DECOUPLING OF CO2 EMISSIONS AND GDP: A TIME-VARYING COINTEGRATION APPROACH

Jeyhun I. Mikayilov, King Abdullah Petroleum Studies and Research Center, Riyadh , Saudi Arabia, T +966 11 290 3000, jeyhun.mikayilov@kapsarc.org
Fakhri J. Hasanov, King Abdullah Petroleum Studies and Research Center, Riyadh , Saudi Arabia, fakhri.hasanov@kapsarc.org
Marzio Galeotti, University of Milan, and IEFE-Bocconi, via Guglielmo Roentgen, Milano MI, Italy, marzio.galeotti@unimi.it

Overview and background

There is general consensus about the need to stop the planet from warming and the pressing need to reduce emissions of greenhouse gases. The Paris agreement itself is based on national pledges to make the best efforts to limit the increase in global temperature from exceeding 2ºC above pre-industrial levels. No country, either in the developed world or in the developing one, is however prepared to obtain a reduction in emissions at the cost of giving up economic growth opportunities. The ability of the growth process itself to bring about technological progress, efficiency improvements, structural changes in the economy so as to bring emissions down eventually to zero is therefore a critical issue. Environmental and energy policies are crucial to that end.

There is a large literature on the so-called Environmental Kuznets Curve (EKC) hypothesis according to which the process of economic growth is in its initial phases responsible for environmental degradation, but later on it may create the conditions for environmental improvement. Several papers have empirically addressed this issue and the evidence in favor of an Inverted-U shape of the relationship – as far as CO2 emissions are concerned – is mixed. The use of conventional polynomial approach might give different specifications depending on the starting degree of the chosen functional form. For example, if one limits her/his study with linear or quadratic functional form s/he migt end up with one of these specifications, while the appropriate relationship between the emissions-income level is indeed the cubic one. Jaforullah and King (2017) discussed these issues, while Liddle and Messini (2015), Apergis (2016) and Moosa (2017) employed different methods to avoid this problem.

Aside from the EKC rhetoric, one could regard the potential ongoing process of decoupling of carbon dioxide emissions from economic growth as valuable information for policy intervention. Thus decoupling is key in the above respect.

The present paper provides an empirical investigation of the decoupling issue using very long time series data where the relationship between carbon dioxide emissions and its two main drivers – GDP and population – is investigated. We analyze twelve Western European countries for which we have data from 1861 to 2015.

We study decoupling notion by estimating the income elasticity of emissions. If such elasticity is positive but less than unity, then emissions increase less rapidly than income, implying relative decoupling. For absolute decoupling, however, we have to have that over a range of GDP values, the income elasticity turns negative: as income increases emissions will decline. An EKC relationship is one where the income elasticity is initially positive and below one and then turns negative.

Methodology

The most popular parametrization to quantify the income elasticity of emissions and obtain evidence on the potential existence and type of decoupling between a country emissions and its GDP is a log-linear polynomial function of income with constant coefficients. In this case the income elasticity of emissions is varying over time, driven by per capita GDP.

Of course the log-linear specification is not the only one possible parametrization of a relationship that will be in general non-linear. One important and relevant aspect is the theorem established by Swamy and Mehta (1975) and confirmed by Granger (2008) which states that any non-linear functional form can be exactly represented by a model that is linear in variables, but that has time-varying coefficients. This is an attractive perspective, as the emissions-income relationship, and therefore the income elasticity of emissions, needs not depend only on the evolution of GDP, but may be in principle affected by several other variables. In addition, Wagner (2008) notes that conventional panel cointegration test should not be applied to non-linear functions of unit root processes such as per capita GDP. Hong and Wagner (2008) note that the square of per capita income, which is an integrated process, does not have the

usual linear unit root and cointegration distribution. In addition, Chang and Martinez-Chombo (2003) and Salisu and Ayinde (2016) note that an income elasticity based on time varying parameters may be more appropriate in light of the changes an economy may undergo over long periods of time, when structural breaks and parameter instability are likely to occur.

Results and conclusions

In this paper we first test for unit roots in the relevant series allowing for structural breaks, given that the long period under study includes two world wars. Augmented Dickey Fuller (ADF) and Zivot-Andrews unit root test with structural break (ZA) (Zivot and Andrews, 1992 show that the logged variables are I(1). Because a time-varying parametric approach is convenient for the empirical analysis of decoupling possibilities between emissions and GDP we apply the time-varying coefficient cointegration (TVC) method proposed by Park and Hahn (1999) which allows for the possibility of a time-varying long-run elasticity that is a smooth function of time. The cointegration relationship between the variables tested by Variable Addition Test (VAT, Park, 1990).

We find that for ten countries out of twelve there is a TV cointegrating relationship at least at 0.5% significance level. For the other two countries we have cointegration only at 0.2% significance level. Additional testing enables us to conclude that the income coefficient in five countries is time varying. We show the time evolution of the income elasticity of CO2 emissions for each country and we discuss our findings, also in comparison with the evidence of the few other published papers as well with estimation results based on usual fixed-coefficient econometric methods, such as Dynamic OLS technique employing the conventional cubic polynomial approach.

References

Boden, T.A., Marland, G., Andres, R.J., 2016. Global, Regional, and National Fossil-Fuel CO2 Emissions. DOI 10.3334/CDIAC/00001_V2010. Available at http://cdiac.ornl.gov/CO2_Emission/timeseries/national.

Bolt, J., van Zanden, J.L., 2014. The Maddison Project: collaborative research on historical national accounts. The Economic History Review, 67 (3): 627–651. Available at: http://www.ggdc.net/maddison/maddison-project/home.htm.Levinson, A., 2002.

Chang, Y.; Martinez-Chombo, E. Electricity Demand Analysis Using Cointegration and Error-Correction Models with Time Varying Parameters: The Mexican Case; Working Paper 2003-08; Department of Economics, Rice University: Houston, TX, USA, 2003.

Dickey, D., Fuller, W., 1981. Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. Econometrica 49, 1057-1072.

Galeotti, Lanza and Pauli 2006. Galeotti, M., A. Lanza, and F. Pauli (2006),"Reassessing the Environmental Kuznets Curve for CO2 Emissions: A Robustness Exercise", Ecological Economics 57, 152-163.

Granger, CliveW.J. (2008)Non-linearmodels:Where dowe go next—Time varying parametermodels. Studies in Nonlinear Dynamics and Econometrics12, 1–10.

Park, J.Y.; Hahn, S.B. Cointegrating regressions with time varying coefficients. Econ. Theory 1999, 15, 664–703.

Swamy, P.A.V.B. and Jatinder S. Mehta (1975) Bayesian and non-Bayesian analysis of switching re-gressions and a randomcoefficient regressionmodel.Journal of the American Statistical Association 70, 593–602.