Journal of Cleaner Production 175 (2018) 696–706

Contents lists available at ScienceDirect

Journal of Cleaner Production

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

Cyclical fluctuation patterns and decoupling: Towards common EU-28 environmental performance

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A R T I C L E I N F O

Article history:
Received 26 August 2017
Received in revised form
6 November 2017
Accepted 29 November 2017
Available online 7 December 2017

JEL codes:
C38
E32
Q51

Keywords:
CO_2 emissions
Dynamic factor model
Recursive
Cyclical environmental performance

A B S T R A C T

The EU-28 is one of the largest emitters of CO_2 in the world and the most committed to reducing emissions. However, the national environmental strategies of the Member States are still diverse. This study is aimed at evaluating the environmental performance of European economies by analysing the fluctuations of CO_2 emissions and their links with economic activity over the period 1950–2012. The methodological framework is based on a dynamic factor analysis to determine an index of the EU fluctuation of CO_2 emissions in parametric form. This index can be used to monitor the progress towards common behaviour across Member States, with a time-varying recursive method. Following this approach, we also track the efforts made to decouple CO_2 emissions from GDP. Based on these analyses, we develop a CO_2 emissions-GDP linkage matrix to attain useful information on the EU Member State environmental performance.

1. Introduction

As a world leader in responding to climate change, the EU has made significant progress in the mitigation of carbon dioxide (CO_2) emissions that has attracted a great deal of attention. The EU commitment to combatting climate change was recently strengthened with the signing of the Paris Agreement (Council Decision, 2016), which provides a binding target of at least a 40% domestic reduction in greenhouse gas emissions (GHG) by 2030, as compared to the 1990 levels. Considering its important role in global CO_2 emissions, the EU has become a key progress analysis target.

Throughout its history, the EU has constantly demanded environment regulations, which became a reality with the approval of the first Environmental Action Program (EAP) in 1973. The EU Environmental Action Programs set a common target of incremental CO_2 emissions, as shown in Table 1.

These regulations have contributed to the progress in the EU's environmental achievements. Accordingly, the report of the European Environmental Agency (EEA, 2015) shows that Europe's efforts to cut greenhouse gas emission and invest in energy efficiency and renewable energy has resulted in a decrease in GHG emissions of 23% from 1990 to 2014. This was achieved at the same time the European economy grew by 46% in the same period.

Despite the interest in the evaluation of the experience accumulated in the EU from environmental and energy policies, there is still insufficient research on the issue. Table 2 provides a summary of the recently published articles on the EU that can be grouped into two key and challenging areas of research: (1) understanding the driving forces behind the changes in CO_2 emissions and decoupling, and (2) assessment of environmental efficiency and convergence in terms of CO_2.

Another emerging area of research focuses on the study of the business cycles effects on energy variables. A better understanding of cyclical carbon emission is required to monitor environmental trends, evaluate progress and establish environmental targets. Table 3 provides a summary of the recent literature in this area, however no studies have been implemented in the EU. Our research

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https://doi.org/10.1016/j.jclepro.2017.11.244
0959-6526/

Table 1
EU environment Action programs on climate change.

EAP Period covered	Date approved	GHG Reductions Target
1st EAP 1973–1976	22/11/1973	No Target
2nd EAP 1977–1981	17/05/1977	No Target
3th EAP 1982–1986	07/02/1983	No Target
4th EAP 1987–1992	19/10/1987	No Target
5th EAP 1993–2000	01/02/1993	The EC's decision to stabilise CO_2 emissions at the 1990 levels by 2000.
6th EAP 2002–2012	22/07/2002	The EU-15 target is an 8% reduction in emissions, as compared to the 1990 levels.
7th EAP 2013–2020	20/11/2013	The EU-28 target is a 20% reduction in emissions, as compared to the 1990 levels.

Source: Adapted and updated from Pallemaerts (2009).

Table 2
Overview of recent empirical papers examining environmental performance in the EU.

Key area	Reference	Methodology	Period	Scope	Key findings
Driving forces (1)	Bhattacharyya and Matsumura, 2010.	Log-mean Divisia index (LMDI) method	1990–2007	EU-15	Changes in the energy mix, energy intensity and in emission intensity explain success in the EU-15. A scenario analysis is used to show the emission reduction possibilities through cross-learning.
	Fernández González et al., 2014.	LMDI method	2001–2008	EU-27	The EU-27 has adapted to more efficient techniques and technical change, offsetting the joint pressure of economic and population growth.
	Morales-Lage et al., 2016.	The stochastic formulation of the IPAT model (STIRPAT)	1971–2012	EU-28	Differences in the influence of population, industry and energy use are found depending on the group of countries considered.
	Moutinho et al., 2016.	The Kaya Identify and LMDI and Vector Autoregressive system (VAR)	1995–2000 2001–2004 2005–2007 2008–2010	EU-15	The EU-15 has reduced emissions by adopting more efficient techniques, through innovative changes and higher quality energy, particularly observed during the first phase of the Kyoto protocol.
	Diakoulaki and Mandaraka, 2007.	Refined Laspeyres Model and decoupling index.	1990–2003	EU-14	The decrease in industrial energy intensity and the shift towards cleaner forms of energy in electricity generation are found to have the greatest beneficial impact on the decoupling process.
Environmental efficiency and convergence (2)	Robaina-Alves et al., 2015.	Stochastic frontier approach using maximum entropy indicators	2000–2004 2005–2011	UE-26	Evaluates eco-efficiency problems and identifies changes in the positioning of the Member States in the two periods studied.
	Picazo-Tadeo et al., 2014.	Data Envelopment Analysis (DEA), directional distance functions and Luenberger productivity indicators.	1990–2011	UE-28	Environmental performance has been boosted by environmental technical change rather than by increases in eco-efficiency.
	Camarero et al., 2014.	DEA techniques, directional distance functions and Phillips and Sull approach.	1990–2009	UE-27	Existence of different convergence clubs depending on the specific pollutant considered.
	Jobert et al., 2010.	The Bayesian shrinkage estimation method.	1971–2006	EU-22	Member States differ considerably in both their speed of convergence and volatility of emissions, which enables the identification of different groups of countries.
	Herrrerias, 2012.	The distribution dynamics approach.	1920–2007	EU-25	Convergence is much faster when population and economic activity are introduced in the model.

Source: Own data

seeks to fill this gap and expand knowledge on environmental behaviour in the EU. It therefore focuses on the evaluation of national and European cyclical performance by monitoring the fluctuations of CO_2 emissions and their links with economic activity over the period 1950–2012. With this aim, we use a dynamic factor analysis to estimate the EU-28 co-fluctuation pattern in per capita CO_2 emission, in parametric form. This method is based on common factor dynamics that can be used as an index for EU-cyclical performance, contributing to the development of EU environmental indicators. After obtaining the index, we propose the use of a time-varying recursive method to assess the progress of each Member State towards the common pattern. Finally, we employ the same approach to track the efforts made to decouple CO_2 emissions from Gross Domestic Product (GDP). This is the first study we are aware of that combines these two issues.

Following these analyses, we develop a CO_2 emissions-GDP linkage matrix that combines information on possible outcomes of environmental strategies at both an EU and national level. The EU and Member States have launched environmental policies to mitigate CO_2 emissions and promote environmental efficiency. Although Member States have similar objectives, they differ considerably with regard to the scope of the policies they adopt and the means they propose to implement them. Current EU policy up to 2020 (The European Parliament Council, 2013) establishes the dual responsibility of EU institutions and National Governments for the environment. Following these guidelines, we offer an innovative empirical approach that may be a useful tool to evaluate the features of CO_2 emission performance across Member States. The results could lead to environmental recommendations on which countries should make further adjustments to adapt their national environmental objectives to common European targets and to increase efforts to decouple emissions growth from economic cycles.

2. Data and methodological approach

The analysis performed in this study uses annual per capita emissions data from the interval 1950–2012 on the EU-28 Member States. National data on CO_2 emissions (in millions of metric tonnes of carbon dioxide-equivalent) was provided by the Climate Analysis Indicator Tool (CAIT), Climate Data Explorer 2016, available online at http://cait.wri.org and shows the anthropogenic emissions from electricity-heat, manufacturing-construction, transportation, other fuel combustion and fugitive emissions. GDP and population data are taken from The Conference Board (2016), Total Economy