Available online at www.sciencedirect.com
ScienceDirect
Energy Reports 6 (2020) 581–586
www.elsevier.com/locate/egyr

6th International Conference on Energy and Environment Research, ICEER 2019, 22–25 July, University of Aveiro, Portugal

The social face of renewables: Econometric analysis of the relationship between renewables and employment

Sara Proença[a,*], Patricia Fortes[b]

[a] CERNAS and ESAC/Polytechnic Institute of Coimbra, 3045-601 Coimbra, Portugal
[b] CENSE, NOVA University Lisbon, 2829-516 Caparica, Lisbon, Portugal

Received 24 July 2019; accepted 12 September 2019
Available online 25 September 2019

Abstract

Renewable energy promotion has been one of the key driving forces of the world's climate change mitigation strategy. Policymakers have argued that the transition towards a low-carbon energy system has sound economic and social reasoning, since generates economic growth and employment. This central premise has not, however, been consensual in literature, which requires additional research. In this context, the goal of this paper is to analyze and provide empirical evidence of the relationship between renewable energy deployment and job creation, by employing econometric methods from panel data analysis. The research is focused on European Union's 28 member states, analyzing the relationship between historical values of renewable power generation installed capacity and employment over the period 2000–2016. Results suggest a positive relationship between these two variables, showing an increase of 0.48% in employment for each 1% increase in renewable power generation capacity. The outcomes of the present analysis enable better understanding of the social context of renewables, providing relevant insights that can constitute an auxiliary instrument to support decision-making.

Peer-review under responsibility of the scientific committee of the 6th International Conference on Energy and Environment Research, ICEER 2019.

Keywords: Econometric analysis; Employment; Renewables; European union; Panel data regressions

1. Introduction

The Paris Agreement, signed in December 2015, sets the goal of limiting "the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C" (Article 2.1). Net carbon emissions must fall to zero to meet this target, which will require drastic changes in the energy system. Renewable energy sources (RES) have been pointed out as one of the most cost-effective mitigation strategies to decarbonize the energy system, particularly the power sector. Accordingly, the worldwide share of electricity supplied by renewables (RES-E) needs to increase above 59% by 2050 within the 1.5 °C pathway [1].

* Corresponding author.
E-mail address: sproenca@esac.pt (S. Proença).

https://doi.org/10.1016/j.egyr.2019.09.029

Peer-review under responsibility of the scientific committee of the 6th International Conference on Energy and Environment Research, ICEER 2019.

In the last decade, the European Union (EU) has made a huge leap forward in promoting the transition from fossil fuel dependency to the use of renewable energy. The RES-E share in the EU-28 member states raised from around 16% in 2007 to about 31% in 2017 [2]. Its contribution for the reduction of greenhouse gas (GHG) emissions, the improvement of air quality and the increase of energy security are just some of the reasons for this evolution. Moreover, it is often argued that the deployment of RES can also enhance economic growth and promote job creation directly and indirectly. This has always been the premise of EU, which has been adopting policies to support an energy transition to RES justified, beyond the GHG reduction, as a mean for "promoting the security of energy supply, promoting technological development and innovation and providing opportunities for employment and regional development" [3].

However, this optimistic vision of RES has not been consensual in literature, with some authors arguing that its contribution to employment is not as large as envisioned and may even be negative [4–7]. They claim that the effects of RES on employment are highly dependent on the financing mechanisms, the type of technologies and the scope of employment impacts (direct, indirect and induced).

Several methods have been applied to assess the employment effects associated with a penetration of RES in the energy system and particularly in the power sector. These can be distinguished between the ones that:

(i) analyze the linkage between renewable technologies and employment considering future energy scenarios and explicit methodologies, such as: input–output matrixes or computable general equilibrium models, which include the interrelationships between all sectors of the economy, or simpler analytical methods sustained by employment factors, i.e. job intensities.
(ii) set a relationship between renewable technologies and employment using historical data and econometric methods.

Although there is a vast literature focusing in the ex-ante linkages between renewable technologies and employment opportunities (see [8] for a review), fewer have been analyzing the confirmed outcomes of this relation [6]. Ex-post analysis is mainly focused on providing empirical evidence of the relationship between renewable energy consumption and economic development nexus. They tend to study its overall effect on GDP, neglecting the social face of renewables associated with employment creation.

This paper aims to contribute to the ex-post literature by examining the empirical relationship between RES power generation expansion and employment in EU-28 countries, over the period 2000–2016, and using a panel data econometric methodology. This research answers the question: what has been the real impact of renewable power capacity deployment on overall employment?

The remainder of this manuscript is organized as follows: Section 2 describes the employed econometric methodology, the empirical model and the dataset. Section 3 presents and discusses the empirical results of the estimated model. The final section provides the concluding remarks and the possible implications of the outcomes.

2. Methodology and data

In order to estimate the contribution of renewables to employment in the EU-28 economy, we employ an econometric approach with panel data. In the panel data methodology, the datasets comprise multiple observations on each sampling unit thus having more variability and less collinearity among the variables. It has several benefits, such as: improves the reliability of estimates, allows to test more sophisticated behavioral models with less restrictive assumptions, and allows to control for the individual heterogeneity and unobservable or missing values. Panel datasets are also better able to identify and estimate effects that are simply not detectable in pure cross-sections or pure time-series data [9][1]. This study applies standard panel data estimation methods, namely: (i) the ordinary least squares method (OLS) with pooled data, and (ii) the fixed effects method (LSDV), which assumes specific individual effects captured by individual country dummies.

2.1. The model

The empirical model to be estimated assumes the following form (Eq. (1)):

$$lnEMP_{it} = \alpha_i + \beta_1 lnREN_{it} + \beta_2 lnECpc_{it} + \beta_3 ED_{it} + \varepsilon_{it} \quad (1)$$

[1] For additional discussion on panel data technique, see also [10], and [11].

where, i is the country index and t denotes the time period. The dependent variable ($lnEMP_{it}$) is expressed by the logarithm of employment. Among the explanatory variables, it is of particular interest the variable renewable energy, measured by the logarithm of renewable power generation capacity ($lnREN_{it}$). In addition, given their relevance as explanatory factors in this relationship, we also control for the effect of energy consumption per capita, expressed in its logarithm form ($lnECpc_{it}$), and the energy dependence (ED_{it}) which measures the extent to which an economy relies upon imports in order to meet its energy needs. The coefficient α_i is a country-specific effect which captures time-invariant unobserved country characteristics, and ε_{it} is the error term.

The impact of an increasing share of renewable energy ($lnREN_{it}$) on the economy may be twofold: (i) on one hand, the deployment of renewable energy sources requires additional investments which may induce a multiplier effect on the economy, with positive impacts on production and consequently on employment; (ii) on the other hand, there are cost effects, induced by the cost of renewable energy support policies (e.g., subsidies) and by the adjustments in the production structure with the replacement of fossil-based technologies by renewable energy technologies, which may be more expensive. These higher production costs will be transferred to consumers by higher prices of goods and services, that may result in the contraction of economic activity and therefore in negative effects on employment [12]. Consequently, depending on the effect that prevails, the impact of renewables on employment may be positive ($\beta_1 > 0$) or negative ($\beta_1 < 0$), being certain that policymakers have advocated a positive net effect (e.g., [3]).

Concerning the variable energy consumption ($lnECpc_{it}$), also two different effects could be expected: (i) on the one hand, higher energy consumption could be associated with an increase in productive activities, leading to economic growth and job creation, expecting therefore a positive sign; (ii) on the other hand, higher energy consumption may induce an increase in relative energy prices with negative economic impacts and, moreover, it could be associated with activities other than production. Therefore, depending on the effect that prevails the variable sign will be positive ($\beta_2 > 0$) or negative ($\beta_2 < 0$).

Regarding the energy dependence determinant (ED_{it}), defined as the share of net energy imports in gross inland energy consumption, it is expected that this variable has a negative impact on employment ($\beta_3 < 0$). Indeed, increasing external dependency on energy sources leads to higher imports and a greater foreign deficit, as well as greater exposure to international markets.

2.2. Data

Table 1 provides a summary of the definition, data sources and descriptive statistics of the variables used in our empirical analysis. We make use of a balanced panel dataset composed by the 28 EU member states in the period between 2000 and 2016, where data are available for all the variables and countries. This is a panel of countries with similarities that share common goals and strategies concerning energy policy.

Table 1. Variables description, data sources and descriptive statistics.

Variable	Definition	Source	Mean	St. Dev.	Min.	Max.
EMP	Employment [thousand persons]	AMECO [13]	7 992	10 347	146	43 544
REN	Renewable power generation capacity [Megawatt (MW)]		9 138	14 588	1.0	101 594
$ECpc$	Energy consumption per capita [TOE]	EUROSTAT [2]	3.62	1.55	1.59	10.31
ED	Energy dependence [%] (share of net imports in gross inland energy consumption)		55.37	28.42	−50.0	104.1

The figures of the two core variables of the model show that the dependent variable EMP records an average value of 7 992 thousand persons, ranging from a minimum of 146 to a maximum of 43 544 thousand persons, respectively in Malta and Germany. Concerning the dependent variable REN, the values range from 1 MW in Cyprus to 101 594 MW in Germany, with a mean value of 9 138 MW, which reveals a large heterogeneity among the countries of the sample with regard to renewable energy deployment.

According to the historical data, renewable power capacity has been growing significantly since 2000 for most of the EU member states, contrary to non-RES, which has been kept constant or with a modest growth (Fig. 1). This is reflected at EU-28 level, in which RES power capacity increased around 166% over the period under analysis

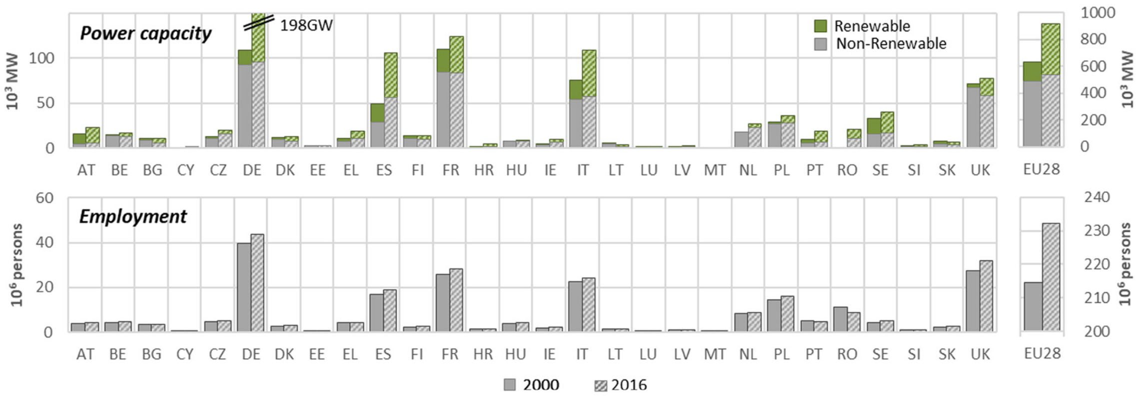

Fig. 1. Renewable and non-renewable power capacity (top chart) and employment (bottom chart) for each member state (left axis) and EU-28 (right axis) in 2000 and 2016 (the absence of values for countries Cyprus (CY), Malta (MT), and Romania (RO) in year 2000 does not represent zero installed capacity but rather data unavailability).

vis-à-vis the increase of only 9% for non-RES. As seen in Fig. 1, in general employment follows a pattern close to renewables, although its growth does not go beyond 8% for EU-28.

3. Results and discussion

This section presents and discusses the results of the estimation model to test the observed positive relationship between renewable energy expansion (REN) and employment (EMP).

First, to avoid potential multicollinearity problems, we performed a correlation analysis. Table 2 reports the calculated correlation coefficients between variables. As can be seen, the values show low levels of correlation among the explanatory variables, which indicate absence of multicollinearity.

Table 2. Correlation matrix.

	$lnEMP_{it}$	$lnREN_{it}$	$lnECpc_{it}$	ED_{it}
$lnEMP_{it}$	1			
$lnREN_{it}$	0.6899	1		
$lnECpc_{it}$	−0.0557	−0.0243	1	
ED_{it}	−0.3270	−0.0087	0.0163	1

To determine which model specification is the most appropriate, the standard F-test for fixed effects was conducted[2]. Results validate the null hypothesis that the pooled OLS model is more adequate than the fixed effects model. Accordingly, and for the sake of simplicity, Table 3 only presents the estimated results from the pooled OLS regression. It should be noted that the Durbin–Watson test statistic (≈1.95) indicates no evidence of autocorrelation among the residuals.

The results of our empirical study reveal robust evidence of a positive and statistically significant effect from RES-E capacity on employment in the EU-28 economy. As can be seen in Table 3, the estimated coefficient of our core variable of interest (β_1) is positive and statistically significant at the highest 1% level. Specifically, it is observed that every 1% increase in RES-E capacity induces a rise of roughly 0.48% in total employment, with everything else constant. These findings support the policymaker's argumentation that renewable energy investments generate direct and indirect job creation opportunities, leading to economic and social benefits beyond the environmental issues. Renewable energy technologies tend to be more labor-intensive than fossil-fuel conventional technologies [14,15] which justifies that the presumed positive impact clearly prevails.

According to the Cambridge Econometrics [16] estimates, an EU reduction of GHG emissions between 80%–90% by 2050 comparing to 1990 levels, associated with a high share of RES, would result in an increase in

[2] This test contrasts LSDV (robust model) with the pooled OLS (efficient model). $F(27, 418) = 0.4724$ with p-value $= P(F(27, 418) > 0.4724) = 0.9896$, validates the null hypothesis that the pooled OLS model is adequate, in favor of the fixed effects alternative.

Table 3. Estimation results — Pooled OLS regression.

Pooled OLS, using 449 observations
Included 28 cross-sectional units
Time-series length: minimum 14, maximum 17
Dependent variable: $lnEMP_{it}$

Variable	Coefficient	Std. Error	t-ratio	*p*-value	
$lnREN_{it}$	0.4833	0.0229	21.08	<0.0001	***
$lnECpc_{it}$	−0.4495	0.1146	−3.921	0.0001	***
ED_{it}	−0.0089	0.0016	−5.704	<0.0001	***
$Constant$	5.4398	0.2490	21.85	<0.0001	***

Sum squared resid	359.1191	S.E. of regression	0.8983
R-squared	0.5303	Adjusted R-squared	0.5271
F (3, 445)	167.4668	*p*-value (F)	<0.0001
Log-likelihood	−586.9571	Akaike criterion	1181.914
Schwarz criterion	1198.342	Hannan–Quinn	1188.390
rho	−0.1001	Durbin–Watson	1.9503

Notes: OLS — Ordinary Least Squares.
***Denotes that coefficients are statistically significant at 1% significance level.

employment between 0% to 1.5%. In its new long-term strategic vision for a climate neutral economy [17], the European Commission also estimates an increase of employment under a 1.5 °C scenario, rising between 0.6% to 0.9% (representing up to 2 100 000 additional jobs). Given our results, these forward-looking estimates do not appear to be excessively optimistic. Although a direct comparison is not possible, since these studies consider the employment effect beyond RES-E deployment, its outcomes give an overall picture that a shift to RES technologies linked to a low-carbon economy induce employment gains.

Concerning the effect of energy consumption per capita ($ECpc$) and energy dependence (ED) variables, empirical evidence also shows statistically highly significant coefficients. Both variables show negative effects on employment, significant at 1% level. Results indicate that when per capita energy consumption rises by 1%, the employment level decreases by approximately 0.45%, *ceteris paribus*, which means that the negative effect discussed above prevails. This negative impact can be explained by the fact that higher energy consumption may induce an increase in relative energy prices, having adverse impacts on economic growth and therefore on employment. In addition, the increase of energy consumption per capita is not necessarily associated with an increase in productive activity. In turn, the impact on employment to a 1% increase in energy dependence is around −0.9%. This negative impact is expected due to the loss of competitiveness and pressure on the balance of payments resulting from an increase in external energy dependence.

4. Conclusions

Besides its role in reducing GHG emissions, improving air quality and enhancing countries energy security, renewables have been pointed out as one of the drivers to promote employment. There is an extensive literature estimating job creation due to renewables deployment. However, the conclusions have not always been consensual, with some authors arguing that the positive impact is not a universal result. Most of the literature on the "employment-renewables nexus" is sustain by ex-ant analysis and not by ex-post methods with confirmed historical links between these two variables. This study contributes to ex-post literature by analyzing the historical linkage between renewable power generation capacity and employment evolution in EU-28 economy over the last sixteen years (2000–2016). Our analysis suggests a positive and statistically significant relationship between these two variables, showing an increase of 0.48% in employment for each 1% increase in renewable power generation capacity, *ceteris paribus*. These outcomes indicate that the EU RES policy support has had a positive effect on EU society, contributing to reduce unemployment, which has important implications for citizens. Thus, future RES deployment associated with the EU goal of being a net-carbon economy, may also carry a positive impact on employment confirming European Commission [17] estimates. Yet, these results should be handled with careful as our analysis present typical limitations of panel data econometric studies, namely, design and data collection problems, short time-series dimension, potential statistical problems, which requires further diagnostic and specification tests.

Acknowledgments

This work was supported by the Portuguese Science and Technology Foundation (FCT/MCTE) through CERNAS, Portugal (UID/AMB/00681/2013) and CENSE, Portugal (UID/AMB/04085/2019) financial support and Patrícia Fortes post-doctoral scholarship, Portugal (SFRH/BPD/100724/2014).

References

[1] Rogelj J, Shindell D, Jiang K, Fifita S, Forster P, Ginzburg V, et al. Mitigation pathways compatible with 1.5 °*C* in the context of sustainable development. In: Masson-Delmotte V, Zhai P, Pörtner H-O, Roberts D, Skea J, Shukla PR, et al., editors. Global Warming of 1.5 °C. An IPCC Special Report. 2018.
[2] EUROSTAT, 2019. Statistical office of the European Union. [Energy Statistics]. Retrieved from https://ec.europa.eu/eurostat/data/database [consulted on 2019].
[3] EU, 2009. Directive 2009/28/EC of the European Parliament and of the Council of 23 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. Off. J. Eur. Union, L 140 (16) (2009).
[4] Böhringer C, Keller A, van der Werf E. Are green hopes too rosy? Employment and welfare impacts of renewable energy promotion. Energy Econ 2013;36:277–85. http://dx.doi.org/10.1016/j.eneco.2012.08.029.
[5] Mu Y, Cai W, Evans S, Wang C, Roland-Holst D. Employment impacts of renewable energy policies in China: A decomposition analysis based on a CGE modeling framework. Appl Energy 2018;210:256–67. http://dx.doi.org/10.1016/j.apenergy.2017.10.086.
[6] Cai M, Cusumano N, Lorenzoni A, Pontoni F. A comprehensive ex-post assessment of RES deployment in Italy: Jobs, value added and import leakages. Energy Policy 2017;110:234–45. http://dx.doi.org/10.1016/j.enpol.2017.08.013.
[7] Almutairi K, Thoma G, Durand-Morat A. A ex-ante analysis of economic, social and environmental impacts of large-scale renewable and nuclear energy targets for global electricity generation by 2030. Sustainability 2018;10(8):2884. http://dx.doi.org/10.3390/su10082884.
[8] Ortega M, del Río P, Ruiz P, Thield C. Employment effects of renewable electricity deployment, A novel methodology. Energy 2015;91:940–51. http://dx.doi.org/10.1016/j.energy.2015.08.061.
[9] Baltagi BH. Econometric Analysis of Panel Data. third ed. Chichester: Wiley; 1995.
[10] Hsiao C. Analysis of Panel Data. second ed. Cambridge: Cambridge University Press; 2003.
[11] Mátyás L, Sevestre P, editors. The Econometrics of Panel Data: HandBook of Theory and Applications. second revised ed. Dordrecht: Kluwer Academic Publishers; 1996.
[12] Hillebrand B, Buttermann HG, Behringer JM, Bleuel M. The expansion of renewable energies and employment effects in Germany. Energy Policy 2006;34(18):3484–94. http://dx.doi.org/10.1016/j.enpol.2005.06.017.
[13] AMECO, 2019. European Commission Annual Macro-Economic (AMECO) Database. [Population and Employment]. Retrieved from http://ec.europa.eu/economy_finance/ameco [consulted on February, 2019].
[14] Markandya A, Arto I, González-Eguino M, Román MV. Towards a green energy economy? Tracking the employment effects of low-carbon technologies in the European Union. Appl Energy 2016;179:1342–50. http://dx.doi.org/10.1016/j.apenergy.2016.02.122.
[15] Wei M, Patadia S, Kammen DM. Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US? Energy Policy 2010;38:919–31. http://dx.doi.org/10.1016/j.enpol.2009.10.044.
[16] Cambridge Econometrics, 2013. Employment effects of selected scenarios from the energy roadmap 2050. Final report for the EC (DG Energy).
[17] EC, 2018. Clean Planet for all. A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy. Brussels: COM(2018) 773 final. Communication from the commission to the European Parliament, the European Council, the European Economic and Social Committee of the regions and the European Investment Bank.