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Fifty shades of green: Revisiting decoupling by economic sectors and air pollutants☆

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ABSTRACT

Using a consistent dataset for eighteen EU countries, six economic sectors, and six pollution indicators, we analyze decoupling of production–based emissions from GDP growth from 1995 to 2008. Computing decoupling factors as defined by the OECD (2002), we find that in almost all sectors and by almost all pollutants the median EU country had at least some decoupling. However, considerable heterogeneity in its magnitude can be observed across countries, sectors, and pollutants. For most pollutants and sectors, median decoupling performance improved from 2001–2008 compared to 1995–2001, while between–country disparities increased simultaneously. In a second step, we investigate country–level changes in decoupling states between the two sub–periods based on Tapio (2005). We find high diversity across countries and over time. To explain these differences across countries and sectors, we assess the impact of environmental policy stringency, and find tentative evidence that stricter policy encourages decoupling, however the effects are small and imprecise, differ by economic sector and pollutant, and take several years to materialize.

1. Introduction

For the first time in over fourty years, in 2014 global carbon dioxide (CO_2) emissions remained constant while global GDP increased by 3% (IEA, 2015), a development that can be described as "absolute decoupling" of CO_2 emissions growth from GDP growth compared to the previous year. Is this a one-time achievement that will be reversed by increasing CO_2emissions in subsequent years, or will this year make history as an important turning-point in achieving absolute decoupling at the global level? Is there evidence of decoupling also of other environmental hazards, including local air pollutants? Empirical investigations of decoupling of specific regions and sectors, that have already partially achieved decoupling in the past, and analyses of decoupling of multiple pollutants, can provide some important insights for these questions.

Analyzing decoupling of environmental bads from their economic driving force has become an important field of research, especially since the publication of the OECD (2002) report. Relative decoupling refers to a state when "the growth rate of the environmentally relevant variable is less than that of its economic driving force (e.g. GDP) over a given time period" (OECD, 2002: p. 11). The stronger, from an environmental perspective desirable case, absolute decoupling, is defined to occur "when the growth rate of the environmentally damaging variable is zero or negative" despite positive GDP growth (OECD, 2002: p. 11). While relative decoupling of production-based emissions can be observed in many countries and sectors around the globe, the technical and political feasibility of achieving absolute decoupling has been debated controversially and lies at the center of the "green growth" versus "de-growth" debate (for contrasting views see Jackson, 2009; Victor, 2008, skeptical of the feasibility of green growth; versus the OECD, 2014, outlining a green growth strategy). Contributing to 11% of global greenhouse gases, the EU is the third biggest emitting region following China and the United States (PBL, 2014). Between 2004 and 2006, energy use and production–based CO_2 emissions in the EU have remained relatively stable, since 2006 they are slightly declining (see Fig. 1). The decline in emissions therefore preceded the recession of 2008, and even in the recession of 2008 real value added fell more than energy use or CO_2 emissions. However, this aggregate development could result from between versus within country and sectoral decoupling trends and therefore tells us little about the driving forces of decoupling in the EU. For material use, de Koning et al. (2015) illustrate the magnitude of aggregation bias and emphasize that the most disaggregated data available should be used to calculate material footprints. There is evidence that decoupling trends of air emissions in the EU vary strongly by country and sector (Kojima and Bacon, 2009), aggregation bias could therefore also be a concern.

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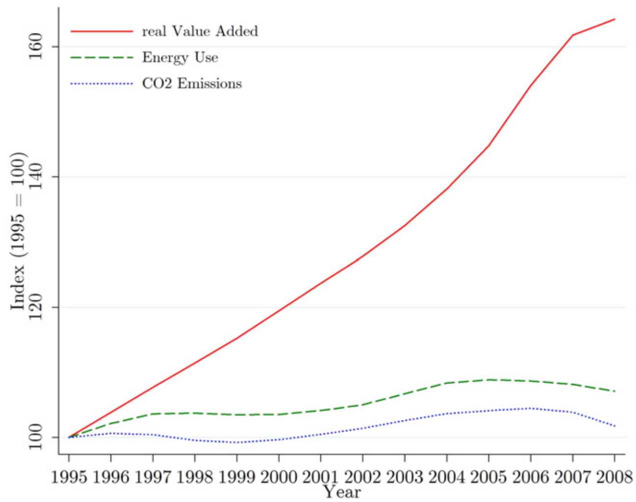

Fig. 1. Decoupling in the EU Note: Own calculations using WIOD (Timmer et al., 2015).

Moreover, an analysis restricted to energy use and CO_2 emissions could give a misleading picture of the overall relationship between GDP growth and environmental damages. The OECD (2002) report suggests that different pollutants could follow substantially different patterns. A recent study by the European Environmental Agency (EEA, 2014) emphasizes high environmental damages from air pollution from industrial activity in the EU, and a recent World Health Organization report (WHO, 2014) suggests that the environmental threats of air pollution have been seriously under-estimated in the past. Besides energy use and the important greenhouse gas CO_2, we will therefore also analyze decoupling of the four main local air pollutants released by industrial activity in the EU: Sulphur Oxides (SO_X), Nitrogen Oxides (NO_X), Ammonia (NH_3), and Particulate Matter (PM_{10}). Sulphur Oxides (SO_X) and Nitrogen Oxides (NO_X) are emitted from fossil fuel combustion and contribute to acidification and local health damages, as well as the formation of particulate matter. Besides being created indirectly through other pollutants, particulate matter is also emitted in various stages of industrial activities. Due to its adverse impacts on the respiratory system its health damages are enormous.[1] The finer the particles, the more adverse are their health impacts. For reasons of data availability, we use PM_{10} which refers to particles of <10 μm in diameter which are already considered highly hazardous. While PM_{25} has even higher adverse health impacts, poor data quality pre 2008 prevents its use. Ammonia (NH_3) is largely emitted in the agriculture sector, but also in other industrial processes, transportation, and waste management, and contributes to eutrophication and acidification (for a more detailed description of the pollutants and their health impacts, see EEA, 2014). In recent years, not only these environmental and health damages have been better understood, but there is increasing understanding that greenhouse gases and many local air pollutants have the same origin – the combustion of fossil fuels – and therefore should be analyzed and regulated together (Parry et al., 2014). According to the EEA (2014), CO_2 emissions and the four atmospheric air pollutants (SO_X, NO_X, NH_3, and PM_{10}) account for 99% of industrial air pollution damage costs in the EU. At the same time these emissions are highly concentrated in some sectors and regions: around half of the emission damages are caused by only 1% (or 147) of large industrial point sources (EEA, 2014: p. 9). A decoupling analysis that includes different industrial air pollutants and sectors is therefore of interest to understand the relationship between economic activity and environmental damage.

In this paper, we follow up on the attempt by the OECD (2002) to develop a broad understanding of decoupling of production-based emissions for eighteen EU countries, six broad economic sectors (Electricity, Manufacturing, Transport, Agriculture, Services, Other), and six pollution indicators (Energy use, CO_2,SO_X,NO_X,NH_3, and PM_{10} emissions) for the years 1995–2008 (see Appendices B and C for descriptive statistics). A unique dataset is generated using the WIOD database (Timmer et al., 2015) which gives Input-Ouput tables at the country and sector level with satellite accounts giving detailed information on energy use and emissions at the sectoral level. The data series is supplemented with information from the Eurostat database (European Commission, 2016) to fill in missing gaps and extend the series.[2]

Using this dataset, we first calculate decoupling factors as defined by the OECD (2002), and second analyze decoupling states based on a modified framework by Tapio (2005). To analyze whether decoupling trends increased or declined, we also investigate two sub–periods 1995–2001 and 2001–2008 (where 2001 becomes the new baseline year for the second sub-period). Overall, we find that some (absolute or relative) decoupling occurred in the median EU country in all sectors except Electricity for NH_3,[3] however there exists considerable heterogeneity between countries, sectors, and pollution indicators. While by most measures the median countries' decoupling performance improved from the first to the second period, at the same time heterogeneity in decoupling also increased. We also find high diversity in decoupling states and no clear patterns of development trends. While some countries and sectors were already able to achieve absolute decoupling in the first sub-period (1995–2001), not all of these were able to maintain this status in the second sub-period (2001–2008).

We finally investigate the effect of an increase in environmental policy stringency on decoupling at the country–year level for the total economy and on the two highest energy using sectors – Electricity and Manufacturing – using the OECD environmental policy stringency indicators (Botta and Kozluk, 2014). We present results from three different models: the canonical two–way fixed effects estimator explaining energy use or emissions controlling for value added, a two–stage–least–squares (2SLS) estimator instrumenting value added by lagged value added, and a two–way fixed effects model with distributed lags. We find some evidence that environmental policy stringency affects decoupling, however the effects are rather small, differ by sector and pollutant, and can take some time to materialize.

The remainder of this paper is structured as follows. Section 2 outlines the previous literature on decoupling, Section 3 describes the methodology, and Section 4 discusses the data used. Section 5 presents stylized facts on decoupling, Section 6 analyzes the impact of environmental policy stringency on decoupling, and Section 7 concludes.

2. Literature Review

Most studies empirically assessing the magnitude of decoupling only focus on specific countries, regions, economic sectors, or pollutants. This narrow focus stands in contrast to the original OECD (2002) decoupling report, which includes a total of 31 different decoupling indicators: economy-wide variables on CO_2 emissions and other greenhouse gases (GHG), local air pollutants such as NO_X,SO_X and particulate matter; water quality, material use, waste management, and natural resource use; as well as additional sector–specific indicators for energy, transport, agriculture, and manufacturing. The OECD report finds that relative decoupling is widespread for GHG emissions in relation to GDP, and absolute decoupling occurs in several countries for air and water pollution relative to GDP and population. However, there are

[1] Compared to all the pollutants included in this analysis, the EEA (2014) estimates the highest average damage costs (between 23,000 and 67,000 dollars per ton of emissions) for industrial PM_{10} releases.

[2] We exclude later years and small countries (see Appendix B for a list of countries in the sample) due to weak data quality and insufficient data points beyond 2009, and moreover to exclude recession-driven effects post-2008.

[3] NH_3 generally only plays a minor role in the electricity sector, so the results can be sensitive to small changes and measurement errors.