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Infrastructure, tariff and legal action: how to achieve a climate-friendly transport system

Salvatore Amoroso
Department of Energy – Transport division
Università degli Studi di Palermo
e–mail: amoroso@unipa.it

Luigi Caruso, Francesco Castelluccio*
Department of Energy – Transport division
Università degli Studi di Palermo
e–mail: caruso@ditra.unipa.it; castelluccio@ditra.unipa.it

ABSTRACT

Transportation absorbs about 70% of oil consumption in EU countries. The burned fuels by the field of transport are composed by 96% of oil. Energy efficiency of road and air traffic has also to be improved. But across Europe transport environmental impacts reductions should be made necessarily through a transfer of traffic from the car, lorries and aircraft to train, ship, and non motorized two-wheelers. Indeed the former are the largest producers of greenhouse gases, while the latter are more environmentally and climate friendly means of transport. An ecologic goal on the environment must be set, reaching an annual increase of 1% of modal split in favour of more sustainable means of transport. Legal, infrastructure and tariff measures have to be proposed, in addition to technical measures (reduction of traffic, growth of vehicles' energy efficiency, reduction of travelled distances, improved logistics, etc.). While legal measures refer to possible law limits in terms on fuel consumption and CO_2 emissions due to European traffic, infrastructure measures can be distinguished on the basis of the concerned territory. On the one hand there is the city, where it seems appropriate that we move using more secure and environmentally friendly intermodal chains. On the other hand fundamentally there are the suburbs, where investments in new transport infrastructures may be contradictory in terms of climate protection. Tariff measures express the already established concept of "who produces pollution, he pays". So the external costs generated by different modes of transport have to be progressively turned over to users.

Keywords

Energy consumption, environmental impacts, sustainable transport, environmental protection measures, clean and bio-fuels, road pricing, infrastructural and regulatory measures.

INTRODUCTION

Investments in transport infrastructures contribute significantly to the economic growth of a country, stimulating demand and supply, especially in those regions and cities that are affected by infrastructural lacks. But such investments may also have negative effects on growth in highly developed economic contexts. Road is responsible for most of the effects that transport has on man (and environment where he lives) in the EU countries. It absorbs more than 80% of the energy consumed by transport and it is the origin of the large part of accidents and air pollutants emissions, of noise and habitat degradation. Although maritime transport has a weaker impact on the environment, oil spills (caused by serious incidents)

* Corresponding author

worry the public opinion. The environmental impact of air transport (whose most recent growth is due especially to tourism) begins to be highly polluting. This transport mode currently accounts for approximately 11% of the energy consumed by the overall transport system. Despite its significant contribution to economic development, transport also involves a significant cost to society.
However, the transport market involves problems concerning equity and accessibility: not all citizens and economic actors have equal access to the transport benefits. In addition, the transport industry generates a series of socio-economic and environmental costs, which are determined by accidents, by different types of environmental impact, by the consequent damage to human health and by the loss of productivity due to increasing traffic congestion. Most of these costs are not paid by transport users, but by the whole society.
EU external costs of transport are estimated to be about 7% of gross domestic product: the main component of these costs is made by the congestion related costs, which weigh on European Union for about 100 billion per year, and they represent 1% of its gross domestic product [1]. An updated estimation of the transport system external costs in Italy is provided by "Ferrovie dello Stato" and "Amici della Terra" [2]. According to this evaluation the Italian external costs related to transport system amounted to 40.566 million euros in 2006. These costs are eligible for a 94.4% to road traffic, 4.3% to the aircraft and 1.3% to rail (Table 1).

Table 1. Estimating the external costs of mobility in Italy†

Transport mode		Greenhouse gases	Environ. pollution	Noise	Accidents	Traffic congestion	TOTAL
Road		**2,407**	**7,278**	**5,224**	**3,940**	**19,435**	**38,285**
	Passengers	*1,606*	*4,329*	*2,599*	*3,599*	*13,087*	*25,220*
	Goods	*801*	*2,949*	*2,625*	*341*	*6,348*	*13,065*
Rail		**58**	**123**	**235**	**34**	**97**	**547**
	Passengers	*40*	*94*	*140*	*31*	*97*	*402*
	Goods	*18*	*29*	*95*	*3*	*0*	*145*
Air		**609**	**580**	**440**	**29**	**74**	**1,734**
	Passengers	*567*	*540*	*408*	*29*	*74*	*1,620*
	Goods	*42*	*40*	*32*	*0*	*0*	*114*
TOTAL		**3,074**	**7,981**	**5,899**	**4,003**	**19,606**	**40,566**

The greenhouse gases related costs represent about 7.6% of the total, not taking into account the congestion costs. Air pollution and accidents costs account respectively for 38% and 19% of total, while the noise ones for 28%. Road transport is the transport mode which involves higher costs (90% of total). Just over half of these costs are attributable to passenger transport.

TRANSPORT INFRASTRUCTURES AND ECONOMIC GROWTH

The difficult task of comparison and conciliation between various costs and benefits generated by transport system is crucial for sustainable development. The European transport policy provides long-term objectives, to seek a balance between economic growth, social welfare and environmental protection in all strategic decisions [3]. EU has the duty to integrate international environmental commitments as well as to help to achieve the objectives of energy policy, especially in relation to security of supply and sustainability. According to the mentioned approach, the new "European Union Strategy for Sustainable Development" [4] states that the transport system should respond to the economic, social and environmental

† Source: [2].

features of society, minimizing the negative impact on these mentioned aspects. European Union has identified the following strategies to achieve these goals: decoupling of economic growth by transport demand, reduction of transport energy consumption and of greenhouse gas emissions, reduction of pollutant emissions, modal rebalancing, noise reduction, improved efficiency of public transport services, reduction of new cars average emissions of carbon dioxide (140g/km by 2008-2009 and 120 g/km by 2012) and additional 50% reduction in the number of fatal road accidents by 2020, compared to 2009 values (figure 1) [5]. With respect to these objectives, the Italian transport system has many unresolved problems, but there are some positive signs. A massive increase of transport demand (+31.9% for passengers and +5.5% for goods, taking in to account only national carriers) [2] occurred in Italy between 1990 and 2009, broadly in line with the growth of gross domestic product. Road transport has played the major role in absorbing the demand. So it produces a strong pressure on roads and on the whole society, with great negative effects (congestion, delays and other externalities), which reduce the competitiveness and increase the energetic vulnerability of the whole economic system. Following the energy industry (production and processing), transportation is the most responsible sector for greenhouse gas emissions (24.2% in 2009), as well it is the one with the highest growth rate between 1990 and 2009 [2].
The air quality of cities still does not respect the limits set by European legislation. So it continues to have a significant negative impact on human health, even the average emissions of carbon dioxide per kilometre from new passenger cars decreased in recent years. But the reduction rate is not sufficient to achieve the objectives set by EU. Similarly, the improvements of road safety allowed a steady reduction in the number of accidents, injuries and fatalities (-44.0% between 1990 and 2009) (Figure 1) [6].

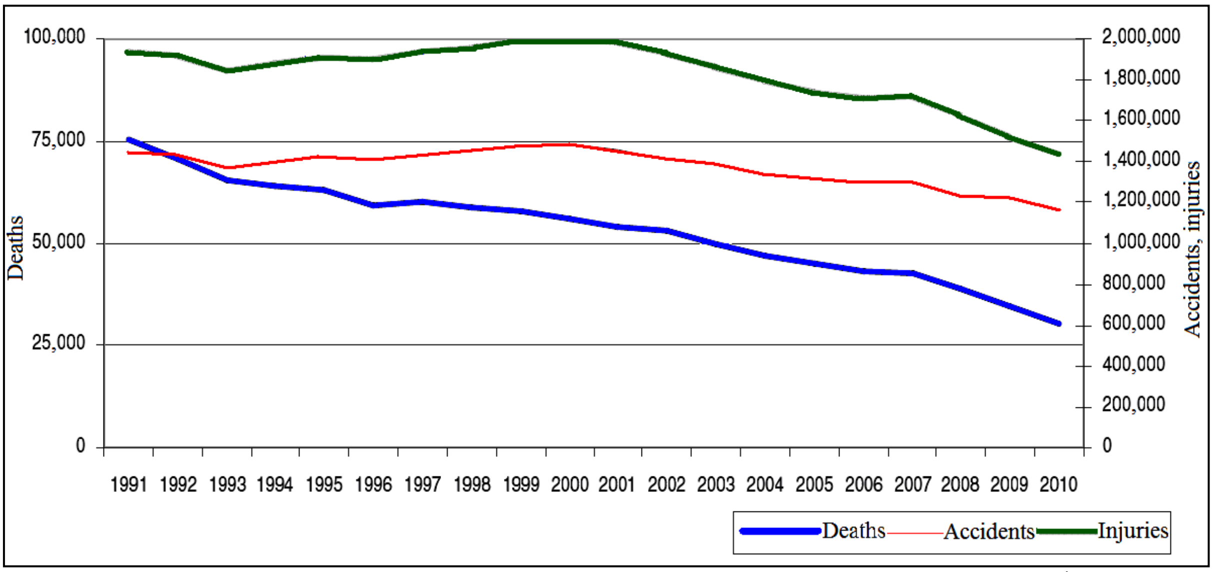

Figure 1. Road accidents, injuries and deaths: yearly evolution 1990-2009‡.

Consequently, the enormous growth in transport demand and the predominance of the road mode compensate progress of environmental impact reduction and of safety of transportation growth (through improvements in technology field or in single infrastructural interventions). The "planning of environmental sustainability" should use measurable indicators, which also allow to monitor of implemented transport policies, as already it happens in different European contexts. Transport policy should be multi-tasking, with respect to the various aspects of the sustainability (economic, environmental, social and institutional). So mobility

‡ Source: ERSO – European Road Safety Organization.

should be a mean to achieve the ultimate goal, not the ultimate target: the access to places and to necessary facilities to the economic and social life of the community [7] [8].

ENERGY CONSUMPTION OF TRANSPORTATION

The energy consumption, especially of fossil fuels, is closely related to greenhouse gas emissions and to security of supply.
EU transport account for 30% of the total energy consumption and 71% of global oil consumption. Road and air, respectively devour 60% and 9% of all the oil, while rail uses 75% of electricity and 25% of fossil fuels [9]. Italian transports reported a slight decrease in energy consumption that began in 2008 and continued in 2009, when the transport was responsible for 32.4% of total final energy consumption and 65% of oil consumption. Road transport consumes the largest amount of energy (equivalent to over 92% of total used energy) and it have seen the highest growth rate of energy consumption across all transport modes, with an increase of 27.7% in 1990-2009. Air transport shows the more incisive trend between all transport modes in the same period, with a fuel consumption increase equal to 29.0% for domestic market and 126.2% for international one [2].
In addition, overall transport energy consumption grew by 18.9% into the same period, not taking into account that vehicles technical improvements led to progressive reductions of fuel consumption.

EMISSIONS DUE TO TRANSPORTATION SYSTEM: DATA AND REGULATORY FRAMEWORK

Greenhouse gases

The increasing air concentrations of Greenhouse gases cause harmful effects on Earth's global temperatures and climate, as well as potential damages to ecosystems, human settlements, agriculture and socio-economic activities.
Ratifying the Kyoto Protocol through the National Law 120/2002, Italy has pledged to reduce total greenhouse gases emissions of 6.5% by 2008-2012 (compared to 1990 levels). Based on the information provided by local authorities ARPA [§], the CIPE[**] Resolution 16/2009 requires an yearly report on the implementation of the measures set by National Law 123/2002 and the study of emissions trends compared to the reference scenario. Furthermore, this Resolution has formulated possible changes to the maximum emission levels to meet the target set in accordance with National Law 120/2002 (and following measures).
European Commission Directive 50/CE has established that Member States have to bring the $PM_{2.5}$ levels under 20 mg/m by 2015 and to reduce the exposure of 20% by 2020, compared to 2010 values, also confirming the previous limits for key pollutants.
While the Directive 2008/101/EC (which amends and integrates the Directive 2003/87/EC) also includes the air transport between sectors regulated by the EU-ETS (such as energy activities and petroleum products refining, etc.) and it sets out basic principles to which the airlines must comply. The commercial airlines departing or arriving at an aerodrome within the territory of an EU Member State (which has to follow the requirements of this Directive) will be within the CO_2 Communitarian emission trade system by 2012. The annual emission upper limit[††] was set at 10,000 tonnes of CO_2. While CO_2 emissions produced by certain types of flights are excluded from the application of the Law (police, military, emergency and rescue flights, flights of aircraft weighing less than 5,700 kg and flights on routes lightly attended with less than 30,000 seats per year).

[§] Agenzia Regionale per la Protezione Ambientale.
[**] Comitato Interministeriale per la Programmazione Economica della Presidenza del Consiglio dei Ministri.
[††] To determine the inclusion of an airline into the EU ETS system.

The EU climate-energy package, approved in December 2008, also includes the following provisions relating to the transport sector:

- Directive 2009/28/EC of the European Parliament and Council on the promotion of energy from renewable sources, which provides that each Member State uses 10% of bio-fuels for transport supply by 2020;
- Regulation (EC) 443/2009 of the European Parliament and Council setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions of light vehicles.

National greenhouse gases emissions (in CO_2 equivalent) declined by about 4.9% from 1990 to 2009. The decrease was concentrated in 2009 (-9.3%) after a first slight downward trend in 2008 (-2.0%) [2].

The reductions are due to the economic crisis, which affected mainly the freight transport. While the increase until 2007 was a result of continued growth in demand for transportation (both passenger and goods) that enlarged the road transport.

Transport is responsible for 24.2% of total greenhouse gases emissions in 2009 and for carbon dioxide emissions, which are 98.9% of the total, since they are closely linked to energy consumption. The 65.2% of carbon dioxide emissions is produced in transporting passengers and the amount due to passengers and goods transport by road, is equal to 97.5%. European transport shows a dynamic similar to the Italian one, with a growth around 20% (EU 15) between 1990 and 2008 (latest available). Emissions increased until 2007 and they slightly decreased (2.7%) in 2008 [2].

With regard to fuel consumption, air had the fastest growth between transport modes, so it became one of most important greenhouse gases sources over the world. Most of the emissions come from international flights by planes that provide the link between EU member states or between a Member State and a third country.

Air Pollutants

Nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), particulate matter (PM_x), lead (Pb), benzene (C_6H_6) and sulphur oxides (SO_x) are the major air pollutants. Nitrogen oxides contribute acid rains, eutrophication and the formation of tropospheric ozone. Indirectly, they also contribute to global warming and changes of the ozone layer.

The primary particulate pollutant is currently the greatest impact on human health, especially fine particulate ($PM_{2,5}$) is very dangerous, because it can penetrate deep into the lungs. While the secondary particulates come from reactions with the decisive contribution of nitrogen oxides. Although ozone is generated in the atmosphere especially during the summer months, since it derives from the reaction between nitrogen oxides and non-methane volatile organic compounds in the presence of heat and sunlight. While benzene is a carcinogen present into gasoline and into exhaust gases c motor vehicles. Pollutant emissions of road vehicles are individually regulated in UE, according to the distinction between light vehicles (cars and light commercial vehicles) and heavy vehicles (trucks and buses). Further directives regulate the "off road vehicle" emissions (railways and inland waterways). Ships and aircraft emissions are regulated in the international arena, however, by IMO and ICAO, except for more restrictive provisions present in certain areas. The Euro 5 and 6 standards were adopted for light vehicles in 2007: their application was partially launched in January 2011 (the first) and from September 2015 (the second), regarding the registration of new vehicles. The Euro 5 reduces emissions of particulate matter from diesel cars from 25 to 5 mg/km, while the Euro 6 will reduce emissions of nitrogen oxides from diesel cars, from 180 to 80 mg/km [2].

The Euro V standards (Directives 2005/55/EC and 2005/78/EC) are currently implemented for heavy vehicles. While the Regulation 595/2009 was approved in 2009 and it establishes the limits of the new Euro VI standards, which will be applied from 2015.
Looking at the time series of major pollutants in Italy between 1990 and 2008 we see that [2]:

- The most significant decrease in pollutants emissions has been registered for lead. These emissions have ended in 2001, thanks to the exclusion of leaded gasoline from the market;
- The benzene emissions have decreased by 85.5%, thanks to catalytic converters and to a reduction of their percentage into the gasoline; currently global emissions of this carcinogenic substance, however, are still relevant, because the circulation of vehicles without catalytic converters and/or to the presence of two-strokes engines;
- The emissions of non-methane volatile organic compounds have decreased by 59.5%. The non-catalysed mopeds and motorcycles (43.8%), followed by boating (22.4%) and cars (21.7%), especially non-catalysed cars still in circulation, are responsible for these emissions;
- PM_{10} particulate emissions decreased by 34.7% and $PM_{2.5}$ by 37.7%. Currently the main PM_{10}sources are passenger cars (approximately 37.4% of total) and commercial heavy and light vehicles (about 36% of total). The navigation has significant PM_{10} emissions (about 17% of total). While if we take into account $PM_{2.5}$ emissions, the role of cars decreases (about 34% of total) and the contribution of light and heavy commercial vehicles remained stable (around 37%);
- The emissions of nitrogen oxides have decreased by 35.8%, but they are still relevant in relation to total emissions: transport is the main source of this important pollutant. Instead emissions of sulphur oxides have decreased by 77% and are now insignificant.

Looking at the distribution of emissions between passenger and freight transport in Italy in 2008 [2], it follows that:

- The freight traffic is the main source of emissive oxides nitrogen (46.3% of total), while passenger traffic produces 45.2% of these pollutants. The first percentage includes, however, the significant effects of the economic crisis on freight market;
- The passenger traffic is the main source of NMVOC (72.6% of total), mainly because of motorcycles. The other sources contribute to producing 19.6% of these pollutants (mainly because of the yachting);
- Instead PM_{10} records a reduction of the contribution of both freight and passenger traffic and an increase in the contribution of other sources, mainly due to freight cabotage.

Specific emissions of carbon dioxide

The average energy efficiency of passenger and freight transport is determined starting from technical efficiency of global motor-vehicle fleet composition (e.g. number and type of vehicles), vehicle use (e.g. load factor) and driving characteristics (e.g. speed and driving style).
The energy consumption per tonne-km also depends on the characteristics of the freight (e.g. the weight and volume of assets). So the variety of transported goods can lead to inequalities in energy efficiency, which is expressed as energy use per tonne-km.
EU strategy to reduce emissions of carbon dioxide from cars and improve fuel economy is based primarily on the commitment of the automotive industry to improve the fuel efficiency of cars, then the certification of cars fuel consumption and finally the incentive of fuel efficiency by fiscal measures. The European Commission adopted two parallel

Communications in 2007[‡‡], which underlined the impossibility of achieving the Communitarian objective stated in 1995 (average emissions for new passenger car fleet of 120g of CO_2/km by 2010), with the application of the old voluntary agreements stated with car manufacturers. Then the Council Regulation (EC) 443/2009 has established the average CO_2 emissions for new cars to 130g of CO_2/km, which should be achieved by 2014. These improvements will be realized through technological improvements of vehicles. A system of sanctions will be applied to defaulting manufacturers. The sanctions will amount to €5/15/25/CO_2/km respectively with excesses of no more than 1/2/3g of the target set. Above that level the cost will amount to € 95 per g of more emissions. Since 2019, the reduction of sanctions for the first 3g of CO_2 excesses will be eliminated. Since 2020, the goal (subject to revision) will be equal to 95g of CO_2/km. The specific carbon dioxide emissions from road transport have decreased in recent years, largely due to improvements in the efficiency of fuel. The voluntary agreement with the automotive industry has led to some reduction. ACEA[§§] has achieved an average CO_2 emission level from new cars of 160g / km in 2006, JAMA[***] and KAMA[†††] respectively equal to 161 and 164 [10]. However, it is not possible to achieve the EU objective of 120g of CO_2/km in 2012, because of the absence of more restrictive agreements. The specific CO_2 emissions of air transport are now decreasing, but they has a similar in value to road emissions. While rail and shipping remain the most efficient transport modes for passengers. As regards Italy, specific emissions of carbon dioxide from diesel cars have fallen more than gasoline ones, due to technological improvements of diesel engines (diesel and gasoline -12.64% -10.94%) [11].

DIFFUSION OF ALTERNATIVE AND CLEAN FUELS

The low environmental impact fuels include natural gas, liquefied petroleum gas (LPG), bio-diesel[‡‡‡] and bio-ethanol[§§§]. Generally the use of these fuels helps to reduce greenhouse gas emissions, to diversify energy sources, with the replacement or integration of fossil fuels. Directive 2009/28/EC (on the promotion of energy from renewable sources) requires that each Member State uses a minimum of 10% (on the energy basis) of diesel, of gasoline and electricity from bio-fuels, and of electricity produced from renewable sources by 2020. While in Italy the law 244/2007 established the minimum quota of 3% for 2009 on the energy basis.

The distribution of lower environmental impact fuels in the Italian domestic market is discrete comparable to other European states. But it is still insufficient to contain the growth of greenhouse gas emissions.

The fleet of LPG/natural gas vehicles had a significant increase in 2009 thanks government incentives. It stands among the largest values of the European Union (4.5% of the total registered vehicles). The distribution network is spread across the country. In recent years, the greatest Italian municipalities have subsidized the conversion of older gasoline vehicles to LPG fuelled ones, as an intervention to combat urban pollution. After 2000 (65.5 PJ) LPG consumption has shown a sharp decrease until 2007 (43.3 PJ), then it remained roughly constant in recent years, with a recovery in 2009 (50.4 PJ) [2]. The fleet of natural gas vehicles is the largest among the EU countries. However, the spread of this power is still hampered by gaps in the distribution network. Today the expansion of natural gas supply

[‡‡] The first communication was based on the results of the review of the Community strategy to reduce CO_2 emissions from cars and light commercial vehicles, the second on a competitive automotive regulatory framework for the XXI Century - CARS 21.

[§§] European Automobile Manufacturers Association.

[***] Japanese Automobile Manufacturers Association.

[†††] Korean Automobile Manufacturers Association.

[‡‡‡] Fuel made from oleaginous plants such as rapeseed and sunflower.

[§§§] Fuel produced from sugar or starch-rich crops, such as beets sugar and cereals.

network is very important, because a diffuse and homogeneous network on the territory is a prerequisite to an expansion of the natural gas vehicles fleet. Today the distribution network is sufficient only in northern Italy.
Biodiesel and other vegetable fuels are still far from the targets set by EU. The gradual rejuvenation of the Italian car fleet has resulted in a substantial increase in diesel passenger cars, despite the price of diesel has risen more than other fuels in last period. The percentage of diesel-powered cars has considerably increased in recent years, rising from 14.7% in 2000 to 36.7% in 2009 [2]. This is due to the improvement of the quality of diesel fuel (now also marketed in "green version") and to the improvement of fuel consumption and engine duration, which determine a user's preference for diesel cars than gasoline ones. Overall, diesel car park covers more miles than gasoline car fleet in Italy, although it is less numerous than the latter. So diesel car fleet is averagely newer (6.1 years) than gasoline one (9.2 years). Gasoline and diesel cars accounted for 94% of the total circulating vehicles, compared to about 6% of LPG, natural gas, electricity and others cars in 2009 [2].

INTERVENTIONS FOR DECOUPLING TRANSPORT IMPACT AND ECONOMIC GROWTH

The role of transport networks (roads, railways, waterways, etc.) for the economic development of territory is very important. These infrastructures help reduce the transport costs. So they contribute greatly to reducing territorial disparities and to improve the competitiveness of various geographical areas, encouraging the mobility of workers and determining economies of scale.
The presence of allocative and positive externalities on different markets (economies of scale, size, concentration, density, and network) is important in order to benefit from economic growth. The combined effect of these factors results in an increase of this growth, usually measured through the evolution of the employment, production and productivity. Improved accessibility to transport system by itself is not enough to generate economic benefits. It reduces transport times, but not necessarily increases traffic volume and, consequently economic growth.
But when we consider a developed Economy, investments in transport infrastructure may have adverse effects on the growth. So the development of a land transport could reduce the competitiveness of a different region. The overall budget could be negative, causing a drop in economic activity. Generally, "decoupling" means breaking of the links between the "elements dangerous for the environment" and the "elements favourable to the economy". So it compares the environmental pressures and the changes in economic variables. The first ones are related to the second ones through a causal relationship [12]. For example, the national growth rate of sulphur dioxide emissions can be compared with the growth rate of GDP. The best strategy to decouple the effects of transport on the environment and the economic growth is the full internalisation of environmental externalities into the public administration transport related decisions.

Economic instruments: taxation and road pricing

External costs are not paid by producers, but by society as a whole. They include the costs for infrastructure use, congestion, accidents and environmental impacts of transport. Almost never such costs are included into fares, so users do not take account of them when they choose how much and how to move. The "command and control" measures are used to reduce the external costs of transport. They directly reduce the environmental impacts of the industry. So applying the pricing mechanisms (e.g. taxes and subsidies) public administrators encourage the adoption of "green" behaviours by users.

The taxation of transportation has a great influence on the development of infrastructures (then on traffic) and, consequently, on the impact and the effectiveness of transport policy. This levy is currently mainly aimed to the maximization of the socio-economic welfare, by charging the external costs on transport infrastructure users. In other words, users pay the additional costs produced by their own mobility choices. So the environmental taxation on fuels is connected to a monetary withdrawal by the public Administration: significant differences exist between the different countries of the OECD[****], with very high levy values within the European Union, Korea, Japan, and smaller in the United States and Canada. The tax component on gasoline price was approximately of 63%, on diesel price of 56%, on LPG approximately of 39% in 2009 in Italy. The revenue arising from these taxes are 2.5% of GDP in the OECD member States. These values fall within a worldwide relatively large fork (from 1.5 to 5%) [12].

The fuel taxes are closely related to mileage and emissions of carbon dioxide. Thus this levy aims to reduce emissions from transport, as it can stimulate the reduction of fuel consumption (for example by stimulating efficiency) and the shift to the use of cleaner fuels. The internalisation of external costs (i.e. their charge on transport users) allows applying the "Polluter Pays" Principle (PPP) and allows users to understand the true value of the price of transport. For several years, economists argue that road pricing should be considered as an efficient and equitable way to finance the network costs, because users pay directly the cost of their circulation on a specific road infrastructure [13].

Table 2 summarizes the different categories of road pricing measures and their goals. Some targets are designed to produce cash receipts, others to reduce peak times congestion. Others still aim to mitigate the environmental impacts of global circulation (congestion, exhaust gases pollution, accidents, road infrastructure and parking costs, etc.), some of them are multitasking.

The European Union is developing a comprehensive strategy on the road transport taxation. Indeed the variability of the applied rates to use the infrastructures, the differences in annual traffic taxes and the disparities of national fuel taxes, create disparities of sustained costs by users into different EU territories. These differences distort transport competition, hindering the creation of a fair, transparent and liberalized market. While the percentage values of transport and environment connected taxes settled by EU are presented in Figure 2.

Table 2. Categories of road pricing[††††]

Denomination	Description	Targets
Congestion charge (variable depending on the time slot).	Higher fee in case of congestion compared to the case of fluid movement, which aims to redirect traffic to other routes, times or transport modes.	To determine the collection of revenue and reduce congestion.
Cordon toll.	Fee to permit circulation within a given area.	To reduce congestion in large urban areas.
Kilometric fee.	Circulation tax on vehicle mileage.	To produce revenues and reduce various traffic problems.
Kilometric car insurance.	Insurance premium calculated in proportion to the annual haul, converting the car insurance into a variable cost.	To reduce several traffic problems, mostly accidents.
Rationing of road space.	Credits used to limit the capacity of the road network during peak hours (without favourable impacts on revenues).	To reduce congestion on major highways or in urban centres.
Roads managed in mixed mode (car-pooling and toll).	Streets for car-pooling and limited number of vehicles (with a low load factor), through the payment of tolls.	To promote car-pooling on ordinary roads and produce income, unlike the streets reserved for car-pooling.
Toll.	Fixed fee for driving on a particular route.	To determine the collection of revenues.

[****] Organisation for Economic Co-operation and Development.
[††††] Source: [12].

By reducing the number of transfers with motorized vehicles, road pricing can lower the costs of road infrastructure and parking facilities. Furthermore, it can increase road safety, protect the environment, promote the more rational use of urban land as well as improve the quality of different social areas. Instead, if the road tax aims to increase the capacity of the road network, the negative effects of motor traffic growth, result in an increased congestion, increased parking costs, more accidents, an aggravation of pollution and urban dispersion.

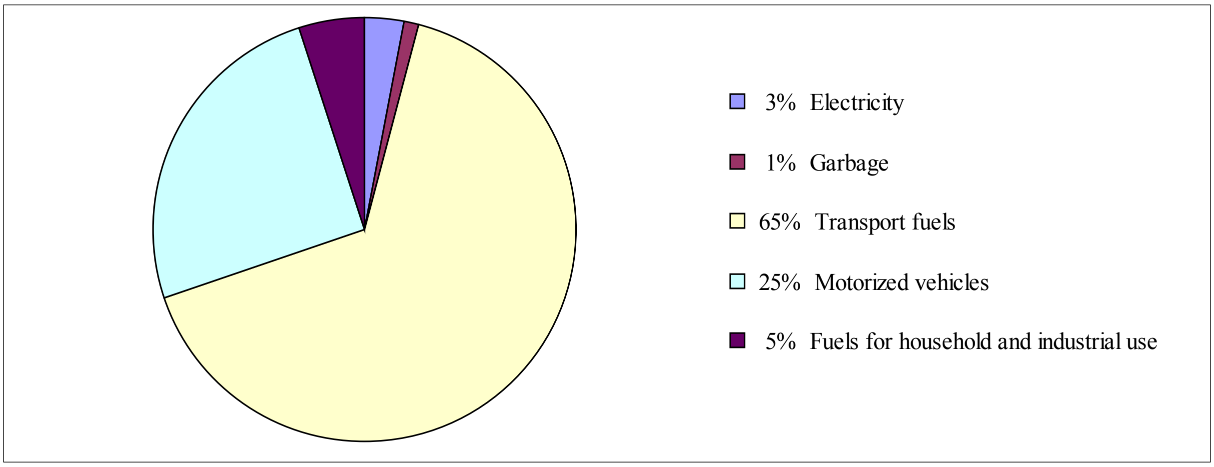

Figure 2. Environment-related taxes ‡‡‡‡.

Legal instruments and regulations

The most promising and more effective perspectives to reduce CO_2 emissions in the transport sector seem to be those aimed to reduce energy intensity. Policies encouraging a modal split to less energy-intensive transport alternatives have a very limited potential, while the engine-related technologies are essential to reduce emissions of NO_x, VOC and PM_{10}. The imposition of rules on this type of emissions helps the evolution of long-term technology, while these rules cause a reduction in transport demand in the short term.
Speed control and punitive measures to violations of driving/rest times (in the field of heavy vehicles) place the emphasis on the application of existing monitoring mechanisms and on the interventions to ensure respect for rules. These mechanisms improve the balance of intermodal competition. In this way the possibility to use of railway and sea to move freights grows, thus the possibility to enforce environmental compatibility. According to existing statistics, these controls lead to increased costs of road transport. This result has the same effects of a toll increase (or other interventions with the same effect on costs), without changing existing laws or regulations.
On the other hand, the international harmonization of rail transport regulations would be very useful to promote the competitiveness of the railway sector. Considering the economic perspective, the benefits would flow from the clarity of regulations in Europe countries and as a result of a modal shift to rail.

Infrastructural interventions

The percentage of EU public transport dedicated to daily mobility reaches 20% and it suffers of a decline. The public transport over long distances is still weaker than the first one. Some of the main reasons for this status are the following:

- the slowness of public transportation;

‡‡‡‡ Source: [12].

- the low level of comfort;
- the complexity of this type of transport system (use of a transport chain, with changes in some bad organized nodes, information problems, etc.).

Improvements in these three areas would help to increase the proportion of people who choose public transport. But the improvements of infrastructure and of service quality are an important part of this process. However the improvement of the road infrastructure would not be effective without the parallel progress of service quality (and vice versa).

Economy also benefits from having efficient infrastructures for public transport, to meet the needs of transport users. The efficiency of infrastructures indeed aims also to encourage potential users to review their travel habits, using public transport instead of own car.

On the other hand, the factors that determine the modal choices in the field of freights transport are the following:

- the price;
- the quality criteria corresponding to the concerned market.

So the most important features are the reliability, the frequency of departures, the duration of transport, the departure and arrival time grids, the information availability and the security of transport. The progress of rail intermodality and of combined public transport infrastructures could lead to expect important possibilities of decoupling. But these opportunities are closely related to the efficiency of such infrastructures, since they are essential to improve the road-rail intermodality [14].

Awareness-raising tools

The analysis of the Italian context reveals that the enterprise management of employees' choices regarding home-work trips offers the opportunity to promote a more environmentally friendly mobility. It also allows to yield the potential for transport rationalization within the same company, to pursue environmental goals.

This intervention aims to the modal shift from car to more environmentally friendly public transport and also to realize reductions of individual motorized transport. So the "mobility management"[§§§§] must deal with the rationalization of the home-work trips. This type of management can provide useful results by reducing the circulating cars, increasing the load factor of transportation trough the planning and organization of employers mobility. According to the forecasts, an increase in trips on foot, by bicycle and mostly by public transport, should result in a reduction of approximately 15% of commuting by car [15]. Typically the expected benefits would be a better social health protection (reduction of transport-related PM_x and greater compliance with the noise laws) and an increase in road safety on home-work paths.

CONCLUSIONS

Economic growth requires efficient and effective transportation networks, but on the other hand the transport continues to have adverse effects on the environment, health and economy. Is the negative impact of transport on the environment an inevitable consequence of economic growth?

This paper presents an analysis of the relationship between transport demand and economic growth. It consists of a depth reflection on environmental and economic effects of a wide range of tools, which aim to decouple the impact of transport on the environment and economic growth. The study shows that it is possible to reach this goal by using taxes, regulations and road pricing in an efficient way, as well as other economic instruments.

[§§§§] In Italy mobility management is applied by the professional figure of "mobility manager", prescribed by the Ministry Decree on "Sustainable mobility in urban areas" of 1998.

These approaches can complete the regulatory measures to support a shift towards more environmentally friendly modes of transport (for example, a shift from road to different types of rail transport). The improvement of freights transport logistics is another factor which may contribute to decouple the impact of transport and economic growth. These different tools shoud be implemented, especially taking into account the situation and the peculiarities of each territory, since tools suited to a particular area may not be suitable for others.

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