtains money from the state via the fiscal equalization mechanism. Municipalities with a business tax multiplier below the reference multiplier potentially lose more in fiscal equalization grants than they obtain in additional revenue from an additional firm locating there. Thus, incentives to increase tax rates are stronger for these municipalities. Our results confirm this line of reasoning. We also split the sample according to the replacement rate, which is the rate at which the state government reimburses municipalities if budget needs exceed fiscal capacity. The results point to somewhat stronger effects in states with high replacement rates.[28]

Third and last, we assess in col. (6) to (10) whether the effect differs between the north, south, west and east Germany. The effect is greater in northern Germany compared to southern Germany. The difference between western and eastern Germany is small. One potential explanation for this finding is that in north Germany around 50% of the jurisdictions have a business tax rate below the reference tax rate, while in south Germany the share is only 35%.

Spending. We also investigate what jurisdictions do with the additional tax revenue raised. To assess whether municipalities increase spending or reduce the property tax, we estimate a reduced form model where we regress the natural logarithms of a) current spending per capita and b) the property tax multiplier on our excluded instruments. Our results suggest an increase in current spending (point estimate: 0.010, standard error: 0.006) that coincides with the increase in local business tax rates, while property tax rates remain unchanged (point estimate: 0.001, standard error: 0.002).

[24] To ensure a sufficiently good instrument quality and that short-run strategic behavior does not influence our results, we use in the following only the years 1995–1999 and 2008–2011.

[25] While we are aware that the neighboring tax rate is endogenous, our instrumental variable strategy is not strong enough to employ it in this context.

[26] While the OLS estimate is an average treatment effect, the IV estimate is a local average treatment effect. Given that our two instruments exploit different variation but point estimates are very similar, we believe that the local average treatment effect is a reasonable approximation of the average treatment effect. Thus, bias in the OLS estimate likely explains most of the difference to the IV estimate.

[27] In more detail, we first regress (i) the tax rate and (ii) the tax base share on the control variables. We then use the error terms from these regressions to create new variables for the parts of the tax rate and the tax base share that are unexplained by the control variables. Using these new variables for estimating Eq. (7) yields the same value for σ_ϵ^2. We calculate $V(T_I/T_O)$ from the new variable (the tax base share not explained by the control variables). In this way we can apply the standard bias formula for regressions without control variables in our setting.

[28] One potential explanation for the finding is that the fiscal equalization schemes also differ with respect to the generosity of budget needs. For example, Bavaria, which is the "richest" state in Germany, has the lowest replacement rate in our sample.

Table 3
Heterogeneity Analysis: Municipalities' Tax Rate Choice and the Tax Base Share of Immobile Firms.

Dependent variable	Local Business Tax Rate									
	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)
Tax base share IF	0.092	0.028	0.042	0.030*	0.045**	0.031*	0.052	0.029**	0.038**	0.045
	(0.068)	(0.020)	(0.027)	(0.017)	(0.021)	(0.018)	(0.036)	(0.014)	(0.017)	(0.035)
Municipality FE	x	x	x	x	x	x	x	x	x	x
Tax base quintile–year FE	x	x	x	x	x	x	x	x	x	x
Agr. land quintile–year FE	x	x	x	x	x	x	x	x	x	x
IV controls	x	x	x	x	x	x	x	x	x	x
State-year FE	x	x	x	x	x	x	x	x	x	x
Observations	45,846	43,695	24,048	54,306	26,028	63,513	31,050	58,491	69,876	19,665
F-statistic	1	8	3	10	3	9	2	11	8	2

Notes: Table shows the results of heterogeneity analyses for the impact of the share of immobile firms on municipalities' tax rate choices. The dependent variable is the municipality-specific local business tax rate. IF stands for immobile firms. In all columns we estimate instrumental variable fixed effect models using 1995–1999 and 2008–2011. The instrument is the triple DiD based on wind strength, agricultural land, 1 over urban and industrial land and a reform dummy (REA) that is one for the years after 1999. 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 (peripheral). 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, 1995–2011, the operator database, 1990–2011, and the German Weather Service.

5. Conclusion

Our paper points to the commitment problem of governments: Low tax rates attract both firms with low and high relocation costs. Governments then face an incentive to increase the tax rate on immobile firms' profits once these firms have made their location decisions. We show that local governments do indeed increase the tax rate if the average firm mobility decreases in their jurisdiction. Our results 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.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Model Extension to Public Good Provision

Assume that the government maximizes the utility of a representative household, $V(TB, G)$, which is a function of a public good, G, and the tax burden borne by households, TB. The public good is financed by tax revenue, $T = G$. We assume that capital is mobile, whereas workers and landowners are not. Thus, local households bear a share of $1-\alpha$ $(1-\beta)$ of the tax burden of immobile (mobile) firms. The government's maximization problem may be written in terms of the Lagrangean

$$\mathscr{L} = V(TB, G) + \lambda(T - G). \tag{A.1}$$

Solving this maximization problem shows that the government chooses the tax rate and public good provision so that

$$-\frac{\partial V}{\partial TB}\frac{\partial TB}{\partial \tau} = \frac{\partial V}{\partial G}\frac{\partial T}{\partial \tau}, \tag{A.2}$$

i.e. the marginal cost of public funds equals the marginal benefit of public good provision.

If the government maximizes tax revenues (as in the main part of the paper), the optimality condition is $\frac{\partial T}{\partial \tau} = 0$. Rewriting Eq. (A.2) shows that in the model with the public good,

$$\frac{\partial T}{\partial \tau} = \frac{-\frac{\partial V}{\partial TB}\frac{\partial TB}{\partial \tau}}{\frac{\partial V}{\partial G}} > 0. \tag{A.3}$$

As $T(\tau)$ is a concave function (see Eq. (2)), it follows from Eq. (A.3) that τ is lower if the government provides a public good with the tax revenues than in the main model where the government maximizes tax revenues.

Inspection of Eq. (A.3) shows that the tax rate will be lower when more of the tax incidence is on local factors, in line with the tax exporting hypothesis (see e.g. Oates, 1972).

For the immobile firms in our empirical analysis, wind turbines, capital and land are the most important factors of production, as wind energy production requires very little labor input. Thus, we may expect that the share of tax incidence borne by local factors (esp. labor) is lower for immobile firms ($\alpha > \beta$). If that is case, the incentives to increase the tax rate after the entry of an immobile firm are even stronger than in the main part of the paper.

Appendix B. Additional Tables and Figures

Figs. A.1 and A.2.
Tables A.1, A.2, A.3, A.4, A.5.

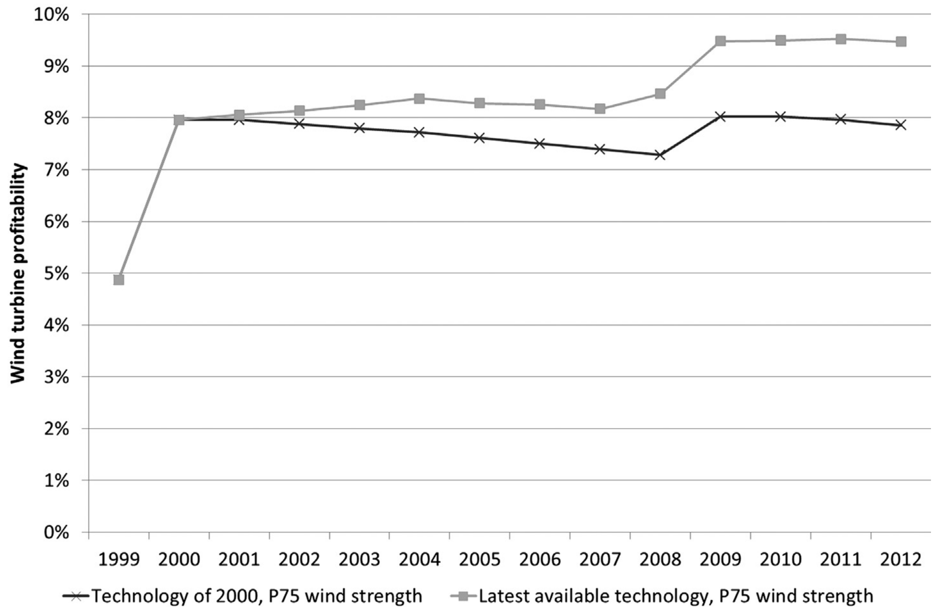

Fig. A.1. Evolution of Wind Turbine Profitability. *Notes:* Fig. A.1 depicts the evolution of expected wind turbine profitability for the 75th percentile of wind strength, using the latest available technology and the technology in 2000. We calculate the profitability of a wind turbine as expected profit over costs. We define the latest available technology as the median technology of wind turbines built in that year. For more information see Haan and Simmler (2018). Source: Authors' calculation based on data from the operator database, 1990–2011.

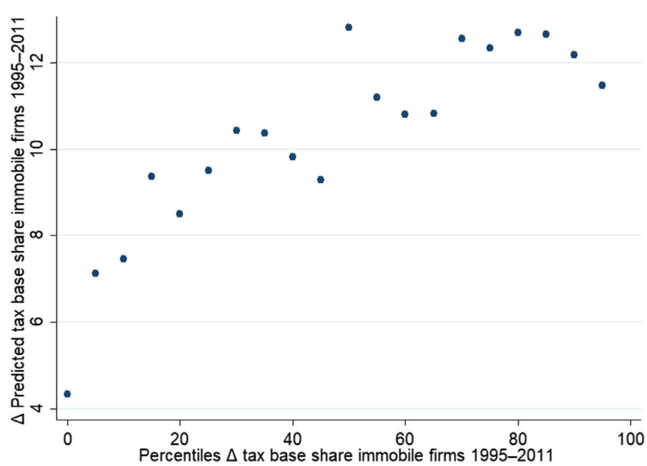

Fig. A.2. Scatter Plot of Change in the Tax Base Share of Immobile Firms. *Notes:* Fig. A.2 plots the average mean change in the first stage prediction for the tax base share of immobile firms based on the triple DiD estimator and controls for percentiles of the change in the observed tax base share of immobile firms between 1995 and 2011. Source: Authors' calculation based on Statistik Lokal, 1995–2011, and data from the operator database, 1990–2011, and the German Weather Service.

Table A.1
Predictive Power of Simulated Wind Turbine Tax Base.

Dependent Variable	Local Business Tax Base	
	All Municipalities	Without Top and Bottom 1% of Tax Base
	(1)	(2)
Simulated Tax Base of Wind Turbines	1.11**	0.88***
	(0.51)	(0.18)
Municipality FE	x	x
R^2	0.010	0.044
Observations	139,286	136,537

Notes: Table shows estimated coefficients for the simulated tax base generated by wind turbines. The dependent variable is the municipality's overall tax base. Standard errors, shown in parentheses, are robust to heteroscedasticity and clustered at the municipality level. ***, **, * indicate significance at the 1%, 5%, 10% levels. *Source:* Authors' calculations based on Statistik Lokal, 1998–2011, the operator database, 1990–2011, and the German Weather Service.

Table A.2
Variable Definitions and Sources.

Variable	Definition	Source
Local business tax rate (LBTR)	Calculated by multiplying the local business tax multiplier, which is set by the municipality in the beginning of each year, with the local business tax factor, which was 5.5% before and 3.5% after 2008. The calculation of the local business tax rate takes into account that the local business tax was deductible from its own tax base until 2008.	Statistik Lokal
Local business tax base (only available from 1998 onwards)	Tax base for the local business tax (≈ profits plus part of financing costs).	Statistik Lokal
Population	Population of the municipality.	Statistik Lokal
Agricultural land	Agricultural land in hectares.	Statistik Lokal
Wind strength	Average wind strength 10 m above ground in meters per second between 1981 and 2000.	Calculation based on square kilometer grid data from the German Weather Service using SAGA
Tax base share immobile firms (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 based on data from Operator Database, German Weather Service and financial statements database DAFNE
Neighbors' LBTR	Average local business tax rate in municipalities within a 20 km radius.	Calculation based on Statistik Lokal

Table A.3
Conditional Correlations Municipality Characteristics and Excluded Instrument.

Dependent variable (ln)	Tax base (1)	Income tax rev. (2)	Property tax rate (3)	Total revenue (4)	Current spending (5)	Pop. (6)	Urban + ind land (7)	Agric. land (8)
Control variables: State-year, tax base quintile–year, agricultural land quintile–year FE and DiD estimators								
Panel A: All jurisdictions								
Level	0.078**	0.030	−0.008	0.128**	0.106	0.057	0.035	−0.017
	(0.034)	(0.051)	(0.007)	(0.056)	(0.068)	(0.038)	(0.027)	(0.015)
Change	−0.066	0.001	−0.000	0.019	−0.001	−0.001	.	.
	(0.041)	(0.002)	(0.001)	(0.014)	(0.016)	(0.002)	.	.
Panel B: Jurisdictions in top and bottom quartile								
Level	0.169***	0.165***	0.006	0.329***	0.294***	0.170***	0.140***	−0.013
	(0.043)	(0.059)	(0.007)	(0.066)	(0.082)	(0.045)	(0.030)	(0.016)
Change	−0.073	−0.000	−0.001	0.026	0.003	−0.002	.	.
	(0.049)	(0.002)	(0.001)	(0.016)	(0.021)	(0.002)	.	.

Notes: Table shows estimated coefficients for the conditional correlation between our excluded instrument (the triple DiD estimator) and the level and the change in municipality characteristics before the introduction of wind turbine subsidies. The dependent variables are (ln) local business tax base (col. (1)), (ln) income tax revenue (col. (2)), the property tax rate (col. (3)), (ln) total tax revenue (col. (4)), (ln) municipality spending (col. (5)), (ln) population (col. (6)), (ln) urban and industrial land (col. (7)), and (ln) agricultural land (col. (8)). Urban and industrial land and agricultural land do not vary over time. In both panels the control variables include state-year, tax base quintile–year, agricultural land quintile–year FE and the parts of the DiD estimator. Panel A includes all jurisdictions and Panel B includes only jurisdictions in the top and bottom quartile of a continuously defined variant of the instrument. The sample for the levels specification includes the years 1998 and 1999 and for the changes specification only 1999. 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, 1998–1999, data from the operator database, 1990–1999, and the German Weather Service.

Table A.4
Reduced Form Results for Municipalities' Tax Rate Choice and the Tax Base Share of Immobile Firms.

Time Span	1995–2011 (1)	1995–1999 and 2000–2003 (2)	2004–2007 (3)	2008–2011 (4)
Panel A				
Dependent variable: Tax base share immobile firms				
$REA \cdot \frac{D(Wind) \cdot D(Agr.)}{D(U+I)}$	2.634***	0.955***	2.738***	4.209***
	(0.782)	(0.344)	(0.958)	(1.187)
Panel B				
Dependent variable: Local business tax rate				
$REA \cdot \frac{D(Wind) \cdot D(Agr.)}{D(U+I)}$	0.077**	0.004	0.084*	0.144***
	(0.037)	(0.024)	(0.046)	(0.050)
Municipality FE	x	x	x	x
Tax base quintile–year FE	x	x	x	x
Agr. land quintile–year FE	x	x	x	x
IV controls	x	x	x	x
State-year FE	x	x	x	x
Ratio of estimates	0.029	0.004	0.031	0.034
Observations	169,133	89,541	89,541	89,541

Notes: Table shows reduced form results using the tax base share of immobile firms (Panel A) and municipalities' tax rates (Panel B) and as dependent variable. IF stands for immobile firms, agr. for agricultural land area, and U + I for urban and industrial land area. In col. (1) we use information from 1995–2011, in col. (2) from 1995–1999 and 2000–2003, in col. (3) from 1995–1999 and 2004–2007 and in col. (4) from 1995–1999 and 2008–2012. All specifications include municipality, tax base quintile-year, agricultural land quintile–year and state-year fixed effects and the IV controls (except D(Wind) ·D(Agr.) · REA). 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, 1995–2011, the operator database, 1990–2011, and the German Weather Service.

Table A.5
Sensitivity Analysis: Municipalities' Tax Rate Choice and the Tax Base Share of Immobile Firms.

Dependent variable	Local Business Tax Rate			
	(1)	(2)	(3)	(4)
IV with Excluded Instrument: Triple DiD				
Tax base share immobile firms	0.021**			
	(0.010)			
(Tax base immobile firms)/(tax base)		0.036**		
		(0.014)		
(Tax base immobile firms)/(tax base in 1998)			0.010***	
			(0.004)	
(# turbines)/(# all firms in 1998)				0.089**
				(0.036)
Neighbors' local business tax rate	0. 870***			
	(0.047)			
Municipality FE	x	x	x	x
Tax base quintile–year FE	x	x	x	x
Agr. land quintile–year FE	x	x	x	x
IV controls	x	x	x	x
State-year FE	x	x	x	x
Observations	89,541	87,058	89,541	89,541
F-statistic	13	12	14	12

Notes: Table shows the results of sensitivity analyses for the impact of the share of immobile firms on municipalities' tax rate choices. The dependent variable is the municipality-specific local business tax rate. IF stands for immobile firms. In all columns we estimate instrumental variable fixed effect models using 1995–1999 and 2008–2011. The excluded instrument for the tax base share is the triple DiD estimator based on wind strength, agricultural land, 1 over urban and industrial land and a reform dummy (REA) that is one for years after 1999. In col. (1) we additionally control for the inverse distance–weighted tax rate of neighboring jurisdictions within a 20 km radius. In col. (2) we construct the tax base share of immobile firms based on the time-varying observed tax base. The number of observations is lower for this specification as we exclude jurisdictions with a non-positive tax base. In col. (3) we use the ratio of the tax base of immobile firms to the tax base of mobile firms (in 1998) and in col. (4) we use the ratio of the number of wind turbines to the number of firms (in 1998). All specifications include municipality, tax base quintile-year, agricultural land quintile–year and state-year fixed effects and the IV controls (without D(Wind) · D(Agr.) · REA). 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, 1995–2011, the operator database, 1990–2011, and the German Weather Service.

Appendix C. Supplementary material

An online appendix associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jpubeco.2021.104530.

References

Altshuler, R., Goodspeed, T.J., 2015. Follow the Leader? Evidence on European and US Tax Competition. Public Finance Review 43, 485–504.
Becker, J., Schneider, A., 2018. Taxation of firms with unknown mobility. Journal of Public Economic Theory 20, 202–217.
Becker, R., Henderson, J.V., 2000. Effects of air quality regulations on polluting industries. Journal of Political Economy 108, 379–421.
Brülhart, M., Jametti, M., Schmidheiny, K., 2012. Do agglomeration economies reduce the sensitivity of firm location to tax differentials? Economic Journal 122, 1069–1093.
Buettner, T., Holm-Hadulla, F., 2008. Fiscal equalization: The case of German municipalities. CESifo DICE Report 6, 16–20.
Carlsen, F., Langset, B., Rattsø, J., 2005. The relationship between firm mobility and tax level: Empirical evidence of fiscal competition between local governments. Journal of Urban Economics 58, 273–288.
Devereux, M.P., Lockwood, B., Redoano, M., 2008. Do countries compete over corporate tax rates? Journal of Public Economics 92, 1210–1235.
Devereux, M.P., Loretz, S., 2013. What do we know about corporate tax competition? National Tax Journal 66, 745–774.
Figueiredo, O., Guimarães, P., Woodward, D., 2002. Home-field advantage: location decisions of Portuguese entrepreneurs. Journal of Urban Economics 52, 341–361.
Foremny, D., Riedel, N., 2014. Business taxes and the electoral cycle. Journal of Public Economics 115, 48–61.
Fossen, F., Steiner, V., 2018. The tax-rate elasticity of local business profits. German Economic Review 19, 162–189.
Fuest, C., Peichl, A., Siegloch, S., 2018. Do higher corporate taxes reduce wages?. Micro evidence from Germany. American Economic Review 108, 393–418.
Gordon, R.H., 1992. Can capital income taxes survive in open economies? Journal of Finance 47, 1159–1180.
Haan, P., Simmler, M., 2018. Wind electricity subsidies—a windfall for landowners?. Evidence from a feed-in tariff in Germany. Journal of Public Economics 159, 16–32.
Haufler, A., Klemm, A., Schjelderup, G., 2009. Economic integration and the relationship between profit and wage taxes. Public Choice 138, 423–446.
Haupt, A., Krieger, T., 2020. The role of relocation mobility in tax and subsidy competition. Journal of Urban Economics 113, article no. 103196.
Jofre-Monseny, J., 2013. Is agglomeration taxable? Journal of Economic Geography 13, 177–201.
Keen, M., Konrad, K.A., 2013. Chapter 5 - the theory of international tax competition and coordination. In A.J. Auerbach, R. Chetty, M. Feldstein, E. Saez eds. Handbook of public economics, vol. 5 5 of Handbook of Public Economics, Elsevier, 257–328.
Koh, H.-J., Riedel, N., Böhm, T., 2013. Do governments tax agglomeration rents? Journal of Urban Economics 75, 92–106.
Marceau, N., Mongrain, S., Wilson, J.D., 2010. Why do most countries set high tax rates on capital? Journal of International Economics 80, 249–259.
Oates, W.E., 1972. Fiscal Federalism. Harcourt Brace Jovanovich.
Riedel, N., Simmler, M., 2021. Large and influential: Firm size and governments' corporate tax rate choice. Canadian Journal of Economics. forthcoming.
Ross, J.M., Carley, S., 2016. Do local governments site nuisance activities along borders? An empirical strategy applied to wind turbines. Indiana University working paper.
Slemrod, J., 2004. Are corporate tax rates, or countries, converging? Journal of Public Economics 88, 1169–1186.
Suárez Serrato, J.C., Zidar, O., 2016. Who benefits from state corporate tax cuts?. A local labor markets approach with heterogeneous firms. American Economic Review 106, 2582–2624.
Wang, Y.-Q., 1999. Commodity taxes under fiscal competition: Stackelberg equilibrium and optimality. American Economic Review 89, 974–981.
Wildasin, D.E., 2003. Fiscal competition in space and time. Journal of Public Economics 87, 2571–2588.