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Is energy efficiency a driver or an inhibitor of energy consumption changes in Spain? Two decomposition approaches☆

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ABSTRACT

The 2000–2008 expansion period of the economy was accompanied by an important increase of energy consumption. The desire of decoupling has led us to analyse the driving forces behind the energy consumption changes during this expansion period through a structural decomposition analysis (SDA) based on the Spanish input-output tables. Previous decomposition has been supplemented by a Logarithmic Mean Divisia Index (LMDI) analysis of the energy consumption changes during a longer period: 2000–2013. The results show that the energy intensity was the main inhibitor effect of the energy consumption changes of sectors of production, not only during the recession but also during the expansion period. Secondly, the energy intensity was a driver of the energy consumption change of households during the expansion period. However, during the recession period, the energy intensity of private transport contributed to reducing energy consumption, having an inhibitor effect. Therefore, if the activity effect is still the most important driver, the energy intensity effect has become the main inhibitor of energy consumption changes. The energy policy recommendation is to focus on household energy consumption in the future if the Spanish Government aims to attain the EU energy efficiency objectives.

1. Introduction

Within the area of the European Union (EU), the State Members have the reduction of energy consumption amongst their priorities. In the short term, "A European strategy for smart, sustainable and inclusive, Europe 2020" establishes, amongst its aims, a reduction of 20% of the tendency of the primary energy consumption for 2020 (European Commission, 2010). On the 2030 horizon, the minimum established goal is a reduction of energy consumption and CO_2 emissions of 27% and 40%, respectively (European Commission, 2014). The target of the European Union for 2050 is much more ambitious, as it means to decarbonise the European economy by 80–95% with respect to the levels of emissions of 1990, accompanying this with a reduction of energy consumption (Eurostat, 2011).

In order to achieve the EU objectives, member states have to implement the appropriate energy policy measures. The analysis of the decoupling process of energy consumption with economic activity has been a constant object of study over time (Ozturk, 2010, dos Santos Gaspar et al., 2017). Among the reasons that justify this relationship are the evolution of technological development, the sectoral economic structure that determines the uses of energy, as well as human well-being (Brand-Correa and Steinberger, 2017). The specialised literature shows how the coupling process between energy consumption and economic growth occurs mostly in large economies (Fernández González et al., 2014). Therefore, in these economies is more difficult to reduce energy consumption and alternative efforts should be made in order to achieve the decarbonisation of the economy.

Concretely, the analysis of energy consumption in relation to the Spanish economy has been characterised by the existence of a coupling between energy consumption and economic activity growth (Fuinhas and Cardoso, 2012; Fernández González et al., 2014, Lima et al., 2017). If we limit our analysis to the 2000–2013 period, we note a moderate growth of the consumption of energy of 0.9% (Institute for Diversification and Saving of Energy, 2016), while the GDP increased by 18.2% (National Statistics Institute, 2016a). Nevertheless, these figures are not representative of what took place in this period, in which two clearly differentiated subperiods can be identified from the point of view of energy consumption and economic activity (Hospidio and Moreno-Galbis, 2015). The year 2008 marks the end of the expansion period of the Spanish economy and the beginning of a deep recession.

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Between 2000 and 2008, gross value added and energy consumption growth were 16% and 29%, respectively, while between 2009 and 2013 both these indicators decreased, by 7% and 6%, respectively (Spanish Industry Ministry, 2009b, 2015).

During the period 2000–2013, household consumption became the most relevant component for energy consumption change in Spain. Therefore, while energy consumption from sectors of production was reduced by 8.1%, residential consumption increased by 25.1% and that of private transport decreased by 22.3% (Institute for Diversification and Saving of Energy, 2016). Specifically, the growth of economic activity during the expansion period was linked to a higher standard of living of households that led them to increase energy consumption around 42% (Institute for Diversification and Saving of Energy, 2016). This important energy consumption growth of households is becoming an important issue to be analysed in Spanish economy as well as the driver factors (Labandeira et al., 2006).

In order to reduce energy consumption (both from sectors of production and households) and move to a decarbonise economy, Spanish Government implemented some energy plans during the analysed period (Spanish Industry Ministry, 2005a; 2009a and 2011b). After the implementation of the 1990–2000 National Energy Plan (Spanish Industry Ministry, 2000), some planning tools specifically aimed at energy saving and efficiency, and involving renewable energies, were carried out to meet the goal of the energy and environmental policy of the European Union: the 2004–2012 Energy Saving and Efficiency Strategy (Spanish Economy Ministry, 2003), the 1999–2010 Plan for the Promotion of Renewable Energies (Institute for Diversification and Saving of Energy, 2000), this latter plan being updated and revised with the 2005–2010 Renewable Energies Plan (Spanish Industry Ministry, 2005b). Subsequently, and in order to comply with the European commitments of 2020, the following were approved: the 2011–2020 Action Plan of Energy Savings and Efficiency (Spanish Industry Ministry, 2011a) and the 2011–2020 Renewable Energies Plan.

Besides a moderate energy consumption growth during the analysed period, some relevant changes occurs in the Spanish energy matrix. The structure of energy production experienced an important change, in fact, there was a significant increase in power generation, passing from 18.2% of the final energy consumption in 2000 to 23.2% in 2013 (Spanish Industry Ministry, 2015). This increase of electricity consumption meant more primary energy used as a result of the efficiency of the electric system being very low, being highly dependent on power plants due to coal and natural gas. Specifically, until 2010, the generation of electricity in Spain was based by more than 50% on power with natural gas, coal and, to a lesser extent, petrol. The rest of the power came from nuclear energy (29%) and renewable energies (18%). Yet this situation changed in the last years due to the important growth of renewables, specifically wind power, which in 2013 was 68.7% of the renewable electric energy power and 20% of the total energy power (Spanish Industry Ministry, 2015; García and Román, 2014).

The aim of this paper is to provide a further understanding of the driving forces that explain the energy consumption changes in Spain, focusing on the results for the whole 2000–2013 period and distinguishing two sub-periods – 2000–2008 and 2009–2013 - that correspond to the expansion and regression periods of the Spanish economy. Specifically, the identification of the effects that drive the energy consumption changes can contribute to identifying the optimal saving and efficiency measures to achieve the goals set out. The sectoral analysis of energy consumption changes supplement this information.

To carry out this study there are different methodologies, for example, those based on econometric models, systems dynamics, computable general equilibrium (CGE) models, and decomposition analysis (Wang et al., 2017). This study focuses on decomposition analysis and, specifically, on two different methods: a structural decomposition analysis (SDA) based on the Spanish input-output tables and an index decomposition analysis (IDA).

Currently, research papers widely use SDA and IDA techniques as analytical tools for environmental and energy purposes. They have been compared in order to highlight the main characteristics that should be taken into account (Su and Ang, 2012; Hoekstra and Van Den Bergh, 2003; Wang et al., 2017). The comparison shows that the IDA method is more flexible in its formulation and has a relatively lower data requirement than the SDA method. On the contrary, the IDA method only provides information about the direct effects, ignoring the indirect and final demands effects (Zeng et al., 2014). Additionally, the SDA method offers a broader range of information concerning technical aspects, including the final demand effects. As Xie (2014) and Cansino et al. (2016) highlighted, the SDA studies are able to provide more detailed structural factors, such as the Leontief effect (or technical effect) and can shape socio-economic drivers from both production and final demand perspectives. Recently, the SDA method has also been applied to study the aggregate carbon intensity change (Su and Ang, 2015).

Several papers have been developed using the SDA technique for the Spanish economy. Some studies have investigated CO_2 emissions, e.g., in the services sector (Butnar and Llop, 2011) and even water consumption (Cazcarro et al., 2013). Research related to energy consumption has been applied to the primary energy consumption in the period 1995–2004 (Guerra and Sancho, 2010), and to the analysis of the productive sectors that most contribute to electricity consumption (Alcántara et al., 2010). Other studies have focused on the economic impact of different energy policies (Llop and Pie, 2008), and there are also studies that establish a relationship between the energy consumption in Spain and that of other countries of the European Union (Alcántara and Duarte, 2004). Moreover, previous papers have analysed the Spanish energy situation, but using other methods of decomposition. In particular, the Logarithmic Mean Divisia index (LMDI) method has been used for a comparative study of the primary energy intensity in Spain and in the EU by Mendiluce (2007), Marrero and Ramos-Real (2008), Mendiluce et al. (2010), Mendiluce (2012), Mendiluce (2013), Fernández González (2015) and Fernández González et al., (2013 and 2014). Additionally, Fernández and Pérez (2003) have studied the energy intensity in Spanish industry, and Colinet and Román (2016) studied the final energy consumption in one region of Spain (Andalusia). A combination of both methodologies to study energy intensity is carried out by Nie and Kemp (2013).

The novelty of this paper is to be found in the following aspects. First, we analyse the main drivers that determine the energy consumption changes in Spain, distinguishing between productive sectors and households. The household energy consumption is additionally decomposed into residential and private transport. This latter decomposition is specifically a novelty of this paper as energy consumption due to the private transport sector is usually included in the productive sector named the Transport sector, preventing the possibility of analysing its behaviour separately from commercial transport (passengers, goods, etc.). Second, the LMDI and the structural decomposition analysis of final energy consumption changes are applied to the subperiod 2000–2008, allowing a comparison of the results although some differences also arise. These two decomposition approaches are complementary to some extent by providing different decomposition factors and sectoral disaggregation. In fact, the structural decomposition enables the analysis of 73 productive sectors and, therefore, the results allow us to provide energy policy recommendations to those sectors that are required to improve their energy consumption. Third, the LMDI decomposition analysis has been extended to the period (2000–2013), analysing the changes occurred in two relevant subperiods that are 2000–2008 and 2009–2013. The results give interesting information related to the drivers and inhibitors of the Spanish economy depending on the economic growth. These results also let us offer some energy policy recommendations.

This paper is organised as follows: Section two introduces the methodology and its application to energy consumption analysis. Section three describes the data used. Section four introduces the discussion of the collected results obtained concerning the two