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Local Economic Impacts of Wind Power Deployment in Denmark

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Abstract: An argument sometimes used to support renewable energy is that it may contribute to job creation. On the other hand, these technologies often face local opposition. On the case of Denmark, the country with the longest experience with wind power, we examine whether the installation of new turbines had local economic benefits. We use a quasi-experimental set-up and exploit time and regional variations at the municipal level. We find that the deployment of wind power contributed to the increase in personal income for entrepreneurs and some retirees. As municipalities received payments from wind investors ahead of the construction, the new wind revenues were followed by increases in local public spending. Regarding employment, we find very minor effects in some sectors but the aggregate local employment does not change significantly.

Keywords: Wind power; renewable energy; climate policy; co-benefits; employment

JEL classification: C23, H23, Q42, Q48

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1 Introduction

As part of their energy and climate policies, nations develop schemes to support renewable energy (RE) deployment. Beyond the objective to reduce greenhouse gas emissions, RE may play a key role to reduce air pollution and increase energy independence in a context of uncertainties regarding global market prices of energy carriers. In the case of wind power, new deployment often faces local opposition, known as the "not in my backyard syndrome" due to the noise it creates, the visual impacts and consequences on real estate prices in the surroundings. On the other hand, policy makers often argue that energy deployment may contribute to local job creation in addition to the environmental benefits. With such a potential double dividend, RE would be a key element to enable growth to be green.

We quantify the local economic impacts of wind power deployment in the case of Denmark, the country which has the longest experience with this technology. Employing a comprehensive panel that takes advantage of the availability of very detailed data at the municipality level, we aim to identify the effects throughout the revenue chain by exploiting regional and time variations. More specifically, we examine the impacts on the personal per-capita income at the municipal level, the local public budget and employment, potentially taking into account spill-over effects on the various economic sectors. We focus on the time period 1993-2005, i.e. when the extension of wind power was the largest in Denmark, stage at which many other European countries are now. To account for potential endogeneity concerns, we employ a quasi-experimental set-up, building on the generalised propensity score (GPS) introduced by Hirano and Imbens (2004) and constructed to allow for causal inference with observational data.

We find that one euro per capita of new revenues from wind power deployment generates an increase of 1.33 € per capita of personal income in the municipality. Analysing the results for more granular income categories, we see that the positive impact is largely explained by increases in entrepreneurial income and pensions. Our estimates suggest that local entrepreneurial income increases by 57 cents for every euro of new wind revenues. This is consistent with the observation that around two thirds of the wind turbines in Denmark were owned by individuals, in which case the revenues could be reported as entrepreneurial income. Together with the impact on pensions (22 cents for one euro in additional new revenues), this leads to an overall impact greater than one, which suggests the presence of a multiplier effect. There is no additional income increase after the first year.

We also find a positive impact on the municipal budget. Our results suggest that one euro of new wind revenues per capita is associated with an increased public spending of 36 cents (per capita) in the first year, and 28 cents in the second year. This effect is mostly composed of additional healthcare spending (respectively 25 and 23 cents in the first and second years after the connection of the new wind power capacity to the grid), increased administrative spending (7 cents in the first year) and additional funding for education and culture (5 cents in the second year).

We find no evidence of effects of the additional revenues from wind power deployment on aggregate local employment. There are some minor effects on employment subcategories, but these compensate one another accross sectors.

The existing literature on the local economic impacts of RE deployment focuses mostly on the effects on employment and is not fully conclusive. It consists of studies using structural methods or empirical identification approaches. On the one hand, some positive effects are found in the RE sector or in related sectors due to the local sourcing of components and services. The benefits seem to be detected mostly during the manufacturing and construction phase. The positive spill-overs in related sectors are observed only if a sufficient share of parts and services are supplied by local firms. On the other hand, negative impacts are identified as a consequence of increased costs of energy generation or the crowding out of alternative investments.

Our main contribution relies on the fact that we analyse the case of Denmark, country which has been a pioneer in the deployment of wind power and that has the longest experience with this technology. In addition, we use a unique dataset combining detailed information on installed turbines and official statistical data at the municipal level. We do not restrict our analysis on employment but we also examine the effect on the personal income and the municipal budget. We employ a statistical identification that allows to fully capture spillovers on the other sectors of the economy, without having to impose the structural assumptions of input-output tables.

2 Literature Review

In this section, we present the existing literature on the economic effects of renewable energy deployment. There are potentially several impact channels, as explained by Frondel et al. (2010). These can be divided into macroeconomic mechanisms, for example via changes in the cost of electricity or in the imports and exports of new technologies, and more locally relevant channels, for example via changes in the demand for manufacturing and production of components, in the demand for maintenance and operation services or changes in the local labour market.

We choose to focus our analysis on the local economic impacts, as these are likely the most relevant in shaping the local acceptance of RE deployment. The existing literature on the regional effects employs a range of methods that address direct and indirect impact mechanisms in different manners. They find that there is a potentially contracting impact through increased costs of energy generation, which can be offset by employment impacts related to the local sourcing of inputs. Whilst most studies find that the positive impacts on the local economy dominate (Cai et al., 2011; Tourkolias and Mirasgedis, 2011; Heinbach et al., 2014), there are also opposing results (Hillebrand et al., 2006; Frondel et al., 2010).

Most papers opting for structural models choose an input-output approach (Lehr et al., 2008; Cai et al., 2011; Tourkolias and Mirasgedis, 2011; Heinbach et al., 2014; Cai et al., 2017; Többen, 2017). The majority of the studies we identified in the literature review focus on the employment impacts. The early work by Lehr et al. (2008) employs a structural input-output model to measure the impact of RE investment incentives on the regional labour market in Germany. Whilst they find a positive impact on employment in the RE sector, they point towards the importance of accounting for potential negative impacts in other sectors due to the crowding out of alternative investments which would have been made in the absence of RE investment.[1] Cai et al. (2011) contribute to the literature on employment impacts and analyse the job market impacts of greenhouse gas mitigation policies for the power sector in China. Whilst there is a direct loss of employment in the electricity sector, they find that this was more than compensated by indirect job creation in related upstream sectors. This is complemented by Tourkolias and Mirasgedis (2011) who study the impacts of RE deployment in the power sector in Greece. They also find positive employment impacts through indirect channels, notably due to the economic activity created in up-stream sectors supplying the components of the RE investments.

Heinbach et al. (2014) further decompose the potential mechanisms behind the indirect employment effects. In the case of the German power sector, they emphasise that the potential impacts of increased RE deployment can be explained by channels involving four stages along the value chain: the manufacturing and production of components, maintenance, system operation, the collection of revenues and the payment of corresponding taxes. However, the extent to which the local economy benefits from the positive effects from these four stages is largely determined by the share of local sourcing for the components and services, as shown by Cai et al. (2017). The local economy might only benefit if a sufficient share of these parts and services is supplied by regional firms.

Employing an econometric identification as opposed to a structural input-output approach, Hillebrand et al. (2006) investigate the local economic impacts of increased RE deployment due to the compulsory compensation scheme for green energy in Germany. Particularly, they estimated the impacts of additional investment into renewable energies in monetary value. The study also considers two opposing effects: a spurred economic growth through potential local sourcing of components and services versus a potential local economic contraction due to increased electricity costs. The authors argue that these may arise due to the high capital investment necessary for scaling-up RE production and potential distortions due to the shifting of electricity production away from the efficient path as a consequence of public incentives. Whilst this effect is at the level of the electricity bidding zone, there can still be a local impact of these cost increases. They find that, over time, the increased energy costs offset the positive economic impacts. On the contrary, exploiting the variation in green energy policy across U.S. metropolitan areas, Yi (2013) finds that policies enhancing green energy deployment have a positive impact on local employment. The main explanatory variable they employ is a clean energy policy index measuring the intensity of renewable energy subsidies at

[1] Lehr et al. (2008) actually find that whether RE incentives have a net positive impact of renewable energy deployment crucially depends on the cost assumptions for RE deployment.

the regional level. It is important to note that this analysis focuses specifically on employment effects in the electricity sector. Hillebrand et al. (2006) find negative impacts on other sectors through higher electricity costs, sectors that Yi (2013) does not incorporate in his study. On the case of Portugal, Costa and Veiga (2021) use the number and capacity of newly installed turbines separately to estimate the impact of wind power investment on local unemployment. They find that wind power deployment has a short-term positive effect during the construction of turbines and a very small impact in the operation phase. Kammen et al. (2008) use the amount of energy produced by renewable or conventional methods to measure renewable energy deployment. Their analysis indicates that jobs are generated during the manufacturing and construction phases but not really during the operation and maintenance phase.

This literature review shows that the results of the existing analyses of the local economic impacts of RE deployment are not conclusive. We contribute to this discussion by analysing the local economic impacts of wind power deployment in Denmark, using a comprehensive panel that takes advantage of the long Danish experience in wind power and the availability of very detailed data at the municipality level. Employing a generalised propensity score approach, constructed for causal inference with observational data, we aim to identify the impact on personal income, municipal budget and employment by exploiting time and regional variations. This approach has advantages over the frequently employed input-output approach, especially in the case of Denmark. First, as the wind power deployment in Denmark is largely driven by private household investments, the granular disaggregation of the data allows to capture these impacts throughout the revenue chain at the local level. In particular, we can examine the effects on the entrepreneurial income, the aggregate per-capita income, the public budget and local employment, potentially via fiscal multiplier effects and spill-overs to the various economic sectors. Additionally, we do not rely on the structural assumptions of input-output tables. This analysis sheds light on the "not in my backyard" issue as we analyse the impacts on local agents potentially affected by RE deployment.

3 Institutional background

In Denmark on-shore wind power started to develop in 1976 (see Figure 1). It was largely driven by private household investments, themselves supported by successive government policies: direct government support to the investment cost for building turbines, feed-in tariff, variable or fixed premium on top of the electricity market price. Utilities are obliged to buy the power produced from renewable energy sources (Helby, 1998). The process for building turbines takes two to four years, including the time dedicated to the exploration of potential sites. To give some order of magnitude, the average capacity of a commissioned wind turbine was 250kW in 1993 and 860kW in 2000.[2]

A large share of Danish wind turbines are owned by individual entrepreneurs, e.g. farmers. Gorroño-Albizu

[2]Source: own calculation using data from the Master Data Register on Wind Turbines.

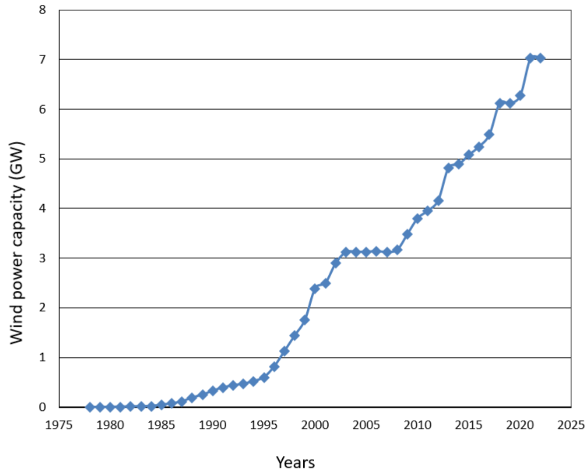

Figure 1: On-shore wind capacity in Denmark since 1976

et al. (2019) give the example of the Skinnerup installation, a 0.66MW wind turbine installed by a farmer in Thisted Municipality in 2000. Shared ownership in the form of a partnership is also common.[3] The rest is owned by companies. In the case of partnerships, individuals jointly invest in the construction of the turbine and sell the power to the local utility.[4] While the participation in a wind partnership was initially limited to individuals living close to the turbine site (Bolinger, 2001), this constraint was progressively relieved.[5] In parallel, the government imposed stricter siting guidelines for building turbines in the best wind areas.[6] Individual wind power producers may use part of the electricity produced for the consumption of their own household (Bolinger, 2001). In the example of the Skinnerup installation above, around 7% of the production is used for self-consumption and the rest is sold to the grid (Gorroño-Albizu et al., 2019). On the contrary, investors in a wind partnership have to sell the whole power production to the grid. In case of a partnership, the electricity produced by the wind turbine is taxed at the individual level, in proportion to the share the partner owns and according to his or her individual tax situation. Given possible tax exemptions, only a part of what is sold to the grid is taxed (Bolinger, 2001).

Local communities may benefit from turbine installations as some wind project developers make payments or donations to municipalities ahead of the project development, in particular to promote local acceptance. Municipalities have some freedom to use this additional source of revenues, for example to contribute to cultural and recreational activities.[7]

[3] Bolinger (2001) explains that one advantage of a partnership in comparison with a cooperative is that an individual in a partnership can deduct the interest on a loan for his share of a wind turbine from income taxes.

[4] According to Bolinger (2001), shares are computed as parts of the expected production. A share is usually 1000 kWh/year and costs about $ 450 (assuming $ 1000/kW project costs and 25% capacity factor).

[5] Bolinger (2001) indicates that, according to the Danish Wind Turbines Manufacturers Association, the participation in a wind partnership was initially limited to individuals living within a radius of 3k from the turbine site. The radius was extended to 10 km in 1985. In 1992, individuals living in neighboring boroughs could also participate. In 1996, individuals who had their job or their own property in the borough were allowed to join a partnership. Finally any person living in Denmark (from 1999 onwards) or in the the entire European Union (from 2000 onwards) could participate.

[6] Since 1999, a national directive has set detailed conditions (for example the distance to residential areas and requirements for installing groups of turbines) for designating the areas that are suitable for windmill installation (Pettersson et al., 2010). The regional planning of these areas has to comply with this directive. Projects of wind mill installations at the municipal and local levels can only be completed in these zones.

[7] Later in the history of wind power in Denmark, this support to municipalities where turbines are built was institutionalised in the

We decide to focus our analysis on the time period 1993-2002. The first reason is that this is one of the time periods where the deployment was the fastest. Second, this is before the change in municipality territorial definition which took place in 2007. The number of municipalities was then reduced from 240 to 90. Using the time period with the larger number of municipalities allows to conduct a more granular analysis with a larger number of observations. We present the successive policies in place during that time period in Table 8 in appendix, based on Energistryrelsen (2011) and Jaureguy-Naudin (2010). We use this information for the data preparation as explained in Section 4.

4 Data

For the econometric analysis, we build a panel covering 250 municipalities from 1993 to 2005. This includes all Danish municipalities except those in the greater county of Copenhagen and the municipality of Christiansø.[8] The panel contains municipality-level data on the new wind power revenues, i.e. the revenues from the new wind turbines connected to the grid in the municipality each year, as well as data on personal income, the municipal budget, and employment. The employment and budget data are disaggregated by category and the employment data by sector.[9] We identify the municipalities according to their boundaries as of 2004.[10]

4.1 New Revenues

Following Feyrer et al. (2017), we define the "new revenues" in municipality i in year t as the revenues from wind power production from the turbines connected to the grid in municipality i in year t. We compute them based on the annual power production of each turbine, as well as the electricity price and the support policy when the turbine was built. The Master Data Register on Wind Turbines provides the power production of each turbine in each year. We find detailed information on the support policies in Energistryrelsen (2011). We use the electricity price data from Dansk Energi for the time period 1985-1999 (before the electricity market liberalisation). For the time period 2000-2010, we compute the weighted electricity price, based on the hourly wind power production and hourly prices from Energinet.[11]

form of the so-called "green scheme" (Danish Energy Agency, 2009), itself succeeded by the "green fund" (Olsen, 2022).

[8] We indeed identify, merge and exclude the 21 urbanised small municipalities that belong to the greater county of Copenhagen as this urban area is significantly different from the other municipalities. We also do not keep the municipality of Christiansø. It is outside of the geographical area of the study.

[9] The dataset contains observations on new revenues from 1993 to 2002), data on budget, employment, unemployment and agricultural surface from 1993 to 2006 and data on personal income from 1993 to 2005. The panel is balanced.

[10] The geographical distribution of agricultural land surface in municipalities is shown in appendix.

[11] Note that the data available to compute the new wind power revenues only provide the electricity sold to the grid. As individual owners may use part of the electricity for their own consumption, we cannot take into account this additional implicit revenue. Its is, however, a small part of the total wind power production (typically less than 10% of the wind capacity owned by individuals is used for their own electricity consumption (Gorroño-Albizu et al., 2019).

4.2 Municipal Budget, Personal Income, Employment

The data on the municipal budget, personal income and sectoral employment come from Statistics Denmark. Figure 2 presents the disaggregation available for the personal income data.[12] The personal income is composed of the primary income and the current transfers.[13] The primary income itself covers the entrepreneurial income, the wages and salaries. The wages and salaries are further spilt into wages, gratuities and remuneration. The entrepreneurial income aggregates entrepreneurial income and income deductions. The current transfers category is composed of pensions, education grants and daily benefits. The pensions can be further split into social pensions, special early retirement pay, pensions from the *Arbejdsmarkedets Tillægspension* (ATP), other pensions and civil servant pensions. The daily benefits include unemployment benefits, temporarily leave benefits, cash benefits and other benefits.

Figure 3 shows the share of the income categories (per capita) in the total aggregated personal income.[14] [15] We observe that wages represent the largest part (over 60%), followed by pensions (17%), entrepreneurial income (10%) and daily benefits (7%). The share of the primary income in the total income is hence over 70%.

The municipal budget data are disaggregated into five expenditure category and one income category. Figure 4 shows the share of each expenditure category in the total expenses.[16] We observe that the largest part of the municipal spending is devoted to health care activities (61% of the spending). This is followed by spending in education and culture (23%), administration (12%), traffic and infrastructure (3%) and, finally, housing and community amenities (1%). Besides these sources of expenses, municipalities also have income via their public utilities, for which we also have data available.

Table 1 shows the distribution of total employment in the various economic sectors, as reported by Statistics Denmark.[17,18] The average is computed on all municipalities for the whole time period of the study. In this time range, most people were employed in social institutions (11.5%), the manufacturing of basic metal products (8.5%), the construction sector (7%), agriculture (7%), education (6.5%), the trade and repair of cars (6.5%) and business activities (5.5%).[19]

As explained in Section 5, we follow Feyrer et al. (2017) and scale our variables by the one-year lagged

[12]The personal income data are reported in the municipality where the person resides.
[13]The aggregate personal income data from Statistics Denmark also include wealth generated income (interest payments and return from stock investments) but the latter is not included in any of the subcategories.
[14]The average is computed on all municipalities for the whole time period of study.
[15]The figure refers to whole Denmark, except for the greater region of Copenhagen and Christiansø.
[16]The figure refers to whole Denmark, except for the greater county of Copenhagen and Christiansø.
[17]The employment data from Statistics Denmark are compiled according to the international guidelines from the International Labour Organization and follow the International Classification of Status in Employment. Employed persons are people who are working at least one hour in the week of reference. The employed are either employees, self-employed or assisting spouses. Data represents employment in the municipality where the employee works.
[18]The table refers to whole Denmark, except for the greater county of Copenhagen and Christiansø.
[19]The full description of the sectors is available in the Manual on Statistics of International Trade in Services (United Nations, 2011). For example, the retail trade and repair category is retail trade, except of motor vehicles and motorcycles; repair of personal and household goods.

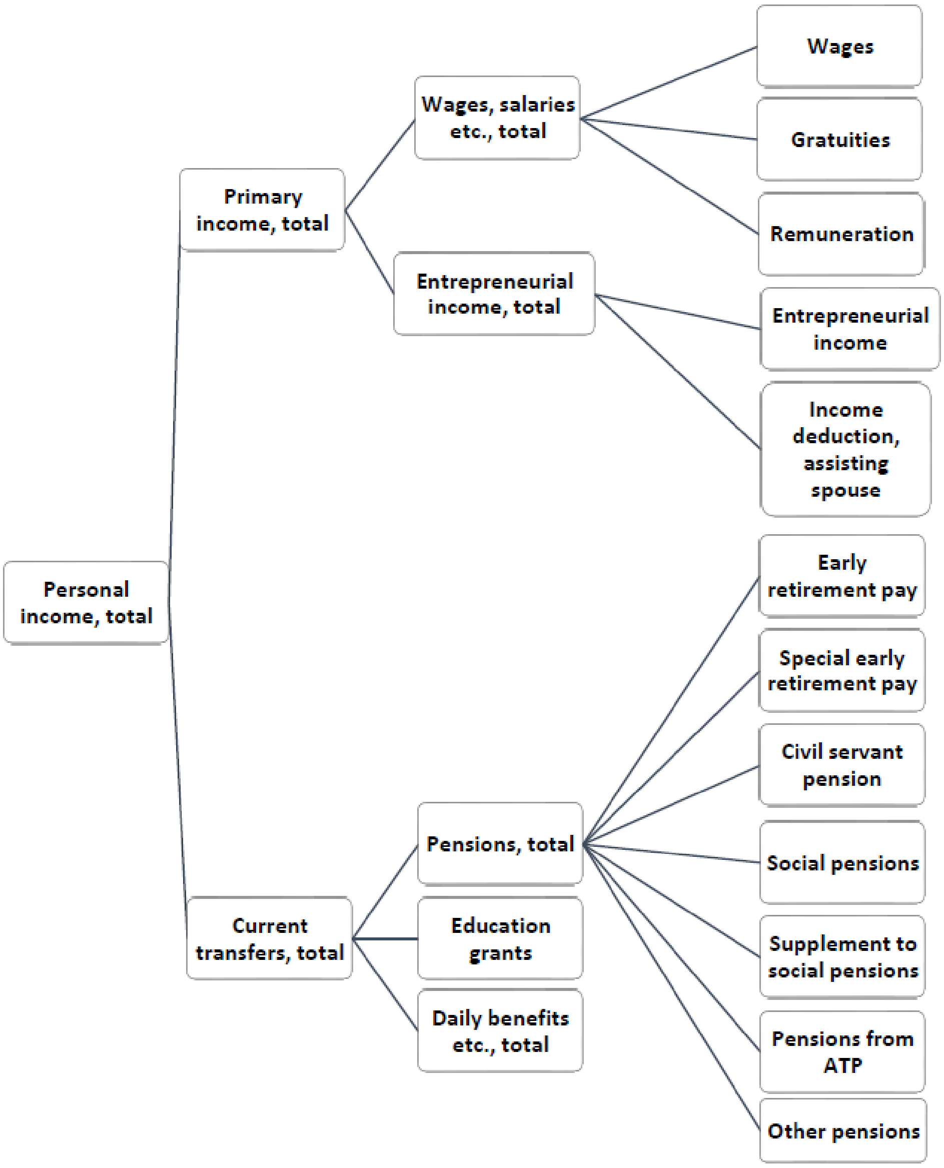

Figure 2: Disaggregation in the personal income data

employment to deal with the fact that a same increase in new revenues can have a significantly different impact on municipalities of different size.[20]

In appendix, we present the summary statistics for key variables at the municipal level (variables in absolute terms in Table 9, per capita values in Table 10, and the first differences of the per capita variables in Table 11), differentiating municipalities where wind turbines were installed in the time period of our study and municipalities where that was not the case. We checked the t-statistics of differences in means across groups. The differences are not significant (see Table 12 in appendix).

[20]In the following, all references to per capita values refer to the values scaled by the lagged total employment.

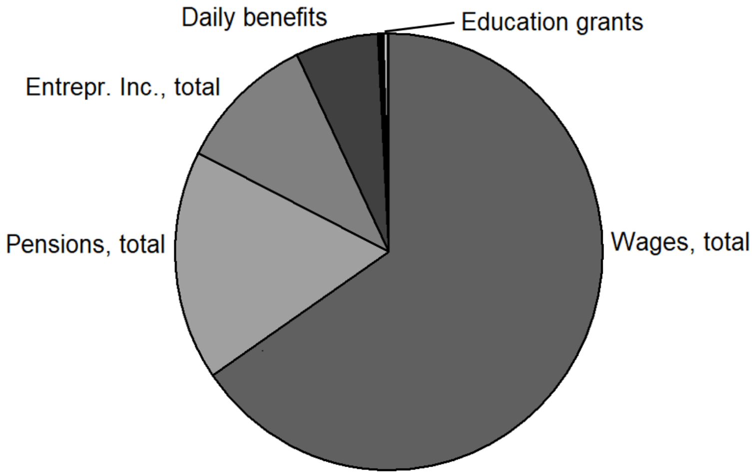

Figure 3: Personal income categories (shares)

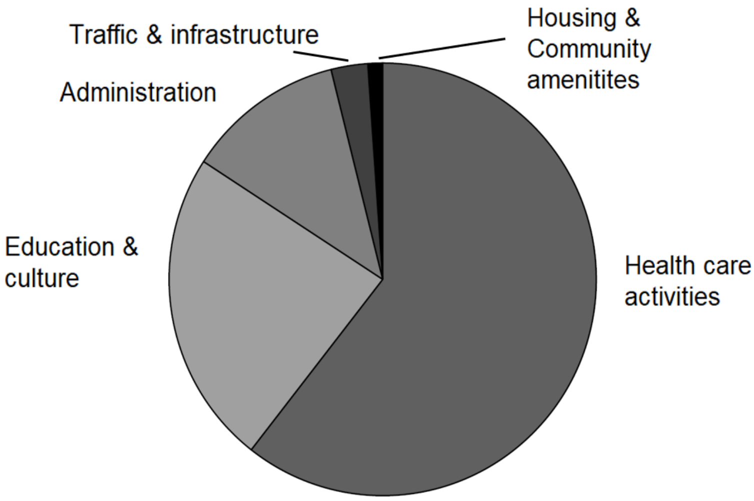

Figure 4: Municipal budget categories (shares)

4.3 Control Variables

Our controls include data on the unemployment rate, a computed proxy for the average available agricultural land surface, the average wind density for each municipality and the stock of already installed wind turbines. We calculate the unemployment rate out of unemployment and employment data from Statistics Denmark.[21] The data on the average wind density for each municipality is deducted from the Global Wind Atlas with the use of geographic information system (GIS) tools.[22] The data on the stock of already installed wind turbines is from the Master Data Register of Wind Turbines from Energistyrelsen. For the average available agricultural land surface, we have municipal level data from a 1999 census and yearly county-level data (both datasets from Statistics Denmark), but no yearly data at the municipal level. We hence compute

[21]The unemployment rate is defined as the ratio of unemployed people to the number of people eligible for employment, in each municipality.
[22]Data are downloaded in a GeoTiff format and then transformed into municipal-year data with the use of QGIS and Stata.

Table 1: Share of employment categories

Employment Category	**Percent**
Social Institutions	11.5
Mfr. of basic metals	8.5
Construction	7
Agriculture	7
Education	6.5
Retail trade and repair work (no vehicles)	6.5
Business activities	5.5
Public administration	5.5
Wholesale trade (no motor vehicles)	5
Human health activities	4.5
Transport	4.5
Associations and culture	4
Mfr. of food, beverages and tobacco	4
Sale and repair of motor vehicles, sale of automobile fuel	3
Mfr. of wood products,	2.5
Hotels and restaurants	2.5
Finance and insurance	2
Mfr. of chemicals and plastic products	2
Mfr. of furniture	2
Post and telecommunications	1.5
Letting and sale of real estate	1.5
Mfr. of other non-metallic mineral products	1
Mfr. of textiles and leather	<1
Electricity, gas and water supply	<1
Activity not stated	<1
Fishing,	<1
Mining and quarrying	<1

a proxy for the latter. We first deduct the share of each municipality average available agricultural land surface in the county's average available agricultural land surface in 1999. Next, we compute the proxy for the average available agricultural land surface for each municipality and each year by assuming that the relative share of the municipality in the county's average available agricultural land surface remains constant. These controls are used to compute the generalised propensity score, as explained in Section 5.

5 Methodology

We analyse the local economic impacts of wind power deployment. More specifically we look at the effect of the installation of new turbines on personal income, the public budget and employment at the municipality level.

The effect of a given amount of new turbines is expected to depend on the size of the municipalities where there are installed: a same amount of new turbines installed in a small municipality will not have the same impact as in a large municipality. To address this, we follow Feyrer et al. (2017) and normalise the treatment as well as the outcome variables by the lagged total employment at the municipality level.[23]

We aim to identify the impact on personal income, municipal budget and employment by exploiting regional variation as well as variation over time on the municipal level. As support policies for renewable energy were implemented at the national level, we suspect the regional variation in wind power deployment to be largely driven by favourable wind conditions and the availability of land. However, wind power deployment might also be correlated with regional economic conditions and unobservable regional economic shocks. For example, municipalities that have low employment level might offer unobserved incentives or better conditions to wind power producers for building turbines on their land. On the contrary, high incomes might translate into more investments due to an increased availability of funds. To address this potential endogeneity concern, we employ the generalised propensity score approach, provided by Hirano and Imbens (2004). Employing the GPS-covariate adjustment as opposed to using the variables as direct controls allows for a richer potential functional form of the impact of the controls used to calculate the GPS. In the direct regression approach, the effect of the controls is imposed to be linear, whereas the GPS-calculation routine of Hirano and Imbens (2004) tests and selects the best fit.

In the standard propensity score methods, the probability of a binary treatment is estimated based on potentially confounding covariates.[24] In contrast, Hirano and Imbens (2004) use these exogenous covariates to estimate the distribution of a continuous treatment. The result is a generalized propensity score. This allows to model the expectation of the outcome variable depending on the treatment level and GPS. As opposed to controlling for the covariates directly, the GPS-covariate adjustment improves the estimation precision by decreasing the dimensionality of the estimation problem and is effective in addressing all biases introduced by the covariates used to estimate the GPS (Austin, 2008). Originally salient in epidemiological literature, the generalised propensity score method has been proposed for use in regional economics by Mitze et al. (2012). They apply this method to analyse the regional impacts of an infrastructure subsidy program in Germany. Arguing that regional economics can benefit from the quasi-experimental approaches pioneered in other economic disciplines, they find that endogeneity arising from differences in district characteristics, impacting both subsidy inflow and outcomes, can be addressed convincingly using the proposed generalised propensity score method. However, they point out the importance of checking the covariate balancing properties in order to ensure the consistency of the estimates. Subsequent applications include the analysis of the effect of innovation on firm success for European firms (D'Attoma and Pacei, 2018) or of the role of innovative activity in ensuring economic sustainability for the case of dairy farms in Ireland (Läpple and Thorne, 2019) as well as the impact of federal financial aid programs on firms in northern Italy (Bia and Mattei, 2012)

We use this technique using the propensity-score based covariate adjustment. The next paragraphs elaborate in more detail, closely following Hirano and Imbens (2004) and Bia and Mattei (2008).

[23]The mentions to per capita variables in the rest of the paper refer to the outcome variables after normalization by the lagged total employment at the municipal level.

[24]A comprehensive introduction to propensity score methods is provided by Austin (2011).

5.1 Estimation of the Generalised Propensity Score

We first estimate the generalised propensity score. As opposed to a binary treatment setting, the generalised propensity score relies on estimating the distribution of the treatment amount, given the observable covariates. As derived in Bia and Mattei (2008), the following paragraph explains the underlying theory.

Let N be a random sample from a large population. For every observational unit i, there is a vector of pre-treatment covariates, X_i. We also observe the amount of treatment received, D_i. The model is based on the potential outcome framework, known as the Rubin Causal Model (Holland, 1986). Here, the potential outcome variable, Y, is defined as $\{Y_i(t)\}_{d\in\tau}$, where τ represents a continuous set of treatment levels. The outcome is thus modelled as a random variable that maps a treatment level to a potential outcome. Hirano and Imbens (2004) define the generalised propensity function, $r(d, x)$, to model the density of the realised treatment conditional on observed covariates, $f_{D|X}(d|x)$. To keep the notation manageable, the subscript i is dropped below.

$$r(d, x) = f_{D|X}(d|x) \tag{1}$$

The generalised propensity score, R, is defined as the value of the conditional density function for the realised treatment and observed pre-treatment covariates:

$$R = r(D, X) \tag{2}$$

One important property of this GPS is that, as shown by Hirano and Imbens (2004), within strata of a given value of $r(d, X)$, the likelihood that a certain treatment value $D = d$ occurs is independent of the covariates. Together with the appropriate unconfoundedness assumption, stating that the assignment of the treatment level is independent of the outcome, given the level of covariates, the utilisation of the GPS can remove any bias resulting from an a-priori imbalance in the included covariates.

The original approach derived by Hirano and Imbens (2004) requires the treatment variable to follow a normal distribution. However, as this is not supported by our data, we employ an extension of the propensity score published by Ventura and Guardabascio (2013). Their methodology allows an unbiased calculation of the GPS for other distributions of the treatment variable. Specifically, it employs a log-transformation of the treatment variable and allows to describe the treatment variable with a gamma distribution. A suitable two-sided t-test indicates that the covariate balance is supported at the 0.01% level.

As with any identification approach, the quality of the propensity score estimation crucially depends on the richness of the data used to estimate it. In our case, we identify the following exogenous variables that may impact wind power deployment: wind potential, the availability of agricultural land, past unemployment rates as a proxy for economic conditions,[25] and the stock of already installed wind turbines. We use them to estimate the generalised propensity score. We employ the lagged unemployment (third lag) to address the potential reverse causality issue mentioned above (potential impact of the local economic conditions on the installation of new turbines, e.g. via unobserved incentives for wind parks). Fixed-effects at the municipality level in the final estimation rule out a potential bias from time-invariant unobservable characteristics of municipalities.

We use the computed generalised propensity score to identify the effects using a Propensity-Score Based Covariate Adjustment.

5.2 Propensity-Score Based Covariate Adjustment

We then employ the propensity-score based covariate adjustment with an ordinary least squares (OLS) estimator to identify the impact of the revenues from new wind turbines (installed within the previous year) on each of the following outcome variables separately: personal income and its components (entrepreneurial income, wages, etc.), municipality budget and its components, employment and sectoral employment.

Following Feyrer et al. (2017), we want to estimate the following equation:

$$\Delta Y_{it} = \beta_1 Revenues_{i,t} + R_{it} + \alpha_i + \omega_t + \epsilon_{i,t} \tag{3}$$

where Y_{it} denotes the outcome variable (personal income, municipal budget, or employment) in municipality i in year t, $Revenues_{i,t}$ the revenues from power production from new wind turbines ("new revenues") connected to the grid in municipality i in year t, R_{it} the value of the generalised propensity score R for municipality i in year t, α_i the municipality fixed effect, ω_t the year fixed effect and $\epsilon_{i,t}$ the error term.

6 Results and discussion

We analyse the impact of the revenues from the new turbines (revenues from the turbines newly built and connected to the grid in the municipality) on the personal income, the municipal budget as well as local employment. The results of the estimation with GPS-covariate adjustment are reported in Tables 2 to 7.[26]

We expect the new revenues to impact the local economy via several channels. First, the new revenues directly induce an increase in the income of local entrepreneurs, e.g. farmers, who own the turbines. This

[25] We consider that using the second or third lags of the unemployment rate is sufficient to be considered exogenous with regard to the contemporaneous new revenues.

[26] Note that, according to Hirano and Imbens (2004), there is no qualitative interpretation of the coefficient associated with the GPS.

positive budget effect may have repercussions on sectors of the economy where these entrepreneurs procure some of their goods. The generated revenues might translate into increased local spending and a significant share of the resulting profits may be retained by small local enterprises. The local municipal budget might also be impacted by the payments made by wind power project developers ahead of the construction and by local taxes.[27] Finally, spill-over effects may result in changes in local sectoral employment.

Table 2: Effect of Wind Power Deployment on the Personal Income - GPS Covariate Adjustment

Outcome variable: Income by type, normalised per capita. Explanatory variables: Generalised Propensity Score, New revenues from wind power deployment						
	Total	Entre.	Wages	Pensions	Educ.	Benefits
L.Revenue per capita	1.281***	0.581**	0.0734	0.214***	0.0157	0.103
	(0.004)	(0.025)	(0.786)	(0.009)	(0.299)	(0.229)
L(2).Revenue per capita	-0.336	-0.0859	-0.237	-0.0611	0.0142	0.104
	(0.440)	(0.628)	(0.287)	(0.589)	(0.455)	(0.178)
L(3).Revenue per capita	-0.486*	-0.128	-0.261	-0.0601	-0.00178	-0.0486
	(0.093)	(0.548)	(0.188)	(0.523)	(0.794)	(0.343)
GPS	348.2***	97.60***	224.3***	12.73	-2.611**	-2.422
	(0.000)	(0.000)	(0.000)	(0.335)	(0.047)	(0.709)
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2500	2500	2500	2500	2500	2500

p-values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

We start by discussing the impact of the new revenues from renewable energy on the various components of the personal income in the municipality (see Table 2). Given our specification in per capita-values, the coefficients are to be interpreted as the absolute monetary change per capita as a response to one extra euro per capita of additional revenues from wind power deployment. We expect the new revenues to directly impact the personal income in two ways. First, in the study period, around two-thirds of Danish wind power were owned by individual citizens, for example farmers (Gorroño-Albizu et al., 2019). In such a case, most of the net income generated by the power produced by the new turbines is reported as entrepreneurial income,[28] a category of the personal income data (as explained in Section 4).[29] Second, according to Statistics Denmark, the private income from land rental is also reported in entrepreneurial income. There is hence a potential additional direct income effect if wind turbines are built on rented land.

Considering the total income effect, we indeed observe a positive effect of the first lag of the new revenues on total income: one euro of new revenues per capita in the municipality induce an increase in the

[27] In Denmark, municipalities are rather large organisations. According to Blom-Hansen (2002) and Blom-Hansen (1998), they are responsible for a large share of public consumption (37% in 1990 and 45% in 2002) and can finance expenditure by independent local income taxation.

[28] Individuals who own their turbines and are not member of a partnership may consume part of the electricity they produce. This consumed electricity is not reported in the wind turbine register and cannot be taken into account into our analysis. In the example of the Skinnerup installation mentioned in Section 3, around 7% of the power produced is consumed by the farmer while the rest is sold to the grid.

[29] Costs in connection with operating a personally owned business are eligible to be deducted in determining the taxable income.

total income per capita in the municipality by 1.33 euros in the following year, which would suggest the existence of a multiplier effect. Looking in further detail at the impact on the reported categories, we see that the impact is positive for all categories, but significant at the 1% level for entrepreneurial income and pensions. In the case of entrepreneurial income, we find that one additional euro of new revenues leads to an increase of 57 cents after one year, with no additional impact observed the following years. This covers the income gain due to power produced by new wind turbines owned by individual entrepreneurs as well as the potential income gain for owners of land rented for wind power production. Somewhat surprising, we also find positive impacts on pensions with a magnitude of 22 cents. If we examine this in more detail, we find that this positive effect is on pensions from ATP, supplement to social pensions, and special early retirement pay (see Table 13 in appendix).[30] Some pensions schemes, for example the supplements to social pensions, are subject to adjustments that are function of the work related income, the income from financial sources (interest payments, private pensions, etc.) and the income generated by self-employment in case the recipient is an entrepreneur. This may be a channel by which wealth generated by the new wind turbines, either from the new electricity produced or from interests from participation in wind power investments, may result in pension increases. Additionally, according to Blom-Hansen (2009), Danish municipalities also have some autonomy to allocate pensions that are not old age pensions, i.e. various types of early retirement pensions. This might be a second channel via which wind power deployment may impact some pension revenues: some wind project developers make payments or donations to municipalities ahead of the project development, and local administrations have some freedom to decide how to use these additional revenues.[31] Finally we note that the coefficient found for the total personal income is larger than the sum of the coefficients found for each category. As explained in Section 4, the aggregate personal income data from Statistics Denmark also include wealth generated income (interest payments and return from stock investments) but the latter is not reported in the available detailed categories. We hence suspect that wind power also induces an increase in such wealth generated income.

In the second year after the connection of the new turbines to the grid, there is no additional increase in the personal income. The new turbines involve new revenues in the first year of connection. These revenues continue in subsequent years but do not necessarily grow. This suggests there is no impact of the first year revenue increase on the income in the following year. Any additional impact observed on the other outcome variables in the second year or later would have to arise from a spill-over on other sectors over time. On the contrary, we note a possible, though only significant at the 10% level, reversing impact in the third year after the connection of the turbine to the grid.

To analyse the impact of renewable energy deployment on the municipal budget, we have examined the budget spent by municipalities for current expenditures in the six main categories of municipal public spending,

[30] In Denmark, besides the labour market pension, which is firm-based and agreement based, the state pension includes two statutory schemes, the ATP (complement to the labour market pension) and the Special Pension (SP). For more details we refer to Stougaard (2001).

[31] We note that, as indicated by Helby (1998), some pension funds are creditors to renewable energy projects. The capital gain is then even exempted from a special tax that applies to other capital gains in pension funds. However pension funds are not necessarily located in the municipalities where the projects in which they invest take place.

namely administration, education and culture, health care activities, traffic and infrastructure, housing and community amenities, public utilities. The results are reported in Table 3. We find that the total budget spent by municipalities for current expenditures increases in the first two years following the connection of new turbines to the grid: 36 cents more per capita in the first year and 28 cents more in the second year (for each additional euro per capita of new wind revenues). This increase is significant for the budget categories of health care (25 cents more per capita in the first year, 23 cents more in the second year), administration (nearly 7 cents more per capita in the first year) and education and cultural activities (5 cents more per capita in the second year). We explain this increase in some categories of the municipal budget by donations or payments made by wind project developers ahead of the construction of new turbines. Such agreements with municipalities contributed to facilitate the local acceptance. As explained by Olsen (2022) (see Section 3), this was later formalised under the green scheme and the green fund. Municipalities may use this additional income to contribute, for example, to health care activities (the largest municipal budget category), to administration (possible additional load of administrative procedures following the construction of new turbines) or to cultural and recreational activities. In the third year after the connection of new turbines to the grid, we observe a significant reduction of the budget for public utilities. For this specific category, however, the budget mostly consists in revenues, reported as negative expenditures. The negative coefficient (-8 cents per capita for each additional euro per capita of new wind revenues) means a gain in revenues or a reduction in expenses. Local public utilities are likely to be impacted by wind power deployment: new wind installations may compete with them or municipalities themselves may participate in wind power projects. Helby (1998) indeed indicates that a significant share of wind turbines is utility owned (15% in 1996 while around 85% of wind turbines were privately owned).

Table 3: Effect of Wind Power Deployment on the Municipal Budget - GPS Covariate Adjustment

Outcome variable: Municipal budget by type, normalised per capita.
Explanatory variables: Generalised Propensity Score, New revenues from wind power deployment

	Total	Admin	Educ.	Health	Housing	Utilities	Infra
L.Revenue per capita	0.363***	0.0662***	0.0215	0.257***	0.0123	-0.0424	0.0611
	(0.001)	(0.000)	(0.566)	(0.008)	(0.711)	(0.344)	(0.427)
L(2).Revenue per capita	0.279***	0.0228	0.0489	0.229**	-0.0135	0.00645	0.00299
	(0.002)	(0.377)	(0.112)	(0.014)	(0.617)	(0.791)	(0.881)
L(3).Revenue per capita	-0.0905	-0.00574	-0.0370	0.0663	-0.0117	-0.0892**	0.0288
	(0.386)	(0.822)	(0.295)	(0.407)	(0.622)	(0.023)	(0.152)
GPS	-32.77	8.839***	19.26***	-62.96***	17.57	6.066***	-5.931***
	(0.246)	(0.004)	(0.000)	(0.000)	(0.234)	(0.001)	(0.007)
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2500	2500	2500	2500	2500	2500	2500

p-values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Effect of Wind Power Deployment on Employment - GPS Covariate Adjustment

Outcome variable: Employment by sector, normalised per 10.000 capita.
Explanatory variables: Generalised Propensity Score, New revenues from wind power deployment

	Total	Social Institutions	Mfr. of basic metals	Construction	Agriculture	Education	Retail and Repair
L.Revenue per capita	0.145	0.0848***	0.0561	0.0228	0.0275	0.000306	-0.00918
	(0.192)	(0.000)	(0.133)	(0.309)	(0.321)	(0.987)	(0.529)
L(2).Revenue per capita	0.108	0.0475	0.0599**	0.0431***	-0.0696***	0.0150	-0.00488
	(0.170)	(0.150)	(0.022)	(0.004)	(0.004)	(0.422)	(0.808)
L(3).Revenue per capita	-0.118	-0.00604	0.0467	-0.00722	-0.0408**	-0.0204	-0.00263
	(0.204)	(0.848)	(0.115)	(0.592)	(0.024)	(0.459)	(0.925)
GPS	8.506*	-2.694*	-1.664	-5.012***	10.61***	-3.965***	-1.525
	(0.054)	(0.094)	(0.440)	(0.000)	(0.000)	(0.002)	(0.230)
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2500	2500	2500	2500	2500	2500	2500

p-values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Effect of Wind Power Deployment on Employment - GPS Covariate Adjustment

Outcome variable: Employment by sector, normalised per 10.000 capita.
Explanatory variables: Generalised Propensity Score, New revenues from wind power deployment

	Business Activities	Public Administration	Wholesale (No vehicles)	Health activities	Transport	Associations and Culture	Mfr. of food
L.Revenue per capita	-0.00636	-0.0256**	0.00792	0.000998	-0.00293	-0.000943	0.0207
	(0.700)	(0.049)	(0.614)	(0.934)	(0.925)	(0.950)	(0.175)
L(2).Revenue per capita	-0.0334***	0.0103	0.0112	-0.0142	0.00435	0.0617**	-0.00364
	(0.007)	(0.463)	(0.404)	(0.507)	(0.855)	(0.021)	(0.844)
L(3).Revenue per capita	-0.0435**	0.0279	-0.0312*	0.00620	-0.0492***	0.0207	0.0433**
	(0.022)	(0.105)	(0.050)	(0.665)	(0.008)	(0.314)	(0.017)
GPS	5.607***	-4.420***	-9.620***	-0.00251	-1.564	-0.905	2.413**
	(0.005)	(0.000)	(0.000)	(0.998)	(0.177)	(0.384)	(0.044)
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2500	2500	2500	2500	2500	2500	2500

p-values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Effect of Wind Power Deployment on Employment - GPS Covariate Adjustment

Outcome variable: Employment by sector, normalised per 10.000 capita.
Explanatory variables: Generalised Propensity Score, New revenues from wind power deployment

	Sale and repair of vehicles	Mfr. of wood products	Hospitality	Finance and Insurance	Mfr. of chemicals	Mfr. of furniture	Communication
L.Revenue per capita	-0.00928	0.00285	-0.00937	0.00308	-0.0252**	-0.000553	0.00437
	(0.380)	(0.831)	(0.490)	(0.630)	(0.046)	(0.954)	(0.466)
L(2).Revenue per capita	-0.00442	0.0162	-0.0452*	0.0101*	0.0117	0.00189	-0.00460
	(0.773)	(0.230)	(0.073)	(0.072)	(0.208)	(0.896)	(0.356)
L(3).Revenue per capita	-0.00555	0.0205	-0.0499	-0.00795	0.00172	-0.0172	-0.0164***
	(0.632)	(0.105)	(0.248)	(0.325)	(0.857)	(0.317)	(0.004)
GPS	0.472	0.419	0.0132	2.722***	3.316***	1.166	-1.034
	(0.462)	(0.686)	(0.990)	(0.000)	(0.006)	(0.524)	(0.112)
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2500	2500	2500	2500	2500	2500	2500

p-values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Effect of Wind Power Deployment on Employment - GPS Covariate Adjustment

Outcome variable: Employment by sector, normalised per 10.000 capita. Explanatory variables: Generalised Propensity Score, New revenues from wind power deployment							
	Letting and Real Estate	Mfr. of mineral products	Mfr. of textiles	Utilitities	Not stated	Fishing	Mining
L.Revenue per capita	0.00275	-0.000512	0.0306*	0.00316	-0.00164	-0.00952*	-0.00279
	(0.744)	(0.984)	(0.063)	(0.727)	(0.791)	(0.079)	(0.337)
L(2).Revenue per capita	-0.00819	-0.00163	0.0134	-0.000601	0.000535	0.00901*	0.00211
	(0.420)	(0.895)	(0.271)	(0.932)	(0.942)	(0.081)	(0.552)
L(3).Revenue per capita	0.0119	-0.00155	0.0238	0.00609	-0.00125	-0.00838	0.00115
	(0.121)	(0.902)	(0.209)	(0.336)	(0.876)	(0.452)	(0.653)
GPS	0.475	0.291	2.966***	1.937***	1.194***	1.396**	-0.386
	(0.436)	(0.769)	(0.000)	(0.000)	(0.003)	(0.019)	(0.108)
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2500	2500	2500	2500	2500	2500	2500

p-values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Regarding the impact on employment, we expect direct and indirect effects of the installation of new turbines on local employment. The results are reported in Tables 7 to **??** (in the order of the sector description presented in Table 1). The outcome variable used here is normalised by 10,000 capita. In aggregate, we find that total employment in a municipality is not significantly impacted by new wind revenues: the coefficient 0.148 is positive but not significant (see Table 7). When we examine employment sector by sector, we observe very limited impacts: significant coefficients are always smaller than 0.09 in absolute values. To better explain the order of magnitude that this represents, this means that absolute new wind revenues of 50,000 euros in an average municipality of 10,000 capita[32] induce a change of less than half a position in a given sector in this municipality. In addition, job creation in some sectors are compensated by job losses in others. For example, in the first year after the connection of new turbines to the grid, there seems to be a very small employment increase in social institutions and the manufacturing of textiles, but a very small decrease in fishing, public administration or the manufacturing of chemicals. Similarly in the second and third years after connection of the new turbines, small employment increases in some sectors are compensated by small reductions in others.

To conclude, coming back to the earlier motivation of this study to examine the local economic impacts of wind power deployment, we find that wind power deployment does induce an increase in personal income at the local level, in particular in entrepreneurial income and some pension revenues: one euro of new revenues per capita in the municipality induces an increase in the total income per capita in the municipality by 1.33 euro in the following year, which even suggests a multiplier effect. We also observe an increase in the current expenditures of municipalities after new turbines are installed: respectively 25 and 23 cents more per capita for health care activities in the first and second years after the connection of a new turbine, and for each additional euro per capita of new wind revenues; nearly 7 cents more per capita for administration in the first year after the connection of a new turbine. This might be explained by donations and payments that municipalities receive from some wind project developers ahead of the turbine construction.

Regarding employment, wind power deployment seems to induce only very limited job creations in some sectors, compensated by similarly small job losses in others. In aggregate we do not find any significant impact of new wind revenues on employment in the municipality. This is rather consistent with the finding from Costa and Veiga (2021) in the case of Portugal. Focusing on unemployment, they find a very limited impact in the operation phase of the turbines. With regard to the debate on green growth or the double dividend, our study suggests that entrepreneurs investing in wind power projects and persons enrolled in some specific pension plans benefit from local wind power deployment. So does the municipal public administration. However, in aggregate, local employment alone cannot really be an argument for encouraging these projects, as job creations or losses are very limited and compensate one another among sectors.

[32]In our sample, average total employment is 10,758 and average new revenues are 49,699 €

7 Conclusion

We analyse the local economic impacts of wind power deployment in the case of Denmark. We take advantage of the long Danish wind power experience to examine the effect of the revenues from new wind turbines on the personal income, the municipal budget and employment at the municipal level, potentially taking into account spill-over effects on the various economic sectors. Using the very detailed data available, we build a panel and exploit the regional and time variations. We focus on the time period 1993-2002, when the extension of wind power was the largest. To address potential endogeneity concerns, we employ a quasi-experimental set-up and use the generalized propensity score introduced by Hirano and Imbens (2004), which allows for causal inference with observational data.

We find positive impacts of new wind power deployment on the personal per capita income on the municipality level in the year after the grid connection. This effect is mostly on entrepreneurial income and some pension revenues. One euro of new wind revenues per capita in a municipality induces an increase in the total income per capita in the municipality by 1.33 euro in the following year. The increase in the entrepreneurial income is explained by the fact that a significant share of wind turbines are owned by individuals, for example farmers. We observe an increase in the current expenditures of municipalities after new turbines are connected to the grid: for one euro of new wind revenues per capita in the municipality, we observe an increase of 36 cents in the municipal expenditures, particularly for health care and administration. This can be explained by donations and payments made by wind project developers to municipalities ahead of the construction. Finally we find that the addition of new wind turbines does not significantly increase employment in the municipality. Some sectors experience very small job creations but these are compensated by comparable losses in others. This is rather consistent with the finding from Costa and Veiga (2021) in the case of Portugal.

Our findings suggest that the political communication to support wind power deployment needs to be nuanced. Whilst our estimates imply that there are positive impacts of wind power deployment on the local economy, in particular on the personal income and the public spending, these are rather focused on specific groups and issues. The impact on employment remains rather limited and is not alone a sufficient argument to address the not-in-my-backyard syndrome.

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Appendices

Table 8: Onshore wind support policies in Denmark in the time period of the study

Date of commission	Support scheme
From 1984 to 2001	Electricity price paid to producers: 85% of the local retail price, excluding taxes
From 1991 to 2001	Fixed premium of 3.6 eurocents/kWh in addition to the previous scheme
Existing turbines bought before the end of 1999	Feed-in tariff of 8 eurocents/kWh for a number of full load hours, Then feed-in tariff of 5.8 eurocents/kWh until the turbine is 10 years old, Then premium of 1.3 eurocents /kWh or less until the turbine is 20 years old
From 2000 to 2002	Feed-in tariff of 5.8 eurocents/kWh for 22,000 full load hours, Then premium of 1.3 eurocents/kWh or less until the turbine is 20 years old with a limit of 4.8 eurocents/kWh on the sum of market price and premium, and an additional premium of 0.3 eurocents/kWh for balancing costs

Source: Jaureguy-Naudin (2010).

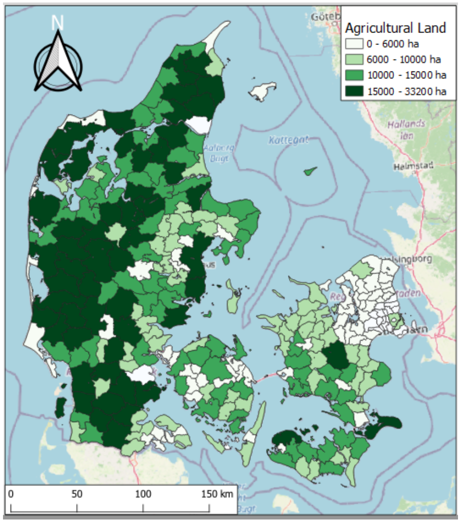

Figure 5: Geographical Distribution of Agricultural Land in 1993

Table 9: Summary Statistics of key variables, by group of municipalities for the year 1993

Group	Observations	Population	Income, total (millions)	Entrepr. Income (millions)	Budget, total (millions)	Employment (in persons)
1	31	14800.94	269.1761	18.91264	43.68279	7818.161
		(11849.74)	(218.7201)	(16.86055)	(40.13262)	(5990.789)
2	219	16276.71	264.6099	22.87164	43.68279	8205.265
		(25859.13)	(430.3454)	(25.26555)	(85.4612)	(12687.46)

Group 1 : municipalities without any wind turbine installations in the time period of the study.
Group 2 : municipalities with wind turbine installations in the time period of the study.
Standard deviation in parentheses.

Table 10: Summary Statistics of key variables per capita, by group of municipalities for the year 1994

Group	Observations	Population	Income, total (millions)	Entrepr. Income (millions)	Budget, total (millions)	Employment (in persons)
1	31	1.910813	.0358137	.0027862	.0059252	.9876874
		(.1871147)	(.0034084)	(.0009169)	(.0011061)	(.0122036)
2	219	1.98447	.0338739	.0036793	.006002	.9893458
		(.1319038))	(.0018571)	(.0010226)	(.0007108)	(.0007108)

Group 1 : municipalities without any wind turbine installations in the time period of the study.
Group 2 : municipalities with wind turbine installations in the time period of the study.
Standard deviation in parentheses.

Table 11: Summary Statistics of the first differences of the per capita variables, by group of municipalities for the year 1994

Group	Observations	Population	Income, total (millions)	Entrepr. Income (millions)	Budget, total (millions)	Employment (in persons)
1	31	.0287088	.0019713	.0003456	.0003456	.0003456
		(.0272124)	(.0007605)	(.0004186)	(.0001846)	(.0140426)
2	219	.0249681	.0017615	.0002296	.0002722	.02096
		(.0261183)	(.0004896)	(.0001759)	(.0001756)	(.017294)

Group 1 : municipalities without any wind turbine installations in the time period of the study.
Group 2 : municipalities with wind turbine installations in the time period of the study.
Standard deviation in parentheses.

Table 12: T-statistics of the difference in means of key variables between the two groups of municipalities for the year 1993

Variable	T-statistics of the difference in means
Population	-0.313
Income, total	0.058
Entrepreneurial Income	-0.845
Budget, total	-0.253
Employment, total	-0.167

Following results of the Levene test, the test statistics assume equal variance for all variables.
Group 1 : municipalities without any wind turbine installations in the time period of the study.
Group 2 : municipalities with wind turbine installations in the time period of the study.

Table 13: Effect of Wind Power Deployment on Pensions - GPS Covariate Adjustment

Outcome variable: Pensions by type, normalised per capita.
Explanatory variables: Generalised Propensity Score, New revenues from wind power deployment

	Other Pensions	ATP	Social	Supplements	Early Retir.	Earl. Ret. Pay
L.Revenue per capita	0.0618	0.00515**	0.0897	0.0115***	0.0149	0.0393
	(0.220)	(0.021)	(0.113)	(0.009)	(0.289)	(0.104)
L(2).Revenue per capita	-0.0910	-0.000930	-0.0566	0.00620	-0.0308***	0.0403*
	(0.252)	(0.694)	(0.298)	(0.525)	(0.003)	(0.078)
L(3).Revenue per capita	0.0763*	0.000870	-0.0144	-0.00120	-0.0367**	0.0100
	(0.092)	(0.727)	(0.755)	(0.791)	(0.023)	(0.784)
GPS	29.09***	1.257*	-26.35***	-1.384***	7.751***	-4.211
	(0.000)	(0.078)	(0.000)	(0.003)	(0.000)	(0.239)
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2500	2500	2500	2500	2500	2500

p-values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

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