Journal of Environmental Management 183 (2016) 959–971

Contents lists available at ScienceDirect

Journal of Environmental Management

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

Research article

EU effect: Exporting emission standards for vehicles through the global market economy

M. Crippa, G. Janssens-Maenhout, D. Guizzardi, S. Galmarini*

European Commission, Joint Research Centre, Institute for Environment and Sustainability, Air and Climate Unit, Ispra, Italy

ARTICLE INFO

Article history:
Received 29 January 2016
Received in revised form
15 September 2016
Accepted 19 September 2016
Available online 25 September 2016

Keywords:
Emissions
Euro standard
Road transport
California and EU effect
EDGAR
Global air quality

ABSTRACT

Emission data from EDGAR (Emissions Database for Global Atmospheric Research), rather than economic data, are used to estimate the effect of policies and of the global exports of policy-regulated goods, such as vehicles, on global emissions. The results clearly show that the adoption of emission standards for the road transport sector in the two main global markets (Europe and North America) has led to the global proliferation of emission-regulated vehicles through exports, regardless the domestic regulation in the country of destination. It is in fact more economically convenient for vehicle manufacturers to produce and sell a standard product to the widest possible market and in the greatest possible amounts. The *EU effect* (European Union effect) is introduced as a global counterpart to the *California effect*. The former is a direct consequence of the penetration of the EURO standards in the global markets by European and Japanese manufacturers, which effectively export the standard worldwide. We analyze the effect on $PM_{2.5}$ emissions by comparing a scenario of non-EURO standards against the current estimates provided by EDGAR. We find that $PM_{2.5}$ emissions were reduced by more than 60% since the 1990s worldwide. Similar investigations on other pollutants confirm the hypothesis that the combined effect of technological regulations and their diffusion through global markets can also produce a positive effect on the global environment. While we acknowledge the positive feedback, we also demonstrate that current efforts and standards will be totally insufficient should the passenger car fleets in emerging markets reach Western per capita figures. If emerging countries reach the per capita vehicle number of the USA and Europe under current technological conditions, then the world will suffer pre-1990 emission levels.

1. Introduction

Air quality has been a priority of European legislators since the 1970s. In the wake of US citizens' environmental protection initiatives of the 1960s, which led to the Clean Air Act (CAA) of 1963 (Kuklinska et al., 2015), concerns about air quality also rose in Europe and became one of the main priorities on the EU agenda. Partly stimulated by rising awareness about acid rain, the intensification of industrial activities, the constant increase in the number of vehicles and the extreme diversity in the standards and regulations of different countries, the first EU Air Quality Directive was issued in March 1970. Since then, and on a fairly regular basis, amendments to the Directive were gradually introduced, backed up by the National Emission Ceilings and Fuel Quality directives. Among the measures to regulate the emissions from energy production and industrial activities are those that regulate the quality of emissions from motor vehicles. The latter are in fact source of primary concern for human health, ecosystems and visibility in many urban areas (e.g. Lelieveld et al., 2015; Karagulian et al., 2015).

Despite large efforts in emission reduction in Europe and North America, air pollution is still the primary environmental cause of premature death in Europe, notably due to high concentrations of fine particles and ground-level ozone, according to the Cleaner Air report of UNECE (2016). Rapid urbanisation caused increasing urban air pollution in major cities, especially in developing countries. According to UNEP - Partnership for Clean Fuels and Vehicles (2010) more than 90% of air pollution in cities in these countries is attributed to vehicle emissions due to the high number of older vehicles coupled with poor vehicle maintenance, inadequate infrastructure and low fuel quality.

This paper focuses on pollution related to road transport. It analyses emission data in an attempt to demonstrate that the

* Corresponding author.
E-mail address: stefano.galmarini@jrc.ec.europa.eu (S. Galmarini).

http://dx.doi.org/10.1016/j.jenvman.2016.09.068
0301-4797/

environmental regulations imposed in Europe over the years, combined with the globalisation of the automobile market, have been consistently beneficial, both within and outside Europe. The issue is not new in the literature in relation to the automobile industry in general and emissions in particular. Several studies have analysed this aspect, which is generally referred to as the "California effect". The process of devising and indirectly exporting a standard on vehicle emissions, *de facto*, started in California in the 1970s. The export of cars to the very important Californian market, quickly led to the extension of the regulation to the US federal level, thus imposing on European exporters to develop dedicated production lines. So it remained until the disadvantages relating to the organization of the production stimulated the lobbying of the European Commission for the development of a European standard, which was finally issued in 1991 as amendment 91/441 to the first EU directive 70/220/EEC of 1970. The new limits on emissions in the amended directive led to the introduction in Europe of the catalytic converter, a technology long before adopted in the USA. However, due to the different emission limits and test procedures, cars that are certified with an EU standard still cannot be sold to the USA market, and vice versa.

Rather than focusing on the differences between the USA and EU standards and their respective roles over time in the evolution towards today's standards (refer to Feng and Sauer (2004) and Delphi (2014)), we highlight the mechanisms established between the requirements of producers and regulators that have led to a positive feedback for the general population and the quality of air. For example, despite the reluctance of European manufacturers to take up more stringent standards following the introduction of Euro1/I (Arabic and Roman numerals identify standards used for passengers and freight vehicles respectively), progress was made up to Euro6/VI thanks to the interplay of industry and policy makers. Subcontractors of automobile manufacturers, producing filters and catalytic converters demonstrated to the automobile manufacturers that the new standards proposed by the policy could be met in an economically viable way. This is an example of the multiplayer mechanism in which policy interests stimulate technological development. This is in turn adopted by automobile manufacturers and thereafter used to penetrate domestic and global markets through a potential technological/economic marketing advantage over competitors. Although the regulation is developed in the interests of the environment and public health, this mechanism produces indirect benefits for all stakeholders involved.

In this paper we set out to quantify the benefits of this process at both the European and global level. The complicated juggling exercise between policy and car makers on fixing standards, and finding and selling technical solutions, showed to be successful in Europe for the past two decades and to have produced cascading positive effects on several other regions of the globe, where automobile manufacturers sold cars produced according to EU emission standards and requirements, sometimes beyond the existence of national requirements.

Perkins and Neumayer (2012) carried out a detailed quantitative analysis of the effect of emission standards, which demonstrated the existence of a trading-up effect. The latter is a form of economic integration (Perkins and Neumayer, 2012; Prakash and Potoski, 2007; Vogel, 1997; Saikawa, 2013), whereby the compliance of manufacturers with the environmental standards of highly regulated economies also produces a rise in domestic standards and a positive feedback in the local economy and environment. The environmental regulation nationally imposed and sometimes also adopted in international treaties (such as the General Agreement on Tariffs and Trade (GATT), the Agreement on Technical Barriers to Trade (TBT), the World Trade Organization (WTO)), produces a double effect. Firstly, firms that wish to export to highly regulated countries need to develop or adopt technological solutions that comply with the standards fixed in the foreign market. Secondly, the economic sector of the importing country puts pressure on domestic policymakers to change the internal regulation and standards so that the same product can become competitive on the domestic market.

As presented by Perkins and Neumayer (2012): *"(a) producing a single product for both home and export markets allows firms to benefit from greater economies of scale; and (b) tightening domestic environmental standards may grant exporters a commercial advantage over their home market competitors lacking requisite of compliance technologies by raising the latter's relative costs*". Furthermore, foreign direct investment (FDI) indirectly implies the acceptance by investors of environmental standards defined in other parts of the world (Bach and Newman, 2007; Perkins and Neumayer, 2012; Prakash and Potoski, 2007; Vogel, 1997; Saikawa, 2013). The development of high-end technology, which leads to advancements in market competition and the necessity of automobile manufacturers to produce large volumes, pushes transnational corporations (TNCs) to lobby for worldwide consistency in regulatory standards, so that one product fits multiple markets. These elements are depicted schematically in Fig. 1, which assumes a transnational relationship scheme. The Perkins and Neumayer (2012) analyses are based on volumes of cars sold and expressed in economic parameters such as Gross Domestic Product per capita (GDPpc) and FDI stock. They demonstrate the clear existence of a cross-border trading-up effect which causes a ratcheting-up of regulations in countries that do not have high standards.

The same idea is supported by Saikawa and Urpelainen (2014) who carried out a detailed analysis of the car industry, market and trade of China, and the effect of FDI and environmental standards. Saikawa (2013) refers to these mechanisms as direct and indirect export pressures. The direct export pressure implies that "the greater the export to countries with emission standards, the more likely it is that a country will adopt such standard." At the same time "the more market diversity (that is a greater number of exporting markets and/or a larger share of importers' imports), the more likely it is that a country will adopt emission standards". Several other studies have analysed the implicit transfer of environmental regulations from an economic or commercial view point, considering the volumes of cars traded from country to country and the volumes of high-tech regulated products sold to non-regulated countries.

When issuing a new directive that defines new air quality standards, several factors need to be taken into consideration: the effects of air pollution on human health and ecosystems, the physical processes regulating the dispersion and chemical formation/transformation of species, the national legislation, the technical feasibility of devising engineering solutions which could abate emissions and their implementation costs and the societal impacts. The effect of a political decision on air quality can also be analysed by considering the reduction in the concentration of various air pollutants, or the emission trends of primary pollutants. Emission inventories and the activities that lead to their compilation constitute a very important source of information, especially if the data cover long historical time series of road transport emissions for all world countries.

In this paper we use this information to demonstrate what others have already proven through economic analysis, and to quantify the result of the implementation of emissions regulations from the physical/chemical and technological viewpoint. We aim at corroborating the conclusions presented in the literature by means of the Emissions Database for Global Atmospheric Research (EDGARv4.3.1, Crippa et al. (2016)), which gathers four decades of emission data of the road transport sector and for all countries of