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EFFECTIVE CO_2 REDUCTION POLICIES FOR PASSENGER CAR TRANSPORT BASED ON EVIDENCE FROM SELECTED OECD COUNTRIES[*]

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Abstract

The core objective of this paper is to analyze the impact of income, fuel prices and technical standards on on energy consumption and related CO_2 emissions of passenger cars. Of specific relevance in this context is the question to what extent cheaper service prices – due to lower fuel intensity – lead to more km driven and larger cars and, hence, increases in absolute terms fuel intensity again. The analyses focuses on EU-15 and to some extent comparisons are made including also USA and Japan.
The major conclusions of this analysis are: With respect to implementing effective portfolios of policy instruments it is important to complete efficiency procurements with tax policies for fuels as well as on car investment (to reduce kW of cars). The final conclusion is that only a combination of

(i) standards to reduce FI,
(ii) fuel taxes to curb vehicle kilometre (vkm) driven and
(iii) registration taxes to slow down the increase in the size of cars

will bring about significant reductions in energy consumption as well as related CO_2 emissions.

Keywords: policies, passenger transport, size-effect, CO_2 emissions

1. Introduction

Growth in transport is the biggest contributor to the increase in oil demand as well as greenhouse gas emissions in OECD countries (IEA, 2010). Passenger cars contribute to a large share to these increases. To cope with this problem increasing car efficiency and reducing CO_2 emissions per km driven (gCO_2/km) are important strategies in Europe, the USA, Japan and other OECD countries. In 2007 the EC adopted a comprehensive strategy for reduction of average CO_2 emissions from new cars to 120 gCO_2/km by 2012 - a reduction of around 25% from 2006 levels. However, already in 2010 it could be noticed, that this goal of reducing emissions of new cars was not likely to be achieved (EC, 2010). In Fig. 1 is shown the evolution of CO_2 emissions from new passenger cars by the European (ACEA), Japanese (JAMA) and Korean (KAMA) car manufacturer associations (adjusted for changes in the test cycle procedure) as well as European goals up to 2020, (EC, 2010).

In this paper we focus on the major impact parameters on energy consumption and related CO_2 emissions of cars and household light trucks/SUV in road passenger transport. The core objective of this paper is to analyze the impact of income, fuel prices and technical standards on CO_2 emissions of

[*] This paper is based on work done together with Lee Schipper, see e.g. Ajanovic/Schipper/Haas (2009).

passenger cars. Of specific relevance in this context is the question to what extent cheaper service prices – due to lower fuel intensity – lead to more km driven and larger cars and, hence, increases in absolute terms fuel intensity again. The analyses focuses on EU-15 and to some extent comparisons are made including also USA and Japan.

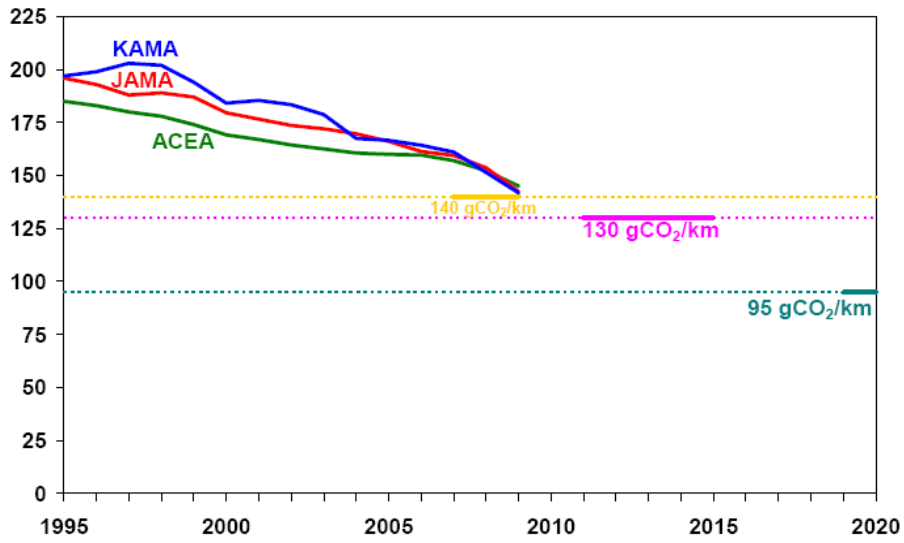

Figure 1. CO_2 emissions from new passenger cars by the European (ACEA), Japanese (JAMA) and Korean (KAMA) car manufacturer associations (adjusted for changes in test cycle procedure) (EC, 2010)

The method of approach is based on time series for fuel prices, intensities, income, vkm driven and size of cars. We compare the impact of different fuel prices on fuel intensity and analyze the effect of different sizes of cars. Most of the data used for European countries, USA and Japan are for the period from 1973 to 2010 or at least, 1980 to 2008.

2. Energy consumption, income and CO_2 emissions

Energy consumption for cars and household light trucks/SUV in passenger road transport per capita is continuously increasing, but the highest increase was in Japan and Italy in period 1980 – 2006. United States have more than three times higher energy consumption per capita than most of the European countries, see Fig. 2.

From the analyzed European countries the highest energy use per capita for cars is in Sweden and the lowest in Spain.

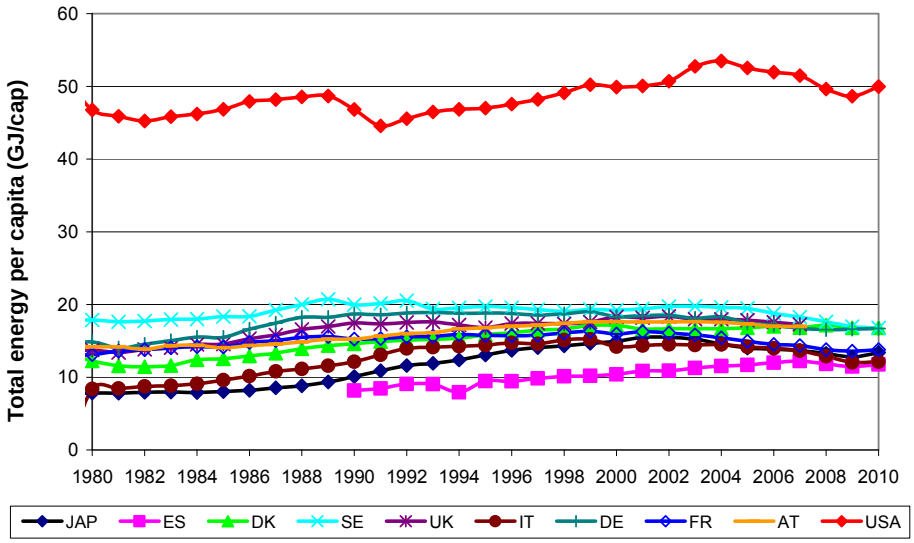

Figure 2. Development of energy use per capita for passenger cars and household light trucks/SUV

A major parameter that impacts vkm driven and straightforward CO_2 emissions is income. Fig. 3 shows how CO_2 emissions per capita for cars and household light trucks/SUV in passenger road transport are related to GDP per capita. It is obvious that with higher GDP per capita CO_2 emissions are growing yet at a rather moderate rate. However, United States has by far the highest CO_2 emissions per capita, more than twice as high than European countries and Japan.

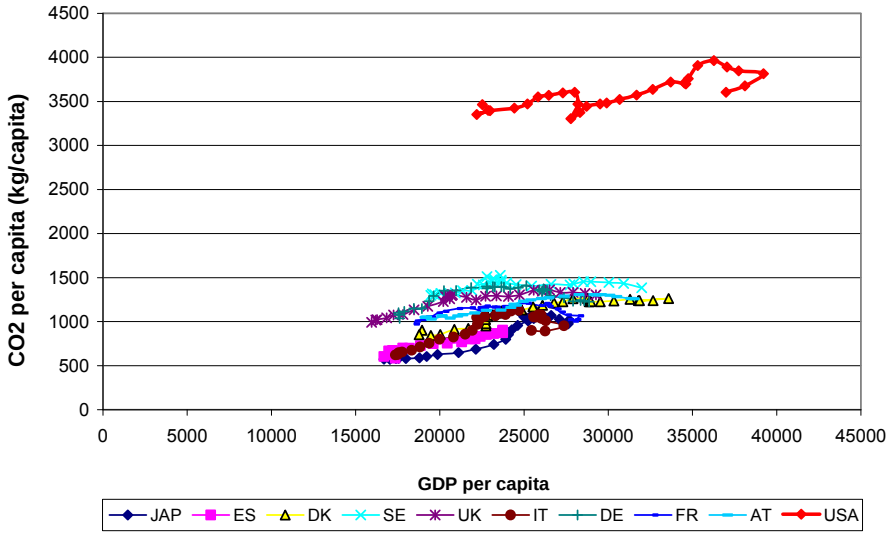

Figure 3. Energy use per capita for cars and household light trucks/SUV in road passenger transport versus GDP per capita

3. Fuel and service prices

Fuel prices may have a significant impact on travel demand and fuel intensity. The development of the costs of the service mobility for cars[1] in road passenger transport (fuel price*fuel intensity, or the cost of fuel for 1 km of travel) in US$ 2000 PPP/100 km is shown in Fig. 1. The range of service prices varies widely across the analyzed countries. Over time the lowest service price was in the United States and highest in Italy. Between 1985 and 1998 fuel prices as well as service prices have been slightly decreasing in real terms. After 1998 fuel prices increased significantly in many countries due to increases in world oil prices, as well as increases in fuel taxes mostly in European countries, as for example in Germany and United Kingdom. In the last years we can see high price volatility.

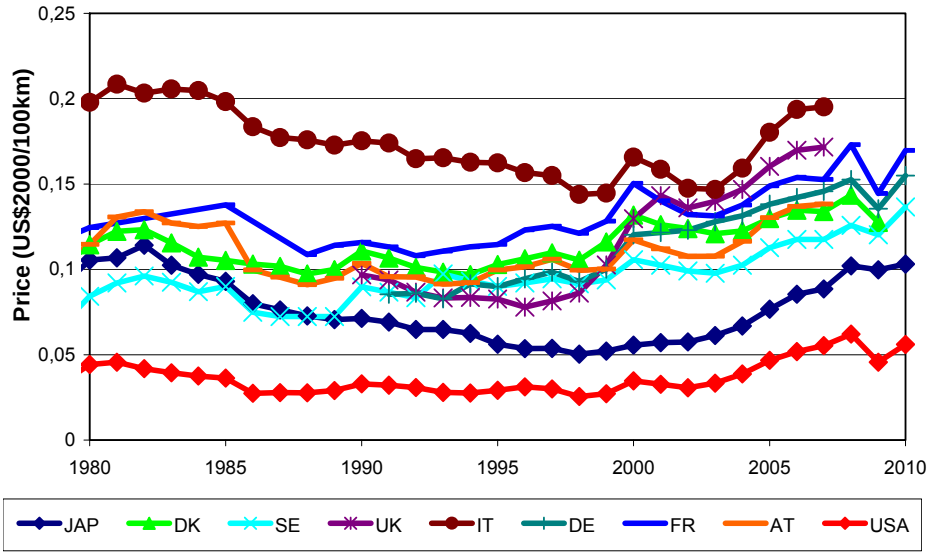

Figure 4. Price of service mobility for cars and household light trucks/SUV in road passenger transport (fuel price*fuel intensity) in US 2000$ PPP/100 km (including all taxes)

4. Fuel intensity

As shown in Fig. 5 since 1980 the average fuel intensity of stock of cars decreased in almost all countries.

Between 1980 and 1990 fuel intensity was rapidly decreasing, especially in United States, mostly due to the different fuel intensity improvements programs. But after 1986 oil price fell and by 1990, the rate of improvement in most countries had slowed, see Fig. 5.

In 2010 the fleets in the European countries analyzed have had on-road fuel intensity in the range of 6.0-9.3 liter per 100 kilometer, and non-European countries, Japan and United States, in the range of 10.5-11.4 liter per 100 kilometer.

[1] "Car" here refers to automobiles and light trucks, SUV or vans owned by private households and driven as automobile

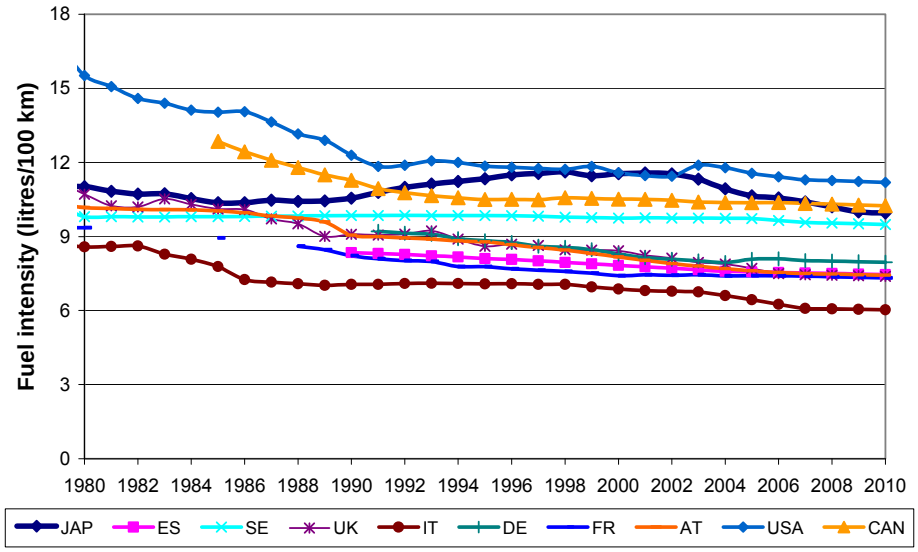

Figure 5. Average on road fuel intensity of stock of cars and household light truck fleet, gasoline equivalent (Diesel and LPG are converted to liters of gasoline at their energy content. 1 litre diesel = 1.12 litre gasoline)

The fuel intensity improvement of new cars in Europe between 1980 and 2010 according to tests, was in range of 18% - 30%. These improvements were mainly due to the voluntary agreements to improve fuel intensity, but currently agreements in Japan and Europe are expected to be both tighter and mandatory. The US passed new standards in late 2007 that would bring its fleet to an on road average of about 7.5 l/100 km by 2030-2035, about where Europe lay in 2006 (Schipper, 2008).

The lowest fuel intensity improvement took place in Japan, only 4%. On road and new vehicle test fuel intensity of cars rose in the 1990s as larger cars entered the stock. A boom in mini cars after 1998 led to improvements in new vehicle fuel economy and by 2002 the stock begin to improve significantly as well.

Note that for a harmonized comparison the average test new car fuel economy in the US to on road values requires multiplying the sales weighted test averages about 1.2-1.25, Japan by 1.33, and Europe by 1.12 (Schipper 2009 from various sources).

Summing up, the major fact is that important technical improvements have been made to engine and other cars components, but these have been mostly outweighed by heavier, larger and more powerful cars.

Fig. 6 shows a relatively clear correlation between higher fuel prices and lower fuel intensity. For example, the United States and Japan have highest fuel intensity and lowest fuel prices. Italy has high fuel prices and relative low fuel intensity.

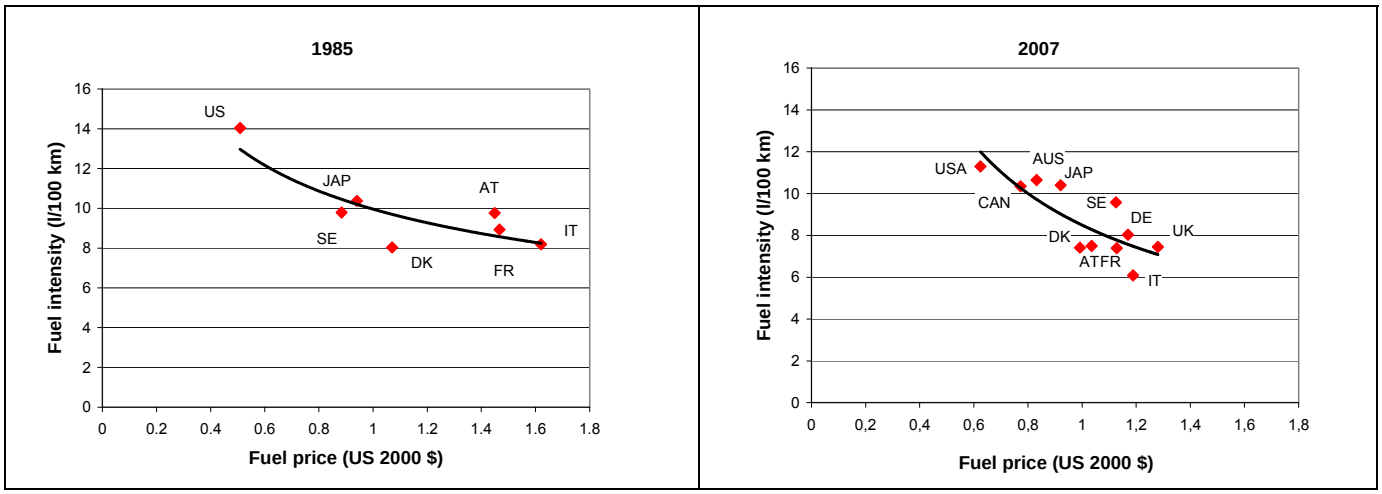

Figure 6. Car fuel intensity versus average fuel price, 1985 and 2005

The cost of diesel is included in the average fuel price according to its proportion of total fuel used in the years shown.

5. Travel activity

Overall travel activity is continuously increasing in all countries, but the range of vehicle kilometer driven per capita is very wide, between 4.500 and 13.500 vehicle kilometers per capita, see Fig. 7. Obviously, the United States is well above all other analyzed countries. High travel activity per capita reflects also high car ownership and utilization rates in United States

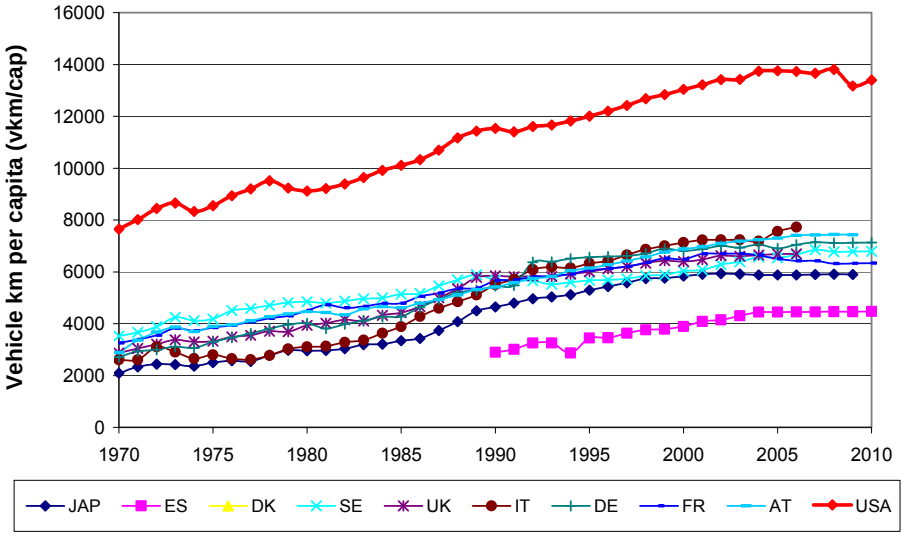

Figure 7. Development of vehicle kilometer per capita

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6. Increases in power of cars

A major reason why theoretical efficiency improvements have not been reflected by corresponding decreases in fuel intensity is the considerable increase in car size since the early 1990s. Fig. 8 depicts the average developments of power of cars (kW) for a sample of EU-countries investigated[2]. We can see that continuous increase took place in all countries until 2007 with Sweden leading followed by Germany and UK. Car power was lowest in Portugal, Italy and France. After 2007 average car power decreased or at least stagnated in all countries. It is especially of interest that the absolute increase was rather similar in most countries (except Sweden) – about 30 kW between 1990 and 2010.

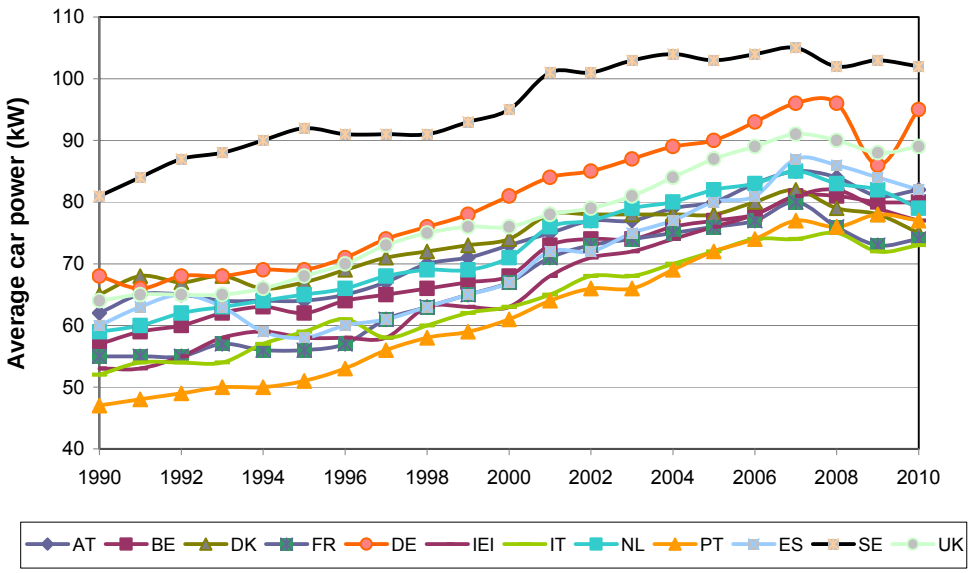

Figure 8. Average developments of car power (kW) of new cars in various EU-15 countries from 1990 to 2010 (Source: (EU-DB, 2009), (EC, 2007)). Note that vertical axis does not start at zero.

In the next Figures 8 and 9 we look at the effects of power on fuel intensities. Fig. 8 shows the development of fuel intensity, power-specific fuel intensity and power (kW) of stock of vehicles in EU-15 from 1990 to 2010. Fuel intensity (FI) in Fig. 8 and Fig. 9 does not reflect the real efficiency improvement because it is distorted by the switch to larger cars. To correct for this we define power-specific fuel intensity (FIP), see also Schipper (2008):

$$FIP = \frac{FI}{kW} \quad \text{(l/(km kW))} \qquad (1)$$

kW….vehicle power.

It can be seen clearly from Fig. 8 and Fig. 9 that the decrease in FIP from 1990 to 2010 was virtually twice as high as the decrease of FI.

[2] Note that all figures for 2010 used in this paper are still preliminary. Yet, to include the very interesting recent developments we have at least considered the so far existing data.

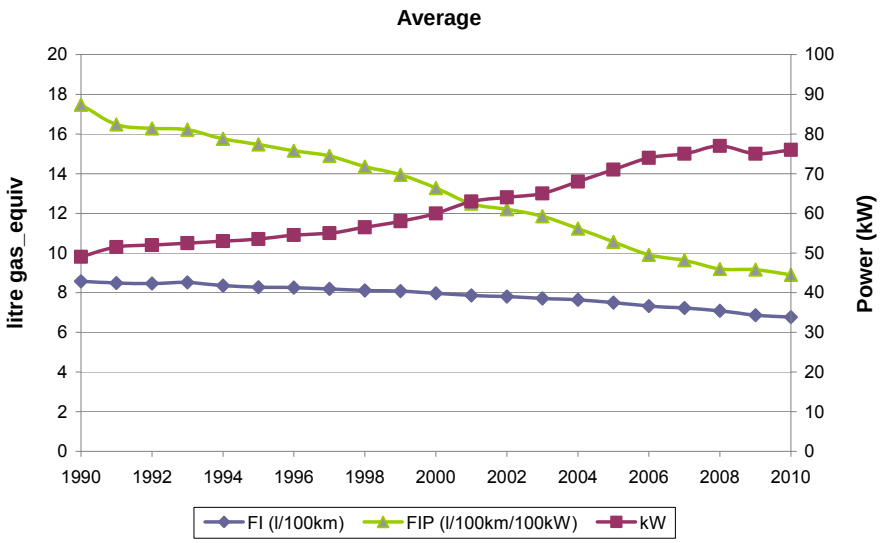

Figure 8. Development of fuel intensity, power-specific fuel intensity and power (kW) of stock of vehicles in EU-15 from 1990 to 2010

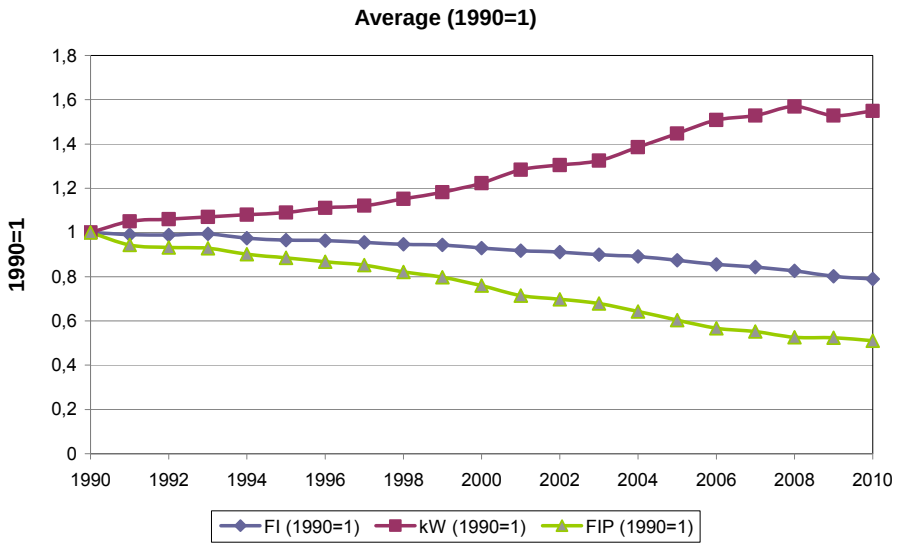

Figure 9. Normalised development (1990=1) of fuel intensity, power-specific fuel intensity and power (kW) of vehicle stock in EU-15 from 1990 to 2010

From Figures 8 and 9 we can clearly see that a major reason why theoretical efficiency improvements in EU-15 countries have not been reflected by corresponding decreases in FI are the remarkable increases in car sizes since the early 1990s.

7. The impact of the switch to diesel

Another reason why the expected benefits of standards were not realized was the continuous dieselization of the European car fleet. As Fig. 10 depicts in some EU countries (e.g. Austria, Belgium,

France, Spain, Luxemburg) the shares of diesel in purchasing new cars increased considerably and were since the early 2000s above 60%.

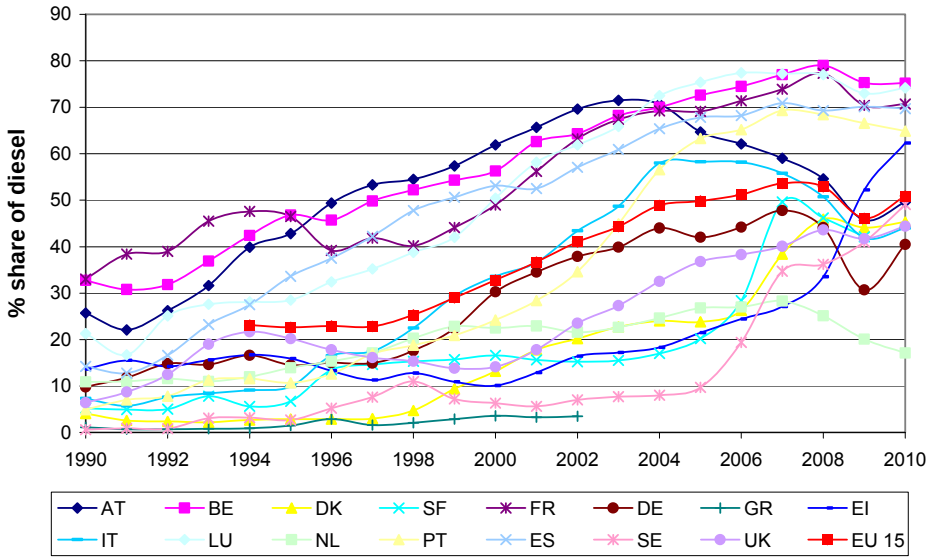

Figure 10. Increase in the share of diesel on stock of cars in some EU countries,1990-2010

Figures 11 and 12 show the development of fuel intensity, power-specific fuel intensity and power (kW) of stock of gasoline and diesel vehicles in EU-15 from 1990 to 2010. It can clearly be seen from these figures that the increase in power was higher and steeper for diesel cars than for gasoline cars. As a consequence the decrease in FI was much more flat for diesel than for gasoline vehicles.

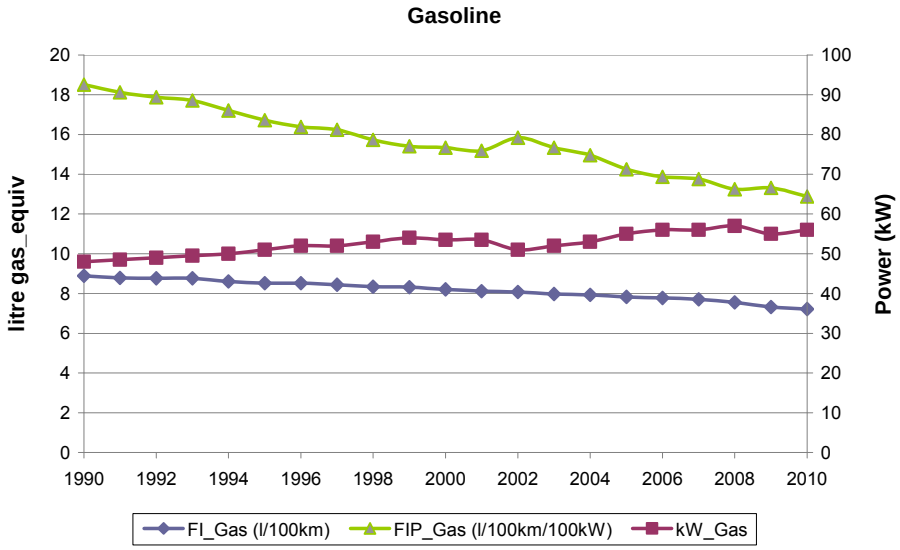

Fig. 11. Development of fuel intensity, power-specific fuel intensity and power (kW) of stock of gasoline vehicles in EU-15 from 1990 to 2010

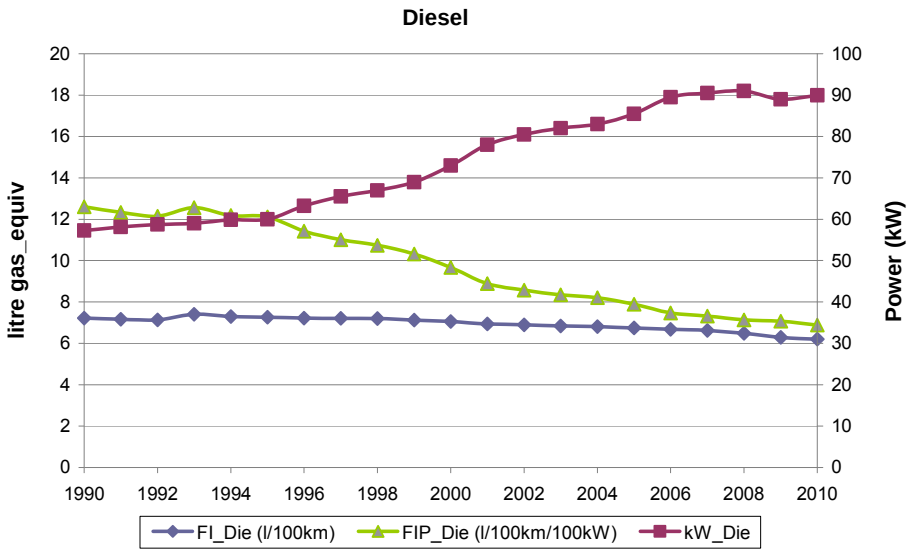

Fig. 12. Development of fuel intensity, power-specific fuel intensity and power (kW) of stock of diesel vehicles in EU-15 from 1990 to 2010

These effects led to the sobering perception that the expectations that diesel cars will contribute to reduction of CO_2 emissions were not fulfilled. Fig. 13 shows average CO_2 emissions from new passenger cars from new gasoline and diesel passenger cars in EU countries. Due to this figure by 2009 new gasoline and diesel cars had virtually the same emissions. The figure shows also European targets till 2020 regarding the reduction of CO_2 emissions from new passenger cars.

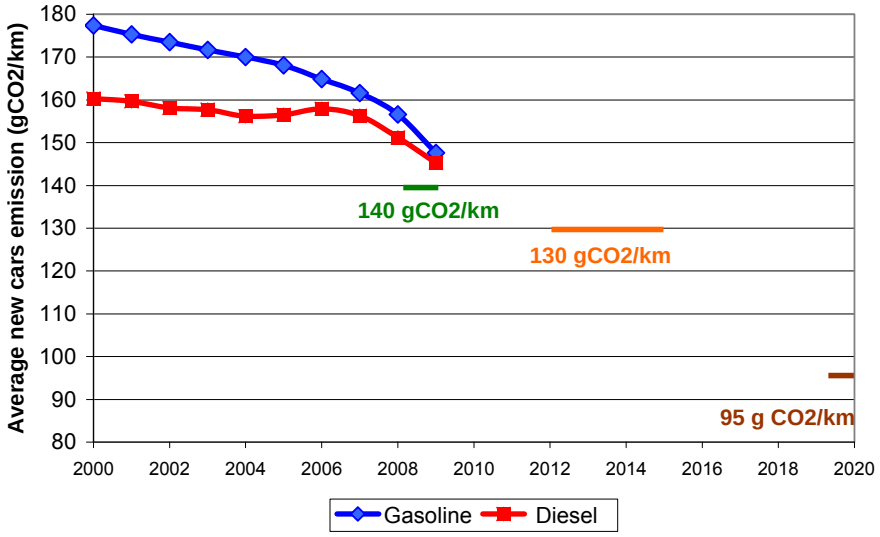

Figure 13. Targets and average CO_2 emissions from new passenger cars by fuel (EU27) (EC,2010)

So the phenomenon we face is that in terms of CO_2_equ new diesel cars emit about 17% less than gasoline cars by same size. Yet, the average new diesel car emits about the same amount of CO_2_equ emissions as the average new gasoline car because its much higher power in kW.

8. Efficiency versus price effect

So summing up the perceptions with respect to price and efficiency effects are as follows: the efficiency improvements achieved have been diluted to a large extent by driving more and by switch to bigger cars. From a cross-country comparison of prices and FI we can see that fuel prices are strongly correlated with fuel intensity. From other works we have derived service price elasticities of about (-0.4) (Ajanovic/Haas (2012)). This leads to the important perception that price has a significant direct and indirect impact on energy consumption and CO_2 emissions.
The rebound effect of driving more and bigger cars due to efficiency improvement can be compensated more or less, by the simultaneous introduction of a fuel tax, as shown in Fig. 14. In this case an additional tax – increasing the price Ps_1 to Ps_2 for the service km driven – would fully compensate the rebound and for the owner of a new car the service price would remain the same ($Ps_2 = Ps_0$).

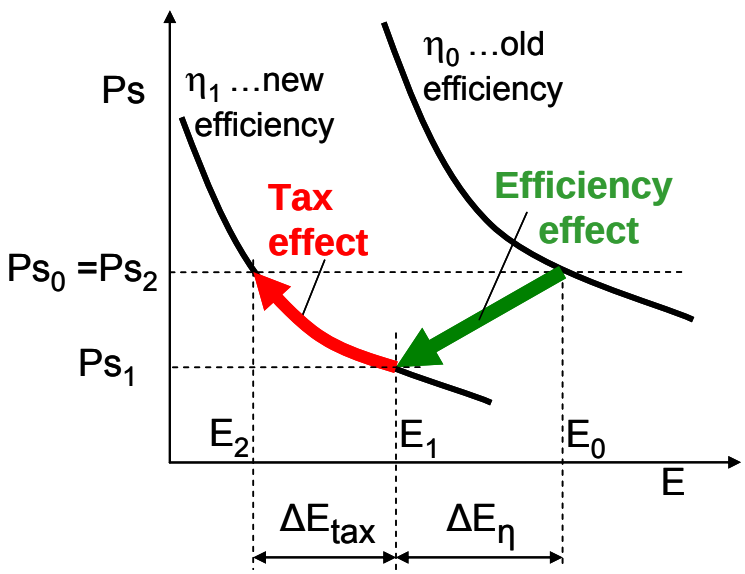

Figure 14. How taxes and standards interact and how they can be implemented in a combined optimal way for society

9. Conclusions

The major conclusions of this analysis are: Due to the CO_2 targets in the transport sector in OECD-countries, the efficiency of new cars is significantly improved. Yet, the major problem is that overall energy conservation effects focusing on efficiency improvements are offset to a considerable extent by increases in overall travel activity and a trend to larger vehicles.
Moreover, from a cross-country comparison we can see that fuel prices are strongly correlated with fuel intensity and in other works we have derived service price elasticities of about (-0.4). This leads to the important perception that price has a significant direct and indirect impact on energy consumption and CO_2 emissions.
With respect to implementing effective portfolios of policy instruments it is important to complete efficiency procurements with tax policies for fuels as well as on car investment (to reduce kW of cars).

The final conclusion is that only a combination of

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