EXTENDED ABSTRACT

The effect of Green Electricity change and Ecoinnovation on Inequality. Evidence from European Union panel data

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Abstract:
This study examines the role of the deployment of Green electricity and Ecoinnovation on income inequality in the European Union Members, using panel data econometric models.

There is an extended literature focusing on the impact of the Electricity from Renewable Energy Sources (RES-E) on the energy inequality. At the European level, Bonatz *et al.* (2019) studied the interlinkages between energy poverty and low carbon development in China and Germany and Neacsa *et al.* (2020) explored the relations between energy poverty, quality of life and renewable energy in Romania. Biernat-Jarka *et al.* (2021) indicated investments in renewable energy sources that may have a positive impact on reducing the scale of energy poverty in Poland and explored how some local communities with low possibilities of accessing unconventional energies could decrease its energy poverty through government programs supporting the access to green (renewable) energies. Recently, Ramos *et al.* (2022) showed the effect of distributed generation renewable resources on energy poverty for the 28 countries of the European Union through the construction of an Energy Poverty Index in the years 2008 and 2017. Their results showed that microgeneration units based on renewable contributes to reduce energy poverty in all EU members.

Theoretically, in the European Union wholesale electricity markets, the increased generation of electricity from renewable energies RES-E is integrated in wholesale market reducing wholesale prices, but the final effect over household prices is not clear. An energy transition is not unlikely to drive up energy prices, at least in countries moving away from coal and other cheaper energy sources and investing in renewables (examples

include Energiewende in Germany as well as the Iberian Electricity Market-MIBEL- in Spain, where costs and electricity prices are a pertinent topic).

In fact, most of the European Countries has increased the electricity prices at the same time increases RES-E, thus reducing energy affordability in the short term of vulnerable consumers.

Most of the European Union members have adopted support schemes to encourage electricity generated from renewable sources RES-E, as feed-in tariffs (FIT). Although RES-E reduces wholesale electricity prices (i.e. Würzburg *et al.* 2013 and Dillig *et al.* 2016, among others) most RES-E support systems are charged to household electricity bills, so a higher share of renewables, may then drive final household electricity prices up, contributing to increased levels of Energy Poverty.
It should be noticed that some authors have analyzed the impact of renewable power on electricity tariffs for domestic consumers under the context of feed-in tariff support for renewables, since feed-in-tariffs are passed on directly to the access charges of final consumers. For example, Blazquez *et al.* (2018) observed an increase in the price paid by consumers of 62 percent for the period 2008–2014, with an increase in renewable penetration from 23.7 percent to 37.8 percent in Spain.
Recently, Mastropietro (2019) by analyzing the relationship between RES-E charges and energy poverty, showed how the growth of the annual budget dedicated to RES-E support had a significant impact on electricity tariffs in many European countries, especially for residential consumers. He reviews some recent research (i.e.Farrell and Lyons 2015) that shows the potential regressive impact of RES-E support (wealthier households pay a much lower share of their income to cover RES-E support costs than that paid by poorer households). Similarly, Inderberg *et al*. (2018) studied, among other factors, the effect of support schemes on the development of prosuming (consumers with connected RDG unit) in Germany, UK and Norway between 1990 and 2017. The study concludes that a generous and stable support scheme that addresses grid feed-in emerges as a major factor in promoting prosuming in national electricity systems. However, high FIT rates in turn lead to concerns about oversubsidization, social fairness and erosion of the solidarity principle.
This study examines the role of the deployment of RES-E on income inequality in the European Union Members.

Basically, strategies and energy policy measures aimed at reducing income inequality (Dobbins *et al*. 2015 and Pye *et al.* 2017 and) include not only financial interventions for ensuring energy affordability in the short term of vulnerable consumers as social welfare payments, direct payments to specific groups to assist with energy bills or social tariffs, but also Energy efficiency programs targeting improvements to the efficiency of building stock, or energy using appliances.
In that sense, the European Commission has developed an Eco-innovation Action Plan (EcoAP) which fosters a comprehensive range of eco-innovative processes, products and services which can improve resource efficiency.
Innovation activities have the potential to reduce income inequality, however, there is some countries as China with the high number of patents and high-income inequality. Thus, the effect of innovation on inequality is not clear.

In order to contribute to this debate, this paper provides an empirical investigation of the effect of Ecoinnovation and RES-E on income inequality in the European Union Members.

Econometric model

This research examines the role of ecoinnovation and the deployment of RES-E on income inequality by using panel regression econometric models. We use the dataset on 27 European Union members, and the sample period covers from 2010 to 2019.

In the panel econometric model, the dependent variable is inequality (GINI) measured as natural logarithms of the Gini coefficient of equivalised disposable income published by the The European Union Statistics on Income and Living Conditions and available at Eurostat database.

The independent variables are ecoinnovation, the integration of renewables on electricity market and a vector of controls, including other determinants of inequality referenced in the literatures such as GDP per capita, human capital, globalization, inflation, unemployment rate (see Law et al. 2020).

Ecoinnovation (ECO) is extracted from the Eco-innovation Action Plan (EcoAP). The Eco-innovation index measures the performance of EU Member States on environmental innovations. It is a composite indicator obtained by taking an unweighted average of the 16 indicators included in the measurement framework.

The integration of renewables on electricity market is measured as share of Renewable energy sources in electricity (RES) is obtained from the Eurostat database.

The labor force data, unemployment rate (UNEM), comes from the EU Labour Force Survey (EU LFS) data and downloaded from Eurostat's online database

Human capital (HUM) is proxied by percentage of people with less than primary, primary and lower secondary education (levels 0-2). The importance of human capital through educational attainment is correlated with economic development in Barro (1991). A labor force with high education level implies skilled workers with high ability to absorb advanced technology, affecting social outcomes, such as the education of children, together with income distribution.

Globalization (GLOB) is proxied by Export to import ratio downloaded from Eurostat's online database, which measures the economic dimensions of globalization.

Real Gross Domestic Product per capita (GDPpc) and inflation (INF) are obtained from from Eurostat's online database.

The variables are used in natural logarithms in order to estimate elasticities produced by the independent variables
Country fixed effects are included in order to capture country specific determinants.

The model specification is as follows:

$$GINI_{it} = \beta_0 + \alpha_i + \beta_1 GDP_{it} + \beta_2 GLOB_{it} + \beta_3 HUM_{it} + \beta_4 INFL_{it} + \beta_5 UNEM_{it} + \beta_6 RES_{it} + +\beta_7 ECOIN_{it} + \beta_8 ECOIN_{it-1} + \beta_9 ECOIN_{it-2} + \boldsymbol{\mu_{it}}$$

where *i* stands for the income inequality of the country *i* and the α_i parameters denote country effects, which are included in the model in order to take account of any possible country-specific factors that may have an influence on inequality beyond the explanatory variables included. The disturbances of this model are denoted by μ_{it} and are assumed to be independently and identically distributed random variables with mean zero and variance σ_u^2.

In order to identify the most suitable panel model specification, the proposed model have been estimated considering both fixed and random effects. According to the fixed effects model, α_i is considered a regression parameter, while the random effects model treats it as a component of the random disturbance. To establish whether the fixed or the random effects estimator is more appropriate, a Hausman test is performed (1978). Further, the existence of country-specific effects is checked though the F-test (for fixed effects) or Breuch-Pagan test (for random effects). In both cases the null hypothesis is the existence of equal α_i for all EU members. If the individual country effect α_i is assumed to be equal across all countries, then the pooled OLS is consistent and efficient.

Results

The obtained estimation of the model is summarized in Table 1.

Table 1. Results basic specification

Coefficients	Random Effect
β_0	4.2395*** (0.3097)
β_1 (GDPpc)	−0.1261*** (0.0414)
β_2 (GLOB)	0.2971** (0.1263)
β_3 (HUM)	0.0051 (0.0019)
β_4 (INFL)	-0,0033 (0,0026)
β_5 (UNEM)	0.0041* (0.0024)
β_6 (RES)	0.0014** (0.0007)
β_6 (ECOIN)	−0.0005 (0.0182)
β_6 ($ECOIN_{-1}$)	-0.0432* (0.0224)
β_7 ($ECOIN_{-2}$)	-0.0324 (0.0215)
Chi-Test of the Model	56.7315***
Breuch-Pagan	562.215***
Hausman test	14.0709

White heterokedasticity. Robust Standard deviation on brackets; *stands for estimates significantly different from 0 at a 10% level, ** stands for estimates significantly different from 0 at a 5% level and *** stands for estimates significantly different from 0 at a 0% level based on a t-ratio test.

The Hausman test indicates that random effects estimator is more appropriate than fixed effects estimator. Thus, the existence of country-specific effects is checked though the Breuch-Pagan test. The null hypothesis (existence of equal α_i for all the countries) is rejected at the 1% level. Thus, the individual effect α_i is assumed not to be equal across all countries

The estimation provides empirical evidence for a positive impact of the share of renewables on income inequality. A higher share of renewables contributes to increased levels income inequality. The value of the estimated RES coefficient (0.0014) is modest, nevertheless. There is also evidence for a negative impact of Ecoinnovation on income inequality. The estimated coefficient of the indicator variable with one year lag (−0.0432) shows a statistical significance.

References

Barro, R. J. (1991). Economic growth in a cross section of countries. *The quarterly journal of economics*, *106*(2), 407-443.

Biernat-Jarka, A., Trębska, P. & Jarka, S. (2021). The Role of Renewable Energy Sources in Alleviating Energy Poverty in Households in Poland. *Energies* 14: 2957

Blazquez, J., Fuentes-Bracamontes, R., Bollino, C. A., & Nezamuddin, N. (2018). The renewable energy policy Paradox. *Renewable and Sustainable Energy Reviews*, 82, 1-5

Bonatz, N., Guo, R., Wu, W., & Liu, L. (2019). A comparative study of the interlinkages between energy poverty and low carbon development in China and Germany by developing an energy poverty index. *Energy and Buildings*, *183*, 817-831.

Dillig, M., Jung, M., & Karl, J. (2016). The impact of renewables on electricity prices in Germany–An estimation based on historic spot prices in the years 2011–2013. *Renewable and Sustainable Energy Reviews*, 57, 7-15.

Dobbins, A., S. Pye, C. Baffert, J. Brajković, I. Grgurev, R. De Miglio, & Deane, P. (2015). Energy poverty and vulnerable consumers in the energy sector across the EU: analysis of policies and measures. *Dobbins, S. Pye, C. Baffert, J. Brajković, I. Grgurev, R. De Miglio, P. Deane//Policy Report, 2.*

Farrell, N., & Lyons, S. (2015). Who should pay for renewable energy? Comparing the household impacts of different policy mechanisms in Ireland. Energy Research & Social Science, 7, 31-42.

Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica: Journal of the econometric society*, 1251-1271.

Inderberg, T. H. J., Tews, K., & Turner, B. (2018). Is there a prosumer pathway? Exploring household solar energy development in Germany, Norway, and the United Kingdom. *Energy Research & Social Science*, *42*, 258-269.

Law, S. H., Naseem, N. A. M., Lau, W. T., & Trinugroho, I. (2020). Can innovation improve income inequality? Evidence from panel data. *Economic Systems*, *44*(4), 100815.

Mastropietro, P. (2019). Who should pay to support renewable electricity? Exploring regressive impacts, energy poverty and tariff equity. *Energy Research & Social Science*, 56, 101222.

Neacsa, A., Panait, M., Muresan, J.D. &Voica. M.C. (2020). Energy poverty in European Union: Assessment difficulties, effects on the quality of life, mitigation measures. some evidence from Romania. *Sustainability* 12: 4036.

Pye, S., Dobbins, A., Baffert, C., Brajković, J., Deane, P. & De Miglio R. (2017). Energy poverty across the EU: Analysis of policies and measures. *In Europe's Energy Transition (*pp. 261-280). Academic Press.

Ramos, C., Alvargonzález, M., & Moreno, B. (2022). Study of energy poverty in the European Union: the effect of distributed generation. *Energy Sources, Part B: Economics, Planning, and Policy*, 1-24.

Würzburg, K., Labandeira, X., & Linares, P. (2013). Renewable generation and electricity prices: Taking stock and new evidence for Germany and Austria. *Energy Economics*, 40, S159-S171.

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