ENERGY EFFICIENCY AND INSTITUTIONAL QUALITY: THE ROLE OF ENERGY EFFICIENCY GOVERNANCE

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Overview

The successful deployment of EE can be compromised by institutions and governance performance. While the influence of institutions on this issue is well-documented in the literature (Laponche et al. 1997; Limaye, Heffner, and Sarkar 2008; Álvarez, Marrero, and Ramos-Real 2015), the absence of an Energy Efficiency Governance Index (EEGI) has prevented testing the relationship between EE governance and the improvements in EE. This work contributes to fill this gap proposing the construction of a composite EEGI that captures the institutional, economic and political environment underpinning EE governance. The index assesses 32 OECD countries and represents the period between 2000 and 2015.[1] On average, the EEGI score is shown to be positively correlated with economic development and general governance quality. Furthermore, the EEGI is included in a Stochastic Frontier Analysis (SFA) in which an aggregated energy demand function is calculated, enabling the estimation of the level of EE for each country in the sample. This empirical approach demonstrates the utility of the EEGI to improve those econometric models in which EE is estimated without taking into consideration governance indicators, providing at the same time new insights to explain the evolution of EE. Therefore, the index may be an interesting tool to facilitate the development of EE policies adapted to each specific country context.

Methods

According to the International Energy Agency (IEA 2010), EE governance is the combination of three main areas (i.e., legislative and funding frameworks, institutional arrangements and co-ordination mechanisms) which enable the implementation of EE policies. Likewise, each area is compound of a set of indicators. The Energy Efficiency Database (2016) of the IEA provides accurate and updated information regarding EE policies for the set of countries in the sample. This information has been filtered and analysed in order to identify what area (and indicators) of EE governance the data refers to. Concerning the construction procedure of EEGI, it has been inspired by Dabla-Norris et al. (2012). Since the available information is mostly qualitative, a set of coding rules is used to assess the data relative to each indicator, scoring them in a scale between 0 and 4. A higher score reflects better EE governance. Then, indicators in each area are aggregated through an arithmetic mean to construct a sub-index, one for each EE governance area. Finally, the three sub-indices are aggregated again through the arithmetic mean to construct the overall EEGI. A robustness assessment is also carried out.

Regarding the SFA, the analysis conducted in this paper is inspired by previous works developed by Filippini and Hunt (2011, 2012) and Filippini, Hunt and Zoric (2014). From a theoretical lens, the stochastic frontier provides the optimal combination of inputs to obtain an optimal output or, in this case, to obtain the lowest aggregated energy demand. The next equation provides the model used to conduct the analysis.

$$e_{it} = \alpha + \alpha^{p}\, p_{it} + \alpha^{y} y_{it} + \alpha^{pop} pop_{it} + \alpha^{c} cold_i + \alpha^{o} oceanic_i + \alpha^{a} a_i + \alpha^{I} ISH_{it} + \alpha^{S} SSH_{it} + \alpha^{UR} UR_{it} + \delta_t D_t + v_{it} + u_{it}$$

Where e_{it} is the natural log of the aggregated energy demand of the country i in the year t, p_{it} is the natural log of the real energy price index, y_{it} is the natural log of the GDP, pop_{it} is the natural log of the population and a_i is the natural log of the country area. Likewise, $cold_i$, $oceanic_i$, ISH_{it}, SSH_{it} and UR_{it} provide, respectively, dummies for cold and oceanic climates, the gross value added for industry and services, and the urbanization rate. D_t is a time variable that captures the technological progress and other exogenous factors. Table 1 summarizes the main statistics of these variables and the sources used. Finally, in this kind of models the error term is divided in two parts. The first part is v_{it}, which provides the random noise of the model. The second part is u_{it}, which represents the underlying level of EE and it is interpreted as an indicator of the inefficiency level. Some specifications, such as the True Fixed Effects (TFE, Greene, 2005), True Random Effects (TRE, Greene 2005) and Battese and Coelli (1995), allow to reestimate u_{it} in a second step, varying over time and according to a set of explicative factors:[2]

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[1] The countries included are: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Polonia, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. Israel and Iceland have been excluded due to the lack of information.

[2] TFE and TRE models tipically result in overestimation of efficiency. However, this paper aims to provide empirical evidence of the relevance of EE governance to estimate EE levels through SFA, rather than to assess the quality of the EE estimations of different SFA models. This is why we have used three different specifications to check the suitability of the EEGI. Furthermore, it is needed to use specifications in which the u_{it} term can vary according to explanatory variables, since de EEGI is more related to energy efficiency or inefficiency (i.e., to u_{it}) than to energy consumption.

$$u_{it} = \beta Z_{it} + \varepsilon_{it}$$

Where Z_{it} represents the explicative factors for the inefficiency estimation and ε_{it} is a random error term. In our case, Z_{it} is compound by the EEGI, which provides a single score for the period 2000-2015, so it is considered as a fixed factor for each country.

TABLE 1. MAIN DATA STATISTICS AND SOURCES.

Variable	Time period	Mean	Std Dev	Min	Max	Obs	Source
e	2000-2015	11.153	1.286	8.457	14.665	464	IEA
p	2000-2015	4.540	0.137	4.187	4.835	464	IEA
y	2000-2015	6.407	1.284	3.038	9.717	464	IEA
pop	2000-2015	2.929	1.271	0.270	5.774	464	IEA
a	2000-2015	19.290	1.614	17.260	22.984	464	IEA
$cold$	2000-2015	0.241	0.428	0	1	464	OE[a]
$oceanic$	2000-2015	0.310	0.463	0	1	464	OE[a]
ISH	2000-2015	0.257	0.051	0.137	0.403	456[b]	WB
SSH	2000-2015	0.622	0.062	0.481	0.764	456[b]	WB
UR	2000-2015	0.757	0.102	0.534	0.979	464	WB
$IGEE$	2000-2015	2.540	0.677	0.55	3.55	464	OE

[a] Own elaboration.

Results

The enabling framework sub-index seems to be highly correlated with the overall EEGI. More concretely, the laws and decrees indicator is crucial to achieve a high EEGI score. These results are partially explained by economic development and general governance quality, since there is a positive correlation between these variables and the EEGI score. In fact, the correlation between the EEGI and economic development is higher than that corresponding between the EEGI and general governance quality (measured through the World Governance Index –WGI– of the World Bank), confirming the need to distinguish between energy governance and general governance.

Regarding the SFA, the approach based on TFE, TRE and Battese and Coelli (1995) provide the next results (see Table 2). All the estimated coefficients have the expected magnitudes, signs and significances. Furthermore, the EEGI takes an important role. It is significant in all the estimated models and with high magnitude. According to the results, increasing the EEGI by one tenth would mean improving EE by 10%. This is a comprehensive contribution, since the EEGI is a measure of the entire governance structure in EE issues in a country, so changing a tenth of the EEGI would mean changing a large part of that structure.

TABLE 2. SFA RESULTS.

Coefficient	BC95	TFE (Greene 2005)	TRE (Greene 2005)
Parameters of the demand function			
Constant	4.276***	/	4.758***
p	-0.214*	-0.128***	-0.085***
y	0.763***	0.687***	0.645***
pop	0.175***	0.369***	0.280***
a	0.066***	0.088**	0.071***
cold	0.258***	0.638*	0.181***
oceanic	-0.055**	0.298	0.031
ISH	1.719***	4.355***	0.673***
SSH	1.282***	2.825***	0.019
UR	1.489***	1.968***	0.868***
D	-0.012***	-0.013***	-0.012***
Parameters in the one-sided error			
Constant	0.145	-3.332***	-3.732***
IGEE	-1.823***	-1.011***	-1.047***
Variance parameters for the compound error			
Sigma	0.153***	0.031***	0.030***
lambda	0.82***	1.806***	1.517***

*, **, *** denotes 10%, 5% and 1% significance level, respectively.

Conclusions

This work constructs, for the first time, a multi-dimensional index of the quality of EE governance in a set of 32 OECD countries. This index breaks new ground, since indices about EE governance are not available yet and it complements the available institutional indices in the assessment of the influence of institutions on EE performance.

The results seem to maintain a positive correlation with economic development and general governance quality. Furthermore, this work has demonstrated the important role of EE governance in order to estimate EE levels. The index proposed in this paper has been included into a stochastic frontier analysis in which an aggregated energy demand function has been estimated through different econometric specifications. The results are consistent through the three models. Therefore, the EEGI provides a noticeable contribution, since increasing the EEGI score in one tenth could change the EE level by 10%.

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