EXTENDED ABSTRACT

Title: Energy footprint of households and the place they are living

Authors and e-mail of all:

Langarita, R.[a] (rlan@unizar.es); Cartone, A.[b] (alfredo.cartone@unich.it) ; Díaz-Dapena, A.[c] (diazdalberto@uniovi.es); Rubiera-Morollón, F.[c] (frubiera@uniovi.es)

Department:

[a] Department of Economic Analysis, University of Zaragoza, Zaragoza, Spain. Agrifood Institute of Aragon.

[b] Department of economic studies, University G. d'Annunzio of Chieti-Pescara, Pescara, Italy.

[c] REGIOlab – Regional Economics Laboratory, University of Oviedo, Oviedo, Spain.

University: (see department)

Subject area: *4. Sostenibilidad, medio ambiente y recursos naturales*.

Abstract:

Urban sprawl is recently increasing in Europe and Spain, and the expectations after the health crisis of COVID19 are in the line of the acceleration of this process. There are several papers evidencing the negative environmental consequences of this type of *sprawled cities*.

In Langarita & Rubiera-Morollón (2021) three scenarios of change for the *Urban Sprawl Index (USI)* were planned: (1) 25% increase, moderated scenario whose achievement is very realizable in the next decade; (2) 50% increase, scenario with a moderated increase with respect to the past trend; and, (3) 100% increase, situation

which could be plausible due to the pandemic effects, which has changed the preferences of the people.

First, authors make use of Cartone et al. (2021), where we can find the relation between the level of *sprawl* and electricity consumption. Then, we apply the input-output model to identify the sectoral economic and environmental effects.

They particularize the analysis to the case of Madrid, since this is the most important city, together with Barcelona, of the Spanish urban system, and because Madrid is in transition from a traditional compact model to a sprawled model (Rubiera-Morollón, González Marroquín, & Pérez Rivero, 2017). In the scenarios with the highest growth of this urban phenomenon, a relevant increase in CO_2 emissions is observed, which supports that the urban form should be taken into account not only for territorial policies but also to improve energy efficiency.

Linked with the *sprawl* of the cities is the idea of living in flats or detached houses. In this paper we propose to see the relationship between the energy footprint of the different households in Spain, with its associated consumption patterns, with type of residence they are living.

To this end, we first apply the input-output methodology, which has been highly used in energy and electricity studies (Duarte, Langarita, & Sánchez-Chóliz, 2017). Input-output methodology (Leontief, 1941) is a good tool because it is able to quantify all the relations among sectors and agents and it can also be used to analyze effects of exogenous changes, because it takes the direct and the indirect effects (derived from the intersectoral relations) into account. Its extensions let also analyze impacts in terms of environment, see (Cazcarro, Duarte, & Sánchez Chóliz, 2013).

The concept of water, emissions, or energy footprint has been studied in the literature (Cazcarro, Hoekstra, & Sánchez Chóliz, 2014). Carbon/water footprint has also been analyzed for the case of the consumption of households, see (Tobarra, López, Cadarso, Gómez, & Cazcarro, 2018).

What we propose here is to analyze the relationship between the energy embodied in the different households, according with their consumption patterns, and the type of residence they are living.

To do that, we particularize the analysis to the case of Spain. In Langarita et al. (2021a) an input-output table is constructed from the supply and use tables, where a disaggregation of the energy and electricity sectors was previously addressed. The starting point was the supply and use tables (SUTs) for Spain of 2016 (NSI, 2019). The energy industry was initially aggregated in only one sector (energy product was disaggregated into Electricity and Gas).

For the case of the industries, the energy sector was first disaggregated into: "Electricity", and "Gas and steam and air conditioning". Then, authors estimated the percentage of "Related activities to the electricity sector". The rest of the electricity was disaggregated, making use mainly of SABI (2017), into the different activities included in the production process of electricity: Generation, Transmission, Distribution, and Commercialization. Generation activity was, at the same time, split into several production technologies: hydropower; conventional thermal: coal, oil, gas; nuclear; wind; and other types (where solar, biomass, and biogas are included). A similar disaggregation was done for commodities. Specifically, in the supply table, Electricity products were disaggregated according to the proportions of the total production of the industries, except for Nuclear energy (only nuclear companies produce nuclear energy). In the use table, electricity sub-products were disaggregated proportionally to their total productions. As expected, the sum of rows and columns was not balanced, and, finally, the GRAS method (Junius & Oosterhaven, 2003; Lenzen, Wood, & Gallego, 2007) was applied. With these two disaggregated supply and use tables, in Langarita et al. (2021) an industry-by-industry symmetric input-output table was constructed by the authors, following model D of (Eurostat, 2008).

According to the objective of this paper, we will make use of these disaggregated SUTs, but we will construct a product-by-product symmetric input-output table, since the data of the household's consumption is on products and not in the industries. With this, we will be able to calculate the energy embodied in the consumption of the households distinguishing among different parts of the process of electricity and different production technologies.

With this energy embodied in consumption we can see the relationship with the type of building.

This is a work in progress, but the expected results are that people living in detached housed have a higher energy embodied in their consumption.

References

Cartone, A., Díaz-Dapena, A., Langarita, R., & Rubiera-Morollón, F. (2021). Where the city lights shine? Measuring the effect of sprawl on electricity consumption in Spain. *Land Use Policy*, *105*, 105425. https://doi.org/10.1016/j.landusepol.2021.105425

Cazcarro, I., Duarte, R., & Sánchez Chóliz, J. (2013). Multiregional Input–Output Model for the Evaluation of Spanish Water Flows. *Environmental Science & Technology*, *47*(21), 12275–12283. https://doi.org/10.1021/es4019964

Cazcarro, I., Hoekstra, A. Y., & Sánchez Chóliz, J. (2014). The water footprint of tourism in Spain. *Tourism Management*, *40*, 90–101. https://doi.org/10.1016/j.tourman.2013.05.010

Duarte, R., Langarita, R., & Sánchez-Chóliz, J. (2017). The electricity industry in Spain: A structural analysis using a disaggregated input-output model. *Energy*, *141*, 2640–2651. https://doi.org/10.1016/j.energy.2017.08.088

Eurostat. (2008). *Eurostat Manual of Supply, Use and Input-Output Tables*. *Methodologies and working papers, Economy and finance*. European Commission. https://doi.org/http://ec.europa.eu/eurostat

Junius, T., & Oosterhaven, J. (2003). The solution of updating or regionalizing a matrix with both positive and negative entries. *Economic Systems Research*, *15*(1), 87–96. https://doi.org/10.1080/0953531032000056954

Langarita, R., Cazcarro, I., Sanchez-Choliz, J., & Sarasa, C. (2021). The role of fiscal measures in promoting renewable electricity in Spain. *Energy Conversion and Management*, *244*(114480). https://doi.org/10.1016/j.enconman.2021.114480

Langarita, R., & Rubiera-Morollón, F. (2021). Impactos urbanos de la pandemia: el fenómeno de la dispersión urbana y sus consecuencias. El caso de Madrid. *ICE, Revista de Economía*, (920), 111–132. https://doi.org/10.32796/ice.2021.920.7204

Lenzen, M., Wood, R., & Gallego, B. (2007). Some comments on the GRAS method. *Economic Systems Research*, *19*(4), 461–465. https://doi.org/10.1080/09535310701698613

Leontief, W. (1941). The structure of American economy 1919-1929: An empirical application of equilibrium analysis. *Cambridge, Massachusetts. Harvard University Press.*

NSI. (2019). Instituto Nacional de Estadística. Economía. Cuentas económicas. Contabilidad Nacional Anual de España. Año 2016. Marco input-output. Tablas de origen y destino 2016. Retrieved November 19, 2019, from https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736177059&menu=resultados&idp=1254735576581

Rubiera-Morollón, F., González Marroquín, V. M., & Pérez Rivero, J. L. (2017). Urban sprawl in Madrid? An analysis of the urban growth of Madrid during the last quarter of the twentieth century. *Letters in Spatial and Resource Sciences*, *10*(2), 205–214. https://doi.org/10.1007/s12076-016-0181-7

SABI. (2017). Sistema de Análisis de Balances Ibéricos. Available under license. Retrieved April 5, 2017, from https://sabi.bvdinfo.com/version-20191128/Search.QuickSearch.serv?_CID%BC0&context%BC3VTIBVFGGIWNW7U

Tobarra, M. A., López, L. A., Cadarso, M. A., Gómez, N., & Cazcarro, I. (2018). Is Seasonal Households' Consumption Good for the Nexus Carbon/Water Footprint? The Spanish Fruits and Vegetables Case. *Environmental Science & Technology*, *52*(21), 12066–12077. https://doi.org/10.1021/acs.est.8b00221

Keywords: *Households consumption; energy efficiency, input-output.*

JEL codes: *R14, R15, R21, Q24.*