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European Environmental Policy for Road Transport: Analysis of the Perverse Effects Generated and Proposals for a Good Practice Guide

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***Abstract*—**The aim of this paper is to analyse the different environmental policies adopted in Europe for car emissions, to comment on some of the possible perverse effects generated and point out these policies which are considered more efficient under the environmental perspective. This paper is focused on passenger cars as this category is the most significant in road transport. The utility of this research lies in this being the first step or basis to improve and optimise actual policies. The methodology applied in this paper refers to a comparative analysis from a practical and theoretical point of view of European environmental policies in road transport. This work describes an overview of the road transport industry in Europe pointing out some relevant aspects such as the contribution of road transport to total emissions and the vehicle fleet in Europe. Additionally, we propose a brief practice guide with the combined policies in order to optimise their aim.

***Keywords*—**Air quality, climate change, emission, environment, perverse effect, road transport, tax policy.

I. Introduction

THE automotive industry is one of the largest employers with a significant presence in practically all European countries. The automobile market is one of the most widely used economic "thermometers".

In production terms, the EU produced 21% of global car output in 2018 with 16.5 million passenger cars and more than 2.6 million commercial vehicles. For this reason, the automotive sector also represents an important income for public finances in Europe, the fiscal income from vehicles (EU15) in 2017 is worth €428 billion (more than two and a half times the total EU budget) [1]. On the other hand, Air Pollutant Emissions from transport are a main contributor to air quality problems in Europe [2]. As a consequence of air pollutants, every year more than 400,000 people in the EU die prematurely and another 6.5 million people fall sick because of air pollution [3]. Due to this ambivalence perspective, different policies have been adopted to regulate the situation, creating in some cases some perverse effects due to the complexity of this issue. For this reason, the effects of the public policies on the sector are very important in economic and social terms.

The methodology applied in this paper refers to a comparative analysis from a practical and a theoretical point of view of European environmental policies in road transport. Section II describes a brief overview on the vehicle fleet in Europe. Section III gives a brief and general revision about environmental policies. Section IV evaluates the different environmental instruments in order to detect some perverse effects. Section V presents the summary and conclusion, showing the main results and proposing a short good practice guide.

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II. Vehicle Fleet in Europe

The main characteristic of the European fleet is the high presence of diesel cars. This situation is not casual and has been facilitated by the environmental policies focused in CO_2 emissions, due to the higher efficiency of diesel cars. The differentiation in taxes between petrol and diesel in Europe is on average 30% in favour of diesel [4].

Fig. 1 shows the passenger car fleet by fuel type in percentage of categories in 2018 in EU [5].

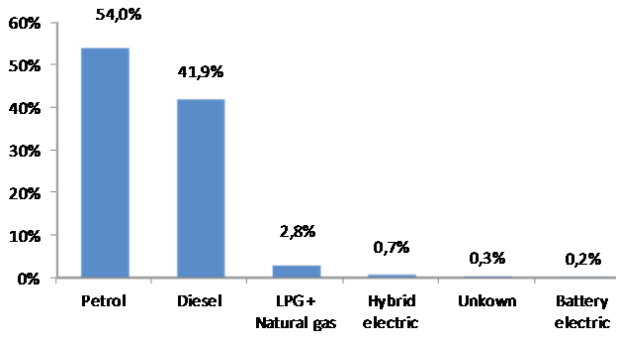

Fig. 1 Passenger car fleet by fuel type. EU in 2018 (ACEA)

The fleet is not static and the effect of some policies against NOx and subsidies of alternative vehicles has produced some results.

Fig. 2 shows the new passenger cars (new registrations) in the EU by fuel type in percentage of categories in 2018 [1].

It is important to clarify some considerations in Fig. 2:

- In the category Electrically–chargeable vehicles are included battery electric vehicles (BEV), extended-range electric vehicles (EREV), plug-in hybrid electric vehicles (PHEV) and fuel cell electric vehicles (FCEV).
- In the category Hybrid are included full and mild hybrids.
- In the category others are included natural gas vehicles

(NGV), LPG-fuelled vehicles and ethanol (E85) vehicles.

Considering also the average age of the EU vehicle fleet, combustion vehicles will continue to have an important presence in the coming years. The appearance of new technologies makes it necessary to review and improve the environmental policies in the sector to avoid possible perverse effects and optimize the transition to new and future technologies.

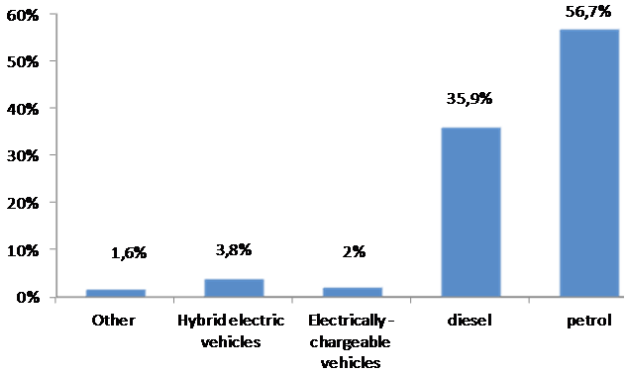

Fig. 2 New registration passenger car fleet by fuel type for EU (Data for Croatia, Cyprus, Luxembourg and Malta not available) in 2018 (ACEA)

III. Environmental Policies

According to the European Commission, air pollutant emissions from transport are a main contributor to air quality problems in Europe [2]., hence, the importance of implementing environmental policies.

As far as environmental economic policies are concerned, probably the most important principle is "Polluter Pays"; this principle was taken on in 1970 in Japan by an amendment according to which the enterprises are economically responsible for the damage caused to the community [6]. This principle later was adopted by OECD (Organisation for Economic Co-operation and Development) as an analytical basis in environmental policies. From there it has become present in international law; here are some examples:

- Declaration of the United Nations Conference on the Human. Environment (Stockholm Declaration, 1972). Principle 22.
- The Rio declaration on environment and development (1992). Principle 13.
- Treaty on European Union (Maastricht 1992). Article 130.2.
- Kyoto Protocol (1997).
- Consolidated versions of the Treaty on European Union and of the Treaty establishing the European Community (2002). Article 174.2.
- Directive 2004/35/EC of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage.
- Consolidated version of the Treaty on the Functioning of the European Union (2012). Article 191.2.

This principle is accepted as the principal argument for the implementation of different environmental policies by authorities. The main policies used are shown below.

A. Vehicle Standards

In Europe there are two vehicle standards with different purposes. On the one hand, there is the REGULATION (EC) No. 443/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23rd April 2009. The purpose of this regulation is to set emission performance standards for new passenger cars and reduce CO_2 emissions from light-duty vehicles. It is important to pay attention that this normative puts a limit for the average of the cars manufactured for the company, not in each car separately. This kind of policy may reduce fuel consumption; they will also reduce the cost of driving creating a stronger incentive to drive. This "rebound effect" of additional driving could be as large as the benefits [7]. On the other hand, there is the Euro normative (started in 1970 with the Directive 70/220/EEC) that introduces emission limits of nitrogen oxides (NOx), total hydrocarbon (THC), non-methane hydrocarbons (NMHC), carbon monoxide (CO) and particulate matter (PM) for diesel and petrol vehicles.

Successive Euro emission standards have led to very significant drops in emissions of exhaust PM and other pollutants such as HC and CO [2]. However, NOx emissions by European diesel cars have not decreased at all, over the various emission standards [8].

The measurement of emissions is under a standard cycle (WLTP from September 2017), for this reason carmakers are more focused on this test than on real efficiency. An example of the perverse effect was "dieselgate" in 2015, where Volkswagen used devices to cheat the test. The experience highlights a perverse effect a gap between the standard cycle and real driving. The average gap has grown up to 42% in 2015 from 28% in 2012 [9].

As an example of discrepancy, it is observed that the TREMOVE model assumes as the average trip length of 12.4 km [10], according to available statistical data [11], however, the distance covered by the WLTP is 23.25 km. This difference has implications for estimating hot and cold emissions.

The difference between theoretical and real emissions is not homogeneous in the different technologies, PHEVs present the strongest gap with an important difference [12]. So, another perverse effect would be the encouragement of not real efficient technologies.

B. Taxes on Purchase and Ownership of a Vehicle

Many countries use this economic instrument. However, according to several authors, it is a perverse incentive that induces a longer tenure. This induces overconsumption of older and more polluting models. On the other hand, purchase and ownership taxes also increase business costs of a country and harm its competitiveness [13]. In Europe, each country applies this policy under different criteria, and even in some countries there are different criteria applied in the different regions. The CO_2 emission is the most common criterion in

this policy. This circumstance has encouraged diesel cars and actually also PHVs due to their theoretical consumption in a standard cycle. Thus, Tables I and II summarise the different policies applied by each European country according to the data from ACEA [14]. CO_2 emission and fuel consumption have been considered in the same category because both units are strongly linked by stoichiometric relationship. About taxes on acquisition, only eight European countries do not apply any tax related to any factor (the taxes are related to administrative license and are not significant). The most common element considered is the CO_2 emissions. This circumstance benefits diesel cars and PHEVs. This could be considered as a perverse effect. Only one country (Denmark) applies a tax reduction for safety equipment.

Only six countries in the European Union tax second-hand acquisition. The non-adoption of this measure is a disincentive for fleet renovation and induces ownership for older cars (more polluting models). This second-hand acquisition tax is only related to vehicle age in three countries (Belgium, Hungary and Slovakia). Surprisingly, this tax only increases depending on the age of the car in one region of Belgium (Flanders region).

Analysing taxes on ownership, the tax based on CO_2 is also the most commonly used encouraging diesel cars and PHEVs. Four countries (Estonia, Lithuania, Poland and Slovakia) do not apply any ownership tax. On the contrary, they do apply acquisition taxes. Neither ownership taxes incentives maintenance on older cars. In the same trend, this is considered when tax decrease depends on the age of the car (Croatia and Hungary). Only Malta increases the ownership tax depending on the age and Italy with tax related to the emission standard has a similar effect. The differentiation in type of fuel in tax policy is still in the minority.

The focus on CO_2 emissions causes an increase in others pollutants as seen in the diesel increase in the European fleet. This also encourages some other technologies with enormous discrepancies between theoretical and real emissions.

The meanings of the subscripts in Tables I and II are:

1. Brussels-Capital Region of Belgium. In this region, the "registration tax related to age", decreases depending on the age of the car.
2. Flemish Region of Belgium. In this region, the "registration tax related to age", increases depending on the age of the car.
3. Walloon Region of Belgium.
4. Tax related to age. The tax decreases depending on the age of the car.

TABLE I
TAXES ON ACQUISITION

	First registration tax independent to any factor	Registration tax related to CO_2 emissions and/or fuel consumption	Taxes on the acquisition of second-hand cars	Registration tax related to exhaust emissions standards	Registration tax related to engine capacity or power	Registration tax related to fuel type	Registration tax related to age	Registration tax related to other factors
Austria		X						
Belgium		$X_{2,3}$	X	X_2	X_1	X_2	$X_{1,2}$	
Bulgaria	X							
Croatia		X						
Cyprus		X			X			
Czech R.			X	X				
Denmark		X_5				X_5		$X_{6,7}$
Estonia	X							
Finland		X	X					X_7
France		X						
Germany	X							
Greece		X		X				X_7
Hungary			X	X	X	X	X_4	
Ireland		X						
Italy			X		X			
Latvia	X							
Lithuania	X							
Luxembourg	X							
Malta		X						X_9
Netherlands		X				X		
Poland					X			
Portugal		X				X		
Romania	X							
Slovakia			X		X		X_4	
Slovenia		X				X		
Spain		X						
Sweden		X						
U.K.	X							

TABLE II
TAXES ON OWNERSHIP

	Annual circulation tax based on CO_2 emissions and/or fuel consumption	Annual circulation tax related to fuel type	Annual tax related to cylinder capacity and/or engine power	Annual tax related to other factors
Austria			X	
Belgium	X	X	X	
Bulgaria			X	
Croatia			X	X_4
Cyprus	X			
Czech R.			X	
Denmark	X			
Estonia				
Finland	X			
France	X			
Germany	X		X	
Greece	X			
Hungary			X	X_4
Ireland	X			
Italy			X	X_8
Latvia	X			X_{11}
Lithuania				
Luxembourg	X	X		
Malta	X			X_{10}
Netherlands	X	X		X_{11}
Poland				
Portugal	X		X	
Romania			X	
Slovakia				
Slovenia			X	
Spain			X	
Sweden	X	X		
U.K.	X			

5. There are tax policies related to the consumption of cars with different values in gasoline and diesel cars. This policy is indirectly related to CO_2 emissions.
6. Tax reduction depending on safety equipment.
7. Tax related to value.
8. Annual tax related to exhaust emissions standards.
9. Length and value.
10. Tax related to age. The tax increases depending on the age of the car.
11. Gross Vehicle Weight.

C. Subsidies to Efficient Vehicles

The successful design of subsidies involves in-depth knowledge about technological information and the specific local characteristics. Care must be taken not to inadvertently create perverse incentives [7].

An example of a perverse incentive is in the UK, where the government has subsidised PHEVs that have never been charged [15].

D. Low Emission Zone

This policy focuses on air quality in some areas, prohibiting access for vehicles that are considered to be polluting. Depending on the technologies considered environmentally friendly, in some cases, this can encourage polluter technologies.

In many countries, PHEVs are considered green cars, but there are no controls about the use of their batteries that in some cases can be charged by an internal combustion engine.

E. Scrappage Incentives

The aim of this economic instrument is a voluntary accelerated vehicle retirement. The immediate benefit that this policy aims at is an earlier scrappage of some vehicles and a consequent reduction in fuel consumption due to both the higher fuel efficiency of newer vehicles, and a reduction in the number of vehicles if the old ones are not replaced [16]. However, it needs to be pointed out that scrappage incentives may lead some individuals to keep their vehicles longer so as to reach the age at which they become eligible for the scrappage scheme [17]. Different European countries have applied a scrappage program; normally these programs are temporary or fund limited.

If the scrappage program is temporary and does not coordinate with the other policies, this situation can reduce the efficiency of this policy.

F. Emission Taxes

It would be really easy to design a tax in relationship with carbon emissions, because there is a direct correlation between petrol/diesel and CO_2 emissions, but it is not the same for the other pollutants. Nevertheless, no such policy for CO_2 emissions in road transport has been implemented anywhere in the world to date [7]. Emission taxes are the first best

instrument to correct emission externalities and induce the optimal driving behaviour and vehicle's purchase and usage choice [16]. However, under current technology, direct charging for emissions is not feasible due to the lack of cost effectiveness and impracticability of monitoring techniques [18]. Implementation of an emission tax would require of actual pollution generated by each monitoring vehicle on circulation [19].

G.Fuel Taxes

There are different fuel taxes but it is not directly linked with the emissions. Only CO_2 has been considered in some way. Nonetheless, fuel taxes have been cited as an extremely effective climate policy instrument [20]. Probably, taxes are the easier and more extended economic instrument to implant. However, there is currently no country that transfers the emissions generated to a fuel tax, so the actual taxes are not linked to the environmental effect.

IV. Evaluation of Perverse Effects

The principal aim in European transport policies has been the CO_2 mitigation. As a result, there has been an enormous growth of diesel cars in some countries, and now the principal problem in air quality of urban areas is the NOx from them. Now the principal aim is the NOx reduction, but probably that will mean an increasing level in HC and others pollutants.

TABLE III
Summary of the Perverse Effects Linked to Environmental Policies

Policies	Possible perverse effect
Vehicle Standards:	• The gap between vehicle standard and real driving conditions • Generating a "pendulum shift effect" • Infringement to the PPP (Polluter Pays Principle)
Taxes on Purchase of a Vehicle	• Tax related CO_2 emissions benefits to diesel cars and PHEVs • No tax on second hand acquisition with increase depending on the age which induces ownership on older cars • Apply Taxes on purchase discourage buying new and more efficient cars
Taxes on Ownership of a Vehicle	• Do not apply any ownership tax incentive maintenance on older cars
Subsidies to Efficient Vehicles	• Subsidise PHEVs when the Internal Combustion Engine can be used to charge the batteries or when they are not plugged
Low Emission Zone	• Encourage vehicles with inefficient driving modes promoting relocation of emission
Scrappage Incentives	• The temporary program without coordination with other policies can reduce efficiency
Fuel taxes	• Actual taxes are not linked to the environmental effect

Actual policies are generating a "pendulum shift effect", thus it would be necessary to considerer the emissions like a whole and not pollutants individually. Furthermore, the emission taxes applied to the vehicles is on the total car price. Hence, the not polluter components (security system, comfort, sound system, etc.) are supporting an environmental tax when their activity is not polluting (Infringement to the Polluter Pays Principle). Normally the new technologies are applied to luxury vehicles, so this imperfection can harm sector competitiveness.

Table III summarises the perverse effects argued in this paper according to different environmental policies.

V. Summary and Conclusion

We can summarize that probably a good combination and integration of policies can lead to positive side-effects and synergies. Next, we propose as a good practice guide the following combined policies:

- We recommend not putting acquisition taxes on new cars (to motivate acquisition of new cars, so they are more efficient).
- We recommend putting acquisition taxes on second-hand vehicles, increasing taxes related to the age of the car (discourages the ownership of older cars).
- We recommend put ownership taxes related to the age of the car, increasing taxes with the age of the car (discourages the ownership of older cars).
- Vehicle standard must consider the vehicles in the most inefficient "driving mode" (to encourage manufacturers to offer only the most efficient driving modes).
- Subsidies for "efficient vehicles" must consider they are in the most inefficient "driving mode" (to encourage manufacturers to offer only the most efficient driving modes).
- In the low emission zone, we recommend to consider the "efficient cars" in the most inefficient "driving mode" they can offer. (To encourage manufacturers to offer only efficient driving modes).
- We recommend that public administrators promote public parking in border areas, connecting them to the Low Emission Zone with public transport.
- It is evident that emissions are produced by fuel consumption, so emission taxes would be implemented in fuel tax. This implementation needs to develop methods to estimate emissions (considering emissions like a whole to avoid the pendulum shift effect) and quantify their environmental cost. Taxes on fuel encourage a rational use of the vehicle.

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