**Income, Energy and the role of Energy Efficiency Governance**

**J. Barrera-Santanaa,b, Gustavo A. Marreroa,b,c(\*), Francisco J. Ramos-Reala,b,d**

a Department of Economics, University of La Laguna (Tenerife, Spain)

b CEDESOG, University of La Laguna (Tenerife, Spain)

c IUDR, University of La Laguna (Tenerife, Spain)

d ISTUR, University of La Laguna (Tenerife, Spain)

\* Corresponding author: Gustavo A. Marrero, Departamento de Economía, Contabilidad y Finanzas. Universidad de La Laguna, Camino la Hornera, s/n, La Laguna, 38071, Spain. E-mail: [gmarrero@ull.edu.es](mailto:gmarrero@ull.edu.es).

**Overview**

Understanding the relationship between income and energy consumption is essential for the correct design of energy policy. Many works study this relationship, but none of them adequately control for double causality, which may lead to biased estimates. For a set of 32 OECD countries, we construct an energy efficiency governance index (EEGI) between 2000 and 2015. We propose an instrumental variable approach that draws on this index in order to characterize the aforementioned relationship. The EEGI affects growth only through energy consumption, favoring a more efficient use of energy in the production process and, thus, fostering growth. The elasticity between (energy-governance-driven) energy consumption and income growth is close to unity, which almost doubles that commonly found in the literature. For the other side of causality, we construct an adjusted income growth series, where the response of income to energy consumption is ruled-out. The resulting elasticity is negative (around -3.0), which is of opposite sign to the usual finding in the literature. Therefore, energy consumption driven by improvements in energy governance is good for growth, while income growth enhances energy efficiency. Since energy consumption is the main driver of carbon emissions in OECD countries, energy governance could play a remarkable role for decoupling carbon emissions from GDP growth.

**Method**

For a set of 32 OECD countries, we draw upon the theoretical framework proposed by the International Energy Agency (IEA, 2010) to construct an Energy Efficiency Governance Index (EEGI) representative for the 2000-2015 period, which is used as an external instrument to characterize the effect of energy consumption on income growth.4 For the EEGI to be a valid instrument, the exclusion restriction, which is that energy governance affects income growth only through its impact of energy consumption, must be satisfied. The theoretical background that dictates this proposal draws on existing well-known results in the literature, in which institutional quality and governance have proven to be a highly relevant factor for economic growth and other environmental concerns such as CO2 emissions and natural resource abundance (Ji, Magnus, & Wang, 2014; Dées, 2020). Energy governance, a very different concept from the general governance of a country (IEA, 2010; 2016), favors a more efficient use of energy (Goldthau & Sovacool, 2011; Holley & Lecavalier, 2017; Ringel & Knodt, 2017; Haley, Gaede, Winfield, & Love, 2020), and these gains in energy efficiency can benefit productivity (Boyd & Pang, 2000; Worrell, Laitner, Ruth, & Finman, 2003; IEA, 2014) and then economic growth (Florini & Sovacool, 2011; Bazilian et al., 2014; Lesage & de Graaf, 2016; Díaz, Marrero, Puch, & Rodríguez, 2019).

We begin by showing that EEGI affects income growth only through its impact on energy consumption growth. Therefore, empirically, the exclusion restriction is satisfied and the EEGI is a good candidate to characterize the causal effect of energy consumption on economic growth. However, it does not mean that there are no other indirect (theoretical) channels through which energy governance could affect income growth, regardless of energy consumption (e.g., technological externalities derived from R&D applied to new, more efficient energy sources).

To analyze the effect of income on energy consumption growth, we use the Instrumental Variable (IV) estimates of the previous relationship and construct an adjusted per capita income growth series, in which the response of economic activity to energy consumption (driven by energy governance) is ruled-out (Brückner, 2012, 2013; Brueckner & Lederman, 2018). Then, the adjusted variable instruments income growth and, following previous works in this field (Ciccone et al., 2012; Esseghir & Khouni, 2014; Galiani, Knack, Colin Xu, & Zou, 2017; Dées, 2020), we apply a Two-Stage Least Squares (2SLS) approach to a first-differenced model.

**Results**

The construction of an unprecedented energy efficiency governance index is a relevant contribution of this work. Energy governance is defined as the combination of a regulatory framework (laws, plans and financing mechanisms), institutional arrangements (energy agencies, public-private agreements, among others) and the coordination mechanisms necessary for a successful development of energy policies (IEA, 2010). Our index captures these dimensions underpinning energy governance through the analysis of almost 1,800 entries on energy efficiency measures for the 32 OECD countries analyzed. These entries are extracted from the IEA’s Energy Efficiency Database (2016), covering measures implemented for the 2000-2015 period. Next, we follow Dabla-Norris, Brumby, Kyobe, Mills, & Papageorgiou (2012), who build an indicator of efficiency in public investment management, to construct our composite index on energy efficiency governance.

Our results suggest, firstly, that increasing energy governance by one standard deviation (around 32% over its average score) could reduce energy consumption growth by approximately 0.50% per year. Quantitatively, this amount is a little bit higher than the average drop of this variable in our panel of OECD countries between 2000 and 2015. Secondly, we find that the estimated elasticity from energy to income growth is close to unity. This result almost triples the elasticities estimated under OLS with fixed effects, which are likely to be biased, but it also almost doubles the elasticities commonly found in the related literature (Masih & Masih, 1996; Fatai et al., 2004; Esseghir & Khouni, 2014, among others). This means that the part of energy consumption driven by energy governance has a stronger effect on income growth than total energy consumption. A more efficient use of energy in the production process and the consequent impact on overall productivity and, thus, on growth, might explain this result.

Thirdly, for the other side of causality (from income to energy consumption growth), our 2SLS estimates shows a sizable negative elasticity (around -3.0), which is of opposite sign to our OLS fixed effects estimates and the usual finding in the literature (Chen, Chen, Hsu, & Chen, 2016; S. Wang et al., 2018). This change of sign must be explained because we are duly taking into account the double causality effect between income and energy. This finding represents a drastic change with respect to the results obtained up to now and the policy recommendations derived from them. Thus, for our set of 32 OECD countries between 2000 and 2015, while energy is a growth enhancing factor, economic growth may improve a more efficient use of energy in the economy. Moreover, to the extent that energy use is the main source of greenhouse gases (Tahvonen & Salo, 2001; Bosello, Buchner, & Carraro, 2003; Hassler & Krusell, 2012), improvements in energy governance would help to combat climate change and environmental damage by increasing energy efficiency without hampering economic growth.