REVISTA BRASILEIRA DE ENERGIAS RENOVÁVEIS

THE IMPACT OF WIND POWER CONSUMPTION ON THE LABOR MARKET- A STUDY OF TEN EUROPE UNION MEMBER COUNTRIES[1]

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Abstract

The impact of wind power consumption on the labor market was analyzed for a panel of ten European Union countries in a period from 1990 to 2015. The Autoregressive Distributed Lag Methodology was used in order to decompose the total effect of wind power consumption on the labor market in its short- and long-run components. The empirical results indicate that wind power consumption has a positive impact of 0.0191 on the labor market, and oil consumption does not cause any impact whatsoever.

Keywords: Energy, econometric, energy economics, energy conservation, applied economics

O IMPACTO DO CONSUMO DE ENERGIA EÓLICA NO MERCADO DE TRABALHO - UM ESTUDO SOBRE OS PAÍSES MEMBROS DA UNIÃO EUROPÉIA

Resumo

O impacto do consumo de energia eólica no mercado de trabalho foi analisado em um painel de dez países membros da União Europeia, durante o período compreendido entre 1990 e 2015. Neste sentido, foi utilizada a metodologia *Autoregressive Distributed Lag Panel* de forma a decompor o efeito total do consumo de energia eólica no mercado de trabalho em seus componentes de curto e longo prazo. Os resultados empíricos indicam que o consumo de energia eólica tem um impacto positivo de 0.0191 no mercado de trabalho e o consumo de óleo possui o efeito inverso, não causando qualquer impacto.

Palavras-chave: Energia, econometria, economia energética, conservação de energia, economia aplicada

1. Introduction

In the last two decades, the renewable energy sources have been gaining more relevance and being more discussed due to the climate change. Regarding this subject, the Kyoto Protocol was created in 1997 during a United Nations Convention and entered later into force in 2005. This treaty promotes the use of renewable energy sources in order to reduce carbon dioxide emissions (CO_2). In this regard, each country has sought to implement the use of renewable energy sources in accordance with its own potential and characteristics. In this context, European Union (EU) has also set a long-term GHG reduction goal of 80 to 95 percent from 1990 levels by 2050 (Cludius, et al., 2012). It should be pointed out that Wind power is an important renewable energy source considering that it is highly responsible for reducing greenhouse emissions. Moreover, this source could supply up to 20 % of the global electricity demand by 2050 (Rodrigues, et al.,2016). In literature, several authors have been investigating the impact of wind power consumption on the labor market. One example is Li, et al. (2017) who researched and studied 28 countries, all members of the European Union (EU), in a period from 1996-2013. The authors concluded that the investments in wind power have a positive impact on economic growth and consequently a positive impact on the labor market. Costa and Veiga (2016) investigated Portugal in a period from 2001-2014. The researchers found that the installation and investments in wind power have a positive impact on the labor market.

Rodrigues, et al. (2016) researched in Brazil, in a time series of 1990 to 2013, the impact of wind farms in regional economy. The results suggest that the implementation of wind farms may raise wages in the construction, transportation and logistics sectors. Moreover, the presence of these plants may shift resources to the agricultural sector, stimulating the activity in the local economy. Indeed, other authors confirmed that wind power consumption has the capacity to create jobs (e.g Okkonen and Lehtonen 2016; Wiser, et al.2016; Bobinaite and Priedite, 2015; Ejdemo and Söderholm, 2015; Valodka and Valodkiené,2015; Gkatsou, et al. 2014; Kondili and Kaldellis, 2012).

The aim of this study is to answer the following question: Does wind power consumption has any impact on the labor market? In order to answer this question, the impact of wind power consumption on the labor market will be analyzed for ten European Union (EU) member countries namely: Belgium, Denmark, Germany, Greece, Italy, Netherlands, Portugal, Spain, Sweden and United Kingdon in a period from 1990 to 2015 using Unrestricted Error Correction Model (UECM) form of the Auto-Regressive Distributive Lag (ARDL).

The study of this theme is fundamental to be able to understand the real impact of wind power consumption on the labor market in European Union countries. Additionally, the choice of these countries is justified due to the rapid consumption growth of this energy source.

This article is organized as follows: Section 2, will present a brief literature review. Section 3, the methodology, databases, and preliminary tests that were used. Section 4, the empirical results. Section 5, discussions. Finally, the conclusions and policy implications are shown in Section 6.

2. Literature Review

The influence of wind power consumption on the labor market has been object of a vast body of literature evidencing that this kind of energy has in fact, a positive influence on the labor market. Table 1 presents a summary of the literature review, namely authors, periods, countries, methodology, influence, and main conclusions.

Table 1. Summary of literature review

Author(s)	Period	Country(ies)	Methodology	Impact on the labor market	Main conclusion(s)
			Wind power consumption		
Li, et al. (2017)	1996-2013	28 member countries of the EU.	Pooled regression model and Fixed effect model	+	The investments in Wind power have positive impact on economic growth, and the wind power development has been influenced by the energy intensity of the economy.
Costa and Veiga (2016)	2001-2014	Portugal	n.a	+	The installation and investments in wind power have a positive impact on the labor market.
Rodrigues, et al. (2016)	1990-2013	Brazil	ATT	+	The results suggest that the implementation of wind farms may raise wages in the construction, transportation and logistics sectors. Moreover, the presence of these plants may shift resources to the agricultural sector, stimulating the activity in the local economy.
Okkonen and Lehtonen (2016)	2009	Northern Islands of Scotland	n.a	+	The wind power creates less income and employment in local communities.
Wiser, et al. (2016)	2020-2050	USA	n.a	+	In the U.S.A wind industry that grows from roughly 100,000 full-time-equivalent jobs today (inclusive of onsite, supply-chain, and induced jobs) to 201,000–265,000 in 2020 and then to 526,000–670,000 in 2050.
Bobinaite and Priedite (2015)	2005-2013	Latvia	Cost-benefit analysis method	+	The wind power investment reduces the unemployment in Latvia.
Ejdemo and Söderholm (2015)	2014-2030	Sweden	n.a	+	The wind power sector promotes regional development and employment.
Valodka and Valodkiené (2015)	2004-2013	Lithuania	n.a	+	The wind power consumption has a positive impact in creating new jobs.
Gkatsou, et al. (2014)	2012-2050	Greece	LCA methodology	+	The wind power creates “green jobs”.
Kondili and Kaldellis (2012)	n.a	n.a	n.a	+	The wind energy creates new job positions.

Notes: n. a. denotes ‘not available’. The abbreviations are as follows: Average Treatment Effect on The treated (ATT); Life Cycle Assessment (LCA); United States of America (U.S.A).

The literature provides evidence that the wind power consumption has a positive impact on the labor market.

3. Data and Methodology

This section is divided into three parts. In the first one it will be presented the data used in this research. The second section contains the methodology used. The third approaches preliminary tests.

3.1 Data

To analyze the influence of wind power consumption on the labor market, it was utilized the data, from 1990 to 2015, of ten member countries of the European Union (EU) namely: Belgium, Denmark, Germany, Greece, Italy, Netherlands, Portugal, Spain, Sweden and United Kingdon .All of the approached european countries have increased their wind power consumption and as such, they are higly relevant to this research. The variables used in our analysis were: (i) Total labor force that comprises people ages 15 and older, representing the economically active population according to the International Labour Organization: all people who supply labor for the production of goods and services during a specified period. It includes both the employed and the unemployed. Moreover, the labor force includes the armed forces and first-time job-seekers, but excludes homemakers and other unpaid caregivers and workers in the informal sector.This variable comes from World Bank Database (WBD);(ii) Wind gross inland consumption in Thousand tonnes of oil equivalent (TOE). This variable comes from EUROSTAT; (iii) Gross Domestic Production (GDP) based on purchasing power parity (PPP). PPP GDP is the gross domestic product converted to international dollars using purchasing power parity rates. This variable comes from World Bank Database (WBD); (iv) Oil consumption in Million of Tonnes. This variable comes from BP Statistical Energy Review 2016. Indeed, the variables (e.g Wind Gross Consumption, GDP in PPP, and Oil consumption were transformed in *per capita*, using the total population of each cross). Table 2 shows the summary statistics of variables. The panel descriptive statistics, can see in (Table A1).

Table 2. Summary statistics of variables

Variables	Obs	Mean	Std Dev	Min	Max
LLABOUR	260	15.8752	0.7878	14.8382	17.3127
LWIND	260	4.4162	2.6215	-2.3026	8.8262
LGDP	260	10.4211	0.2113	9.9118	10.7608
LOIL	260	3.5462	0.8546	2.0440	4.9225

Notes: The prefixes L and denote natural logarithms. The Stata command *sum* was used.

Moreover, to the realization of this analysis were utilized following software: Stata 14.0, and EViews 9.5.

3.2 Methodology

The Autoregressive Distributed Lag (ARDL) in the form of Unrestricted Error Correction Model (UECM) was applied, to analyze the influence of wind power consumption on the labor market in ten EU member countries. The ARDL model has a capacity to decompose the total effect of a variable into its short and long-run components. (e.g. Fuinhas, et al. 2016). Moreover, this model is consistent with efficient estimations and parameters inferences based on the standard test. To denote the natural logarithms and first differences of variables were used the prefixes (L) and (D). Moreover, to analyze the influence of differents sources like renewable and fossil in the labor market were created, two models. Indeed, the model (I) analyzes the influence of wind power consumption and model (II) the influence of oil consumption.Inr order to be able to analyze the influence of wind power consumption, the following equation was used:

Model (I)

$$LLABOR_{it} = \Delta_{0it} + \sum_{t=0}^{k} \Pi_{2it} LWIND_{it} + \sum_{t=0}^{k} \Pi_{3it} LGDP_{it} + \Omega_{1it} \qquad (1)$$

Where, (***LLABOR)*** is the dependent variable, and (***LWIND*** and ***LGDP***) are the independent variables in the model. Indeed, the Δ_{0it} is the intercept, $\Pi_{2it\ldots}\Pi_{3it}$ are the parameters of variables and Ω_{1it} is the error term of the model. To study the influence of oil consumption on the labor market the following equation was used:

Model (II)

$$LLABOR_{it} = \Delta_{0it} + \sum_{t=0}^{k} \Gamma_{2it} LOIL_{it} + \sum_{t=0}^{k} \Gamma_{3it} LGDP_{it} + \Omega_{2it} \tag{2}$$

Where, (***LLABOR***) is the dependent variable and (***LOIL*** and ***LGDP***) are the independent variables in the model. The Δ_{0it} is the intercept, $\Gamma_{2it\ldots}\Gamma_{3it}$ are the parameters of variables, and Ω_{2it} is the error term of the model. To analyze the influence of wind power consumption on the labor market the following equation was used:

Model (I)

$$DLLABOR_{it} = \Delta_{0it} + \sum_{t=0}^{k} \Pi_{2it} DLWIND_{it} + \sum_{t=0}^{k} \Pi_{3it} DLGDP_{it} + \Lambda_{1it} LLABOR_{it} + \Lambda_{2it} LWIND_{it} + \Lambda_{3it} LGDP_{it} + \Omega_{3it} \tag{3}$$

Where,(***DLABOR*** in short-run**,** and ***LLABOR*** in long-run*)* are the dependent variables, and (**DLWIND**, ***DLGDP*** in short-run, and ***LWIND***, ***LGDP*** in long-run) are independent variables. The Δ_{0it} is the intercept, $\Pi_{2it} \ldots \Pi_{3it} \ldots \Lambda_{2it} \ldots \Lambda_{3it}$ are the parameters of variables, and Ω_{3it} is the error term of the model. To study the influence of oil consumption on the labor market the following equation was used:

Model (II)

$$DLLABOR_{it} = \Delta_{0it} + \sum_{t=0}^{k} \Pi_{2it} DLOIL_{it} + \sum_{t=0}^{k} \Pi_{3it} DLGDP_{it} + \Lambda_{1it} LLABOR_{it} + \Lambda_{2it} LOIL_{it} + \Lambda_{3it} LGDP_{it} + \Omega_{4it} \tag{4}$$

Where, (***DLABOR*** in short-run**,** and ***LLABOR***- in long-run*)* are the dependent variables, and (***DLOIL***, ***DLGDP*** in short-run, and ***LOIL***, ***LGDP*** in long-run) are independent variables. The Δ_{0it} is the intercept, $\Pi_{2it} \ldots \Pi_{3it} \ldots \Lambda_{2it} \ldots \Lambda_{3it}$ are the parameters of variables, and Ω_{4it} is the error term of the model.

Before regression of model, it is necessary to apply some specification tests like (i) Variance Inflation Factor (VIF) to check the presence of multicollinearity among the used variables. This test indicates the impact of multi-collinearity in the accuracy of estimated regression coefficients (O'Brien, 2007); (ii) Cross-section dependence (CSD-test)

(Pesaran,2004) to check the presence of cross-section dependence in variables. The null hypothesis of the CD Pesaran test is the presence of cross-section independence CD ~ N(0,1); (iii) First-generation unit root test, where included the LLC (Levin, Lin, and Chu, 2002), the ADF-Fisher (Maddala and Wu, 1999), and the ADF-Choi (Choi, 2001), to verified the existence of unit root in variables were used . The null hypothesis rejection of this test is that the variable has a unit root or I(1), this is, the variable is stationary;(iv) Second-generation unit root test (CIPS-test) (Pesaran, et al. 2013) to identify the integration orde of variables. The null hypothesis rejection of this test is that the variable has a unit root or I(1), this is, the variable is stationary;(v) Westerland cointegration test (Westerlund, 2007) to double-check the cointegration between the variables was used. The Westerlund test built in four statistical tests, to identification the existence of a normal distribution in the model. The statistics Gt and Ga test the hypothesis of at least one cross-section, having all the variables co-integrated, and the Pt and Pa test the cointegration of the model;(vi) Hausman test (Hausman, 1978) specification test, which compares an estimator that is known to be consistent with an estimator that is efficient under the assumption being tested. In this case, this test will compare the Random Effects (RE) with individual Fixed Effects (FE).

After the regression, it is necessary to apply the specification tests like (i) the Mean Group (MG) or Pooled Mean Group (PMG) estimators to check the heterogeneity of parameters both in the short and long-run. The MG is a technique that creates regressions for each cross and computes and average coefficient to all individuals (Fuinhas, et. al, 2016). Indeed, this estimator is consistent with the long-run average. However, in the presence of slope homogeneity this estimator is not efficient (Pesaran et al., 1999). The PMG estimator makes restrictions among cross-sections and adjustment speed term. This estimator with the existence of homogeneity in the long-run is more efficient than the MG estimator (Fuinhas, et al. 2016); (ii) Pesaran test of cross-section independence (Pesaran, 2007), to identify the existence of contemporaneous correlation among cross-sections. The null hypothesis of this test specifies that the residuals are not correlated and it follows a normal distribution; (iii) Breusch and Pagan Langrarian Multiplier test of independence (Breusch and Pagan, 1980) to measure whether the variances across individuals are correlated; (iv) Wooldridge test, (Wooldridge,2002) to check the existence of serial correlation; (iv) Modified test (Greene,200) to identified the existence of groupwise heteroscedasticity in the residuals of a fixed effect regression model, and (v) Pairwise Granger Causality test (Granger, 1969) to check the existence of causality between variables.

3.3 Preliminary tests

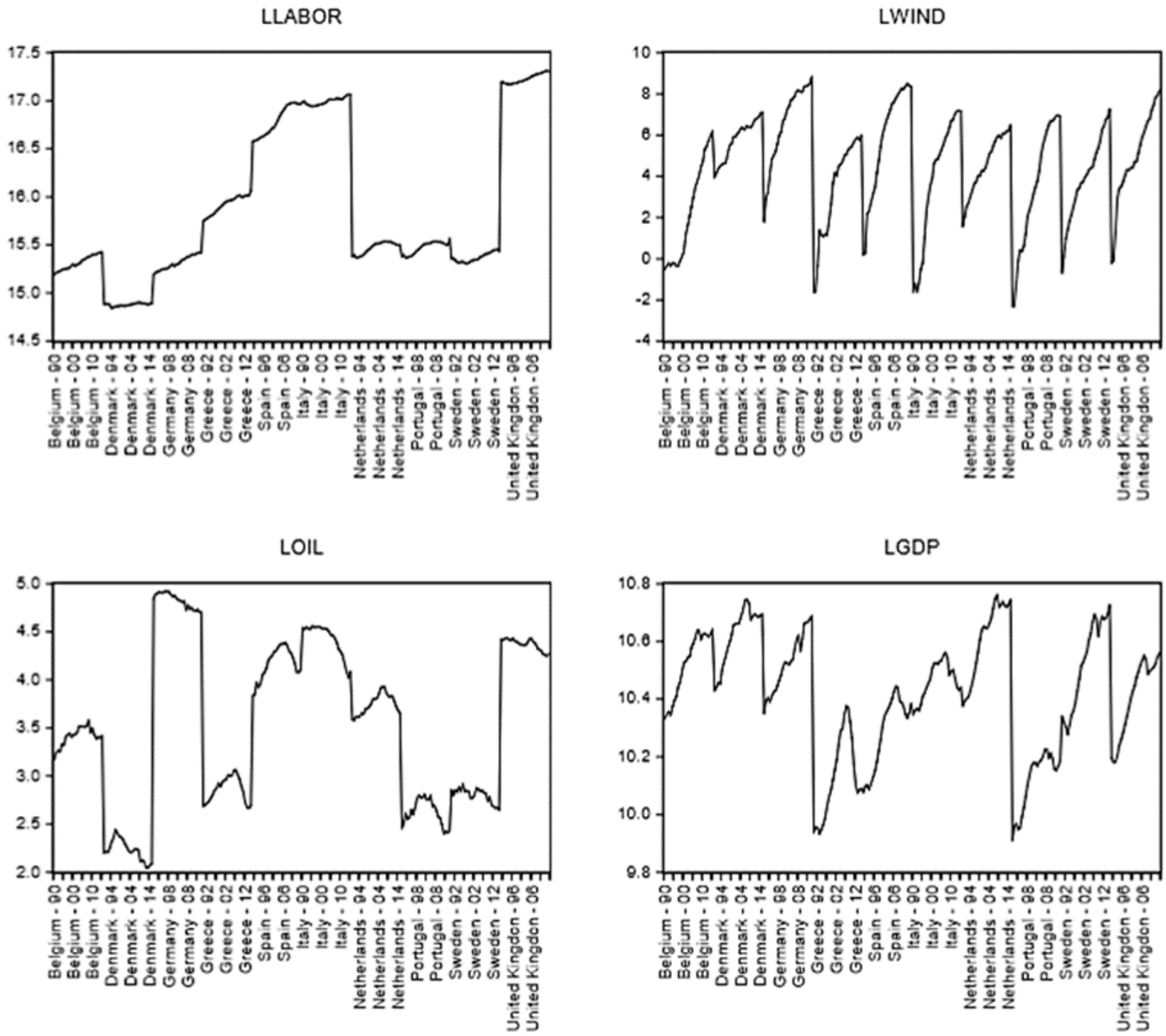
This section shows the preliminary tests on data to check the proprieties of the variables. To check the presence of multicollinearity, and presence of cross-section dependence among the variables. The VIF-test and CSD-test were applied. The results of both tests can be seen in Table 3.

Table 3. VIF-test and CSD-test

Variables	VIF	1/VIF	CD-test	p-value		Corr	Abs (corr)
LLABOR	n.a		28.41	0.000	***	0.831	0.831
LWIND	1.38	0.7255	32.71	0.000	***	0.956	0.956
LOIL	1.37	0.7316	13.46	0.000	***	0.394	0.504
LGDP	1.040	0.9650	30.82	0.000	***	0.901	0.901
Mean VIF	1.26						
DLLABOR	n.a		5.35	0.000	***	0.160	0.245
DLWIND	1.03	0.9739	5.38	0.000	***	0.161	0.298
DLOIL	1.36	0.7334	10.71	0.000	***	0.319	0.327
DLGDP	1.33	0.7502	22.48	0.000	***	0.670	0.670
Mean VIF	1.24						

Notes: The Stata command *xtcd* was used. n.a denotes (not available). *** denotes 1% of significance.

The results of VIF-test indicated that, at the level, the value of the average of VIF was 1.26, and in the first differences it was 1.24. In both results, all individual VIFs are lower than the benchmark of 10%. Those results mean that the multicollinearity between variables does not represent a problem in the model. The CSD-test indicated the existence of cross-section dependence in all variables in levels, and first-differences. In fact, due to the existence of cross-section dependence is necessary to examine the stationarity proprieties of the variables included in the analysis. First, a visual inspection of the behavior of variables is allowed in Fig. 1. With the possible exception of (***LLABOR***), it appears that all variables have patterns that suggest non-stationarity. Figure 1, shows the graph of variables in levels.



The 1st and 2nd generation of unit root test (CIPS-test) were executed. The results of both tests can be seen in Table 4.

Table 4. Unit roots tests

	1st Generation unit root tests						2nd Generation unit root tests			
	LLC		ADF-Fisher		ADF-Choi		CIPS (Zt-bar)			
	Individual intercept and trend						Without trend		With trend	
LLABOR	-1.8444	**	32.5727	**	-1.3630	*	-3.095	***	-0.531	
LWIND	-4.4917	***	43.2992	***	-1.4127	**	0.103		0.384	
LOIL	0.26941		11.6186		2.4102		1.303		-0.063	
LGDP	-0.3988		18.8468		1.7129		-0.878		-2.606	***
DLLABOR	-3.9969	***	38.1697	***	-2.1077	***	-3.497	***	-2.222	***
DLWIND	-6.3051	***	75.9155	***	-5.5888	***	-3.398	***	-1.906	**
DLOIL	-6.5270	***	47.4543	***	-3.6718	***	-6.354	***	-4.710	***
DLGDP	-4.5859	***	60.1396	***	-4.6916	***	-4.667	***	-3.638	***

Notes: *** denotes statistically significant at 1% level. The LLC test has H_0: unit root (common unit root process), the test controls for individuals' effects, individual linear trends, has a lag length 1, and Newey-West automatic bandwidth selection and Bartlett kernel were used; the ADF-FISHER and ADF-Choi test has H_0: unit root (individual unit root process), the test controls for individual effects, individual linear trends, has a lag length 1. The CIPS test has H_0: series are I(1). To compute the CIPS test was used the Stata command *multipurt*.

The results of 1st generation unit root test indicate that the variables in levels (***LLABOR, LWIND***) are stationary, that has unit root I(1). However, the variables (***LOIL***, ***LGDP***) are non-stationary. Moreover, all variables in first-differences are stationary. The variables (***DLLBOR*** and ***DLOIL***) are I(2). The 2nd generation unit root test point that the variables in levels (***LLABOR*** without trend, and ***LGDP*** with the trend) are stationary, and all variables in first-differences are I(1). To double-check the cointegration between the variables, the Westerlund test was used. Table 5 evidence the results of this test.

Table 5. Westerlund cointegration test

Statistics	Westerlund cointegration test – Constant: Value	Z-value	P-value	Robust P-value
Gt	-2.504	-0.909	0.182	0.082
Ga	-9.430	0.691	0.755	0.152
Pt	-5.574	0.473	0.682	0.366
Pt	-6.584	0.422	0.664	0.280

Notes: Bootstrapping regression with 500 reps. H_0: No cointegration; H_1 Gt and Ga test the cointegration for each country individually, and Pt and Pa test the cointegration of the panel. The Stata command *xtwest* (with the constant option) was used.

The Westerlund cointegration tests reject the existence of cointegration between variables. The non-detection of cointegration points to use of econometric techniques that are less stringent, i.e. ARDL models. To determine if the panel has random or fixed effects, the Hausman test was performed. The Hausman test supports the presence of fixed effects (see Table 6).

Table 6. Hausman Test

Variables	(b) Fixed	(B) Random	(b-B) Difference	Sqrt(diag(V_b-V-B))S.E.
Model (I)				
DLWIND	-0.0014	-0.0003	-0.0009	0.0004
DLGDP	0.1087	0.1338	-0.0250	0.0075
LLABOR	-0.0939	-0.0003	-0.0936	0.0180
LWIND	0.0017	0.0008	0.0009	0.0004
LGDP	0.0282	-0.0051	0.0334	0.0087
Chi2 (5)	29.96 ***			
Model (II)				
DLOIL	-0.0179	-0.0079	-0.0100	0.0075
DLGDP	0.1287	0.1112	0.0174	0.0119
LLABOR	-0.0698	-0.0007	-0.0691	0.0169
LOIL	-0.0012	0.0020	-0.0032	0.0070
LGDP	0.0450	-0.0097	0.0547	0.0097
Chi2 (5)	43.68 ***			

Notes: *** denote statistical significance level of 1%.

To identify the presence of RE or FE in the model, the Hausman test was applied. This test has the null hypothesis that the best model is RE. The results of Hausman test in two models are statistically significant (e.g.Model I Chi2 (5)= 29.96, and Model II Chi2 (5)= 43.68). These results indicated to select the FE model. Nevertheless, after the choice of FE model, the equations (3) and (4) (hereinafter model I and model II, respectively) were converted in Equations (5) and (6) by changing Ω_{3it} and Ω_{4it} for $\theta_i + \beta_{it}$, representing the FE model, where the models (I) and (II) are based on following equations:

Model (I)

$$DLLABOR_{it} = \Delta_{0it} + \sum_{t=0}^{k} \Pi_{2it} DLWIND_{it} + \sum_{t=0}^{k} \Pi_{3it} DLGDP_{it} + \Lambda_{1it} LLABOR_{it} + \Lambda_{2it} LWIND_{it} + \Lambda_{3it} LGDP_{it} + \theta_i + \beta_{it} \quad (5)$$

Where, (***DLABOR*** in the short-run**,** and ***LLABOR*** in the long-run*)* are the dependent variables, and (**DLWIND**, ***DLGDP*** in short-run, and ***LWIND***, ***LGDP*** in long-run) are independent variables.The Δ_{0it} is the intercept, $\Pi_{2it} \ldots \Pi_{3it} \ldots \Lambda_{2it} \ldots \Lambda_{3it}$ are the parameters of variables,and $\theta_i + \beta_{it}$ is the error term of the model. To study the influence of oil consumption on the labor market the following equation was used:

Model (II)

$$DLLABOR_{it} = \Delta_{0it} + \sum_{t=0}^{k} \Pi_{2it} DLOIL_{it} + \sum_{t=0}^{k} \Pi_{3it} DLGDP_{it} + \Lambda_{1it} LLABOR_{it} + \Lambda_{2it} LOIL_{it} + \Lambda_{3it} LGDP_{it} + \theta_i + \beta_{it} \quad (6)$$

Where, (***DLABOR*** in short-run**,** and ***LLABOR***- in long-run*)* are the dependent variables, and (***DLOIL***, ***DLGDP*** in short-run, and ***LOIL***, ***LGDP*** in long-run) are independent variables. Indeed, the Δ_{0it} is the intercept, $\Pi_{2it} \ldots \Pi_{3it} \ldots \Lambda_{2it} \ldots \Lambda_{3it}$ are the parameters of variables and $\theta_i + \beta_{it}$ is the error term of the model.

4. Empirical results

In this section, we present the MG and PMG estimation outputs,and the results of the DFE model, Pesaran test of cross-section independence, Breusch, Pagan Langrarian Multiplier test of independence, Wooldridge test, Modified test and Granger Causality test. Table 7 shows, the results of MG and PMG estimations.

Table 7. MG and PMG estimations results

Variables	Model (I)						Model (II)					
	MG		PMG		DFE		MG		PMG		DFE	
	Dependent variable (DLLABOR)											
Constant	3.0211	***	0.3076	***	1.1955	***	3.6069	***	1.4183	**	0.6498	***
	Short-run (Semi-elasticities)											
DLWIND	-0.0051		-0.0053		-0.0014		n.a		n.a		n.a	
DLOIL	n.a		n.a		n.a		-0.0354		-0.0291		-0.0180	
DLGDP	0.1123	**	0.1264	**	0.1088	***	0.1150	***	0.1530	***	0.1287	***
	Dependent variable (LLABOR)											
	Long-run (Elasticities)											
LWIND (-1)	-0.0209		0.0074		0.0191	***	n.a		n.a		n.a	
LOIL (-1)	n.a		n.a		n.a		-0.0981		-0.0503	*	-0.0173	
LGDP (-1)	1.0844	*	0.9611	***	0.3005	***	0.5271	***	0.6373	***	0.6445	***
ECM	-0.2790	***	-0.0485	**	-0.0940	***	-0.3089	***	-0.1529	**	-0.0699	***
Statistics												
N	250		250		n.a		250		250		n.a	
R2												
R2_a												

Notes: ***, **,* denotes statistically significant at 1% ,5% and 10% level, respectively; ECM, denotes Error Correction Mechanism; The Stata commands *xtpmg* was used.

The results of MG and PMG estimations in the model (I) and (II) indicate that the DFE is the appropriate estimator, i.e. there is evidence that the panel is ‘homogeneous’. After this test, the regression using the ARDL model was done. The semi-elasticities were calculated by adding the coefficients of variables in the first differences. The elasticities are calculated by dividing the coefficient of lagged independent variable by the coefficient of the lagged independent variable, multiplier by (-1). Table 8, evidence the results of DFE estimator.

Table 8. Estimation results

Variables	Dependent variable (DLLABOR)							
	Model (I)				Model (II)			
	FE (I)		FE Robust (II)	FE D.-K (III)	FE (IV)		FE Robust (V)	FE D.-K. (VI)
Constant	1.1955	***	***	***	0.6498	***	***	***
	Short-run (Semi-elasticities)							
DLWIND	-0.0014				n.a		n.a	n.a
DLOIL	n.a		n.a	n.a	-0.0179			
DLGDP	0.1087	***	***	***	0.1287	***	***	***
	Dependent variable (LLABOR)							
	Long-run (Elasticities)							
LWIND (-1)	0.0191	***	**	***	n.a		n.a	n.a
LOIL (-1)	n.a		n.a	n.a	-0.0173			
LGDP (-1)	0.3004	**		**	0.6444	***	***	***
ECM	-0.0939	***	***	***	-0.0698	***	***	***

Notes: ***, **, denote statistically significant at 1% and 5% level, respectively; ECM denotes Error Correction Mechanism; The Stata commands *xtreg* and *xtscc* were used.

The estimation results of Model (I), indicated that the wind power consumption (***DLWIND***) in short-run does not cause impact on the labor market (***DLLABOR***), and, as expected, the economic growth (***DLGDP***) has a positive impact of 0.1087 on the labor market. Moreover, in long-run, the wind power consumption (***LWIND***) has a positive impact of 0.0191 on the labor market (***LLABOR***), and the economic growth (**LGDP**) has a positive impact of 0.3004. In Model (II), the Oil consumption (***DLOIL***) does not cause impact on the labor market (***DLLABOR***), and the economic growth (***DLGDP***) has a positive impact of 0.1287. In the long-run estimations, the Oil consumption (***LOIL***) does not cause impact, and the economic growth (***LGDP***) has a positive impact of 0.6444.

The estimation results from the DFE estimator, DFE robust standard errors, and DFE Driscoll and Kraay (DFE D.-K.) points to the presence of long memory in the variables, due to the ECM term being statistically significant at 1% level and has also a negative sign. Those results also confirm the presence of Granger causality. Additionally, an ARDL model, when expressed as an UECM, has the capacity to decompose the total causality in short-run and long-run ECM, causing to the Granger causality (e.g.Fuinhas, et al. 2016; Jouini, 2014; Mehrara, 2007). Moreover, given that the ARDL model is robust to endogeneity when a regression parameter is statistically significant, this is very similar for testing Granger causality in a conventional way (Fuinhas, et al, 2016).

The battery of specification test, like (i) Pesaran test ;(ii) Breaush-Pagan LM test ;(iii)

Wooldridge test, and (iv) Modified Wald test were used. Table 9, shows the results of the specification test in two models.

Table 9. Specification tests

Pesaran test	Breusch-Pagan LM test	Wooldridge test	Modified Wald test
	Model (I)		
χ^2 =2.167 **	n.a	F (1, 9) =17.523 ***	Chi2 (10) = 60.50 ***
	Model (II)		
χ^2 =1.730 *	n.a	F(1, 9) = 14.006 ***	Chi2 (10) =121.29 ***

Notes: ***, **,* denote statistically significant at 1% 5% and 10% level, respectively. The Stata commands *xtpmg*, and Hausman (with the sigma more option) were used; in the fixed effects were used the *xtreg*, and *xtscc* Stata commands; for H0 of Modified Wald test: sigma (i)^2 = sigma^2 for all. The results for H0 of Pesaran test: residuals are not correlated; results for H0 of Wooldridge test: no first-order autocorrelation.

The Pesaran test points to the presence of cross-section independence in residuals of Model (I) and (II). The Breusch-Pagan LM test can not be carried because the correlation matrix of residuals is singular. The Wooldridge test which checks for the existence of serial correlation, points to the existence of first order autocorrelation in two models. The Modified Wald test points to the presence of heteroscedasticity in both models.

To check the existence of causality between variables, the Pairwise Granger Causality test was used. Indeed, the Grander Causality was applied just in model (I), due to the acknowledgement that wind power consumption has an effect on the labor market in long-run.

Table 10. Pairwise Granger Causality Tests

Null Hypothesis:	F-Statistic	Prob.
WIND does not Granger Cause LABOR	0.0053	0.9417
LABOR does not Granger Cause WIND	1.1386	0.2870
GDP does not Granger Cause LABOR	1.1700	0.2804
LABOR does not Granger Cause GDP	1.9891	0.1597
GDP does not Granger Cause WIND	2.3574	0.1260
WIND does not Granger Cause GDP	2.9401	0.0877 *

Notes: The EViews 9.5 was used; *, denote statistically significant at 10% level; This test was realization with lags (1).

The wind power consumption (***WIND***) causes an increase inthe labor market (***LABOR***) and the labor market (***LABOR***) increase of the consumption of wind energy (***WIND***). The economic growth (***GDP***) causes the increase of the labor market (***LABOR***), and the labor market (***LABOR***) causes the increase of the economic growth (***GDP***). The economic growth (***GDP***) causes the increase of wind energy consumption (***WIND***), but the wind power consumption (***WIND***) does not cause an increase in economic growth (***GDP***).

Figure 02 summarizes the results of Pairwise Granger causalities test.

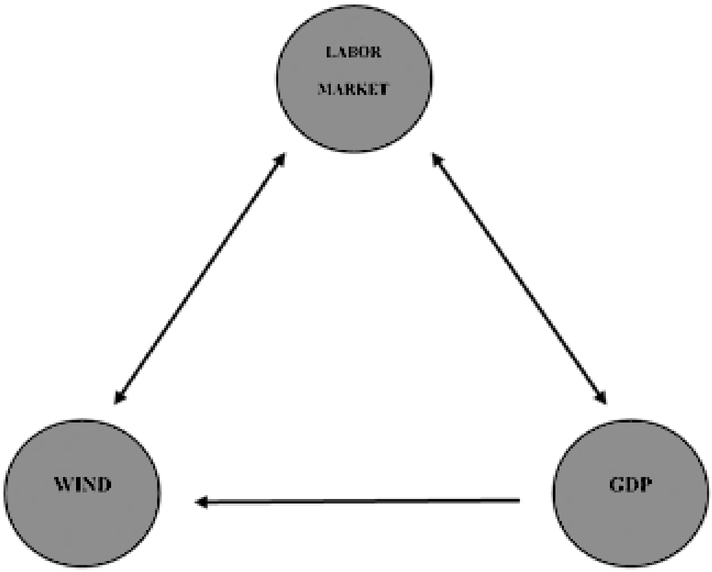
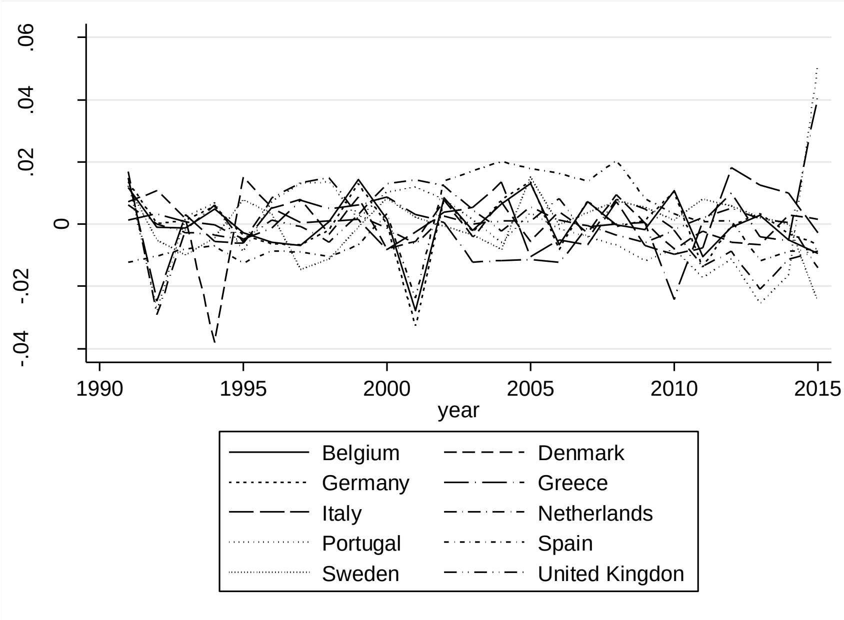
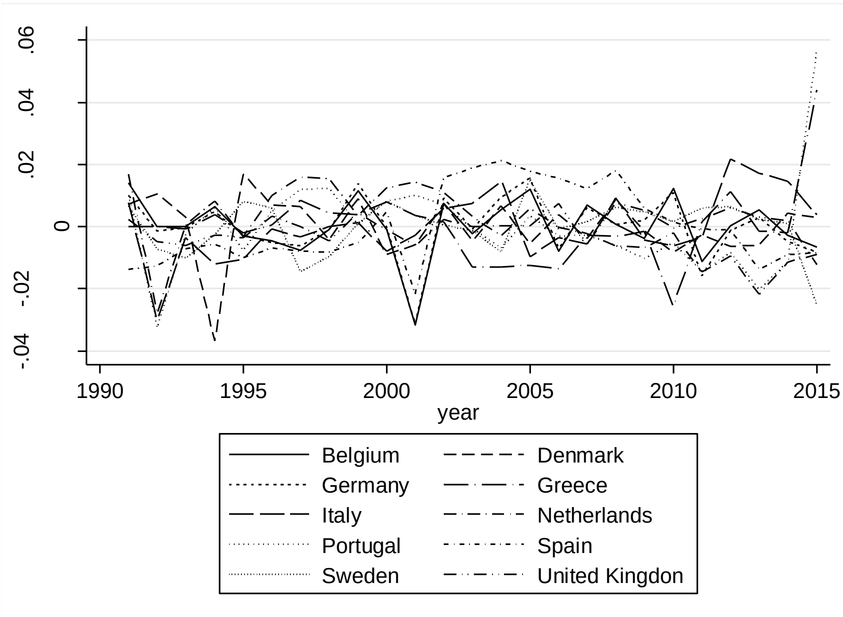


Figure 02 shows that there is a bidirectional relationship between wind power consumption (***WIND***) and the labor market (***LABOR***), and the economic growth (***GDP***) and the labor market (***LABOR***), and a unidirectional relationship among wind power consumption (***WIND***) and economic growth (***GDP***).

5. Robustness check

In order to check the robustness of the model, dummy variables were introduced. Those dummies represent shocks occurred in E.U and specially, in all countries presented in our study. See Figure 3 that shows the residuals of the model (I) and (II).





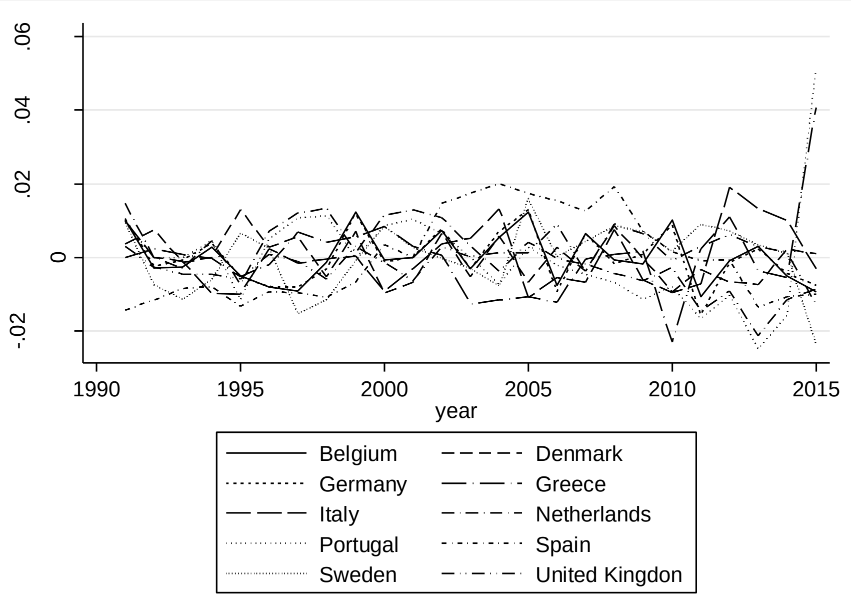
Those shocks in the residuals of the model (I) and (II) for years 1992, 1994, 2001, and 2002 were confirmed. Indeed, the dummy variables like (e.g. ***IDITALY1992; IDNETHERLANDS1992;IDPORTUGAL1992;IDDENMARK1994;IDBELGIUM2001;ID GERMANY2001;IDSPAIN2001***) were created. Those dummies were properly tested and indicated that are statistically significant. Table 11 shows the estimation results with dummy variables in the model (I) and (II).

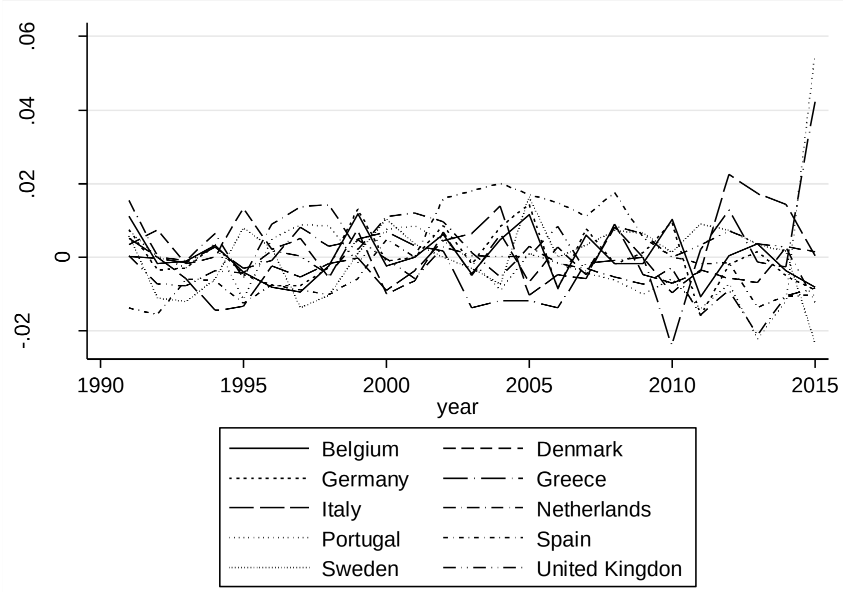
Table 11. Estimation results with dummy variables

Variables	Model (I) FE (I)		FE Robust (II)	FE D.-K (III)	Model (II) FE (IV)		FE Robust (V)	FE D.-K. (VI)
	Dependent variable (DLLABOR)							
Constant	0.9851	***	***	***	0.5814	***	***	***
IDITALY1992	-0.0298	***	***	***	-0.0335	***	***	***
IDNETHERLANDS1992	-0.0313	***	***	***	-0.0311	***	***	***
IDPORTUGAL1992	-0.0317	***	***	***	-0.0374	***	***	***
IDDENMARK1994	-0.0413	***	***	***	-0.0414	***	***	***
IDBELGIUM2001	-0.0339	***	***	***	-0.0333	***	***	***
IDGERMANY2001	-0.0296	***	***	***	-0.0325	***	***	***
IDSPAIN2001	-0.0236	***	***	***	-0.0226	**	***	***
	Short-run (Semi-elasticities)							
DLWIND	-0.0017				n.a		n.a	n.a
DLOIL	n.a		n.a	n.a	0.0092			
DLGDP	0.1190	***	***	***	0.1150	***	***	***
	Dependent variable (LLABOR)							
	Long-run (Elasticities)							
LWIND (-1)	0.0145	**		*	n.a		n.a	n.a
LOIL (-1)	n.a		n.a	n.a	0.0188			
LGDP (-1)	0.3207	***		*	0.5982	***	***	***
ECM	-0.0784	***	***	***	-0.0600	***	***	**

Notes: ***, **, * denote statistically significant at 1%,5%, and 10% level, respectively; ECM denotes Error Correction Mechanism; The Stata commands *xtreg* and *xtscc* were used.

The shocks proved to be statistically significant at 1% level. Furthermore, as it can be seen by comparing tables 6 and 9, the results of both models are the same, proving the robustness of the pursued approach, even in the presence of shocks. Figure 4 shows the residuals of models (I) and (II) after the inclusion of the dummy variables.





After including the dummy variables in the models (I) and (II), the identified shocks in the residual of regression were corrected.

5. Discussions

According to what was mentioned in the previous section, the following lines will show the discussions of the achieved results through this research. The focus of this study is to analyze the impact of wind power and oil consumption on the labor market.

The preliminary tests proved the existence of low multicollinearity, cross-section dependence in all variables in levels and first-differences, and the presence of unit-root. The results of MG and PMG estimations indicated that the DFE is an appropriate estimator, and there is evidence that the model (I) and (II) are homogeneous panels. The semi-elasticities were calculated by adding the coefficients of variables in the first differences, and elasticities were calculated by dividing the coefficient of lagged independent variable by the coefficient of the lagged independent variable, multiplier by (-1) indicates that in the model (I) the wind power consumption in the short-run does not cause impact on the labor market and as expected, the economic growth has a positive impact of 0.1087 on the labor market. The wind power consumption has a positive impact of 0.0191 on the labor market, and the economic growth has a positive impact of 0.3004 in the long-run.

The positive impact of wind power consumption on the labor market in long-run it is due to the construction process of generation towers, operation, transportation and upkeep of the equipment that influencing all involved sectors. Moreover, the presence of these plants, stimulating the activity in the local economy that creates new jobs, and increase the income in a specific area in long of time (Li, et al.,2017; Costa and Veiga ,2016;Rodrigues, et al., 2016;Okkonen and Lehtonen ,2016;Wiser,et al., 2016; Bobinaite and Priedite ,2015;Ejdemo and Söderholm, 2015;Valodka and Valodkiené,2015;Gkatsou, et al.,2014; Simas e Pacca ,2014;Kondili and Kaldellis ,2012).

In model (II), Oil consumption does not cause an impact on the labor market and the economic growth has a positive impact of 0.1287. In the long-run estimations, the Oil consumption does not cause impact and the economic growth has a positive impact of 0.6444. The oil consumption does not have an impact in the labor market since the European Union has been reducing its dependence from fossil fuels and as such, most European countries have been applying different policies underlying the promotion of renewable energy (cost-effective, climate change mitigation, employment creation and reduce dependency on imported fuels).

The estimations results from DFE, DFE robust and DFE Driscoll AND Kraay, indicates the presence of long memory in the variables, due to the ECM term being statistically significant at 1% level and having a negative sign. These results confirm the existence of

Granger causality. This phenomenon is confirmed by (e.g Fuinhas, et al. 2016) in Latin American countries.

The battery of specification tests indicated the presence of cross-section dependence in residual of models (I) and (II). These results indicated that the countries in the both model share common shocks and characteristics, as well as, the existence of the first-order autocorrelation and the presence of heteroscedasticity in the models.

To check the existence of causality between variables, Pairwise Granger Causality test was used. Indeed, the Grander Causality was applied just on the model (I), because was identified an impact of wind power consumption in the labor market in long-run. The results of Grande Causality test indicated that the wind power consumption causes the increase of the labor market, and the labor market increase of the consumption of wind energy. The economic growth causes the increase of the labor market, and the labor market causes the increase of the economic growth. The economic growth causes the increase of the wind energy consumption, but the opposite does not apply. These results indicate that there is a bidirectional relationship between wind power consumption and labor market, especially with investments and construction of new generation towers create more jobs and consequently increase the consumption of energy and/or vise-versa. There is a bidirectional relationship between economic growth and labor market, and a unidirectional relationship between economic growth and wind power consumption, where the economic growth influences the consumption of energy. This unidirectionality among wind power consumption and economic growth was confirmed by (e.g Neseri, et al., 2016; Iglesi-Lotz,2016; Apergis and Danuletiu, 2014; Tugcu, et al., 2012; Apergis and Payne, 2012; Tiwari, 2011; Bowden and Payne, 2010).

The creation of dummy variables was due to the presence of shocks in the residuals. The European Union countries suffered several financial crisis in the 1990s and 2000s. In 1992 Italy, Portugal,Netherlands, and in 1994, Denmark, were impacted by the financial crisis in the European Monetary System (EMS). Between September 1992 and July-August 1993 it started disrupting what previously appeared to be a steady progress towards Economic and Monetary Union (EMU). After that, in 2001, Belgium, Germany and Spain were impacted by the American recession. The results of both models with the inclusion of shocks are the same, proving the robustness of the pursued approach, even in the presence of shocks.

6. Conclusions and policy implications

The impact of wind power and oil consumption on the labor market was analyzed in ten member countries of the European Union (EU), during the period from 1990 to 2015. The pre-testing proved the presence of cross-sectional dependence, thus confirming that these countries share spatial patterns; heteroscedasticity; contemporaneous correlation; and first-order autocorrelation.

The results have shown that wind power consumption in the short-run does not cause impact on the labor market and, as expected, the economic growth had a positive impact of 0.1087 on the labor market. The wind power consumption has a positive impact of 0.0191 on the labor market, and the economic growth has a positive impact of 0.3004 in the long-run. In model (II), the Oil consumption does not cause impact on the labor market, and the economic growth has a positive impact of 0.1287. In long-run estimations, Oil consumption does not cause impact and the economic growth has a positive percussion of 0.6444.

In the long-run, the positive impact of wind power consumption in the labor market is due to the construction process of generation towers, operation, transportation and upkeep of the equipment which ends up influencing all involved sectors. The presence of these plants stimulates the activity in the local economy, creates new jobs and increases the income in a specific area. In this regard, oil consumption does not cause impact on the labor considering that the European Union has been reducing its dependence on fossil fuels. Taking this in consideration, European countries have been applying different policies with the goal of underlying the promotion of renewable energy (cost-effective, climate change mitigation, employment creation and reduce dependency on imported fuels).

The results of Granger Causality indicate that there is a bidirectional relationship between wind power consumption and the labor market. The investments and construction of new generation towers create more jobs and consequently increases the consumption of energy and/or vice-versa. There is a bidirectional relationship between economic growth and labor market and a unidirectional relationship between economic growth and wind power consumption. In this regard, the economic growth influences the energy consumption.

The robustness of the model was proven by identifying and including the main shocks that occurred in the European Union Countries. These results show that the consumption of renewable energy has a positive impact on the labor market and that the European countries are less dependent on fossil fuels. The impact of wind power consumption on the labor market is limited. This evidence points to the need to create more renewable energy policies designed to promote more investments in renewable energy sources and foster the economy of countries or specific regions, as well as, generate income and bring a better quality of life.

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Table A1. Panel descriptive statistics

Variables		Mean	Std.Dev	Min.	Max.	Observations	
	Overall	0.0070	0.0125	-0.0404	0.0648	N =	250
DLLABOR	Between		0.0047	0.0003	0.0156	n =	10
	Within		0.0117	-0.0337	0.0643	T =	25
	Overall	0.2871	0.3154	-0.4055	1.9237	N =	250
DLWIND	Between		0.0748	0.1256	0.3683	n =	10
	Within		0.3073	-0.4687	1.8840	T =	25
	Overall	-0.0020	0.0423	-0.1313	0.1251	N =	250
DLOIL	Between		0.0086	-0.0182	0.0108	n =	10
	Within		0.0415	-0.1431	0.1123	T =	25
	Overall	0.0114	0.0234	-0.0943	0.0545	N =	250
DLGDP	Between		0.0038	0.0038	0.0154	n =	10
	Within		0.0231	-0.0890	0.0593	T =	25
	Overall	15.8717	0.7871	14.8382	17.3127	N =	250
LLABOR	Between		0.8243	14.8777	17.2263	n =	10
	Within		0.0736	15.6646	16.0695	T =	25
	Overall	4.3034	2.6046	-2.3026	8.5034	N =	250
LWIND	Between		1.3765	2.0329	6.4894	n =	10
	Within		2.2520	-1.2516	8.2539	T =	25
	Overall	3.5517	0.8544	2.0440	4.9225	N =	250
LOIL	Between		0.8907	2.2355	4.829	n =	10
	Within		0.1143	3.1375	3.7628	T =	25
	Overall	10.4173	0.2099	9.9118	10.7608	N =	250
LGDP	Between		0.1833	10.1138	10.6210	n =	10
	Within		0.1172	10.1752	10.6627	T =	25

Notes: The Stata command *xtsum* was used to achieve the results for panel between and within statistics.