Ecological Indicators 95 (2018) 615–628

Contents lists available at ScienceDirect

Ecological Indicators

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

Original Articles

Decoupling of CO_2 emissions and GDP: A time-varying cointegration approach

Jeyhun I. Mikayilov[a,b,c,*], Fakhri J. Hasanov[a,d,e], Marzio Galeotti[f,a,g]

[a] King Abdullah Petroleum Studies and Research Center, PO Box 88550, Riyadh 11672, Saudi Arabia
[b] Department of Statistics and Econometrics, Azerbaijan State University of Economics (UNEC), Istiqlaliyyat Str., 6, Baku, Azerbaijan
[c] Institute for Scientific Research on Economic Reforms, 88a, Hasan Bey Zardabi Avenue, Baku AZ1011, Azerbaijan
[d] Research Program on Forecasting, Economics Department, The George Washington University, 2115 G Street, NW, Washington, DC 20052, USA
[e] Institute of Control Systems, Azerbaijan National Academy of Sciences, B. Vahabzade Street 9, Baku AZ1141, Azerbaijan
[f] Department of Environmental Science and Policy, University of Milan, Via Celoria 2, 20122 Milano, Italy
[g] IEFE-Bocconi, Via Roentgen, 1, 20136 Milano, Italy

ARTICLE INFO

JEL classifications:
C14
C32
Q01
Q43
Q52
Q53
Q56

Keywords:
CO_2 emissions
Time-varying coefficient cointegration
Economic growth
EKC hypothesis
Decoupling

ABSTRACT

The relationship between CO_2 emissions, the main gas responsible for global warming, and economic growth is among the most studied themes of environmental economics. Reducing overall emissions while keeping a high pace of economic development is at the heart of the sustainable development concept. When emissions grow less rapidly than GDP environmental economists speak of relative decoupling; if emissions even decrease relative to the pace of economic growth, then decoupling is absolute. Assessing these options requires an empirical analysis of the emissions-GDP relationship. The study of this nexus has special importance for developed countries, given their historical responsibility towards global warming. At the same time, in the last decades, the same countries have been at the forefront of the fight against climate change in terms of emissions-reduction efforts. By applying cutting-edge econometric techniques, this paper aims to investigate the decoupling options, if any, for a group of European economies which can be considered as pioneers in pursuing the sustainable development goals. This question gains further importance considering that some recent studies have found positive GDP elasticities of emissions for certain developed countries, which may be seen as a cause of concern for the sustainable development path of such countries. Unlike the bulk of the literature, in this paper, we allow the income elasticity of emissions – a critical indicator for the study of decoupling – to vary over time. The reason is that the elasticity might change through the time due to the factors affecting the main drivers of the CO_2 emissions. We use a time-varying coefficients cointegration approach to investigate the CO_2 emissions-GDP relationship for 12 Western European countries over a long time period ranging from 1861 to 2015. Our main finding is that the income elasticity of CO_2 emissions is positive in all investigated countries. In addition, we find evidence in favor of relative decoupling in 8 out of the 12 European countries. This is in line with the fact that the selected European countries have shown more determination in adopting carbon reduction policies before and after the Kyoto protocol period and toward the Paris agreement compared to other leading economies such as China, United States, and Russia. For the remaining 4 cases, the income elasticity of CO_2 emissions is in excess of unity. This can be considered as a call for policymakers to take quick and relevant measures to mitigate emissions level without harming the economic development.

1. Introduction

At the COP21 conference on climate held in Paris in December 2015, for the first time in history, almost all countries adopted a universal, legally binding global climate deal. Governments agreed on integrating climate change measures into national policies, strategies and planning on the basis of their Nationally Determined Contributions to the mitigation of greenhouse gas emissions. The key to that agreement is the ability of countries to reduce their own carbon emissions while maintaining a satisfactory, or without compromising, the pattern of their economic development. Not only this is representing a specific Sustainable Development Goal (SDG), but economic growth is the key to the achievement of all the other SDGs. The relevant question, which this paper addresses, is: have indeed emission levels been decoupling

* Corresponding author at: King Abdullah Petroleum Studies and Research Center, PO Box 88550, Riyadh 11672, Saudi Arabia.
E-mail address: jeyhun.mikayilov@kapsarc.org (J.I. Mikayilov).

https://doi.org/10.1016/j.ecolind.2018.07.051
Received 28 February 2018; Received in revised form 29 May 2018; Accepted 24 July 2018

from the economic growth at least in advanced economies, which have at the same time been main contributors of global emissions historically and most determined and effective in the adoption of policies aimed to curb carbon emissions? To empirically investigate this issue the present paper makes use of cutting-edge methodologies and considers Western European countries observed over a very long time span as a case study.

In the past three years, global emissions of carbon dioxide from the burning of fossil fuels have leveled after rising for decades (Figueres et al., 2017, inter alia). This is a sign that policies and investments in climate mitigation are starting to pay off and that individual commitments within the Paris agreement are being pursued. While there is almost unanimous international agreement that the risks of climate change are too great to ignore, it remains critical to aggressively reduce emissions to reach a zero level before the planet dangerously warms.

As countries embark on the transition to a new climate economy, there's a debate about whether growth can drive, or even coexist with, climate stabilization. On the other hand, there is also a discussion as to whether climate stabilization may negatively affect growth. While the relationship is a complex one, we can say that if the patterns of emissions and GDP growth start to diverge, then these two variables are delinked. More precisely, if emissions grow less rapidly than economic growth, we have a situation of relative decoupling. When they instead decline while the economy grows, we speak of absolute decoupling. This is ultimately the goal of any climate agreement.

The environmental and energy economics literature has long been interested in the empirical study of decoupling of emissions from GDP and in the strictly related concept of the Environmental Kuznets Curve (EKC), according to which decoupling of emissions turns from relative to absolute as income grows after some turning point.[1] Decoupling can be simply computed from actual data as the ratio between growth in emissions relative to growth in GDP, so that year-by-year patterns can be observed.[2] Most contributions in the literature, however, prefer to rely on econometric analysis which allows summarizing the relationship between emissions and GDP by means of a few statistical parameters on which the evidence on decoupling and EKCs is based. In this paper, we study decoupling between carbon dioxide emissions and GDP for 12 Western European countries over a very long time period.

A useful metrics to evaluate decoupling is the income elasticity of CO_2 emissions to GDP. By econometrically estimating an emissions-GDP relationship for each country, in this paper, we compute the income elasticity and therefore obtain inference on the decoupling issue. Unlike the bulk of the literature, we adopt a time-varying coefficient specification for our regression model and implement a recently developed time-varying cointegration method. This approach has a few distinct advantages over the "standard" fixed coefficients approach.

The current study contributes to the existing literature in different ways: first, it employs a new methodology (proposed by Park and Hahn, 1999), which takes explicitly into account certain weaknesses of the previous studies (such as Apergis, 2016; Liddle and Messinis, 2016; Moosa, 2017), to examine the relationship between CO_2 emissions and economic growth in the case of a group of European economies, which can be considered as pioneers in pursuing the sustainable development goals. The time-varying coefficient cointegration approach has some advantages over the conventional cointegration methods (Park and Hahn, 1999; Chang et al., 2014) such as addressing and testing the long-run co-movements under the time-varying coefficients framework, as well as addressing the omitted variable bias problem by employing time-varying coefficients. Furthermore, it is much more important in cointegrated regressions, to allow for TVC, compared to the usual stationary regressions. That is, if you have TVC and disregard it, then you would still expect to have its average value possibly with some bias in a stationary regression. Nevertheless, this is not true in a cointegrated regression. It is very important to model TVC appropriately in a cointegrated regression. If not, the regression becomes spurious. In other words, if the true model is a cointegrated regression with TVC but it is estimated using a regression with fixed coefficients, then the regression outcomes would be spurious and completely senseless; second, the study allows the income elasticity of emissions to vary over time; third, it addresses certain weaknesses of the conventional polynomial method as it does not limit the emissions-income relationship to be a specific polynomial, such as cubic, quadratic or linear.

The remainder of the paper is organized as follows. Section 2 briefly reviews the relevant literature, Section 3 discusses the notion of decoupling and of income elasticity of CO_2 emissions. Section 4 presents the data used to implement the methodology outlined in Section 5. Section 6 discusses the findings and the concluding section closes the paper.

2. Literature review

The present paper looks at decoupling on an individual country basis. Most of the literature takes advantage of the availability of statistical information both over time and across countries. Panel econometric methods are the norm. When the model is correctly specified estimated coefficients are more efficient as more information is exploited. However, panel methods typically rest on some cross-sectional homogeneity assumption, which may not be warrantied and in principle should be tested for. On a more conceptual level, since countries show significant differences in political, social, economic and biophysics factors, one should expect that different countries exhibit different patterns for their relationships between environment and income. Therefore, the assumption that the EKC slope coefficients are constant across countries would be misleading most of the time. Generally speaking, the standard econometric model in the literature has per capita emissions that are a linear function of powers of per capita GDP, typically either quadratic or cubic.

To keep things short, we limit our attention to recent papers which have investigated the emissions-income relationship for European countries.

Friedl and Getzner (2003) focus on Austria over the period 1960–1999 and find an N-shaped EKC. Lindmark (2004) examines the long-run relationship between CO2 emissions and economic growth for the most high-income countries over the period 1870–1992, employing the Kalman filter type structural time series method and concluding in favor of the EKC in these cases. Zanin and Marra (2012) investigate the EKC using additive mixed models. The following countries are considered: Australia, Austria, Canada, Denmark, Finland, France, Italy, Spain and Switzerland during the period 1960–2008. Their results show the existence of a classic EKC for France and Switzerland, an increasing relationship for Australia, Italy and Spain, a weak N-shaped relationship for Austria, while new nonlinear shapes are found for Finland (inverted-L-shape relationship), Canada (a special case of the inverted-L-shape relationship), and Denmark (M-shape relationship)[3]. Esteve

[1] The EKC, therefore, consists of an inverted-U shaped graphical relationship between (per capita) emissions and (per capita) GDP. The literature on EKCs is vast and several surveys are available that summarize the evidence: see, for instance, Panayotou (1993), Dinda (2004) and more recently Carson (2010).

[2] One recent example of this approach is Naqvi and Zwickl (2017) which examines the decoupling of six pollutants (including CO2 emissions) from economic activity in six economic sectors of 18 EU over the period 1995–2008. Note that decoupling is not an exclusive concept of CO2 emissions: it also refers to energy consumption and to several other pollutants (OECD, 2002).

[3] Consider a specification where the log of per capita CO_2 emissions is a polynomial function of the log of per capita GDP: $co_2 = a_0 + a_1 * gdp + a_2 * gdp^2 + a_3 * gdp^3 + a_4 * gdp^4 + e$ where, a_i's are the coefficients to be estimated econometrically and e is an error term. We have the following possibilities:1. If $a_1 > 0$, $a_2 < 0$, $a_3 = 0$, $a_4 = 0$, then the relationship has an inverted U-shape, i.e. an Environmental Kuznets Curve;2. If, $a_1 > 0$, $a_2 < 0$, $a_3 > 0$, $a_4 = 0$, then there is an N-shaped relationship between CO_2 and GDP;3. If, $a_1 > 0$, $a_2 < 0$, $a_3 > 0$,