Gone with the wind? The impact of wind turbines on tourism demand

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Abstract

While wind energy production is relatively free from environmental externalities such as air pollution, it is frequently considered to negatively impact landscapes' visual aesthetic values, thereby inducing negative effects on tourism demand. Existing evidence for Germany indeed points towards a negative relationship between tourism demand and wind turbine construction. However, the existing studies primarily rely on interview data and simple bivariate statistics. In contrast, we make use of secondary statistics on tourism and wind turbine locations at the level of German municipalities. Using spatial panel regression techniques, we confirm a negative relation between wind turbines around municipalities and tourism demand for municipalities not located near the coast. In the latter regions, the relation between wind turbines and tourism demand is more complex.

Keywords: wind turbines, tourism, Germany, externality, spatial panel regression
JEL-Classifications: L83, Q42, Q48

1 Introduction

The quest for green energy has led to a massive growth of renewable energy production all over the world. As different sorts of renewable resources are employed, green energy production also varies with respect to its embeddedness into landscapes. For instance, solar panels are frequently hidden on roofs and biogas production facilities are relatively well fitted in agricultural landscapes. In contrast, wind turbines are clearly visible and have a very distinctive design. Moreover, they produce a range of light and visual emissions.

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For instance, in Germany, wind turbines are required to be equipped with a light signal identifying them as obstacle for flight activities when exceeding 100 m of height, which they frequently exceed (BlmSchG, 2013). When wind turbines are installed in large parks, blinking red signals become clearly visible at night time. In addition, they are characterized by a very particular visual appearance. "*[W]hile modern technologies can more or less successfully mitigate other environmental impacts, such as noise and danger to bird populations [...], this is not the case with the visual impact*" (Molnarova et al., 2012, p. 269).

The visual impact of wind turbines on landscapes increasingly matters due to the growing importance of visual consumption and the role of aesthetic judgement of landscapes (Urry, 1992). Not surprisingly, the visual dimension is therefore among the most important predictors of a tourist destination image (MacKay and Fesenmaier, 1997). The growing importance of the aesthetic judgement of landscapes relates to the emergence of the "*romantic tourist gaze*" (Urry, 1990) in general and "green tourism" in particular. Green tourism emphasizes "*small scaleness, local control, modest developments using local labour, buildings in 'traditional' style, the emphasis on personal contact with visitors, the eating of local produce, encouraging the understanding of the area's ecology and heritage, and the setting of limits to the growth of such developments as to avoid a tourist mono-industry*" (Urry, 1992, p. 12-13).

Wind turbines may conflict with such a view, as they commit a "*technological landscape guilt*" (Thayer, 1990, p. 2) inasmuch as they are inappropriate and do not fit in traditional close-to-nature landscapes (Thayer, 1990; Hoppe-Klipper and Steinhäuser, 2002). In particular close-to-nature or natural forms and configurations are perceived as enriching landscapes while the technical design of wind turbines and their non-natural materials may attract negative attention (Peters et al., 2009). Moreover, wind turbines may be perceived as being historically inappropriate, which contradicts the desire for consistency between the natural (original) and artificial environment. Urry (1992) argued that today's tourists are likely to associate rural landscapes with historical periods. The technological, modern, and planned appearance of wind turbines may therefore strongly conflict with tourists' expectations of historic rural surroundings. This conflict remains even when viewing modern wind turbines as advanced versions of historic wind mills: Pasqualetti et al. (2002) pointed out that current wind turbines "*are only distant cousins to the familiar windmills of the Netherlands with which many are comfortable*" (p. 8).

1.1 Wind turbines and landscapes' attractiveness

There exists substantial research evaluating the impact of wind turbines on landscape appearance. While many studies find a generally negative impact, they also identify significant heterogeneity in individuals' assessment of wind turbine impact on landscapes (Landry et al., 2012; Gee, 2010; Molnarova et al., 2012; Jobert et al., 2007). Among others, this heterogeneity concerns individuals' general attitude towards technology and renewable energies (Bayerl, 2005; Molnarova et al., 2012). Differences also seem to exist between local residents and visitors/tourists, although the literature has not yet unanimously clarified which of the two groups is less repelled by wind turbines (Devlin, 2005; Frantál and Kunc, 2011; Megerle, 2013). Generally, wind turbines do not seem to be plagued by the not-in-my-backyard (NIMBY) behavior. For instance, Wolsink (2000) and Devine-Wright (2005) did not find evidence for pronounced NIMBY behavior, as they do not observe that people reject wind turbine installation close to their homes while favoring the general enlargement of wind power utilization. In contrast, visitors and tourists in search for recreation prefer untamed and less artificial landscapes (Devlin, 2005; Hoppe-Klipper and Steinhäuser, 2002).

In addition to individuals' characteristics, the type of landscape where wind turbines are installed matters as well. Molnarova et al. (2012) reported that the surveyed individuals were particularly sensitive concerning the placement of wind turbines in "*landscapes of high aesthetic quality*" (Molnarova et al., 2012, p. 269). In contrast, when placed in rather unattractive landscapes wind turbines are perceived as less problematic. Place attachment also plays a role because negative visual effects of wind turbines are reported to be magnified when individuals attach strong identity values to locations (Strazzera et al., 2012). When installed in large parks, wind turbines also induce stronger negative effects on landscape attractiveness than when positioned in an isolated manner (Devine-Wright, 2005). The magnitude of negative effects is moreover increased with larger numbers of daily encounters, at least up to a level of five encounters (Ladenburg and Dahlgaard, 2012).

1.2 Wind turbines and tourism

The clear prediction of the negative impact of wind turbines on landscape attractiveness makes it plausible to also expect a negative relation between wind turbines and the success of places in attracting tourists. Interestingly, the empirical picture of the matter is less clear. For off-shore wind turbines, Landry et al. (2012), Gee (2010), and Lilley et al. (2010) reported only a weakly negative effect on landscape attractiveness as perceived by tourists. For instance, Lilley et al. (2010) found that just about one-quarter of the surveyed tourists considered chosing another beach if offshore wind turbines were installed less than 10 km away from the coast. This share diminishes significantly with increasing distances between turbines and the coast. On the basis of a quantitative empirical estimation using GIS techniques, Riddington et al. (2010) estimates a weakly negative relation between wind farms and tourist expenditure for Scotland. Eltham et al. (2008) reported that two studies conducted for Wales and Scotland (NFO System Three, 2002, 2003) found "*contradictory responses; a proportion of visitors reported that a wind farm would put them off visiting a location while others suggested a wind farm could actually be used as a tourist destination to bring more visitors into an area*" (Eltham et al., 2008, p. 24). Another survey by MORI Scotland similarly reveals no adverse effects of wind turbines on tourism (MORI Scotland, 2002). Frantál and Kunc (2011) surveyed tourists in the Czech Republic, and their results clearly show that wind turbines "*are less disturbing than other industrial or infrastructural constructions*" (Frantál and Kunc, 2011, p. 514). While the attractiveness of landscapes is highly important to tourists, only a very small share (6%) oppose the presence of wind turbines in places they visit. Interestingly, wind turbines may actually serve as points of interest at times, as almost 66 percent of the surveyed individuals are found to be interested in visiting wind turbines when information centers are available as well.

1.3 Empirical evidence for Germany

The present paper focuses on Germany, which is a very interesting case for studying the effect of wind turbines on tourism. The exploitation of wind energy has seen rapid growth in many countries. However, few countries have experienced growth of renewable energy production like Germany. Since the 1990s the construction of onshore wind turbines rose from 1.652 in 1993 to 24.458 in 2014 (EnergyMap.info, 2014). This led to an increase in wind energy's share in total energy production from close to nothing to almost eight percent in 2013 (BDEW, 2014). Alongside the similarly rapid expansion of biogas and photovoltaic energy production, this growth substantially helped to increase sustainable energy production in Germany, which in 2014 amounted to about 24 percent of total energy production (BDEW, 2014). Hence, the German density of wind turbines is matched by few other countries in the world and it is continuously growing.

Despite the relevance of the tourism and wind energy industry for many German regions, few studies empirically analyze the relation between tourism and wind turbines for this country. The following briefly presents the four most prominent studies:

SOKO Institut (2009) Among the first studies dealing with this issue for Germany is the "*Studien für Windkraft und Tourismus*" (*studies on wind energy and tourism*). These surveys have been conducted between the years 2003 and 2009 by Henry Puhe. About 2,000 individuals over the age of 14 were interviewed. About ten percent of these people found that wind turbines negatively interfere with the appearance of landscapes. About fifteen percent, moreover, indicate that they will avoid places with wind turbines for future vacations.

Institut für Regionalmanagement (2012) (IFR) On behalf of the nature park "*Naturpark Nordeifel*", the institute surveyed almost 1,400 park visitors with respect to their opinions about wind turbines in the year 2012. Similar to SOKO Institut (2009), about twelve percent found wind turbines to negatively impact the visual appearance of landscapes. However, in this case, only six percent stated that they will avoid regions with wind turbines when choosing their destination in the future.

CenTouris (2012) The Center for Market-Oriented Tourism Research at the University of Passau (CenTouris) conducted an online survey in 2012. In total, 977 survey individuals (aged between 18 and 65 years) responded on their views regarding wind turbines in average mountain regions. The percentage of persons stating that wind turbines negatively impact landscape appearance was found to be twice as high as in the studies presented above (31 percent). A similar result applies to the share of individuals planning to avoid regions with wind turbines, which amounts to 26 percent.

NIT (2014) The largest and most recent survey has been organized by the *NIT Institut für Tourismus- und Bäderforschung in Nordeuropa GmbH* in 2014. In the study, more than 7,000 individuals (at least 14 years old) from all over Germany participated in face-to-face interviews on vacation and travel activities. About 7 percent of the interviewed persons perceived wind turbines to be annoying in tourist destinations. The study reveals some interesting heterogeneity with respect to the location of tourist destinations. The share of individuals viewing wind turbines as annoying is higher for regions in the north of Germany (8.1 percent) than for all of Germany (7.1 percent). However, with respect to the most northern federal state (Schleswig-Holstein), which is also characterized by the highest density of wind turbines, the share is only 6.3 percent. Just about one percent of the interviewed individuals plan to avoid regions with wind turbines, whereby this share varies little between destinations in Germany. In a number of additional in-depth interviews, the authors also confirmed that the annoyance with wind turbines increases with growing densities of turbines, while it decreases with larger distances.

The empirical evidence for Germany seems to confirm a negative effect of wind turbines on tourism demand. The magnitude of the effect is also relatively similar in three of the studies (SOKO Institut, 2009; Institut für Regionalmanagement, 2012; NIT, 2014) with 7 to 12 percent of individuals being annoyed by wind turbines. The study by CenTouris (2012) appears to be an outlier in that respect. However, significant variance exists in the reported avoidance intentions. The share of individuals planning on avoiding destinations with wind turbines varies between one percent (NIT, 2014), 15 percent (SOKO Institut, 2009), and 26 percent (Institut für Regionalmanagement, 2012), respectively.

The present paper seeks to provide new and comprehensive insight into the relation between wind turbines and tourism demand. In order to achieve that, we employ an alternative research design, which overcomes shortcomings in the existing literature that are discussed in the following.

2 Methodology

2.1 A new data set

All of the presented studies for Germany (and most for other countries as well) rely on primary data collection by means of questionnaires or interviews. Such an empirical approach is generally useful to obtain detailed and context-specific insight. There are a number of disadvantages when seeking to identify general relationships between variables that apply to the impact of wind turbines on tourism. First, this concerns the representativeness of the interviewed group of individuals. For example, NIT (2014) claims to be representative of the German-speaking population that is 14-years of age or older in Germany. In contrast, the individuals interviewed by Institut für Regionalmanagement (2012) are representative of tourists visiting the Eifel region. Hence, both study results are based on different underlying populations making valid comparisons or generalizations difficult if not impossible. Another problem found in the studies is the type of questions being asked. For instance, NIT (2014) asks individuals "*which of the following aspects [a.o. wind turbines] make you to not want to visit this region again?*" [1]. Accordingly, the studies ask for a hypothetical reaction, implying that an interviewed individual's actual future actions remain unobserved and may potentially even oppose their ex-ante answer to this question. Third, all of these studies do not make use of multivariate analysis implying that their bivariate evaluations are more likely to be subject to issues of spurious correlation. Fourth, most of the existing studies primarily conduct case studies of specific regions, which are of varying representativeness for Germany as a whole.

In contrast to these studies, we do not rely on primary data collection. Fortunately, we can draw on secondary data sources on wind turbines and regional tourism activities for a number of consecutive years. Data on wind turbines is obtained from *EnergyMap*, which is a volunteer initiative by the Deutschen Gesellschaft für Sonnenenergie e.V. (*Association of Solar Energy*). The latter is an association for users and consumers of renewable energy in Germany. The association collects data on renewable energy production because of the German Renewable Energy Sources Act (EEG), which enforces compulsory registration of electricity infeed by network operators. However, network operators exclusively provide

[1] Translated by the author. The original question in German states: "*Welche dieser Dinge führen dazu, dass Sie diese Region nicht wieder besuchen möchten?*"

data on their own websites with each using different data formats. EnergyMap collects this data from all operators and provides some basic data cleaning. Only a share of operators reports the exact location of installment. EngeryMap therefore adds missing coordinates based on centroids of the respective regions (accuracy of 3 km). The final data set includes information on all 23,095 (as of the end of 2012) German wind turbine locations, date of construction, nominal electric capacities, and average yearly capacities (www.EnergyMap.info).

The second data set concerns tourist activities for the years 2008-2012. It was obtained from the national statistic agency DESTATIS. The data includes information on tourist arrivals, available beds, accommodation facilities, and the numbers of inhabitants for each of the more than 11,000 German municipalities (LAU 2 level). Municipalities (or communities) are the lowest level of territorial division in Germany representing the lowest level of spatial delineation for which (some) statistical data are available. On average about 6,800 people live within a municipality in Germany. Their sizes and structures differ considerably. For example, the federal state of Berlin is a single municipality with more than 3.4 million inhabitants. This must be accounted for in the empirical assessment.

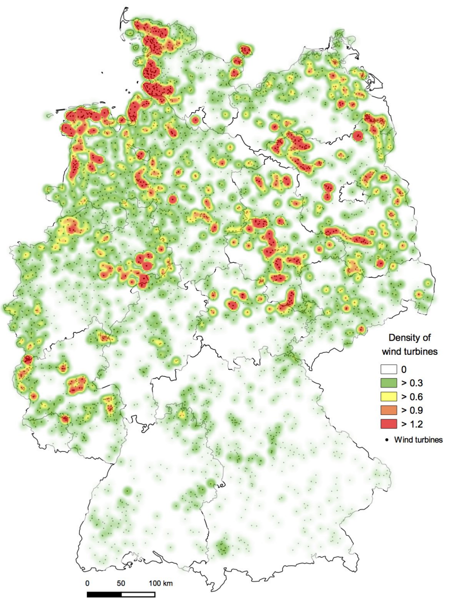

Figure 1: Wind turbines 2012

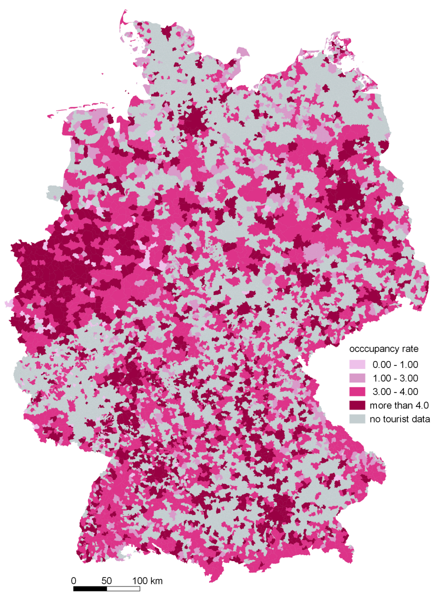

Figure 2: Occupancy rate in 2012

Figure 1 illustrates that wind turbines are geographically concentrated in the northern parts of Germany. The highest concentration can be found at the North Sea coast in the federal states of Schleswig-Holstein and Lower Saxony. In Southern Germany (i.e., in the federal states of Baden Württemberg and Bavaria) the construction of wind turbines is clearly under-developed. Figure 3 visualizes the growth processes of wind turbine installments in Germany between 1984 and 2012. During this explosive growth, which has somewhat declined in recent years, the number of wind turbines increased from close to zero in 1984 to 23,095 at the end of 2012, with an average yearly growth rate of 41.2 percent.

The combined data set allows for circumventing many of the issues troubling existing studies for Germany. For instance, the data covers all municipalities in Germany and is based on actual touristic activities. Moreover, we can establish objective (geographical distance) relations between tourists and wind turbines. However, the data also has a number of issues that need to be discussed. First, the delineation of municipalities has been relatively unstable, as they have been frequently split or merged during these five years. Unfortunately, conversion concordances are not available in all instances. To address this, we used a simple algorithm to merge the annual data into a consistent panel. We defined the 2012 delineation as a basis for constructing a panel data set. In order to match it to the delineation of the year 2011, we randomly place 100 points into each 2012 municipality polygon. Next, we compare these points' distributions across the municipalities with a point-in-polygon operation as defined in 2011. We match a 2012 municipality to a 2011 municipality, whenever at least 95 percent of its 100 random points are found to be placed within a single 2011 municipality. In case of smaller shares or in the rare event that two (or more) 2012 municipality points are being assigned to a single 2011 municipality, we match (by splitting or merging) the 2011 municipalities according to these shares. The 95 percent threshold is chosen due to some blurriness in the shapefiles provided by the German Federal Agency for Cartography and Geodesy.

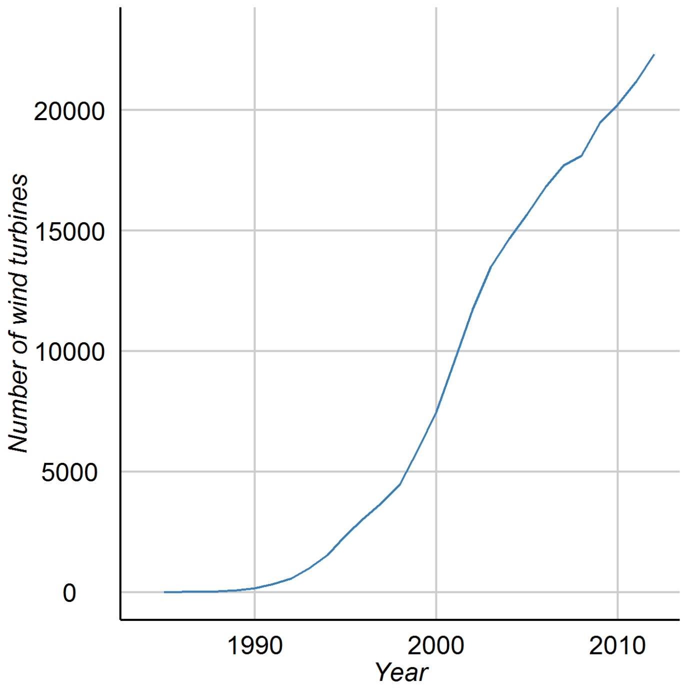

Figure 3: Cumulative growth of wind turbines

The procedure is subsequently applied to the data of the years 2008, 2009, and 2010[2].

The second shortcoming of the data on tourism concerns its scope of coverage. Unfortunately, accommodation facilities with less than 10 beds are not required to report the number of guest arrivals. The same applies to private holiday flats. Therefore, our results may therefore not apply to municipalities in which small facilities and private holiday apartments are the dominant form of tourist accommodation.

Given that we have the geographical coordinates and the year of construction of all wind turbines, they are easily matched to the data on tourist activities with spatial point-in-polygon operations. The final dataset represents balanced panel data for 11,479 municipalities and five years covering tourism and wind turbines.

[2]We checked the algorithm's accuracy by comparing its results to those obtained when manually arranging the data according to official changes in the municipalities' delineation. The results turned out to be extremely similar.

2.2 Variables

In order to investigate the impact of wind turbines on tourism, we chose the occupancy rate (OCCUPANCY) as the dependent variable. It is defined by the ratio between the number of guest (tourist) arrivals and the number of guest beds (BEDS) existing in a municipality. Alternatively, one could have used the ratio between the number of overnight stays and guest beds. However, the number of guest arrivals offers the advantage of being independent of vacation lengths. In other words, it accounts for potential inter-regional differences in the frequency of short- and long-term stays. Using the ratio between arrivals and guest beds also controls for variations in municipalities' potentials to accommodate tourists and their (long-term) touristic attractiveness. Figure 2 provides a graphical representation of the distribution of the occupancy rate.

Employing the occupancy rate as dependent variable requires that we limit our estimations to municipalities with a positive number of guest beds. The large number of zero values in the dependent variable might otherwise bias our results. Removing all municipalities without guest beds leaves a sample of 3,228 municipalities.

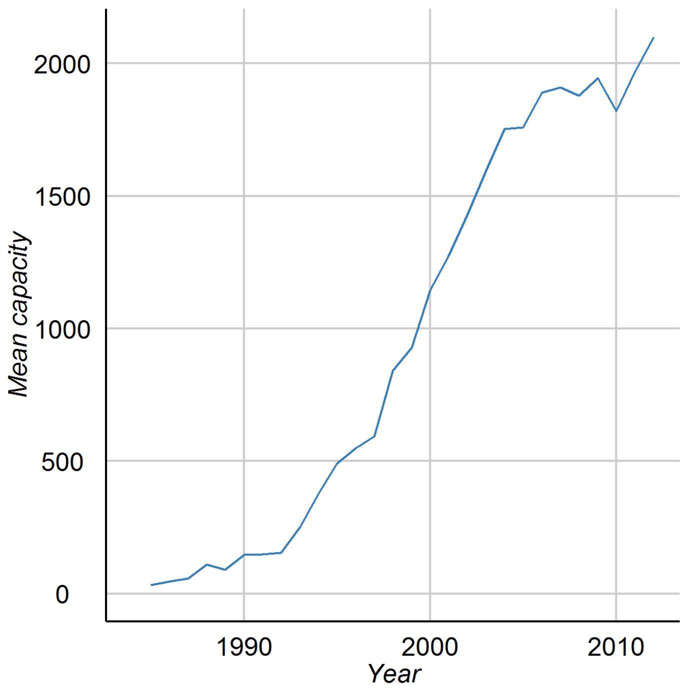

Figure 4: Development of new wind turbines' mean capacity in Germany

The number of accommodation facilities (FACILITIES) is an alternative measure of municipalities' capacities to host tourists and is therefore added as explanatory variable. The number of inhabitants (POPULATION) serves as a control variable for municipalities' sizes and degrees of urbanization.

We are particularly interested in the variables representing the number of wind turbines located in a municipality (WT). Using point-in-polygon methods, we sum the number of wind turbines located in a particular municipality that exist in a specific year.

Wind turbines have grown considerably in size and capacity. Figure 4 illustrates the development of the new wind turbines' mean capacities in Germany constructed per year. The clearly visible increase in capacity goes hand in hand with the growing sizes of turbines' rotors and hub heights. For instance, while most wind turbines' rotor diameters were less than 16 m in the beginning of the 1990s, the common wind turbine installed today has a diameter of at least 90 m (BWE, 2014). It seems plausible that (larger) wind turbines have a stronger effect on the aesthetic image of landscapes and therefore on regional tourism demand. Therefore, we therefore consider the total capacity of wind turbines located in a municipality (CAPACITY.WT) as an explanatory variable, which approximates the number of wind turbines weighted by their sizes.

German municipalities are relatively small with an average area corresponding to a circle with slightly more than a 3 km radius. Few municipalities exceed a 10-km radius. Hence, tourists are likely to experience (visually or when exploring the surroundings) wind turbines outside the municipality in which they are staying. In order to maximize wind conditions, wind turbines are located in open spaces implying that they are frequently visible from large distances. The University of Newcastle (2002) finds that for the UK, a casual observer might take notice of wind parks up to a distance of 10-15 km, while details of individual wind turbines remain unobserved at distances larger than 8 km. For the Netherlands, PBL (2014) report large wind turbines (> 100 m in height) to be visible from 35 km distances under perfect weather conditions. In the case of average conditions, most wind turbines remain invisible from distances larger than 10 km.To capture the effects related to wind turbines in the geographical (and visible) neighborhoods of municipalities, we take their wider surroundings into account with a number of variables. In correspondence with the above literature, we sum the numbers of wind turbines within a 10 km radius to the municipality's geographic center (WT.VICINITY) minus those located directly within the focal municipality (ring area). The same is done for wind turbines' capacities (CAPACITY.VICINITY).[3] In an alternative set-up, we double that radius to 20 km and define WT.VICINITY and CAPACITY.VICINITY with respect to this distance. The 20 km distance captures all neighboring municipalities and is likely to include tourists' most common hiking and bicycling destinations. In order to explore the relation between wind turbines within municipalities and those in their vicinity in more detail, we create two more variables representing the ratio between WT and WT.VICINITY as well as between CAPACITY and CAPACITY.VICINITY. The resulting variables are denoted as WT.RATIO.VICINITY and CAPACITY.RATIO.VICINITY.

The year of the most recent construction of a wind turbine (YEAR.LAST.WT) in a municipality is primarily added for methodological reasons. The operating life of most wind turbines exceeds 20 years. Accordingly, we rarely observe a decreasing number of wind turbines or wind turbine capacities in municipalities. Econometrically it implies that these variables are characterized by a positive trend (i.e., they are either stable or grow over time). The same applies to the values of YEAR.LAST.WT. Hence, potential correlations between the long-term trend growth of wind turbines and guest arrivals will be captured by this variable. The descriptives and the correlations of all variables are shown in Table 4 and Table 5.

2.3 Model specification

We do not know how long it takes for newly constructed wind turbines to impact tourist arrivals. Among others, the time lag depends on the time period tourists need to plan their vacations and on the employed mode of information collection. Zalatan (1996) found that on average US travelers visiting Mexico plan their vacation just 10.3 weeks and their trips in Europe 15.5 weeks in advance. It seems unlikely that these times are significantly longer for the average tourist visiting Germany because most tourists are Germans and domestic vacations usually require less extensive decision-making processes than international destinations (Bargeman and van der Poel, 2006). Accordingly, in the case of wind turbines being relevant for tourists' destination choices, wind turbines constructed in year t are likely to take effect on tourist demand in the same year. However, this requires tourists planning their vacations being aware of newly constructed wind turbines in their

[3] In a similar setting, Riddington et al. (2010) uses a cut-off distance of 15 km.

destinations. Given the availability of webcams, online newspapers, Google Street View, and similar options for gathering virtual impressions, such cannot be ruled out. However, in 2011 only 49 percent of German tourists made use of the Internet in the planning of their vacation (BMWi, 2013). More than half of all tourists are therefore unlikely to receive up-to-date information on their destination and the wind turbines potentially being constructed there. For these tourists, the primary source of information on (new) wind turbines is their own observations, which implies that they have to be in their destination municipality in order to observe them. Many tourists are unlikely to visit the same destination twice a year. Rather, they evaluate their destination choice based on previous years' experiences. Given the unknown length of this time lag, we estimate our models in three scenarios: The first one, wind turbine numbers in year t are related to the occupancy rate in t. In the second, we impose a time lag of one year meaning that the tourist numbers in year $t+1$ are related to the number of wind turbines in t. In the third, the time lag is increased to two years. This time lag applies to all variables based on wind turbine data.

The balanced panel nature of our data set allows for employing panel regression techniques. More precisely, we use a fixed effects regression because it is more appropriate when the sample essentially represents the full population of cases. The reason for this is that municipality-specific effects are better captured by fixed effects, as each municipality is not sampled randomly but represents itself (Beenstock and Felsenstein, 2007; Elhorst, 2012). In addition, this model allows controlling for unobserved time-invariant municipality-specific characteristics, reducing the danger of omitted variable biases (Cameron and Trivedi, 2005). Given that our observations are (very small) spatial units, spatial dependencies are most likely to exist. To test for these, we specify a number of spatial weight matrices[4]. The 20-km distance matrix turned out to work best as an approximation of spatial dependencies. Hence, we model spatial relations to exist between municipalities within a 20-km radius of its geographical centroid. Using the according weight matrix, a joint conditional LM test confirms the presence of spatially correlated errors in the panel model (Baltagi et al., 2007). Therefore, we rely on spatial panel regression techniques with fixed-effects (Elhorst, 2012). A spatial Hausman test confirms this choice.[5] We also test for spatial dependencies in the dependent variable and include spatial lags of the explanatory variables. However, the spatial dependencies remain in the regression's error term, which we address using a spatial panel error model (Millo and Piras, 2012). In a common fashion, we add four year dummies to the model in order to control for year-specific global effects. Given the skewed distribution of some variables and in order to allow for an easier interpretation, we log transform all variables with the exception of WT.RATIO.VICINITY and CAPACITY.RATIO.VICINITY. These variables are not transformed because they represent the ratio between variables also included in the model and a log-transformation would induce multicolinearity.

As indicated above, the use of fixed-effects regressions is advantageous because it allows controlling for time-invariant municipality-specific effects, which is crucial given the limited information on general conditions in municipalities and their touristic attractiveness in the data. However, we suspect that the relationship between wind turbines and tourist demand may differ between the coastal parts and the inland of Germany. There are at least two reason for this. First, wind turbines in the inland are a rather new de-

[4]The following definitions for spatial relations have been used: direct neighbors, 5-nearest neighbors, 20 km distance, 30 km distance, and 50 km distance.

[5]Hausman test for spatial models, $\chi^2 = 1364.28$, $df = 10$, $p - value < 2.2e - 16$.

velopment, while they have already existed for a longer time period in the coastal areas, giving tourists and hoteliers in the coastal municipalities much more time to adapt to their presence. Second, the density of wind turbines is much higher near the coast than in most inland municipalities, and it has been shown that wind turbines especially reduce the visual attractiveness of landscapes when constructed in great numbers (Devine-Wright, 2005). Therefore, we repeat our estimations on the basis of two subsamples. One exclusively includes municipalities near the shore line and the other only municipalities in the inland.

3 Results

Table 1 shows the regression results using the full set of 3,228 municipalities for the three different scenarios (no time lag, a time lag of one year, and a time lag of two years). Moreover, the models are run separately for the wind turbine and wind turbine capacity based variables as well as for the definition of municipality vicinity (10 and 20 km). The first thing to notice is that with the exception of some year dummies, almost none of the control variables (POPULATION, FACILITIES, LAST.YEAR.WT) gains significance in any of the models. Only the negative coefficient of YEAR.LAST.WT is weakly significant in one of the models for the two year time lag scenario. Accordingly, annual changes in the occupancy rates are relatively unrelated to these factors. This also shows in the very low R^2 of just 0.01. This does not come as a big surprise. The most important determinant of tourist arrivals is the number of available guest beds, which are already accounted for in the occupancy rate.[6] However, it might also suggest that the models can still be improved. We do not observe conflicting results for the models assuming different time lags. The models assuming no lag or a one-year time lag deliver the most significant variables and are therefore in the center of the following presentation. While it is beyond the scope of the present paper, future research will clearly need to investigate the time lag issue in more detail and explore whether certain time lag structures fit to the behavior of specific groups of tourists.

The results confirm the generally increasing occupancy rates in 2011 and 2012, which shows in the significantly positive coefficients of the 2011 and 2012 year dummies. With respect to the variables approximating the presence of wind turbines in municipalities (WT, WT.VICINITY, WT.RATIO.VICINITY) and their capacities (CAPACITY, CAPACITY.VICINITY, CAPACITY.RATIO.VICINITY), most of these turn out to be insignificant. The exception is CAPACITY.VICINITY, which gains a significantly negative coefficient, when representing the capacity installed within a 10 km radius of municipalities' centroids and assuming no time lag or a time lag of one year. It also becomes negative significant for the 20 km ring and an assumed two-year time lag.

Hence, the results clearly suggest that the construction of wind turbines within a municipality does not relate to the occupancy rate of guest beds in municipalities. However, a negative relationship appears to exist between the occupancy rate of guest beds in a municipality and the installed wind turbine capacity with a 10 (and 20) km ring surrounding the municipality's centroid (excluding the wind turbines within the municipality itself).

We pointed out above that differences in the relationship between wind turbines and tourist demand might exist between coastal areas and the inland of Germany. Table

[6] When the dependent variable is the number of tourist arrivals and the number of guest beds is added as explanatory variable the R^2 of the regression increases to 0.42.

No time lag	Wind turbines 10 km	Capacity 10 km	Wind turbines 20 km	Capacity 20 km
POPULATION	-0.001 (-0.138)	-0.001 (-0.156)	-0.001 (-0.247)	-0.001 (-0.13)
FACILITIES	-0.02 (-0.481)	-0.019 (-0.475)	-0.019 (-0.466)	-0.02 (-0.495)
Y2009	-0.004 (-0.361)	-0.004 (-0.36)	-0.006 (-0.565)	-0.005 (-0.449)
Y2010	-0.014 (-1.263)	-0.014 (-1.278)	-0.018 (-1.621)	-0.015 (-1.407)
Y2011	0.028** (2.494)	0.028** (2.55)	0.02* (1.719)	0.025** (2.28)
Y2012	0.123*** (10.221)	0.123*** (10.54)	0.111*** (8.49)	0.119*** (9.997)
YEAR.LAST.WT	0.004 (0.492)	-0.003 (-0.348)	0.004 (0.568)	-0.002 (-0.303)
WT	0.009 (0.205)		-0.001 (-0.022)	
CAPACITY		0.012 (1.19)		0.011 (1.078)
WT.VICINITY	-0.035 (-1.494)		0.019 (0.937)	
WT.RATIO.VICINITY	-0.003 (-0.607)		-0.003 (-0.255)	
CAPACITY.VICINITY		-0.012** (-2.411)		-0.004 (-0.639)
CAPACITY.RATIO.VICINITY		0 (-1.019)		0 (-0.764)
R^2	0.01	0.01	0.01	0.01
Rho	-0.019	-0.019	-0.02	-0.02
n / T / N	3228 / 5 / 16140	3228 / 5 / 16140	3228 / 5 / 16140	3228 / 5 / 16140

One year time lag	Wind turbines 10 km	Capacity 10 km	Wind turbines 20 km	Capacity 20 km
POPULATION	-0.001 (-0.146)	-0.001 (-0.107)	-0.001 (-0.2)	-0.001 (-0.172)
FACILITIES	-0.021 (-0.523)	-0.021 (-0.513)	-0.02 (-0.5)	-0.02 (-0.485)
Y2009	-0.005 (-0.423)	-0.005 (-0.423)	-0.005 (-0.44)	-0.005 (-0.435)
Y2010	-0.014 (-1.324)	-0.014 (-1.311)	-0.015 (-1.404)	-0.015 (-1.39)
Y2011	0.027** (2.466)	0.027** (2.5)	0.025** (2.341)	0.026** (2.364)
Y2012	0.122*** (10.587)	0.123*** (10.616)	0.119*** (10.254)	0.12*** (10.332)
YEAR.LAST.WT	-0.011 (-0.532)	-0.009 (-0.255)	-0.012 (-0.565)	-0.005 (-0.132)
WT	0.003 (0.116)		0.002 (0.094)	
CAPACITY		0.002 (0.109)		-0.002 (-0.147)
WT.VICINITY	-0.015 (-1.354)		0.003 (0.4)	
WT.RATIO.VICINITY	-0.001 (-0.219)		-0.001 (-0.291)	
CAPACITY.VICINITY		-0.011* (-1.733)		0.001 (0.164)
CAPACITY.RATIO.VICINITY		0 (-0.735)		0 (-0.713)
R^2	0.01	0.01	0.01	0.01
Rho	-0.019	-0.019	-0.019	-0.018
n / T / N	3228 / 5 / 16140	3228 / 5 / 16140	3228 / 5 / 16140	3228 / 5 / 16140

Two years time lag	Wind turbines 10 km	Capacity 10 km	Wind turbines 20 km	Capacity 20 km
POPULATION	-0.001 (-0.152)	-0.001 (-0.182)	-0.001 (-0.183)	-0.001 (-0.161)
FACILITIES	-0.02 (-0.486)	-0.02 (-0.49)	-0.02 (-0.499)	-0.021 (-0.519)
Y2009	-0.004 (-0.367)	-0.004 (-0.361)	-0.004 (-0.392)	-0.004 (-0.342)
Y2010	-0.014 (-1.33)	-0.014 (-1.311)	-0.015 (-1.352)	-0.014 (-1.289)
Y2011	0.027** (2.475)	0.027** (2.539)	0.026** (2.439)	0.028*** (2.578)
Y2012	0.121*** (10.599)	0.122*** (10.656)	0.121*** (10.525)	0.123*** (10.718)
YEAR.LAST.WT	-0.038 (-1.553)	-0.034 (-0.9)	-0.043* (-1.777)	-0.028 (-0.737)
WT	0.013 (0.572)		0.029 (1.424)	
CAPACITY		0.013 (0.672)		0.003 (0.151)
WT.VICINITY	0.001 (0.049)		-0.001 (-0.073)	
WT.RATIO.VICINITY	0.002 (0.985)		-0.002 (-0.416)	
CAPACITY.VICINITY		-0.008 (-1.097)		-0.011** (-2.07)
CAPACITY.RATIO.VICINITY		0 (-1.429)		0 (-0.515)
R2	0.01	0.01	0.01	0.01
Rho	-0.018	-0.02	-0.019	-0.019
n / T / N	3228 / 5 / 16140	3228 / 5 / 16140	3228 / 5 / 16140	3228 / 5 / 16140

P-values given below coefficients. Significance symbols: $< 0.1, * < 0.05, ** < 0.01, *** < 0.001$.
Rho represents the spatial autoregressive parameter.
n is the number of municipalities,T the number of time periods, and N the total number of observations.

Table 1: Results for ALL

No time lag	Wind turbines 10 km	Capacity 10 km	Wind turbines 20 km	Capacity 20 km
POPULATION	-0.003 (-0.41)	-0.002 (-0.282)	-0.001 (-0.211)	-0.002 (-0.244)
FACILITIES	-0.19*** (-5.001)	-0.19*** (-4.965)	-0.191*** (-5.028)	-0.19*** (-4.97)
Y2009	0.017 (1.092)	0.018 (1.19)	0.014 (0.906)	0.016 (1.061)
Y2010	-0.031** (-1.991)	-0.028* (-1.773)	-0.039** (-2.424)	-0.032** (-2.019)
Y2011	-0.033** (-2.052)	-0.027* (-1.694)	-0.043** (-2.553)	-0.033** (-2.017)
Y2012	-0.025 (-1.431)	-0.016 (-0.963)	-0.037** (-2.013)	-0.024 (-1.361)
YEAR.LAST.WT	-0.003 (-0.43)	-0.007 (-0.972)	-0.003 (-0.389)	-0.006 (-0.783)
WT	-0.052 (-1.129)		-0.055 (-1.249)	
CAPACITY		-0.006 (-0.468)		-0.008 (-0.689)
WT.VICINITY	0.102** (1.977)		0.179*** (2.576)	
WT.RATIO.VICINITY	-0.006* (-1.663)		-0.005 (-1.139)	
CAPACITY.VICINITY		0.000 (0.019)		0.027 (1.001)
CAPACITY.RATIO.VICINITY		-0.000* (-1.932)		-0.000 (-1.411)
R^2	0.05	0.04	0.05	0.04
Rho	0.093	0.094	0.09	0.093
n / T / N	180 / 5 / 900	180	180	180

One year time lag	Wind turbines 10 km	Capacity 10 km	Wind turbines 20 km	Capacity 20 km
POPULATION	-0.000 (-0.018)	0.001 (0.191)	-0.000 (-0.008)	0.001 (0.198)
FACILITIES	-0.186*** (-4.831)	-0.178*** (-4.659)	-0.187*** (-4.876)	-0.178*** (-4.661)
Y2009	0.016 (1.036)	0.016 (1.111)	0.014 (0.954)	0.016 (1.07)
Y2010	-0.032** (-2.106)	-0.034** (-2.3)	-0.034** (-2.247)	-0.035** (-2.32)
Y2011	-0.034** (-2.172)	-0.033** (-2.188)	-0.034** (-2.219)	-0.036** (-2.357)
Y2012	-0.024 (-1.463)	-0.025 (-1.585)	-0.025 (-1.546)	-0.031* (-1.902)
YEAR.LAST.WT	-0.009 (-0.397)	0.041 (1.456)	-0.016 (-0.716)	0.042 (1.506)
WT	-0.019 (-0.9)		-0.008 (-0.426)	
CAPACITY		-0.059*** (-2.694)		-0.043** (-2.262)
WT.VICINITY	0.011 (0.628)		0.044*** (2.713)	
WT.RATIO.VICINITY	0.000 (0.03)		-0.004 (-1.071)	
CAPACITY.VICINITY		-0.017 (-1.17)		0.022** (2.286)
CAPACITY.RATIO.VICINITY		0.000 (0.348)		-0.002 (-1.505)
R^2	0.04	0.05	0.04	0.05
Rho	0.087	0.064	0.085	0.082
n / T / N	180 / 5 / 900	180	180	180

Two years time lag	Wind turbines 10 km	Capacity 10 km	Wind turbines 20 km	Capacity 20 km
POPULATION	0.000 (0.007)	-0.001 (-0.18)	0.001 (0.111)	0.000 (-0.068)
FACILITIES	-0.187*** (-4.899)	-0.182*** (-4.775)	-0.188*** (-4.952)	-0.188*** (-4.934)
Y2009	0.017 (1.098)	0.016 (1.058)	0.017 (1.105)	0.014 (0.922)
Y2010	-0.031** (-2.035)	-0.032** (-2.079)	-0.032** (-2.052)	-0.034** (-2.193)
Y2011	-0.03* (-1.948)	-0.033** (-2.146)	-0.031** (-1.974)	-0.036** (-2.295)
Y2012	-0.019 (-1.167)	-0.02 (-1.228)	-0.019 (-1.135)	-0.026 (-1.566)
YEAR.LAST.WT	-0.064* (-1.919)	-0.016 (-0.417)	0.124735	-0.022 (-0.55)
WT	-0.031 (-1.297)		-0.028 (-1.27)	
CAPACITY		-0.059** (-2.27)		-0.037* (-1.689)
WT.VICINITY	0.015 (0.63)		0.037** (2.186)	
WT.RATIO.VICINITY	0.002 (0.59)		0.001 (0.463)	
CAPACITY.VICINITY		-0.019 (-1.179)		0.023** (2.231)
CAPACITY.RATIO.VICINITY		0.001 (0.937)		-0.000 (-0.246)
R^2	0.04	0.04	0.04	0.05
Rho	0.094	0.093	0.099	0.105
n / T / N	180 / 5 / 900	180	180	180

P-values given below coefficients. Significance symbols: $< 0.1, * < 0.05, ** < 0.01, *** < 0.001$.
Rho represents the spatial autoregressive parameter.
n is the number of municipalities,T the number of time periods, and N the total number of observations.

Table 2: Results for COAST

No time lag	Wind turbines 10 km	Capacity 10 km	Wind turbines 20 km	Capacity 20 km
POPULATION	-0.002 (-0.326)	-0.002 (-0.363)	-0.002 (-0.381)	-0.002 (-0.297)
FACILITIES	0.089* (1.896)	0.09* (1.913)	0.089* (1.901)	0.089* (1.897)
Y2009	-0.005 (-0.369)	-0.005 (-0.362)	-0.007 (-0.499)	-0.005 (-0.417)
Y2010	-0.002 (-0.137)	-0.002 (-0.13)	-0.005 (-0.359)	-0.003 (-0.207)
Y2011	0.043*** (3.209)	0.044*** (3.28)	0.038*** (2.692)	0.042*** (3.113)
Y2012	0.152*** (10.548)	0.152*** (10.836)	0.144*** (9.211)	0.15*** (10.46)
YEAR.LAST.WT	0.002 (0.197)	-0.004 (-0.431)	0.003 (0.355)	-0.003 (-0.386)
WT	0.027 (0.489)		0.004 (0.084)	
CAPACITY		0.014 (1.243)		0.012 (1.128)
WT.VICINITY	-0.042 (-1.64)		0.012 (0.500)	
WT.RATIO.VICINITY	-0.003 (-0.419)		0.017 (0.703)	
CAPACITY.VICINITY		-0.013** (-2.518)		-0.007 (-1.175)
CAPACITY.RATIO.VICINITY		0 (-0.789)		0 (-0.186)
R2	0.01	0.01	0.01	0.01
rho	0.076	0.076	0.076	0.076
sigma_v^2	0.262	0.262	0.263	0.262
n / T / N	2854 / 5 / 14270	2854 / 5 / 14270	2854 / 5 / 14270	2854 / 5 / 14270
One years time lag	Wind turbines 10 km	Capacity 10 km	Wind turbines 20 km	Capacity 20 km
POPULATION	-0.002 (-0.346)	-0.002 (-0.302)	-0.002 (-0.373)	-0.002 (-0.359)
FACILITIES	0.088* (1.878)	0.088* (1.876)	0.090* (1.917)	0.089* (1.897)
Y2009	-0.005 (-0.406)	-0.005 (-0.409)	-0.006 (-0.419)	-0.006 (-0.421)
Y2010	-0.002 (-0.146)	-0.002 (-0.147)	-0.003 (-0.201)	-0.003 (-0.214)
Y2011	0.042*** (3.217)	0.043*** (3.234)	0.041*** (3.138)	0.041*** (3.13)
Y2012	0.152*** (10.881)	0.153*** (10.903)	0.149*** (10.64)	0.149*** (10.689)
YEAR.LAST.WT	-0.004 (-0.152)	-0.007 (-0.161)	-0.004 (-0.155)	-0.002 (-0.057)
WT	-0.009 (-0.305)		-0.012 (-0.463)	
CAPACITY		0.001 (0.06)		-0.005 (-0.24)
WT.VICINITY	-0.025 (-1.62)		-0.002 (-0.244)	
WT.RATIO.VICINITY	-0.001 (-0.275)		-0.003 (-0.281)	
CAPACITY.VICINITY		-0.013* (-1.89)		-0.002 (-0.35)
CAPACITY.RATIO.VICINITY		-0.000 (-0.785)		-0.000 (-0.137)
R^2	0.01	0.01	0.01	0.01
Rho	0.077	0.076	0.076	0.076
n / T / N	2854 / 5 / 14270	2854 / 5 / 14270	2854 / 5 / 14270	2854 / 5 / 14270
Two years time lag	Wind turbines 10 km	Capacity 10 km	Wind turbines 20 km	Capacity 20 km
POPULATION	-0.002 (-0.365)	-0.002 (-0.391)	-0.002 (-0.365)	-0.002 (-0.391)
FACILITIES	0.089* (1.895)	0.090* (1.906)	0.089* (1.895)	0.090* (1.906)
Y2009	-0.005 (-0.382)	-0.005 (-0.374)	-0.005 (-0.382)	-0.005 (-0.374)
Y2010	-0.003 (-0.199)	-0.002 (-0.181)	-0.003 (-0.199)	-0.002 (-0.181)
Y2011	0.042*** (3.165)	0.043*** (3.211)	0.042*** (3.165)	0.043*** (3.211)
Y2012	0.15*** (10.812)	0.15*** (10.837)	0.15*** (10.812)	0.15*** (10.837)
YEAR.LAST.WT	-0.029 (-1.02)	-0.035 (-0.793)	-0.029 (-1.02)	-0.035 (-0.793)
WT	0.008 (0.233)		0.008 (0.233)	
CAPACITY		0.016 (0.686)		0.016 (0.686)
WT.VICINITY	0.000 (0.023)		0.000 (0.023)	
WT.RATIO.VICINITY	0.004 (0.989)		0.004 (0.989)	
CAPACITY.VICINITY		-0.007 (-0.792)		-0.007 (-0.792)
CAPACITY.RATIO.VICINITY		-0.000 (-1.045)		-0.000 (-1.045)
R^2	0.01	0.01	0.01	0.01
Rho	0.076	0.076	0.076	0.076
n / T / N	2854 / 5 / 14270	2854 / 5 / 14270	2854 / 5 / 14270	2854 / 5 / 14270

P-values given below coefficients. Significance symbols: $< 0.1, * < 0.05, ** < 0.01, *** < 0.001$.
Rho represents the spatial autoregressive parameter.
n is the number of municipalities,T the number of time periods, and N the total number of observations.

Table 3: Results for INLAND

2 shows the results for municipalities with their centroid being 10 km away from the shoreline at maximum and Table 3 those for municipalities with their centroid being at least 100 km away from the shoreline. We experimented with different distances for the definition of the inland subsample but the results did not prove sensitive to the exact distance being used.[7] In case of the coastal region definition, we face a trade-off between closeness to the shoreline and number of observations. The chosen distance of 10 km balances this conflict very well and has therefore been chosen. As for the definition of inland region, the results do not differ significantly when using different distances as long as these remain less than 40 km.[8].

The results for the inland region (Table 3) generally mirror those obtained for all regions (Table 1) because the majority of German municipalities are not located close to the shoreline.[9] There is one notable difference; the coefficient of FACILITIES changed from being insignificant to significantly positive. In contrast to coastal municipalities (see Table 2) where the opposite is observed, the occupancy rate tends to improve with increasing numbers of accommodation facilities in the inland region. In other words, agglomerations of accommodation facilities are related to positive effects in the inland while imply negative effects in the coastal region. We suspect that it might be either related to differences in the facility structures existing in the two regions or different kinds of tourists attracted by the coastal region. For instance, BMWi (2013) finds that in contrast to tourists in inland regions, tourists in the coastal region prefer close-to-nature vacations and relaxation related holiday activities. Hence, agglomerations of touristic facilities are less attractive for such tourists. While being an interesting finding, it is beyond the scope of the paper to explore this further.

The results for the variables representing the existence of wind turbines and their capacities are identical in the model for the inland region as those in the models for all regions. Accordingly, the relationship between wind turbines capacity in municipalities' vicinity (up to 10 km) and tourist demand is significantly negative in most German municipalities not located near the coast. The coefficients are also of similar magnitude.

The picture changes when restricting the municipalities to those located within 10 km of the shore-line (see Table 2). The capacity of wind turbines within a municipality gains a significantly negative coefficient in the models including a one-year ($t+1$) and two-year ($t+2$) time lag. The coefficients for the number of wind turbines (WT.VICINITY) and their capacity (CAPACITY.VICINITY) within 10 km, and more frequently within a 20 km distance also obtain significantly positive coefficients in most models (t,$t+1$,$t+2$). In addition, the ratio between installed wind turbines in a municipality and those in 10-km vicinity becomes (weakly) significantly negative in the model without a time lag being considered (t).

The results for the coastal region suggest the existence of a negative relationship between the installed capacity of wind turbines in municipalities and tourist demand. The latter also shows a positive relation with wind turbines and their capacities in the geographical vicinity of municipalities. Moreover, tourist demand is negatively related to the ratio between the number of wind turbines installed within and in the vicinity of municipalities. However, the latter is relatively weak and can only be observed in one

[7]We also used 50, 150, and 200 km distances. The results remained the same. They can be obtained from the authors upon request.

[8]We also used distances of 5, 20, and 30 km. The results did not change. They can be obtained from the authors upon request.

[9]Of the $3,228$ municipalities with at least one guest bed, $2,854$ are located away from the shoreline farther than 100 km.

model.

In summary, the following can be derived from the empirical results. First, the capacity of wind turbines appears to be a more relevant dimension than the number of wind turbines because the coefficients of the wind turbine capacity-based variables tend to become more frequently significant. It highlights that the size of wind turbines matters in addition to the absolute number of wind turbines installed in municipalities. Second, wind turbines (subject to their capacities) generally appear to induce weak but negative effects on tourist demand. Third, the relation between wind turbines and tourist demand differs somewhat in the majority of inland municipalities from that observed in the coastal region. The latter is more complex and not solely negative in nature.

4 Discussion

The present study confirms the idea of wind turbines being negatively related to tourism demand. Accordingly, it supports the existing internal evidence of Riddington et al. (2010) and the empirical evidence for Germany (see, e.g., SOKO Institut, 2009; Institut für Regionalmanagement, 2012; CenTouris, 2012).

However, in the coastal region, we also find evidence for a positive relation between the number of installed wind turbines in the surroundings of municipalities and tourist demand, which contradicts most existing studies and theoretical explanations. The literature offers few ideas about what might be the cause for such a positive relationship. Frantál and Kunc (2011) suggested that in some instances tourists are attracted by objects that do not really fit into a landscape. With a reference to the British Wind Energy Association (2006), they argued that there exist a number of cases in which wind turbines attract tourists because they might "*contribute to better place brand and development of new forms of tourism ('green tourism' or so-called 'turbine bagging') in peripheral rural localities*" (Frantál and Kunc, 2011, 505). The authors particularly observe this mechanism in East-Central Europe where "*WT are still a relatively new phenomenon which tourists may be quite interested in; almost two thirds of respondents expressed an interest in visiting WT as long as there would be an information centre*" (Frantál and Kunc, 2011, p. 515). Frantál and Urbánková (2014) refers to '*energy tourism*' in this respect. However, this explanation does not correspond to the German case because wind turbines are rather common in this country (see Figure 1).

We put forward an alternative explanation, which takes into account the observed negative relations between tourist demand and wind turbines as well. The explanation centers around the idea of a displacement effect, which can simultaneously explain the negative coefficients of WT/CAPACITY and WT.RATIO.VICINITY as well as the positive coefficient of WT.VICINITY/CAPACITY.VICINITY. The negative coefficient of WT/CAPACITY suggests that tourists avoid municipalities with high and further increasing wind turbine densities. In the case where tourists prefer to stay in the larger regions of their original destination (for instance, staying close to the shore-line), but due to increasing wind turbine density in their preferred municipality, they choose nearby municipalities (not more than 20 km away), which are, however, characterized by lower (and stable) wind turbine densities. Such disparities in wind turbine numbers are captured by the variable WT.RATIO.VICINITY. The variable obtains a high positive value in case a relatively large number of wind turbines exists in a focal municipality and a relatively small number in its vicinity. In our models, the coefficient of this variable is (weakly) significantly negative. It supports this argument as the municipality's occupancy rate is found to be particularly low when the ratio is large. Lastly, regions with a more favorable (i.e., smaller) ratio between wind turbines within and outside their boundaries will tend to gain tourists when located relatively close (less than 20 km) to municipalities with large and growing wind turbine installments. Such will show as a positive coefficient of WT.VICINITY and CAPACITY.VICINITY, which corresponds to our empirical findings.

In summary, tourists tend to avoid their preferred destinations when these are characterized by large wind turbine numbers and the surrounding regions offer locations less exposed to wind turbines. These tourists want to stay in the greater region and therefore chose locations in the vicinity of their original destinations with less wind turbines. Moreover, it appears plausible to observe such an effect for coastal regions in particular. In this case, tourists prefer to stay as close as possible to the shore line, which limits their options for choosing alternative and less wind turbine rich destinations far away from their original (coastal) destination. The displacement effect is therefore likely to work at smaller distances (10 - 20 km) and, hence, becomes visible in our model. In inland regions, in contrast, tourists have a greater variety of regions with few wind turbines, which might be at greater distance to their original destinations. This makes an empirical identification of the displacement effect less likely.

Although our results are very much in line with the idea of a displacement effect, we lack the possibility of explicitly testing its relevance. Our data does not include information on 'tourist flows' and their (temporally sequential) choice of destinations. Accordingly, our interpretation must be treated with care and needs to be explicitly evaluated in future research. Moreover, it assumes a causal link between wind turbines and tourist demand, which, despite using a fixed-effects regression and time lags, cannot be proven to exist by our approach.

It is also worthwhile to take a look at the magnitude of the identified negative relation between wind turbines and tourist demand. Given the log-log form of the model, we can interpret the obtained coefficients as conditional elasticities (i.e., elasticities that are conditional on controlling for all time-invariant municipality-specific effects). The obtained values of the significantly negative coefficient of CAPACITY.VICINITY in the full model (all regions) is close to a value of -0.01. It implies that a one percent increase in the installed wind turbine capacity in municipalities' vicinities relates to a reduction of the occupancy rate by 0.01 percent in the same as well as in the subsequent years. To put this into perspective, on average there are $5,282$ kW of wind turbine capacity installed in the 10 km vicinity of municipalities with at least one guest bed. The average mean occupancy rate is 41.44 arrivals per guest bed in these regions (see Table 4). According to our results and assuming a causal relationship, a one percent increase in wind turbine capacity (53 kW) translates into a 0.01 percent decrease in the occupancy rate (ca. -0.004 arrivals per guest bed). An additional $2,000$ kW of wind turbine will hence go along with a reduction of the occupancy rate by about 0.15 arrivals per guest bed. As there are on average 747 guest beds in a municipality, the addition of such a wind turbine in the average municipality's vicinity corresponds to about 112.7 fewer arrivals per municipality in a year (i.e., a reduction of 0.3 percent in guest arrivals) (mean of $37,842$ arrivals per municipality per year). While effect's magnitude is considerable, it is still smaller than what other studies have found (see, e.g., SOKO Institut, 2009; Institut für Regionalmanagement, 2012; CenTouris, 2012). Moreover, it needs to be taken into consideration that although being significant in the model, the effect does not need to translate into decreasing occupancy rates. For instance, we do not observe a statistically significant difference in the growth rates of occupancy rates between the 100 municipalities with the highest numbers of wind turbines in their 10 km vicinity and the group of the 100 municipalities with the lowest numbers.[10]. In addition to the relevance of other control variables (FACILITIES), the general (positive) growth trend in the occupancy rates is captured by the year dummies (Y2011,Y2012). Accordingly, while the number of wind turbines are still growing and tend to induce negative effects on tourist demand, occupancy rates are generally still increasing.[11] This makes the negative effects unobservable in reality because it remains hidden in lower but still positive growth rates.

There are, however, a number of shortcomings in the present study that need to be pointed out. In addition to the missing information on tourist flows, the data is also troubled by missing information on tourist facilities with less than 10 beds and private vacation homes. While our methodology controls for inter-regional variation in the importance of vacation homes, we cannot entirely rule out effects related to these unknowns. Another shortcoming is the relatively short time span covered by our data, which includes just five consecutive years. This might be too short for observing long-term adaptation processes on the side of tourists as well as on the side of tourist facilities.

5 Conclusions and policy implications

The paper presented an analysis of the relationship of tourism demand and wind turbines. While existing studies rely on primary data collection and interviews, we made use of spatial panel regression techniques and secondary data sources covering touristic activities and installed wind turbines in German municipalities for the years 2008-2012.

In accordance with theoretical arguments and most existing empirical evidence for Germany, we find that the construction of wind turbines shows a negative relation to tourism demand in German municipalities. Moreover, significant differences are identified between regions at the coast and those in the inland. In case of the latter, the negative relations exist in particular with wind turbines constructed in the near surroundings of municipalities. The latter have been approximated by 10-km and 20-km radii of municipalities' centroids. In the coastal region, wind turbines constructed directly within municipalities are negatively related and wind turbines in municipalities' vicinities are positively related to growth of tourist demand (occupancy rate). We argued that this can be explained by a type of displacement effect, which implies that tourists tend to avoid destinations where these are characterized by large and further growing wind turbine numbers. As they prefer to stay in the greater coastal region of their original (but wind turbine rich) destination, they chose nearby municipalities that are characterized by less wind turbines.

However, these explanations have been speculative given the lack of empirical data preventing empirical falsification. The paper clearly calls for more research that addresses a number of shortcomings related to the employed data. This particularly concerns the lack of tourist flow data and information on private holiday apartments. Given the lack of secondary data on these two, primary data collection in combination with the use of secondary data is probably the preferred strategy in future research.

The paper's main findings of a negative relation between wind turbines and tourist demand are particularly bad news for the northern regions of Germany that are close to

[10]The mean growth rates are 0.022 (2.2 percent per year) for the 100 municipalities with the the most wind turbines in their 10-km vicinity and 0.019 (1.9 percent per year) for municipalities with the lowest numbers. The Wilcoxon rank sum test statistic is $W = 4,849$ with a p-value of 0.479.

[11]Mean growth of occupancy rate is 2.5 percent per year.

the North and Baltic Sea. The vanishing of the ship-building industry and fishery has left many of these regions with little else than tourism as an economic foundation. Due to their location at the sea side, these regions offer very good conditions for wind turbines leading to the first and largest extension of wind turbines to take place in these regions. According to our results, some of these regions might face a conflict in simultaneously developing both industries. It depends on the strength and relevance of the displacement effect whether the majority of wind turbine rich coastal regions face this trade-off or whether just those locations with the most wind turbines have to deal with this conflict.

The present study is the first that simultaneously considers wind turbines' capacities (as an approximation for their sizes) in addition to their numbers in the analysis. The empirical findings confirmed that it is crucial to add the size-dimension to the analysis of wind turbines, as frequently variables based on wind turbines capacities turned out to be relevant. Besides the relevance for scientific analysis, this finding also implies that re-powering does not represent the solution to the trade-off between wind energy generation and preserving attractive landscapes for tourists. This is particularly relevant for regions in northern Germany where wind-rich regions are almost completely exploited and only limited possibilities remain for further wind turbine installments. For this reason and the growing numbers of wind turbines reaching the end of their time of operation, re-powering has significantly gained in importance in the last years and will continue to do so.

The findings underline the importance of coordination in the planning of wind turbines between neighboring regions. Wind turbine noise and visual externalities are not restricted to their immediate surroundings but may also matter for economic activities (e.g., tourism) in neighboring regions. Therefore, it is essential to coordinate planning processes within larger areas including multiple municipalities. Collaboration with tourist agencies might also be helpful, as these offer knowledge about tourists' expectations and demands.

In addition to onshore wind turbines, offshore wind turbines have also strongly grown in popularity and numbers in recent years. Due to their specific location of installment and larger sizes, their effects on landscape aesthetics and tourism demand are likely to be different than those of onshore wind turbines. Unfortunately, the present study did not cover offshore wind turbines and its results remain limited to onshore wind turbines. Nevertheless, many of the shortcomings characterizing studies on onshore wind turbines that have been overcome by the present study, also apply to evaluations of offshore wind turbines. The paper's empirical approach may therefore also serve as a guide for future studies on offshore wind turbines.

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Appendix

	n	mean	sd	median	min	max	skew	se
FACILITIES	16140.00	13.70	27.35	7.00	1.00	794.00	10.99	0.22
GUEST.BEDS	16140.00	746.77	2782.38	277.50	9.00	125166.00	25.44	21.90
ARRIVALS	16140.00	37842.86	237567.06	11185.50	0.00	10848797.00	26.95	1869.97
WT	16140.00	2.86	9.24	0.00	0.00	178.00	7.01	0.07
CAPACITY	16140.00	3712.63	12648.32	0.00	0.00	257750.00	7.24	99.56
YEAR.LAST.WT	16140.00	628.38	929.75	0.00	0.00	2012.00	0.80	7.32
POPULATION	16140.00	18615.49	83546.90	7008.00	11.00	3501872.00	26.51	657.63
WT.VICINITY (10KM)	16140.00	4.35	12.94	0.00	0.00	272.00	9.57	0.10
WT.VICINITY (20KM)	16140.00	25.79	44.58	9.00	0.00	799.00	5.04	0.35
CAPACITY.VICINITY (10 km)	16140.00	5282.09	15409.78	0.00	0.00	308605.10	8.12	121.30
CAPACITY.VICINITY (20 km)	16140.00	32800.97	54135.60	11110.00	0.00	900708.30	3.88	426.12
OCCUPANCY.RATE	16140.00	41.33	24.20	39.00	0.00	270.69	0.97	0.19
WT.RATIO.VICINITY (10 km)	16140.00	2.07	7.13	1.00	0.00	179.00	11.44	0.06
WT.RATIO.VICINITY (20 km)	16140.00	0.67	4.65	0.20	0.00	116.00	18.65	0.04
CAPACITY.RATIO.VICINITY (10 km)	16140.00	1492.98	9177.68	1.00	0.00	257751.00	12.84	72.24
CAPACITY.RATIO.VICINITY (20 km)	16140.00	363.51	5866.69	0.01	0.00	190159.00	21.96	46.18

Table 4: Descriptives of variables (for 3.228 municipalities with GUEST.BEDS > 0)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) FACILITIES		-	-	-	-	-	-	-	-	-	-	-	-	-	-
(2) BEDS	0.87 ***		-	-	-	-	-	-	-	-	-	-	-	-	-
(3) ARRIVALS	0.77 ***	0.97 ***		-	-	-	-	-	-	-	-	-	-	-	-
(4) WT	0.09 ***	0.08 ***	0.05 ***		-	-	-	-	-	-	-	-	-	-	-
(5) CAPACITY	0.07 ***	0.06 ***	0.04 **	0.94 ***		-	-	-	-	-	-	-	-	-	-
(6) YEAR.LAST:WT	0.06 ***	0.07 ***	0.06 ***	0.45 ***	0.42 ***		-	-	-	-	-	-	-	-	-
(7) POPULATION	0.00	0.00	0.00	0.01	0.01	0.04 **		-	-	-	-	-	-	-	-
(8) WT.VICINITY (10KM)	-0.04 **	-0.03	-0.03	0.18 ***	0.18 ***	0.19 ***	0.01		-	-	-	-	-	-	-
(9) WT.VICINITY (20KM)0	-0.04 **	-0.03	-0.03 *	0.33 ***	0.3 ***	0.34 ***	0.01	0.71 ***		-	-	-	-	-	-
(10) CAPACITY.VICINITY (10 km)	-0.05 ***	-0.03 *	-0.03	0.19 ***	0.2 ***	0.18 ***	0.02	0.95 ***	0.67 ***		-	-	-	-	-
(11) CAPACITY.VICINITY (20 km)	-0.05 ***	-0.03 *	-0.03 *	0.31 ***	0.31 ***	0.33 ***	0.02	0.66 ***	0.96 ***	0.67 ***		-	-	-	-
(12) OCCUPANCY RATE	0.07 ***	0.1 ***	0.17 ***	-0.05 ***	-0.04 **	-0.02	-0.01	-0.1 ***	-0.12 ***	-0.08 ***	-0.1 ***		-	-	-
(13) WT.RATIO.VICINITY (10 km)	0.14 ***	0.13 ***	0.08 ***	0.76 ***	0.69 ***	0.27 ***	0.00	-0.08 ***	0.07 ***	-0.08 ***	0.06 ***	-0.03 *		-	-
(14) WT.RATIO.VICINITY (20 km)	0.18 ***	0.16 ***	0.11 ***	0.48 ***	0.41 ***	0.10 ***	0.00	-0.04 **	-0.06 ***	-0.04 **	-0.07 ***	-0.01	0.65 ***		-
(15) CAPACITY.RATIO.VICINITY (10 km)	0.13 ***	0.11 ***	0.07 ***	0.68 ***	0.68 ***	0.23 ***	0.00	-0.06 ***	0.07 ***	-0.06 ***	0.06 ***	-0.02	0.94 ***	0.59 ***	
(16) CAPACITY.RATIO.VICINITY (20 km)	0.15 ***	0.12 ***	0.08 ***	0.43 ***	0.41 ***	0.09 ***	0.00	-0.02	-0.04 **	-0.02	-0.04 **	0.00	0.58 ***	0.93 ***	0.60 ***

p-values given below coefficients. Significance symbols: ¡ 0.1, * ¡ 0.05, ** ¡ 0.01, *** ¡ 0.001

Table 5: Correlations