Energy Policy 118 (2018) 58–68

Contents lists available at ScienceDirect

Energy Policy

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

The long-run decoupling of emissions and output: Evidence from the largest emitters☆

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ARTICLE INFO

JEL Classifications:
O44
Q43
Q54
Q56
E32

Keywords:
Emissions
Environmental Okun's Law
Environmental Kuznets Curve

ABSTRACT

For the world's 20 largest emitters, we use a simple trend/cycle decomposition to provide evidence of decoupling between greenhouse gas emissions and output in richer nations, particularly in European countries, but not yet in emerging markets. If consumption-based emissions—measures that account for countries' net emissions embodied in cross-border trade—are used, the evidence for decoupling in the richer economies gets weaker. Countries with underlying policy frameworks more supportive of renewable energy and climate change mitigation efforts tend to show greater decoupling between trend emissions and trend GDP, and for both production- and consumption-based emissions. The relationship between trend emissions and trend GDP has also become much weaker in the last two decades than in preceding decades.

1. Introduction

The Paris climate accord in 2015 – the so-called COP21 – was a landmark effort on the part of countries to set and monitor commitments to mitigate global warming. The COP23 in 2017 in Bonn "sought to maintain the global momentum to decouple output from greenhouse gas emissions" (Gough, 2017). However, the extent to which decoupling is taking place remains a matter of dispute. Drops in emissions often provoke claims from climate sceptics that worries over global warming are exaggerated, while increases in emissions lead to concerns among environmental groups that not enough is being done to address the issue. For instance, a rise in German emissions in 2016 led to alarm in some circles that the country had "further dented" its chances of reaching its 2020 climate targets (Wettengel, 2016).

A first crack at the data on emissions and real GDP yields little evidence of decoupling. Fig. 1(a) presents the results of regressions, estimated over the period 1990–2014, of growth in greenhouse gas (GHG) emissions on the growth of real GDP for the 20 largest emitters. The bars in the figure show the estimated emissions-output elasticity, the percent change in emissions for a 1% change in output, for each of the 20 countries.

The elasticity is positive for all countries, with an average of 0.6. Fig. 1(b) illustrates the case of Italy, which has the highest elasticity in Fig. 1(a). As shown, between 1990 and 2014, growth in output and emissions are clearly very highly correlated.

This paper revisits the issue of the extent of decoupling between emissions and economic activity and shows why this first crack at the data can be misleading. By decomposing growth in emissions and real GDP into their trend and cyclical components, we show that the trend components reveal clearer evidence of decoupling in richer nations, particularly in European countries, but not yet in emerging markets. The trend elasticities range in value from − 0.6 to 1.2. For six countries, including Italy, the elasticities are either essentially zero or negative, suggesting that the trend component of emissions has decoupled from the trend component in output.

We then apply the framework to consider the effects of international trade on the emissions-output elasticities. International trade "gives a mechanism for consumers to shift environmental pollution to distant lands" (Peters and Hertwich, 2008). In particular, as Jaunky (2011) notes, it is possible that although developed economies "may have

☆ We thank the Guest Editors and two anonymous referees for useful comments and suggestions that significantly improved the quality of the paper. We are also grateful to Ottmar Edenhofer, Michael Jefferson, Marina Mendes Tavares, Adele Morris, Ian Parry, Willi Semmler, and participants at the IEW, 55th International Symposium on Environment and Energy Finance Issues (ISEFI), Mercator Research Institute on Global Commons and Climate Change seminar and the IMF's Development Macroeconomics seminar for their useful comments and advice. Jun Ge provided excellent research assistance. All remaining errors are our own. The views expressed in the paper are those of the authors and do not necessarily represent those of the authors' professional affiliations.

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https://doi.org/10.1016/j.enpol.2018.03.028
Received 31 August 2017; Received in revised form 19 February 2018; Accepted 11 March 2018

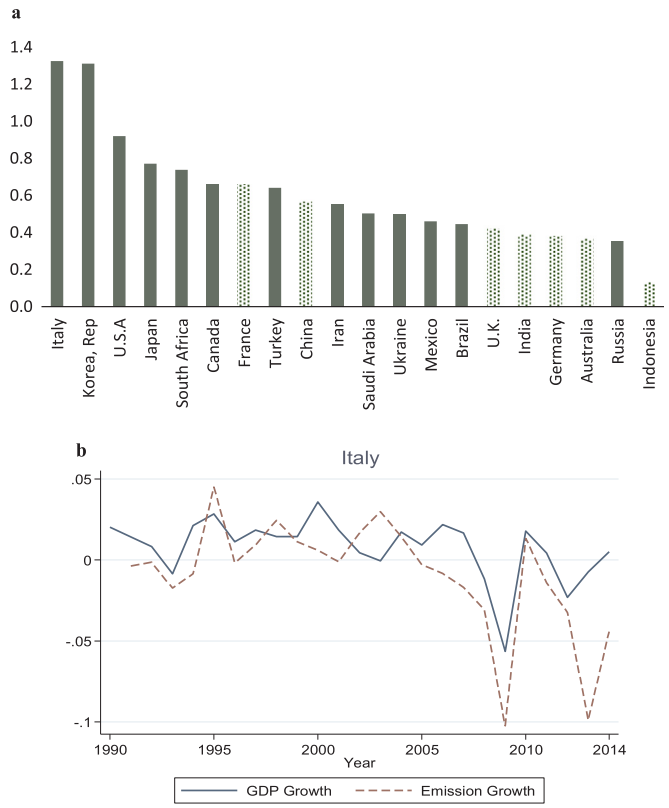

Fig. 1. a: Response of emissions growth to output growth, top 20 emitters. Note: Each bar denotes the response of emissions growth to output growth. Dark shaded green denote statistically significant coefficient estimates at the 10% level or better, while light shaded green bars denote statistically insignificant coefficient estimates. b: Italy's case: time profile of real GDP growth and emissions growth, 1990–2014. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article)

experienced a change in their production structure, their consumption structure remains unchanged"; hence, the decoupling may arise simply be because "dirty industries in developed countries tend to migrate" to developing economies. To account for these effects, we make a distinction between production-based and consumption-based emissions, where the latter add in the emissions embodies in the net exports of countries. This does make some difference to our results and in the expected direction. The evidence for decoupling for the richer nations gets weaker, including for many European countries (France, Germany, Italy and the UK). For instance, Germany's trend elasticity based on consumption-based emissions is − 0.4, compared to − 0.8 for production-based emissions.

To document progress on decoupling over time, the main sample is supplemented with longer time series for CO_2 emissions. For 16 of our 20 countries we have data from 1946 onwards. We find that the trend elasticities have declined over the second sub-period (post-1983) compared to the first (1946–1982). The average elasticity has declined to 0.7 from 1.1. For 13 countries, we have even longer time-series, sometime extending as far back as 1850. In each case, we find that the trend elasticity computed over the post-1990 period is much smaller than the elasticity over the full sample period; in the case of Germany for instance, the two estimates are − 0.6 and 0.9, respectively.

We also provide evidence on some of the factors that may explain the cross-country variation in trend elasticities, such as per capita GDP, environmental and energy policies, and sectoral structure. We find some evidence that trend elasticities are lower for richer countries, measured either by their per capita GDP or sectoral structure (high share of services in value added relative to that of industry or agriculture). There is also evidence that policy actions to encourage use of renewables foster decoupling of emissions and output.

In addition to these findings about trend elasticities, we find that there is a strong cyclical relationship between emissions and output. The cyclical elasticity is positive for all countries and averages 0.5. For Germany, for instance, the cyclical elasticity is nearly 0.2, which can account for some the increase in emissions observed in 2016 as the economy boomed. In general, cyclical developments can often obscure the trend relationship. Moreover, unlike the trend elasticities, the cyclical elasticities have not declined much between the recent decades and the earlier ones.

The contribution of this paper is therefore threefold. First, it provides an account of how the link between emissions and output has evolved across the largest world GHG emitters, distinguishing trends from cyclical fluctuations. Using long-period as well data for the more recent period, we show that trend elasticities have declined over time (i.e. there is a movement towards decoupling). Second, we show that accounting for international trade linkages does not greatly affect estimates of trend elasticities in most cases. Third, we relate differences across countries in trend elasticities to country characteristics and policies. While there is a large literature on the emissions-output nexus, few studies have addressed all these issues for a large group of top emitters in one simple but comprehensive framework, which is the gap this paper seeks to fill.

The remainder of the paper is organized as follows. Section 2 relates our work to the previous literature on decoupling of emissions and output. Section 3 describes our data and empirical approach. Section 4 presents our estimates of trend and cyclical elasticities and explores the determinants of cross-country differences in trend elasticities.

2. Literature review

We situate our paper within the vast literature on decoupling by discussing four themes: (i) long-run emissions-output elasticities; (ii) changes in elasticities over time; (iii) consumption-based emissions; and (iv) cyclical relationships.

2.1. Long-run emissions-output elasticities

The thrust of our analysis is to measure decoupling using the long-run movements in emissions and output. While we use the standard trend/cycle decomposition used in many other fields of economics, other authors have implemented related ideas using other techniques. Narayan and Narayan (2010) use a panel cointegration model to estimate short-run and long-run elasticities—similar in spirit to our cyclical and trend elasticities—of emissions with respect to output; in addition to the difference in technique from our paper, their paper is concerned with developing economies only. Pao and Tsai (2010) also estimate long-run elasticities but only for the BRICs (Brazil, China, India and Russia). Stern et al. (2017) adapt a standard growth model to study the relationship between long-run growth rates in emissions and output.

2.2. Changes in elasticities over time

An important focus of our work is on whether the extent of decoupling has changed over time. This focus is shared by Ajmi et al. (2015), who investigate how relationships among emissions, energy consumption and output have changed since 1960 for G-7 countries using a sophisticated time-varying vector autoregressive model. Kristrom and Lundgren (2005) study CO_2 emissions in Sweden since 1900; they single out the use of long time series as the "key contribution" of their paper and discuss the advantages of studying emissions "through several phases of development" instead of relying solely on "short panel data sets". They estimate the trend in emissions over long windows (1900–99) and shorter ones (1970–99) to see how the trend behavior has changed over time. We follow a similar method for a much larger group of countries and relate changes in emissions to changes in output