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Assessing environmental performance trends in the transport industry: Eco-innovation or catching-up?

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ABSTRACT

This paper analyses the change in environmental performance that took place in the transport industry of 38 countries between the years 1995 and 2009. Data Envelopment Analysis techniques and directional distance functions are employed to compute Luenberger productivity indicators for the change in environmental performance and its determinants, namely, environmental technical change resulting from eco-innovation and catching-up with best available environmental technologies. Eight air pollutants account for the environmental contaminants from transport activities, and these are aggregated into three main categories of environmental pressures, namely, global warming, tropospheric ozone formation and acidification potentials. Furthermore, performance evaluation is based on how these specific environmental pressures are managed. Our principal findings show that there has been a noticeable improvement in environmental performance since the 1990s, primarily as a result of eco-innovations; moreover, this improvement has been markedly greater in low- and middle-income economies, bolstered, in this case, by both environmental technical progress and catching-up. These results reveal the need for policy measures aimed at encouraging catching-up with best available technologies, particularly in more developed countries.

1. Introduction

The impact that productive activity has on the environment is currently generating great interest amongst researchers, company managers, politicians and society as a whole. The conventional view of economic growth as a rise in the quantity of goods and services available to satisfy human needs is progressively giving way to a much broader concept of growth based on *sustainability*, where satisfying present needs should also ensure that future generations can meet their needs (WCED, 1987; p.43). Moreover, acknowledging the environment as a public good has stimulated a breadth of legislation in industrialised countries directly aimed at attaining certain standards of environmental quality.

The transport sector plays an essential role in present-day economies, facilitating the transportation of passengers and freight and the functioning of goods markets by connecting them spatially. Furthermore, transport activities account for nearly 5% of value added and employment in developed economies; although this share is lower in developing and emerging economies, it is expected to increase at a much faster rate in the coming decades due to rising incomes and infrastructure development. At the same time, the transport industry is also one of the world's major contaminators, particularly as far as the emission of air pollutants is concerned. In fact, air pollution is perhaps the most pervasive of all environmental externalities from transportation, mainly because the atmosphere facilitates the rapid widespread diffusion of pollutants.

Transport activities release a number of gases into the atmosphere, including carbon dioxide, carbon monoxide, nitrous oxide, methane and non-methane volatile organic components, amongst others, mainly through the use of final energy and these have harmful effects on the

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environment and human health.[1] Some of these gases are responsible for climate change, some deplete the stratospheric ozone layer that naturally screens the earth's surface from ultraviolet radiation, while others produce acid rain that damages ecosystems and reduces agricultural crop yields. Despite the growth of the transport industry, in the past few decades we have seen a significant decrease in the emissions of some of the most harmful transportation pollutants, such as carbon monoxide and non-methane volatile organic components thanks to technological advances in both vehicles and sources of energy, as well as more stringent standards (EEA, 2012). Conversely, carbon dioxide emissions have increased almost proportionally to the growth of transport activities (Rodrigue, 2013), and, what it is more, the forecasts of future trends are very alarming.

The latest *Intergovernmental Panel on Climate Change* (IPCC) report that uses 2010 figures as the baseline reported that global carbon dioxide emissions from transportation are expected to double by 2050, and transport is set to become the biggest source of emissions unless policymakers take strong action now (IPCC, 2014).[2] Furthermore, the report states that '*Without aggressive and sustained mitigation policies being implemented, transport emissions could increase at a faster rate than emissions from the other energy end-use sector…*' (IPCC, 2014; chapter 8, p.4). Conversely, decisive policy measures could change the expected upward trend and lead to a carbon dioxide reduction; in fact, the IPCC predicts that '*For the transport sector, a reduction in total CO_2 emissions of 15–40% could be plausible compared to* (2010) *baseline activity growth in 2050…*' (IPCC, 2014; chapter 8, p.5). Additionally, several international organisations have acknowledged that effective environmental policies should be based on information from robust environmental indicators combining both environmental and economic issues (UN, 2009); such indicators should, in turn, be seen as an essential tool when assessing environmental trends, tracking progress against objectives and targets and evaluating the effectiveness of past environmental policy measures (EEA, 2014).

Against this background, this paper assesses the trends in environmental performance, understood to be the relationship between economic performance and ecological performance, in the transport industry of 38 countries between the years 1995 and 2009. In keeping with the recent publication by Picazo-Tadeo et al. (2014), we employ *Data Envelopment Analysis* (DEA) techniques and directional distance functions to compute a series of Luenberger productivity indicators of the change in environmental performance, and its decomposition into environmental technical change due to eco-innovation, and eco-efficiency change or catching-up with best available technologies. Ecological performance is accounted for through eight air pollutants grouped into three main categories of environmental pressures, namely, global warming, tropospheric ozone formation and acidification potentials. Notably, environmental performance is assessed at the level of individual environmental pressures, i.e., evaluations are based on how each of these three particular pressures is managed.

It is our contention that this approach could shed some light on relevant questions in the design of environmental policies for the transport industry, such as: *What trends exist in the relationship between economic performance and ecological performance in transport activities? Is this relationship improving?* If so, *what are the driving forces behind such improvement?* And, *which policy measures should thus be prioritised for implementation in the transport industry in order to improve its environmental performance?*

A number of papers have addressed the issue of assessing environmental performance in the transport industry from different angles, and/or have analysed environmental transport policies. These include: Acutt and Dodgson (1997), Noland and Lem (2002), Parkhurst (2004), Kuosmanen and Kortelainen (2005), Feng et al. (2007), Ruzzenenti and Basosi (2009), Yoshino et al. (2010), Heng et al. (2012), Chang et al. (2013), Loureiro et al. (2013), Bergek and Berggren (2014), Bollen and Brink (2014), and Zhou et al. (2014). Of particular note is the recent paper by Krautzberger and Wetzel (2012) that employs directional distance functions and DEA techniques, as does our paper, to compute both conventional Malmquist-Luenberger productivity indicators as well as carbon dioxide-sensitive ones, i.e., with the reduction of carbon dioxide as an additional target, for the European commercial transport industry in the period 1995–2006. One of the foremost findings of this paper is that the majority of European countries studied were unable to keep in line with the technological improvements induced by eco-innovations in transportation activities.

Our contribution to previous empirical literature in this field of research, and particularly with respect to the paper by Krautzberger and Wetzel (2012), is twofold. Firstly, instead of using only carbon dioxide emission figures, we include a much more comprehensive set of eight air pollutants to account for the environmental externalities from transport activities, and these allow a more in-depth and much more accurate assessment of environmental performance; in addition, more countries are also included. Secondly, and more interestingly, provided that performance and its determinants are assessed at the level of specific environmental pressures, our results provide information that goes beyond that of other methodological approaches and that might help policymakers to design better environmental policies for transportation activities.

The remainder of the paper is organised as follows. Section 2 describes the data and the methodology. Section 3 discusses the results, and the final section summarises and highlights certain policy conclusions.

2. Data, variables and methodological notes

2.1. Data and variables

In this paper we use information from the World Input-Output Dataset (WIOD), a project financed by the *Seventh Framework Programme for Research and Development 2007–2013* of the European Commission, which provides disaggregated sectoral data on a series of socio-economic and environmental variables for 40 countries between 1995 and 2011.[3] The WIOD includes 27 European Union (EU) countries and 13 other major countries. However, due to a lack of data on some relevant variables for our analysis, we have excluded Luxemburg and Taiwan, which reduces our sample to 38 countries. According to the World Bank,[4] these countries have been classified into two groups, namely, *high-income countries*, including Austria, Belgium, Denmark, France, Finland, Germany, Greece, Ireland, Italy, the Netherlands,

[1] Transport-related air pollution is a major cause of disease. It has been estimated that these contaminating gases contribute to six of the top ten causes of death (Global Road Safety Facility, The World Bank; Institute for Health Metrics and Evaluation, 2014), including ischemic heart disease, stroke, lung cancer or respiratory infections, amongst others. Moreover, experimental studies suggest that air pollutants from transport increase the risk of developing an allergy or cause adverse outcomes in pregnancy, such as premature birth (Krzyzanowski *et al.*, 2005). The OECD (2014) has estimated that outdoor air pollution kills more than three million people around the world every year, and causes health problems for many more; furthermore, the monetary value of illness and lives lost in developed economies plus China and India was estimated to amount to US$3.5 trillion in 2010, with this figure continuing to rise. In developed countries alone this cost reached US$1.7 trillion, with motorised and road transport being responsible for about half of this figure. Reducing health costs related to pollution created by transport activities therefore constitutes an important co-benefit from environmental improvements.

[2] According to the figures provided by the IPCC, the transport sector produced 6.7 gigatonnes of carbon dioxide (7.0 gigatonnes of carbon dioxide equivalents including non-CO_2 gases) of direct greenhouse emissions in 2010, and was responsible for approximately 23% of total energy-related carbon dioxide emissions. It is estimated that this figure will reach around 12 gigatonnes by 2050.

[3] Timmer (2012) provides an overview of the contents, sources and methods used in gathering the WIOD (also see Genty et al., 2012 for details about the compilation of the environmental accounts), which can be accessed at http://www.wiod.org. Furthermore, this dataset has recently been used in several research papers, including Johnson (2014), Koopman *et al.* (2014), Timmer *et al.* (2014), as well as in policy papers from highly reputed international organisations such as the European Central Bank (di Mauro *et al.*, 2013) or the International Monetary Fund (Saito *et al.*, 2013).

[4] See http://data.worldbank.org/about/country-and-lending-groups.