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Short Communication

Impact assessment of road fleet transitions on emissions: The case study of a medium European size country

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HIGHLIGHTS

- Assess the effects of fleet composition changes on emission in Portugal between 2001 and 2011.
- A baseline scenario was compared with a counterfactual scenario.
- In the baseline scenario the average emission factors decreased 28–62%.
- If a counterfactual scenario would be implemented, the reduction would be 20–80% higher.
- High statistical significance was found only between some pollutants and vehicle features.

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ABSTRACT

This paper aims to examine the impacts of fleet composition changes on emission due to the introduction of different road transportation policies in a medium size European country (Portugal) applying an ex-post analysis (e.g. policies based on fuel pricing, car scraping, car taxation). A baseline scenario was compared with a counterfactual scenario in order to understand what would occur in the absence of the introduction of those policies. For each scenario, four approaches were assessed using economic effects and/or human health costs. HC, CO, NO_x, PM and CO_2 emissions from passenger cars and light duty vehicles were evaluated. The results show high statistical significance ($p \leq 0.05$) between CO emissions and different vehicle features as vehicle age, fuel type and engine classes. The same pattern was observed between the average vehicle age and HC, NO_x and PM. After the implementation of road traffic policies, the average emission factors of the fleet decreased 28–62% for HC, CO, NO_x, PM and 20–39% for CO_2. However, if a counterfactual scenario would be implemented, the reduction would be 20–80% and 26–55% higher, respectively. The results demonstrates that although were recorded some benefits, the fleet characteristics distribution were more environmental friendly in 2001 than in 2011.
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1. Introduction

Today, carbon dioxide (CO_2) emission from the road transportation sector is regulated using fuel price policies, motor vehicles tax and car scrapping incentives. Some of these regulations have been worldwide implemented, however the impact of these policies on fleet transitions on environment are not fully studied. Table 1 summarizes the most relevant policies proposed and/or implemented in the European Union (EU).

The fuel price policy is included in the energy tax directive (Council Directive 2003/96/EC). Such directive defines the minimum tax (421 EUR/ton for leaded petrol and 359 EUR/ton for unleaded petrol), and each country can stipulate your fuel tax above to these minimum levels. Later, in 2011 a proposal for a new directive was presented (EU, 2011). In this proposal the minimum tax rates to be applied to road fuels are based on CO_2 emission of energy products and energy value generated by the energy products. In both approaches fuel tax can affect the environmental impact of the transport sector in two different ways. It can provide the reduction of the transport demand but also it can lead to demand for new and more efficient vehicles. In order to study these issues, Romero-Jordán et al. (2010) assessed the impact of fuel tax on the passenger transport demand in Spain and conclude that would be required a much higher rates in fuel tax to induce significant changes in private passenger transport demand. In addition Kloess and Müller (2011) verified that it will be necessary a correct taxation of fuels and cars to trigger the demand for cleaner technologies and to stagnate the transport demand and

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Table 1
Road transportation policies proposed or implemented in the European Union.

Policy	Highlights
Council Directive 1999/94/EC	New vehicles need to have a label with information about fuel consumption and CO_2 emissions
2003/30/EC Directive	Allow the use of biofuels for transport
2003/96/EC Directive	Energy taxation shall be calculated according to the amount of fuel consumed
COM (2005) 261	Proposal to include an element relating to CO_2 in vehicle taxation
COM (2007) 2	Proposal to promote negotiations for 30% GHG emissions reduction in developed countries by 2020, compared to 1990 levels, and it already now take on a firm independent commitment to achieve at least a 20% reduction in 2020
COM (2007) 19 final	Proposal to promote the use of cleaner vehicles and adopt a more eco-friendly taxation system
Council Regulation (EC) no. 715/2007	Imposes the pollution control by measuring the fuel consumption
2008/50/EC Directive	Establishing measures to reduce emissions by requiring States to develop plans for assessing air quality and dissemination of information on the pollutants concentration
Regulation EC no. 443/2009, de 23 of April	Forces a CO_2 emissions reduction from passenger cars, considering that the global average on fleet of vehicles registered in the European Union must be 130 g CO_2/km in function of vehicles weight
COM (2011) 168 final	Initiated a process of energy taxation based on CO_2 (carbon dioxide), with the aim of reducing emissions of GEE by 20% by the year 2020 (when compared with the levels of 1990[a])
COM (2011) 169 final	Set the minimum tax rates to be applied to road fuels based on CO_2 emissions of energy products and energy value generated by the energy products

[a] This proposal was not approved for political reasons.

Dahl (2012) adjusted the price elasticities for gasoline and diesel fuel for recent fuel mix policies, and suggest an agenda of future research topics.

The EU labelling directive (Council Directive 1999/94/EC) indicates that new vehicles need to have a label with information about fuel consumption and CO_2 emissions. This tax has been used in order to incentive the owners to buy a vehicle that has produce lower CO_2 emissions and therefore with lower annual rates. With the same objective, car scrapping incentives were initially introduced to reduce CO_2 emissions. More recently this was also a measure used to combat the reduction in vehicle sales caused by the economic crisis. In this context, Leheyda and Verboven (2013) verified that the environmental benefits of this policy are very modest, but on the other hand it stabilized the vehicle demand in the crisis years.

All these policies were aimed to increase the development of alternative vehicles technologies as well as to create an early market for cleaner vehicles, but have these policies improved safety and environmental patterns as announced in their implementation? At the safety level, Rich et al. (2013) show that replacing existing cars by cars one year younger would reduce the fatalities by 7%, and replacing by new ones would reduce half the number of fatalities. In addition, some studies highlight their high cost (ECMT, 1999). Nonetheless, the evaluation of the environmental component of this type of policies is not so linear (Gallo, 2011).

Table 2 summarizes some of the most relevant studies which assess the impact of fleet shift on emissions. The analysis of these studies indicate that some emission reductions can be obtained with the introduction of road traffic policies, namely for greenhouse gases (GHG), as CO_2, nevertheless the overall gains are not so linear. In the evaluation of these policies, only some pollutants are analysed so the overall impact is usually unknown, particularly for local pollutants as hydrocarbons (HC), carbon monoxide (CO), nitrogen oxide (NO_x) and particulate matter (PM). Most of the research is based on policy projections (Kim et al., 2003; BenDor and Ford, 2006; ITF, 2011; Leighty et al., 2012; Winther et al., 2012; Lambreras et al., 2008). Only one study applying an ex-post analysis to quantify the real impact of road transportation policies on emissions. Moreover, the identification of the main factors responsible for that impact are not fully examined. Therefore, policies which affect fleet composition related with the introduction of car scrapping schemes or the impact related with the introduction of new technologies should be analysed ideally in the mid to long term (ECMT, 1999). In addition, the emission impact has been assessed individually, i.e. pollutant by pollutant. Different costs were used to assess emissions from different pollutants (Gazis et al., 2012; Goedkoop and Spriensma, 2001; Greene, 2011), although the integration of different components is an issue under analysis. By the other hand, we did not find any study which compares the introduction of road transportation policies with a counterfactual scenario, i.e. what would have occurred in the absence of the introduction of any policy. Thus, the main objective of this paper is to assess how vehicle purchases are influenced by road traffic policies (e.g. policies based on fuel pricing, car scrapping, car taxation, introduction of new technological requirements, etc.) and how would be the impact on emissions for different pollutants when compared with a counterfactual scenario. The main questions of this research are:

1. Have road traffic emissions been improved as a result of fleet transitions?
2. What are the main road traffic policies responsible for these changes?
3. What are the main vehicle characteristics that contribute to the change of emission factors (*EF*)?
4. What would be the impact on emissions in a counterfactual scenario?

The evolution of the road fleet in a particular country is historically influenced by the type of taxes. The influence of different socio-economic and policy factors is difficult to generalize. Thus, this study will be conducted in a European medium size country (Portugal), and presented as a case study. Section 2 presents the data collection analysis and the model, and Section 3 presents the main results and discuss the policy implications. Finally, in Section 4 will be presented the main conclusions of this work.

2. Material and methods

Section 2.1 presents the data collection process. In this section a contextualization of the road policies implemented in Portugal is done. Next, the modelling tools (Section 2.2) and the selected scenarios (Section 2.3) are detailed presented.

2.1. Data collection

In order to analyse the impact of implemented policies in Portugal on emissions, several vehicle characteristics (as fuel type, vehicle age and engine size) were collected from ACAP (2013) for Light Duty Vehicles (LDV) and Light Commercial Vehicles (LCV).

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