Renewable and Sustainable Energy Reviews 76 (2017) 448–459

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

The decomposition of CO_2 emissions from energy use in Greece before and during the economic crisis and their decoupling from economic growth

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ARTICLE INFO

Keywords:
Decomposition analysis
CO_2 emissions from energy use
Decoupling index

ABSTRACT

Greece recorded a significant decline in CO_2 emissions from energy use from 2003 to 2013, accompanied by a reduction in energy consumption, particularly during the economic recession. This study attempts to identify the driving forces of CO_2 emissions related to energy consumption, through the use of the complete decomposition technique developed by JW Sun. The decomposition analysis focuses on the four factors responsible for CO_2 emissions: the carbon intensity effect, the energy intensity effect, the structural effect, and the economic activity effect. The analysis covers all the major productive sectors of the Greek economy. The study covers the period 2003–2013 and is divided into two subperiods (2003–2008 and 2008–2013), in order to assess changes in the contribution of the examined factors during the economic crisis (2008–2013). The analysis is extended to examine the decoupling relationship between CO_2 emissions and economic growth in Greece with the use of the decoupling index.

1. Introduction

1.1. Policy context

The EU 2020 climate & energy package for 2013–2020 [1] has set a collective 20% reduction target from 1990 levels for the EU, which translates to a 14% reduction from 2005 levels. As a member of the EU, Greece faces certain commitments towards curbing Greenhouse Gas (GHG) emissions. The country has managed to meet the Kyoto target of 25% above 1990 levels for the period 2008–2012. For the period 2013–2020 the country-specific emission reduction target is set at 4% below 2005 levels. Nevertheless, the EU has set an even more challenging collective target of 40% reduction in GHG emissions by 2030 compared to 1990 levels [2], which will be broken down into individual national targets for member states based on Gross Domestic Product (GDP) per capita.

In Greece, the current economic crisis has overshadowed climate change on the political agenda and has impeded action on climate change mitigation. As the economy is expected to return to positive growth rates in 2017 [3], it is essential that the country applies policies aimed at restraining the main drivers of CO_2 emissions without hindering economic activity. To that end, the analysis and understanding of energy-related CO_2 emission trends can contribute to the design of effective energy and climate policies, which was the main motivation for the present paper. In particular, the present study aims to provide an insight into the factors affecting energy-related CO_2 emissions and to examine the extent at which the economic contraction of the period 2008–2013 is responsible for the CO_2 emissions reduction recorded during this time frame. For this reason, the complete decomposition technique developed by Sun [4] is applied in order to identify the factors affecting the changes in CO_2 emissions, which are broken down into five economic sectors: energy, industry and construction, transport, services and agriculture.

Until 2016, the main policy instrument adopted in Greece that explicitly aimed at mitigating climate change was the 2nd National Climate Change Programme (NCCP), launched in 2002 [5]. The NCCP focused on restricting the increase of national GHG emissions by 25% during 2008–2012 compared to the base year, mainly by increasing the penetration of natural gas and renewable energy sources (RES) in the energy mix, achieving energy efficiency (EE) improvement, applying structural changes in agriculture and reducing emissions in the transport and waste management sectors. In April 2016 the Ministry of Environment and Energy released the National Strategy for Adaptation to Climate Change [6]. The main goal of the Strategy is to improve the decision-making process regarding the adaptation to climate change and promote the development and implementation of local/regional action plans, as well as to support sectoral adaptation policies.

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http://dx.doi.org/10.1016/j.rser.2017.03.026
Received 7 April 2016; Received in revised form 6 January 2017; Accepted 8 March 2017
1364-0321/

At the EU level, a wide range of tools has been used to ensure that the climate and energy targets for 2020 are met, such as the emission trading scheme, binding legislative acts and financial incentives. During the examined period, Greece promoted the implementation of financial measures aimed mainly at improving energy end-use efficiency. Regarding the residential and services sector, minimum requirements for energy efficiency in buildings have been set, complemented by economic and financial support and energy performance certificates. Tax incentives for EE and RES systems in buildings were put into effect in 2006 with the Law 3522/2006 [7]. In particular, tax exemptions were provided to natural or legal persons for performing a building energy upgrade individually or by taking part in programmes, such as "Exoikonomo". The continuation of the "Exoikonomo" programme ("Exoikonomo II") has promoted energy efficiency applications in existing municipal buildings and infrastructure, street lighting and urban transport. Other programmes, such as "Energy Saving at home" and "Changing my old air-conditioner" were addressed to households. In the industrial sector, financial measures were introduced to improve the energy efficiency of manufacturing enterprises and reduce the impact of climate change resulting from fossil-fuel combustion for energy supply. In the transport sector financial incentives were introduced for the renewal of the aged vehicle fleet, such as differentiated tax rates to promote cleaner vehicles, as well as educational and public awareness measures to increase public transport use and encourage economy driving (eco-Driving) [8–10]. Furthermore, the country has supported electricity generation from RES through a feed-in tariff system that was first introduced in 2006 [11]. It should be noted that Greece, a country heavily reliant on imported fossil fuels (62.2%) [12], has set a target of 20% of its final energy consumption and 40% of its electricity generation deriving from RES by 2020.

As far as the contribution of the present paper is concerned, the decomposition analysis applied can serve as a useful tool to assess the efficiency of the policies Greece adopted during the period 2003–2013 and separate the impact of the economic recession from the emission reduction that can be attributed to applied measures aiming to increase energy efficiency and consequently mitigate climate change, specifically for the period 2008–2013. Thus, it allows for the examination of the short-term direct impacts of the economic recession on the observed CO_2 emissions change. Identifying the main factors affecting the changes in CO_2 emissions can contribute to examining whether positive (negative) changes have occurred through improved (decreased) energy efficiencies or decreased (increased) energy consumptions [13]. The present study serves as a good complement of the emission decomposition analysis in Greece, as it examines and quantifies the factors that have determined the change in CO_2 emissions in the period 2003–2008, during which economic activity was rising, and in the period 2008–2013, for the larger part of which the performance of the economy shriveled. Previous studies employing decomposition analysis are mostly focused on the industrial sector or refer to past periods, before 2003. Moreover, the analysis of the present study is extended to investigate the country's effectiveness in decoupling economic growth from energy-related CO_2 emissions, which will enable Greece to meet its emission reduction targets and is a prerequisite for the transition to an economy with low carbon emissions. The effect of carbon intensity, energy intensity and economic structure on the decoupling progress is also tested.

The present study is structured as follows. In the remainder of Section 1 the relevant literature is reviewed. Section 2 presents the methodology and data employed for the decomposition analysis. In Section 3 the decomposition analysis results are presented and the decoupling index is applied. Finally, Section 4 summarizes the conclusions of the present analysis and provides policy suggestions.

1.2. Literature review

The decomposition analysis was introduced after the two oil shocks experienced in the 1970s aiming to interpret the evolution of energy consumption at sectoral level or at economy level. The decomposition analysis is now widely used for the identification and quantification of factors that cause changes in the emissions of CO_2, which is the primary contributor to the greenhouse gas effect. The main decomposition methods used are the structural decomposition analysis (SDA) and the index decomposition analysis (IDA). The SDA method uses the input-output model, while the IDA method was developed to decompose indicator changes at sectoral level, using aggregate data. Both models have been used to evaluate the effect of economic growth, sectoral shifts and technology changes on a series of environmental and socio-economic indicators. Hoekstra et al. performed a detailed comparison between SDA and IDA methods [14]. They highlighted that IDA has lower data requirements, but it is less capable of detailed decompositions of the economic structure than SDA. On the other hand, SDA uses a more complex economic model and is more data-intensive. As a result, time-series analysis is not as easy with SDA [15]. The analysis performed by Su and Ang focuses on SDA applied to energy and emissions and serves as an update to the study of Hoekstra and van den Bergh by discussing the differences between SDA and IDA using the latest available information [16]. They reported that the number of publications using IDA far exceeds that of SDA, and covers a wider range of problems within the field of energy and environment. Consequently, the IDA methodology is gaining ground in the decomposition analysis literature. Xu and Ang reviewed 80 papers published in peer-reviewed journals from 1991 to 2012, which apply IDA to CO_2 emissions [17]. Their analysis concludes that IDA has been recognized by researchers and analysts as a useful analytical tool for studying the drivers of changes in CO_2 emissions.

Laspeyres and Divisia are the two main approaches of the IDA method. The Laspeyres method is based on the Laspeyres price and quantity indices in economics and was first introduced by Howarth [18] and Park [19]. It isolates the impact of a variable by letting that variable change and keeping the other variables constant. The disadvantage of the aforementioned approach was that it led to a large residual term, which caused a large estimation error and therefore imposed difficulties in result interpretation. Sun proposed the complete decomposition model, also known as the refined Laspeyres index, which can resolve the residual problem by distributing the residual term among the considered effects [4]. According to Ang and Zhang, who performed a survey of index decomposition analysis in energy and environmental studies, the complete decomposition technique passes the tests for time-reversal, factor-reversal and zero-value robustness [20]. On the other hand, the Divisia index is a weighted sum of logarithmic growth rates where the weights are the components' shares in total value, given in the form of a line integral. The Divisia method mainly includes the arithmetic mean Divisia index (AMDI) and the logarithmic mean Divisia index (LMDI) approaches, the properties of which are examined by Ang [21].

Since 1991 a large number of studies have chosen the IDA to identify the factors that affect energy-related CO_2 emissions. In the case of the EU, several studies have been performed, both at sectoral and economy-wide level. Bhattacharya and Matsamura analyzed the reduction in GHG emissions from energy use and other industrial activities in the EU-15 between 1990 and 2007 to determine the contribution of different countries using the LMDI approach [22]. The results indicate that the emission intensity has been reduced significantly in both energy-related activities and other processes at aggregate level, as a result of changes in the energy mix, as well as of a reduction in energy intensity and in the emission intensity from other process-related emissions. González et al. analyzed the factors behind the variations in CO_2 emissions in the EU-27 during the period 2001–2008 using the LMDI method [23]. The results illustrate that most European econo-