IMPACT OF WIND ENERGY ON THE PORTUGUESE LABOR MARKET

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***Abstract*— Portugal is widely recognized as an example of a successful investment in renewable energy, especially wind energy, standing out in the European scenario. This investment has significant impacts on the local labor market. This study examines the effect of wind farm installation on employment using the Generalized Method of Moments (GMM) methodology and data from 278 Portuguese municipalities between 2013 and 2022. In addition, it evaluates the impact on sectoral jobs by gender. The results indicate that the increase in the installed capacity of wind energy boosts total employment and employment in the different economic sectors of the municipalities. In addition, the findings show that this impact is more significant for women in the agriculture and services sectors, while in industry, the effect is more pronounced for male workers.**

Keywords— Labor effects, Municipalities, Panel Data, Wind energy.

I. Introduction

The development of renewable energy in Portugal, especially wind energy, has intensified since 2000 [1]. The country has committed to reducing greenhouse gas emissions in its National Energy and Climate Plan for 2021-2030, setting ambitious targets for using renewable sources [2].

On the other hand, in response to Russia's invasion of Ukraine, the European Union presented the REPowerEU plan, which aims to reduce dependence on Russian fossil fuels. Under this initiative, the target of incorporating renewable sources in energy consumption for 2030 has been increased to 45%, and the energy efficiency target has been increased to 13%, aiming at greater sustainability and energy security [1].

Implementing wind farms also can create jobs in the construction and operation phases. However, these impacts vary across economic sectors, depending on the activity's labor intensity and the required profile [3]. Second [4], wind energy projects are, and remain, capital-intensive investments. Wind energy impacts the economy through several interconnected local, regional, and national mechanisms. Adopting renewable energy sources (RES) can reduce dependence on energy imports, which positively affects the trade balance and stability of supply, with repercussions on GDP. In Portugal, the wind sector was the renewable source with the most impact on GDP in 2022, with more than 45% of total RES. Moreover, between 2018 and 2022, RES generated, on an annual average, around 50 thousand jobs, with added value per average employee approximately twice as high as the national average [1]. Mainland Portugal comprises 278 municipalities according to the Official Administrative Charter of Portugal (CAOP), 2023 version. The number of wind farms has increased in the country, according to data made available by Energias Endogenas de Portugal from 2023. Figure 1 shows the installation of wind farms in municipalities in Portugal based on data from Energias Endogenas de Portugal (e2p) [5].

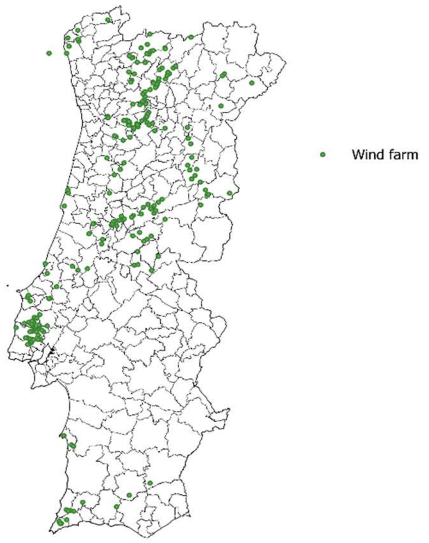

Fig. 1. Territorial distribution of wind turbines (2023) in municipalities of Portugal

In December 2024, the share of renewable sources in electricity generation was 69.9%. In turn, the centers of thermal electricity production from fossil fuels accounted for 21.1%. In 2024, 45,637 GWh of electricity was generated in mainland Portugal, of which 80.4% came from renewable sources, with wind energy accounting for 30% of this total [6]. On the other hand, according to e2p, among renewable energy sources, wind energy continues to play a key role in the Portuguese electricity sector. In 2023, electricity generated from wind energy accounted for just over a quarter of national demand. Installed capacity has also been increasing, consolidating the role of wind energy in the country's energy system [5].

In this context, assessing the effects of the installation of wind farms on employment (variables associated with social well-being and local economic development) in Portuguese municipalities, considering specific sectors and gender, is an essential contribution to understanding the sectoral impact of renewable energy on the local economy. As far as we know,

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few studies have analyzed the effects of the installation of RES in the context of Portugal, despite Portugal being at the forefront of RES, especially in wind energy. Additionally, no further study details this impact at the municipality level by economic sectors, despite the different geographies and economic conditions for RES installation. These variations could bring socio-economic opportunities for residents and migrants in rural areas compared to urban ones, with all the inherent problems associated with urbanization.

The analysis is essential to the recent objectives of Portugal's National Energy and Climate Plan (PNEC), which foresees a generating capacity of 6.3 and 10.4 GW of onshore wind in 2025 and 2030, respectively. In addition, this study contributes to sustainable development at the local level, providing valuable information that can support the formulation of policies capable of reconciling economic growth with environmental preservation, thus aligning with the SDGs. In particular, the following SDGs stand out: Goal 7: Ensure access for all to affordable, reliable, sustainable, and modern energy; Goal 11: Make cities and human settlements inclusive, safe, resilient, and sustainable; and Goal 13: Take urgent action to combat climate change and its impacts [7].

This work is structured in five sections. The first section consists of this introduction, followed by section two, providing an overview of the existing literature. The third section deals with the methodology used, including a description of the databases and variables. The fourth section presents the results and the corresponding discussions. Finally, the conclusions and final considerations are presented in section five.

II. An Overview of the Literature

The impact of the wind energy sector on direct employment in all EU countries was analyzed by [8] through a thematic survey. Their results indicate that in 2008, the expansion of wind energy generated more than 104,000 jobs, especially when other energy sectors were in decline. According to the authors, France, Italy, Ireland, and Portugal stood out as exceptionally dynamic countries in this context.

Indeed, job creation is significant in the construction phase. In contrast, the impacts on employment during the operation phase are modest, as concluded by [9] in a study that analyzed how investments in wind energy can boost regional development and employment and that explored how different benefit-sharing instruments in a wind farm in the Swedish county of Norrbotten can be applied using an input-output matrix. These conclusions were confirmed by [11], which quantifies the creation of direct jobs in the manufacturing, construction, operation, and maintenance phases of wind energy, in addition to indirect jobs in the supply chains of materials and inputs for the manufacture of wind turbines and construction of wind farms. Considering the production, not the installed capacity of wind energy in Brazil, the results indicate that the sector's projected growth should generate approximately 90,000 jobs between 2012 and 2016. More than 74% of these will be created in the construction and operation phases, which stand out for their high potential for local employability.

Also, [14] highlighted that most jobs occur during construction, while permanent positions in operation and maintenance are significantly lower. They analyzed the impact of wind energy in the Aragon region of north-eastern Spain, using a multi-regional input-output (MRIO) model to locate and explain the dynamics of these effects on employment. The overall results of the scenarios studied indicated that between 26% and 30% of the jobs created would occur in Aragon, with 13,500 to 15,000 jobs in Spain's National Energy and Climate Plan (PNIEC) scenario. In addition, when investments are spread over 10 years, approximately 1,350 to 1,500 direct and indirect jobs would be needed annually.

In the United States, [10] examined the effects of wind energy in counties between 2000 and 2008, using an ex-post econometric approach. The authors noted that county personal income and employment increased by approximately $11,000 and 0.5 jobs per megawatt of installed wind power capacity during the reporting period. Also, for U.S. counties, the study by [13] investigated the impact of commercial wind on economic development, using data on the timing, location, and capacity of all wind power facilities in the country between 1995 and 2018. The authors concluded that wind power installation significantly increased GDP per capita, per capita income, median household income, and median housing values in counties. In addition, they noted that the installation of wind power had little impact on total employment but changed the composition of local employment, with a shift from agricultural to non-agricultural activities, highlighting an increase in employment in the construction and manufacturing sectors.

Similar conclusions were found in [12], which analyzed the effects of wind energy on the Brazilian market between 2004 and 2016, using a Differences in Differences (DiD) approach with i) multiple periods, ii) variation in the timing of treatment, and iii) dynamic effects of treatment through an event study design. The authors found that implementing wind farms increased employment and wages in the industrial, agricultural, and construction sectors. Regarding educational level, the authors observed that the positive effect was more evident in unskilled workers up to two years after the installation of wind farms in the municipalities.

The study by [3] analyses the impact of wind energy on the labor market of Portugal's 278 municipalities between 1997 and 2017, using the panel data approach. They find that for every 100 megawatts of installed capacity, there is a reduction of 0.17 to 0.23 percentage points in the unemployment rate, with a more pronounced effect on unskilled work and among male workers. The authors conclude that workers are willing to move but not to migrate since there are positive spatial repercussions for municipalities located 30 km or less away.

In this context, an updated study focused on Portuguese municipalities, intending to analyze the impacts of wind energy on employment, including jobs in the various sectors of the economy, such as agriculture, industry, and services, as well as their disaggregation by gender, would be highly relevant to the existing literature. Such a study would allow for a deeper understanding of the specific effects of the implementation of wind energy projects on the local labor market, addressing changes in the number of jobs, differences between economic sectors, and potential gender inequalities in access to these jobs. In addition, the analysis could contribute to identifying trends and challenges related to social inclusion and the equitable distribution of the sector's benefits, expanding the understanding of the role of renewable energy in the sustainable development of the regions.

III. Methodology and Data

A. Methodology

This study uses the panel data methodology to analyze the impact of the installation of wind farms on the sectoral employment of Portuguese municipalities. A dynamic panel data approach is used to achieve the proposed objectives, adopting the Generalized Method of Moments (GMM), as there may be endogeneity between installed wind energy capacity and unemployment rate. Introduced by [15], GMM is a robust approach to addressing endogeneity and heteroscedasticity issues. To estimate the impact of installed wind energy capacity on employment, this work employs the Generalized Method of Moments in System (System-GMM) proposed by [16].

Thus, the model equation can be written as:

$$E_{\iota\tau} = \alpha E_{\iota\tau-1} + \beta X_{\iota\tau} + \upsilon_\iota + \varepsilon_{\iota,\tau}. \quad (1)$$

E_{it} is the municipality's dependent variable (Employment) ι during the period τ. $X_{\iota\tau}$ represent the explanatory (installed capacity) and control (Gross Domestic Product, Population Density) variables. υ_ι is the municipality-specific fixed effect (not observed) and $\varepsilon_{\iota,\tau}$ is the idiosyncratic error.

The choice of variables and the model arises as wind farm installations can influence employment levels by generating direct and indirect jobs. On the other hand, municipalities with higher unemployment rates may attract renewable energy investments due to tax incentives or the availability of cheaper labor [17], [18].

The control variables are included as the correlation between employment rate and GDP per capita, which is proven in the literature and generally shows a positive relationship (Okun's Law) [19], [20], [21]. Moreover, several academic studies have employed econometric models to analyze the relationship between employment and population density [22], [23].

B. Data

The database of this study is composed of annual data from the 278 municipalities of Portugal, covering the period from 2013 to 2022. The variables related to employment and GDP come from INE (National Institute of Statistics), while e2p (Endogenous Energies of Portugal) provides data on wind energy. The employment variables considered include total employment (Empt), male employment (Emph), and female employment (Empm). In addition, employment data by sector of activity, namely the agriculture sector, with total employment (Emptag), disaggregated by gender (Emphag for men and Empmag for women) are analyzed; the industry sector, with total employment (Emptind), disaggregated by gender (Emphind for men and Empmind for women); and the services sector, with total employment (Empstser), disaggregated by gender (Emphserv for men and Empmser for women). Employment data are measured by the number of people employed (No.). Finally, this study uses as an explanatory variable the installed capacity (Cap) measured in megawatts (MW) and, as control variables, the population density (Denspop) measured in Number per square kilometer and the Gross Domestic Product (GDP) in euro, following the approach adopted by [3], [12]. Variables like employment, GDP, and population density were introduced in the model in log returns, considering that data stationarity tests revealed them to be only stationary after this transformation.

IV. Results and Discussions

A. Descriptive Statistics

Analyzing Table I, total employment shows an average of 7,658 workers per municipality but a high standard deviation of 20,774, reflecting a large variation between municipalities. Male employment (4,158.48) and female employment (3,499.68) have similar values but exhibit high dispersion, suggesting significant differences between the regions. Concerning economic sectors, the agricultural sector registers an average total employment of 161.18 workers, with a standard deviation of 284.43, showing that some municipalities have a significantly larger workforce in agriculture than others. The industrial sector, on the other hand, has an average of 2,447.90 workers, but with significant variation between municipalities, as shown by the standard deviation of 4,078.77. When segmented by gender, it can be seen that male industrial employment (1,664.60) surpasses female (807.90), pointing to a male predominance in industry. On the other hand, the services sector concentrates the most significant number of workers, with an average of 5,121.43, although the standard deviation of 18,591.67 reveals considerable heterogeneity among the municipalities.

Male and female employment in this sector presents more balanced values, suggesting a more homogeneous distribution between genders. In summary, the analysis of Table I reveals that total employment is generally higher among men than women, a trend observed in all sectors of the economy except for services. In addition, the services sector concentrates most of the employment, followed by industry and agriculture.

TABLE I. DESCRIPTIVE ANALYSIS

Variables	Count	mean	Std	Min	max
Empt	2780	7658.17	20774.86	170	355063
Emph	2780	4158.48	10702.09	89	179026
Empm	2780	3499.68	10116.85	64	176037
Emptag	2628	161.18	284.43	0	5934
Emphag	2598	115.07	208.19	0	4509
Empmag	2500	49.42	83.98	0	1425
Emptind	2632	2447.90	4078.77	21	29848
Emphind	2600	1664.60	2681.02	17	17301
Empmind	2504	807.90	1518.48	3	12547
Emptser	2776	5121.43	18591.67	61	334244
Emphser	2778	2430.30	9104.97	27	164276
Empmser	2774	2689.64	9497.15	26	169968
Cap	2780	19.72	106.93	0	1208.9

Notes: The employment variables considered include total employment (Empt), male employment (Emph), and female employment (Empm). Employment data by sector of activity, namely the agriculture sector, with total employment (Emptag), Emphag for men and Empmag for women; total employment in industry (Emptind), Emphind for men and Empmind for women; and the services sector, with total employment (Empstser), Emphserv for men and Empmser for women. Employment data are measured by the number of people employed (No.).

B. Labor impact

The coefficient of most significant interest is that of installed capacity, which represents the effect of an increase of 1 MW in the installed capacity of wind energy on the results of interest. It is worth noting that all variables were transformed into logarithms except installed capacity. Table II presents the impact of installed wind energy capacity on total employment and employment by gender, differentiating male and female workers. We observe that the increased installed capacity of wind energy positively affects total employment. Specifically, a 1 megawatt (MW) increase in installed capacity results in a 0.05% growth in total employment. This finding corroborates previous studies conducted by [9], [10], and [13], which also identified positive impacts of wind energy on the labor market. However, in our analysis, this effect is more pronounced among female workers. While an increase of 1 MW results in a 0.044% increase in male employment, the impact on female employment is 0.073%, suggesting that the expansion of wind energy can proportionally benefit women in the labor market.

TABLE II. IMPACT ON TOTAL EMPLOYMENT

Variables	Ln_Empt	Ln_Emph	Ln_Empm
	GMM-SYS	*GMM-SYS*	*GMM-SYS*
Ln_Emp_{t-1}	0.60079***	0.66691 ***	0.44454***
Cap	0.00053***	0.00044 ***	0.00073**
Ln_Gdp	0.118064***	0.10966 ***	0.15120***
Ln_Denspop	0 .16111***	0.13799***	0.21196***
Constant	0.29448*	-0 .18233	0.28059
AR-1 pvalue	0.000	0.000	0.000
AR-2 pvalue	0.729	0.210	0.979

Notes. *p<0.1; **p<0.05; ***p<0.01

Notes: Additional to the employment variables referred in table I we used as an explanatory variable the installed capacity (Cap) measured in megawatts (MW) and, as control variables, the population density (Denspop) measured in Number per square kilometers and the Gross Domestic Product (GDP) in euros.

Tables III, IV, and V present the impacts of installed capacity on employment in the different economic sectors. We noted an effect on the three sectors but a more significant impact on services, corroborating the findings of [13]. Analyzing Table V shows that agricultural sector employment increases with installed capacity expansion. Specifically, a 1 MWh increase in installed capacity is associated with a 0.042% growth in total employment in agriculture. However, when disaggregated by gender, we find that the impact on male employment in the agricultural sector is negligible, reaching 0.034%, while the effect on female employment is higher, gaining 0.057%. These results suggest that investments in installed capacity benefit female employment in agriculture proportionally more.

Regarding the previous result, investments in installed capacity (for example, improved irrigation systems, mechanization, storage facilities, and processing plants) can disproportionately benefit female employment in agriculture due to several structural and socio-economic factors. Usually, women in agriculture often perform labor-intensive tasks such as planting, weeding, and post-harvest processing. Investments in mechanization and infrastructure reduce the physical burden of these tasks, making it easier for women to participate more effectively. Conversely, investments in storage, processing, and agribusiness facilities create more opportunities in roles where women are already overrepresented, such as food processing, packaging, and quality control. Moreover, better infrastructure and logistics enhance women's ability to bring products to market, increasing their economic participation and employment in agricultural value chains, and investments often lead to the formalization of agricultural employment, which benefits women by providing better wages, social protections, and access to credit. The wage gap in Portugal is increasing, which can be a possible solution to overcome this tendency [24]. Finally, capacity investments often come with training programs, and when women are included, they gain technical skills that make them more employable in modernized agricultural sectors.

TABLE III. IMPACT ON EMPLOYMENT IN THE AGRICULTURE SECTOR

Variables	Ln_Emptag	Ln_Emphag	Ln_Empmag
	GMM-SYS	*GMM-SYS*	*GMM-SYS*
$Ln\text{-}Emp_{t-1}$	0.38359***	0.36813**	0.27109
Cap	0.00042**	0.00034*	0.00057*
Ln_Gdp	0.14338***	0.19347***	0.05399
Ln_Denspop	-0.05221	-0.11736*	0.10438
Constant	0.35390	-0.39816	0.92218
AR-1 pvalue	0.000	0.002	0.005
AR-2 pvalue	0.004	0.574	0.221

Notes. *p<0.1; **p<0.05; ***p<0.01

Notes: The employment variables considered include total employment (Empt), male employment (Emph), and female employment (Empm). In addition, employment data by sector of activity, namely the agriculture sector, with total employment (Emptag), disaggregated by gender (Emphag for men and Empmag for women) are analyzed; the industry sector, with total employment (Emptind), disaggregated by gender (Emphind for men and Empmind for women); and the services sector, with total employment (Empstser), disaggregated by gender (Emphserv for men and Empmser for women). Employment data are measured by the number of people employed (No.). Finally, this study uses as an explanatory variable the installed capacity (Cap) measured in megawatts (MW) and, as control variables, the population density (Denspop) measured in Number per square kilometers and the Gross Domestic Product (GDP) in euros.

Table IV presents the estimation results for the industry sector. It is observed that the installed capacity exerts a positive and highly significant effect on employment in the industrial sector. For total employment in industry, the impact is 0.00062. In the case of male employment, the effect is slightly more significant (0.00042), suggesting that investments in installed capacity benefit men more. For female employment, the impact is 0.00063, indicating that women also benefit from investments in industry, although to a lesser extent than men. According to [25], the wind energy sector significantly boosts industrial employment, particularly in manufacturing wind turbines and related components.

When analyzing the impact on the services sector (Table V), we observed that the installed capacity has a positive and highly significant effect on employment in this sector. For total employment, the estimated impact is 0.00081. When disaggregated by gender, we found that the effect on male employment is slightly more significant, with a coefficient of 0.00096, suggesting that investments in infrastructure tend to benefit men more in the service sector. The coefficient for female employment is 0.00083, indicating that women also benefit from these investments, although to a lesser extent than men. According to [11], the service sector benefits significantly from wind energy development, with increased employment in project management, engineering services, and maintenance.

TABLE IV. IMPACT ON EMPLOYMENT IN THE INDUSTRIAL SECTOR

Variables	Ln_Emptind	Ln_Emphind	Ln_Empmind
	GMM-SYS	*GMM-SYS*	*GMM-SYS*
Ln_Emp_{t-1}	0.46708***	0.61881***	0.25740
Cap	0.00062***	0.00042***	0.00063**
Ln_Gdp	0.14684***	0.11934***	0.16590***
Ln_Denspop	0.27168***	0.18597***	0.45034***
Constant	-0.28923	-0.54365***	-0.95570**
AR-1 pvalue	0.000	0.000	0.025
AR-2 pvalue	0.051	0.049	0.690

Notes. *p<0.1; **p<0.05; ***p<0.01

Notes: The employment variables considered include total employment (Empt), male employment (Emph), and female employment (Empm). In addition, employment data by sector of activity, namely the agriculture sector, with total employment (Emptag), disaggregated by gender (Emphag for men and Empmag for women) are analyzed; the industry sector, with total employment (Emptind), disaggregated by gender (Emphind for men and Empmind for women); and the services sector, with total employment (Empstser), disaggregated by gender (Emphserv for men and Empmser for women). Employment data are measured by the number of people employed (No.). Finally, this study uses as an explanatory variable the installed capacity (Cap) measured in megawatts (MW) and, as control variables, the population density (Denspop) measured in Number per square kilometers and the Gross Domestic Product (GDP) in euros.

TABLE V. IMPACT ON EMPLOYMENT IN THE SERVICE SECTOR

Variables	Ln_Emptser	Ln_Emphser	Ln_Empmser
	GMM-SYS	*GMM-SYS*	*GMM-SYS*
$Ln\text{-}Emp_{t-1}$	0.48596***	0.46960***	0.47718***
Cap	0.00081***	0.00096***	0.00083***
Ln_Gdp	0.16849***	0.18234***	0.15913***
Ln_Denspop	0.17567***	0.20921***	0.15504***
Constant	-0.06582	-0.82866***	-0.02957
AR-1 pvalue	0.000	0.000	0.000
AR-2 pvalue	0.622	0.909	0.726

Notes. *p<0.1; **p<0.05; ***p<0.01

Notes: The employment variables considered include total employment (Empt), male employment (Emph), and female employment (Empm). In addition, employment data by sector of activity, namely the agriculture sector, with total employment (Emptag), disaggregated by gender (Emphag for men and Empmag for women) are analyzed; the industry sector, with total employment (Emptind), disaggregated by gender (Emphind for men and Empmind for women); and the services sector, with total employment (Empstser), disaggregated by gender (Emphserv for men and Empmser for women). Employment data are measured by the number of people employed (No.). Finally, this study uses as an explanatory variable the installed capacity (Cap) measured in megawatts (MW) and, as control variables, the population density (Denspop) measured in Number per square kilometers and the Gross Domestic Product (GDP) in euros.

V. CONCLUSION

Wind energy is an essential renewable energy source for economic and sustainable development at the municipal level. The main objective of this study is to analyze the effects of wind energy on the labor market of Portuguese municipalities. Although some studies explore the impacts on unemployment, this work stands out for analyzing the effects on employment by economic sectors and gender, using the System-GMM approach.

The results indicate that the increase in the installed capacity of wind energy impacts the labor market of Portuguese municipalities. With the sectors of the local economy, this effect is more pronounced in the services sector. As for gender distribution, the impacts are more significant for women in the agriculture and services sectors, while in industry, the effect is more significant for male workers. The installation of wind farms generates short-term employment in construction, civil engineering, and electrical work. Furthermore, once operational, wind farms require technicians for maintenance, albeit at a lower intensity than during construction. In this sense, local workers may benefit from specialized training, increasing their employability in the renewable energy sector.

In this way, our results provide a clear view of the impacts of investments in wind energy on the labor market, generating relevant insights for formulating public policies to promote economic and sustainable development. Suggested policies can focus on maximizing the benefits of wind energy for the local job market and mitigating possible inequalities. Indeed, many wind farms are installed in rural areas, where traditional industries (like agriculture) provide limited employment opportunities. Wind energy can diversify the local economy, offering higher-skilled jobs and reducing reliance on seasonal agricultural work. Also, municipalities hosting wind farms often receive tax revenues and rents from energy companies, which can be reinvested in local infrastructure and services. This can indirectly boost employment in public services, retail, and small businesses due to improved economic conditions.

For instance, qualification and professional training programs for women in the agriculture and services sectors, taking advantage of the more significant generation of jobs in these areas, or initiatives to train male workers in the industry, ensuring adaptation to new opportunities created by the expansion of wind energy. Moreover, incentives for technical and professional courses linked to renewable energy promote the transition of workers to professions in the sector. Similarly, it may be argued that wind energy creates jobs, but there may be some displacement from traditional energy sectors (e.g., fossil fuels), benefiting energy transition requirements. Thus, workers in declining industries may need reskilling programs to transition to renewable energy jobs.

Furthermore, financing programs and incentives for the modernization of agriculture could ensure that the profits generated are secure and well-remunerated. Creating policies that strengthen female participation in agriculture, such as easier access to rural credit and incentives for women-led businesses and partnerships between the wind and agricultural sectors to generate mutual benefits, such as agrivoltaic projects or financial compensation, could enhance the positive results.

Finally, it is essential to ensure that investments in wind energy are accompanied by local development strategies so that economic benefits are distributed equitably. For example, creating policies to encourage population settlement in municipalities with more significant expansion of wind energy, avoiding rural exodus, integrating the renewable energy sector with other local economic activities, promoting balanced growth, and stimulating the creation of local industries linked to the wind energy production chain (maintenance, component manufacturing, logistics), creating more opportunities for workers in the industrial sector. Future research should consider a regional analysis within Portugal, as well as the relocation and transition of workers between sectors, in addition to the impacts on the qualification and specialization of the local workforce.

A more in-depth analysis of the regional economic implications is recommended for future research, particularly in rural areas where wind farms are concentrated. Additionally, a detailed study on the long-term effects on income distribution and social mobility could provide a more comprehensive understanding of the impact of wind energy on economic development. Future studies could also expand the analysis to include other renewable energy sources, allowing for a broader comparison. Finally, more detailed regional comparisons could offer valuable insights into how local characteristics influence the effectiveness of wind energy in promoting employment and sustainable economic growth.

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