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Panel data analysis for renewable energy investment determinants in Europe

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This study is an empirical approach to understand the determinants of renewable energy (RES) investment in European Union (EU-27) through panel data study over the period 1995 to 2011. Random effect panel data modelling technique was used to understand the variables that affect solar and wind energy investments in EU-27. Results suggest that the strong regulation perception plays negative role in the solar energy investment, and lower sunshine hours lead to higher wind investment.

Keywords: renewable energy; investment; panel data; wind energy investment; solar energy investment

JEL Classification: O13; Q42; F21

I. Introduction

In the current trend, investments worldwide in RES are dictated by several factors like technologies, legal frameworks, political will, energy demand etc. However, UNEP Report (2009) presented two import information – first, among technologies available for the generation of RES, wind-generated electricity has attracted the highest investment of 43% followed by the solar at 23%. Second, while a very high investment growth of 123% was observed in wind energy sector, investment through venture capitalists and private equity (USD 5.5 billions) and public markets (6.4 billions) was higher for solar energy projects.

It is important to know the investment drivers that are affecting the competition between solar and wind. Contribution of this study is to empirically identify the investment drivers (for solar and wind energy technologies) at macro level within European

framework (EU-27). Two research questions (RQs) that are addressed in his study are as follows:

RQ 1: Which are the determinants for solar energy investments?

RQ 2: Which are the determinants for wind energy investment?

II. Data and Methodology

Conceptual framework and variables

To answer the major RQs, two dependent variables were chosen and two versions of the econometric model were proposed. Figure 1 represents the conceptual framework for this study.

RES generation is linked to RES installed capacity for higher-generation of energy electricity generated through renewable source (RES-E) investment might

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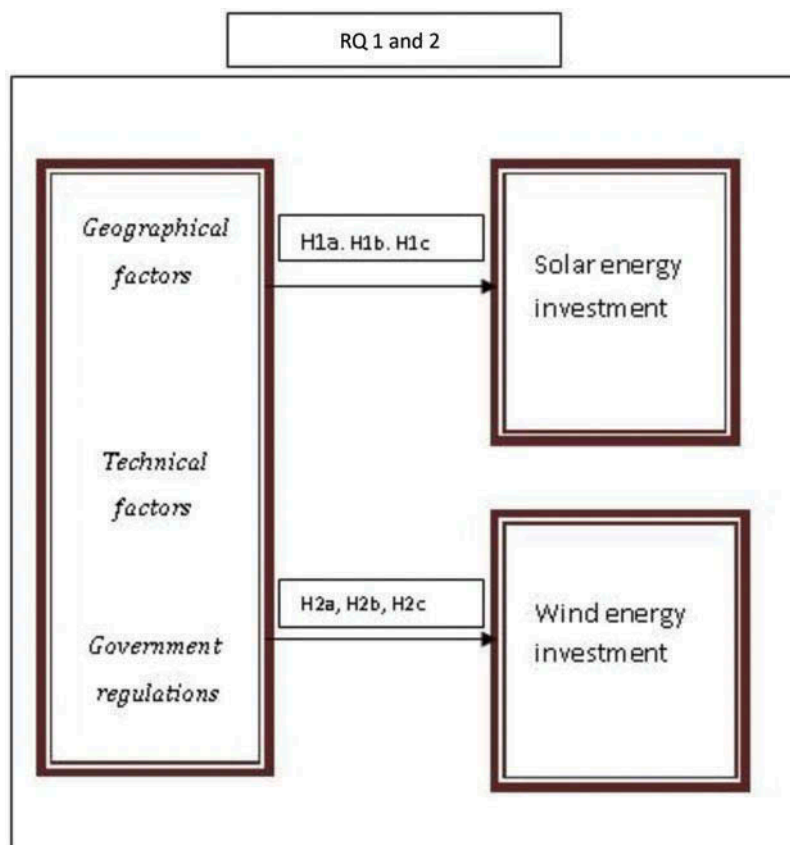


Fig. 1. Conceptual framework for the study

be required for either expansion or setting up a new power plant. Therefore, the above-mentioned two variables were interchangeable also referred as an investment in solar and wind energy sectors. In other words, RES through wind and solar are used as proxies to investment in wind and solar energy sectors, respectively.

Whereas main independent variables considered are annual sunshine hours (ASH), regulatory perceptions and CO₂ emissions (CE).

Geographical factors are important consideration for the investment in clean technologies because of the obvious reasons. For example, for countries that are situated on coastal regions, the speed of wind can favour the generation of electricity, and on the other hand, countries away from the coast and receiving sufficient sunlight may invest more in solar energy projects. For the current study, only ASH is considered. Thus,

H1a: Higher sunshine hours lead to higher electricity generation through solar.

H2a: Lower sunshine hours lead to higher electricity generation through wind.

Regulatory frameworks are other strong consideration in investing in clean technologies. Direct support scheme mechanism includes feed-in tariffs, feed-in premiums,¹ investment incentives and financial incentives such as loans are below market interest rate. Strong regulation is also perceived as more formalities, more paper work, more licences and more taxes. Positively, strong regulation would also control environmental degradation factors, which could include the policy related to adoption of technologies that cause less CE. H1b and H2b would be tested to address the RQ.

H1b: Strong regulation perception leads to higher investment in solar.

H2b: Strong regulation perception leads to higher investment in wind.

¹ Feed-in-premiums (FIP) are payments guaranteed to RES-E generators on top of existing electricity market prices

Table 1. Correlation matrix of dependent and independent variables used in the study

	CE	EI	LS	LW	RG	RES-S	RES-W	ASH
CE	1.00	-0.19	-0.06	-0.11	-0.37	-0.01	-0.31	0.07
LS	-0.06	-0.16	1.00	0.29	0.07	-0.14	0.01	-0.15
LW	-0.11	0.08	0.29	1.00	-0.33	-0.21	-0.22	0.25
RG	-0.37	-0.11	0.07	-0.33	1.00	0.02	0.39	-0.52
RES-S	-0.01	0.32	-0.14	-0.21	0.02	1.00	-0.06	0.16
RES-W	-0.31	-0.09	0.01	-0.22	0.39	-0.06	1.00	-0.36
ASH	0.07	0.30	-0.15	0.25	-0.52	0.16	-0.36	1.00

Source: Compiled by the authors.

Notes: CE, CO₂ emissions; LS, levelized cost of electricity generation through solar technologies; LW, levelized cost of electricity generation through wind technologies; RG, regulatory quality; RES-S, solar energy generation on total RES; RES-W, wind energy generation on total RES; ASH, annual sunshine hours.

Incentives given towards the adoption of green technology are supposed to be one of the instruments of climate change policies, which ultimately aim to reduce the CE. Investment cost in setting up RES plant includes high fixed cost and variable cost, which can be returned over the period of time.

Hypotheses H1c and H2c test the dependency on solar and wind energy investment for controlling CE.

H1c: Higher carbon emissions lead to higher investment in solar.

H2c: Higher carbon emissions lead to higher investment in wind.

Table 1 shows the list of dependent and independent variables used in the study.

Method

To address the RQs, hypotheses were tested through macroeconomic empirical models. Data used were taken from Eurostat and World Bank. For empirical modelling, fixed panel regression was done on four dependent variables, followed by random panel regression with white periods. Along with correlation, white periods were used to control heteroscedasticity (Menegaki, 2011). Hausman test was performed to decide between choosing fixed or random panel data modelling (see Menegaki, 2011; Moreno *et al.*, 2012; Lee, 2013). Results of Hausman test were not significant, and so we used random effect panel data modelling. Granger causality test was performed to understand the relation in the long run. Finally, two model versions (MVs) were proposed. Figure 2 shows the overall methodology flow of the study.

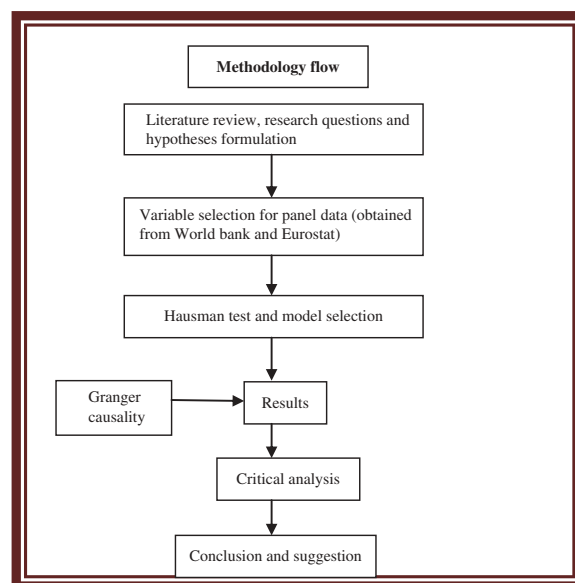


Fig. 2. Methodology flow of the study

III. Empirical Modelling

For the current study, the following four OLS regression models were used to understand the effects of independent variables.

$$Y_{it}(\text{RES} - \text{S}) = \beta_0 + \beta_1 \times \text{LS} + \beta_2 \times \text{CE} + \beta_3 \times \text{ASH} + \beta_4 \times \text{RG} + U_{it} \quad (1)$$

$$Y_{it}(\text{RES} - \text{W}) = \beta_0 + \beta_1 \times \text{LW} + \beta_2 \times \text{CE} + \beta_3 \times \text{ASH} + \beta_4 \times \text{RG} + U_{it} \quad (2)$$

where $i = 1, \dots, 27$; $t = 1995, \dots, 2011$ and β_0 parameters denote country effects that are included in the model in order to take account of any possible country-specific factors that may have an influence on prices beyond the explanatory variables included. The disturbance of this model is denoted by U_{it} and is assumed to be independently and identically distributed random variables with mean zero and variances $\sigma^2 u$.

IV. Results

Major consideration for the analysis is determination of coefficient values and levels of significance (Table 2).

In MV1, we found solar investments were not significantly affected by electricity prices of either household or industries. However, CE and RG negatively affect investment in solar energy sector with a factor of -1.5 and -0.91 , respectively, and were highly significant at the 5% level. Literature suggests that electricity market is highly sensitive to regulatory policies; higher RG is perceived with higher formalities and higher taxes, which can be offset in the short run by giving bribes and saving money (Worldbank Report, 1997; Johnson *et al.*, 1998). Recently, Cambini and Rondi (2010) also studied the relationship between regulatory regimes and investment through panel data modelling and negative relationship between regulatory and investment. It also shows that businesses want to save money on

Table 2. Proposed model versions (MV)

		EU-27		
		RES-S MV 1 ^a	RES-W MV 2 ^a	
Price variables	LS	-0.002		
	LW		-0.044	*
Economic variables	CE	-1.513	*	-9.748 *
Other variables	ASH	8.129	*	-6.699 **
	RG	-0.916	***	-2.231
R^2		0.034	0.128	
Adjusted R^2		0.021	0.116	
F -statistic		2.685	11.261	
Prob(F -statistic)		0.032	0	

Source: Compiled by the authors.

Notes: ^aValues in column represent p -values.

*Significant at the 1% level.

**Significant at the 5% level.

***Significant at the 10% level.

taxes and also want to avoid the tedious formalities because of which they bribe.

Also, lower quality of regulation could also be associated with lesser and easier formalities because of which businesses feel easy to invest. Additionally, the possibility of higher investment in countries that have high quality of regulatory could also be due to their stringent environmental policies.

However, CE were found to be negative and significant at the 5% level. Furthermore, Granger causality test was done (using two lag periods) to find a long-run relationship between RES-S and CE, which indicates that there is no relationship in the long run. In the long run, European countries are able to control the emissions by implementing the renewable policies.

On the other hand, ASH is positively and significantly (at 1% level) found to be associated with RES-S, and the reason seems very obvious too. That means the higher the ASH are, the higher the attraction to investment in solar energy sector is.

In our analysis, we observe low R^2 . However, model correctness is not always associated with high R^2 ; increasing the independent variables in a regression increases the value associated with R^2 , and in some cases, lower R^2 indicates greater selectivity (Amihud and Goyenko, 2013).

MV2 explains the determinants of investments in wind energy sector. Although, LW is highly subsidized (Lazard Report, 2013), still the effect is observed for wind investment due to continuous dip in price in wind technology (Ernst & Young Report, 2012). On the other hand, CE were observed to be highly significant and negatively associated with wind investment with a factor of -9.74 . The result suggests that in the long run (with lag of 2 years), there is no significant relationship between RES-W and CE. However, ASH is negative with a coefficient of -6.7 and is significant at the 5% level. This represents obvious relationship that lower ASH leads to higher investment in wind energy sector.

V. Conclusion

In the framework of RES investment and RES effect on real prices debate in liberalized electricity market, this study explored the impact of several variables on solar and wind generation. Specifically, we used panel data provided by Eurostat that covered EU-27 countries during the time period 1995 to 2011.

Results of the study suggest that strong regulation perceptions reduces the investment chances in solar, whereas regulations have no significant relationship in terms of investment in wind energy sector. On the other hand, CE are reduced to a large extent in the long run, and so this effect might not be clearly observable. However, in our next study, a smaller sample would be studied to compare the results in the long run and the short run.

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