The effects of CO_2-differentiated vehicle tax systems on car choice, CO_2 emissions and tax revenues

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Abstract

This paper assesses the impacts of a CO_2-differentiated tax policy designed to influence car purchasing trends towards lower CO_2 emitting vehicles in the Netherlands. Since 2009, gasoline and diesel cars up to 110 and 95 gram CO_2 per km are exempted from the vehicle registration tax (VRT). In addition, in 2010 a first step was implemented to change the VRT into a CO_2-differentiated tax. This paper provides an ex-post analysis of the first years of the tax change, tracking the change in purchasing trends arising from the measure related to CO_2-emissions, engine power, car weight, car size and segment and fuel type, and government revenues. The analysis shows that Dutch consumers are responsive to price incentives for low carbon cars.

1. Introduction

Carbon dioxide (CO_2) emissions from passenger car fuel consumption comprise the majority of greenhouse gas (GHG) emissions from transport. For example, in the Netherlands 50% of transport's GHG emissions is from passenger car use (PBL, 2011). Most countries and supra-national bodies like the EU want to reduce GHG emissions, not only for environmental reasons, but also for of reasons of securing the energy supply and concerns about increasing energy prices. In the recent EU White Paper on transport (EC, 2011a) one of the key goals is to abandon conventionally fuelled cars in cities by 2050. Many authors intensely debate over whether fuel economy standards and CO_2 standards are the more efficient policy instrument to raise fuel economy and reduce CO_2 emissions of cars as opposed to taxation (Parry, 2007; Clerides & Zachariadis, 2008).

The European directive 2009/443 (EC, 2009) sets emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles. The integrated approach does not only comprise emissions regulation through CO_2 standards for each car manufacturer, but also envisages demand-side measures such as fiscal incentives to promote the purchase of fuel-efficient cars. In 2005, the European Commission presented a proposal for a Directive that would require Member States to restructure and partially harmonize their passenger car taxation systems (EC, 2005). Although this proposal has never been adopted, in the meantime more than half of Member States have amended their car taxation schemes to promote the purchase of fuel-efficient cars (EC, 2010). Vehicle taxes used to be primarily based on pre-tax car prices, vehicle weight or engine size, whereas nowadays the vehicle registration tax (VRT), the annual motor tax (AMT) and the company car tax (CCT) are largely CO_2-differentiated.

CO_2-differentiated vehicle taxes directly influence the type of vehicle purchased and consequently indirectly influence the CO_2 emissions from cars. Ryan et al. (2009) analysed the impact of National fiscal measures on new passenger car sales and CO_2 emissions intensity in 15 Member States from 1995-2004. However, during this time frame voluntary technological improvements by car manufacturers and tax reforms in Member States were very limited resulting in a limited impact on CO_2-emission. Other authors show the impact of fiscal incentives to promote the adoption of specific fuel-efficient cars such as hybrid vehicles (Chandra et al., 2010; Gallagher & Muehlegger, 2011; De Haan et al., 2007; Mabit & Fosgerau, 2011).

Ó Gallachóir et al. (2009) and Rogan et al. (2011) show that CO_2-differentiated tax reforms in Ireland in 2008 had a large impact on new vehicle sales and average CO_2 emissions. The share of lower emitting cars in Ireland (i.e. <155 g/km comprising label bands A–C) increased from 44% to 78%, the share of diesel cars in new sales doubled from 28% to 56%, and the trends for individual fuels show a change towards smaller cars. Since diesel cars have on average a larger engine size than gasoline cars, the strong shift towards diesel-fuelled cars negated the trends in petrol and diesel cars towards smaller cars, thus resulting in an overall trend towards larger engine sizes. As a result of the changes in purchasing trends in Ireland, the weighted average CO_2-emissions fell from 161 gCO_2/km in the first half of 2008 (before the tax change) to 146 gCO_2/km in the first year after the tax change.

Like in Ireland also the Netherlands introduced several vehicle tax reforms since 2006. Registration taxes are gradually being transformed to become fully based on CO_2-emissions by 2013. This paper analyses ex post the impact of the first steps of the transition towards CO_2-differentiated car taxes in the Netherlands. Designing an effective and efficient CO_2-differentiated vehicle tax system requires a good understanding of various relationships and interactions such as consumer preferences with respect to different car attributes, car prices, technological improvements by car manufacturers, macro-economic factors, oil and fuel prices, and many more. This paper aims to add to this understanding. The analysis is based on observed trends in car registration data from 2005 to 2010. Furthermore, important requirements and considerations are explored and discussed in order to keep CO_2-differentiated car taxes fit-for-purpose up to 2015.

2. Policy background

Since 2006, the Netherlands has witnessed a wide introduction of various incentives to promote the purchase of highly fuel-efficient cars and discourage the purchase of less fuel-efficient cars. These policy instruments, such as fuel-efficiency label-based fees and rebates, gas-guzzler-like fees, CO_2-based tax exemptions, and company car tax rebates, have become very complex over the years. The frequency of amendments to the schemes, the different vehicle-environmental attributes, e.g. car weight, fuel type or CO_2-emissions, that were targeted, and finally the interaction and net effects of these schemes all contributed to the complexity of the system. Since 2009, tax reforms are being implemented to simplify the schemes and to become entirely based on CO_2-emissions.

In this paper we specifically focus on the impact of the two most comprehensive tax changes, being an exemption for VRT[1] and AMT[2] for cars up to a limit value for CO_2-emissions, and the transition of VRT to become fully based on CO_2-emissions instead of the pre-tax retail price of a car. The limit values for the VRT and AMT exemptions are 110 grams CO_2 per kilometre for gasoline cars and 95 grams CO_2 per kilometre for diesel cars. These CO_2-emissions values are based on the NEDC standardised test-cycle used for car type approval in Europe. The VRT exemption was introduced in 2009. The AMT exemption was gradually introduced starting with a 50% exemption in 2008 to 75% in 2009 and 100% in 2010. The VRT used to be based on a fixed percentage, being 45.2%, of the pre-tax retail price of a car. In 2010 a first step was introduced in the transition towards CO_2-differentiated VRT. The fixed percentage of the pre-tax retail price of a car was decreased to 27.4% in 2010 and will be annually decreased to arrive at 0% in 2013. As shown in Table 1, the new CO_2-differentiated VRT is based on four emissions bands and increasing tax rates per gram CO_2 in each emission band.

Table 1: New VRT emission bands and band size.

Emission band	**Band size (gram CO_2 per km): gasoline**	**Band size (gram CO_2 per km): diesel**	**Tax rate (€ per gram CO_2) in 2010**
VRT-free	< 111	< 96	0
Band 1	111 – 180	96 – 155	34
Band 2	181 – 270	156 – 232	126
Band 3	> 270	> 232	288

[1] In Dutch: BPM
[2] In Dutch: MRB

The following example of a diesel car with an emission value of 160 g CO_2/km and €20,000 pre-tax price shows how the VRT is calculated before and after the tax change. Before the tax change the VRT would be 45.2% of €20,000 which is equal to €9,040. After the tax change the VRT is based on 27.4% of €20,000 which is equal to €5,480 plus a CO_2-based component of the VRT, being (155-95)*€34 + (160-155)*€126 = 60*€34 + 5*€126 = €2,670 CO_2-based VRT. The new VRT is in total €5,480 + €2,670 = €8,150.

The focus of this paper is primarily on VRT since it makes up a relatively high share of the final retail price of a car in the Netherlands (on average about €5,000 to €7,000 per car, see section 4) compared to other countries. In addition, consumers are generally more responsive to price changes when purchasing a car as compared to the annually recurring car taxes (Geilenkirchen et al., 2009).

3. Changes in purchasing trends

This section shows a selection of purchasing trends from 2005 to 2010. The analysis is based on detailed data on new car sales by the Dutch Vehicle Registration Agency[3], which has been made available by the Dutch Ministry of Finance allowing the authors to assess car purchasing trends before and during the implementation of vehicle tax changes. Table 2 shows the evolution of the total new car sales volume. Annual car sales are historically between 450 and 550 thousand cars in the Netherlands. The drop in total car sales in 2009 is largely a result of the economic recession in that year. Sales recovered in 2010. The share of new diesel-versus-gasoline cars has also changed. The share of new diesel cars has dropped from almost 30% in 2007 to 20% in 2010. This is partly because hybrid gasoline vehicles became an attractive substitute for diesel cars as a company car. The share of diesel cars stabilised in 2010, because new models became available below the VRT-free limit value of 95 g CO_2 per km and captured a large market share, see also figure 7.

Table 2: New vehicle sales by fuel type, 2005-2010.

Annual new car sales	2005	2006	2007	2008	2009	2010
Gasoline (x1,000)	333	351	359	370	308	381
Diesel (x1,000)	122	129	143	123	77	96
Total (x1,000)	455	480	502	493	385	477
Gasoline share	73%	73%	72%	75%	80%	80%
Diesel share	27%	27%	28%	25%	20%	20%

[3] Dienst Wegverkeer, RDW.

Figure 1 shows the evolution of the engine power of new car sales by size/market segment[4]. The engine power is normalised with an index value equal to 100 in base year 2005. While the engine power remained equal to, or increased from 2005 in each individual segment, the total weighted average engine power decreased about 5%. This trend indicates that purchases have shifted between the car size classes.

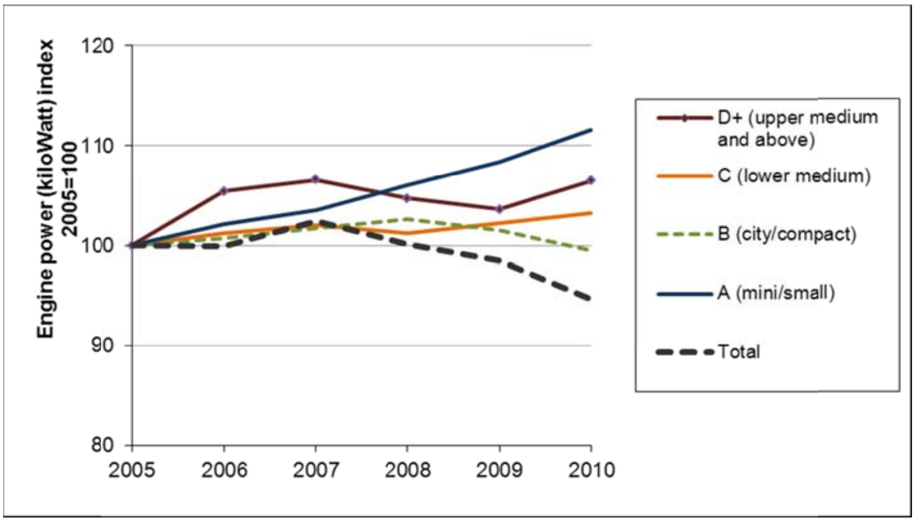

Fig.1: Engine power of new car sales by market segment, 2005-2010.

Figure 2 shows that the average vehicle weight in each segment remained constant from 2005, while the total weighted average vehicle weight decreased. This again indicates a shift in size classes towards smaller cars.

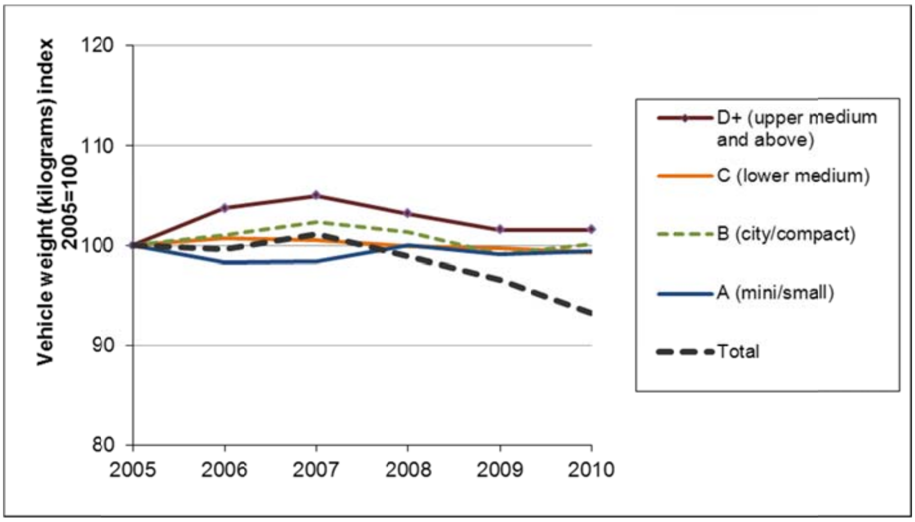

Fig.2: Vehicle weight of new car sales by market segment, 2005-2010.

The analysis of new car sales by size class confirms that the share of the C and D segments have decreased, while the share of A and B segments have grown substantially, see figure 3. During the period that VRT exemptions were introduced,

[4] The classification of size/market segments is based on the product of vehicles' Length and Width. In addition, a correction was made based on engine power to move small but expensive sports cars from segment A to D+.

the share of A and B segment cars has increased from 40% in 2008 to 50% in 2010. This growth of 10% share in two years is larger than the growth of 7% in three years between 2005 and 2008.

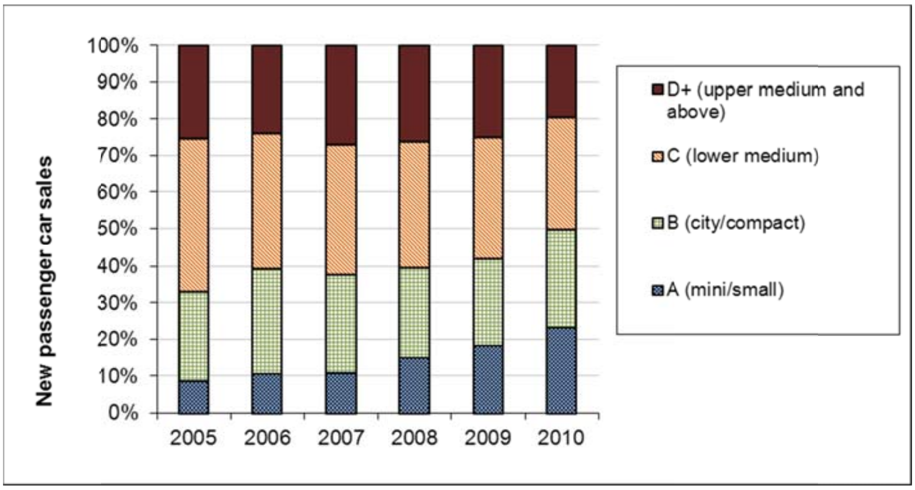

Fig.3: Market share of new car sales by market segment, 2005-2010.

As shown in figure 4, the average CO_2-emissions have decreased in each size class. The largest decrease is observed in the A and B segments. Due to the shift in size classes towards smaller cars, the total weighted average CO_2-emissions of all new car sales have decreased even more than observed in the individual size classes.

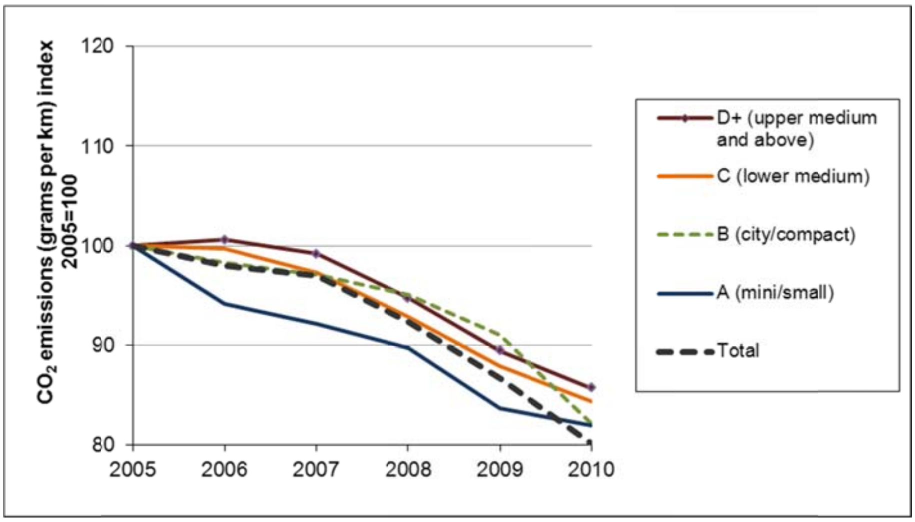

Fig.4: CO_2-emissions of new car sales by market segment, 2005-2010.

Although VRT exemptions were not introduced until 2009, figure 5 shows that cars within the VRT-free band have gradually grown to 23% of the total sales in 2010. One of the main reasons for this rapid growth is that on the one hand the emission bands are kept constant while on the other hand manufacturers have improved the emissions performance of their cars and consumers have on average chosen for smaller cars with lower emissions. In addition, also other factors may have contributed to this trend such as increasing fuel prices in the Netherlands.

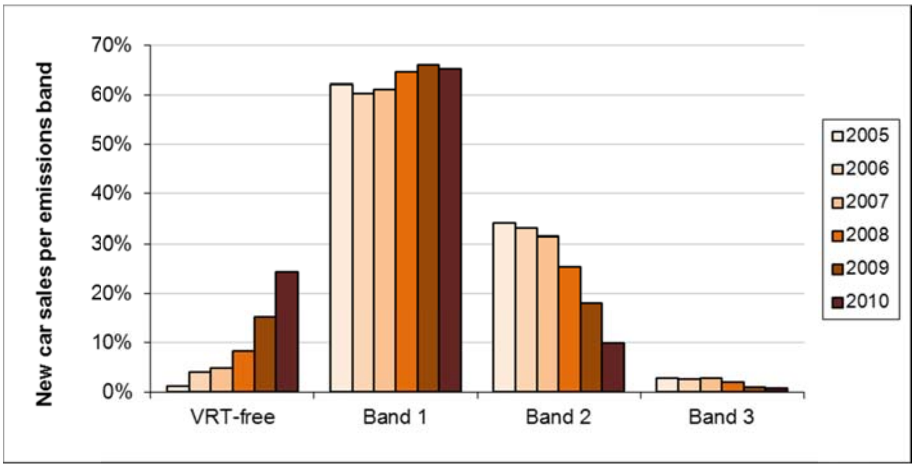

Fig.5: New car sales by VRT emissions band, 2005-2010.

The total number of cars in the VRT-free band was 115,000 in 2010. The majority of these cars were A-segment gasoline cars. The VRT exempted cars in the B segment comprised only diesel cars, whereas the cars in the C segment were only made up by hybrid gasoline cars. There were no VRT exempted cars in the D+ segment.

As shown in figures 6 and 7, fiscal incentives and car purchasing trends are strongly correlated. The solid vertical lines represent the limit values for the VRT emission bands. The most left limit value also corresponds to a limit value for a strongly reduced company car tax, being 14% of the car price instead of 25%. The dashed vertical line represents another limit value for a moderately reduced company car tax, being 20% instead of 25%.

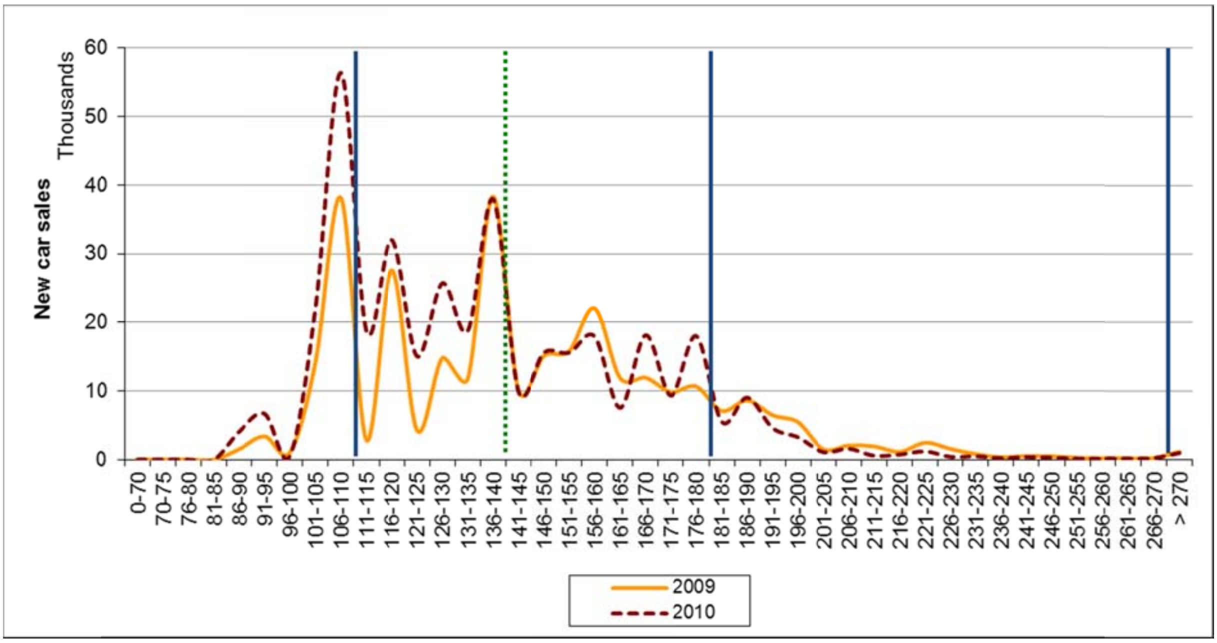

Fig.6: Distribution of new gasoline cars by CO_2-emissions (gram CO_2/km), 2009-2010.

There are two important mechanisms behind these purchasing trends. On the one hand people are encouraged to choose for more fuel efficient cars and benefit from substantial tax reliefs when purchasing a car below certain CO_2 values. On the other hand car manufacturers may purposefully introduce certain makes and models on the market which are just below certain CO_2 thresholds. For diesel cars it is clearly visible in figure 7 that in 2009 there were simply no diesel cars available below 96 gram CO_2 per km. Once these became available in 2010, they immediately captured a huge market share as they were free of the VRT and AMT.

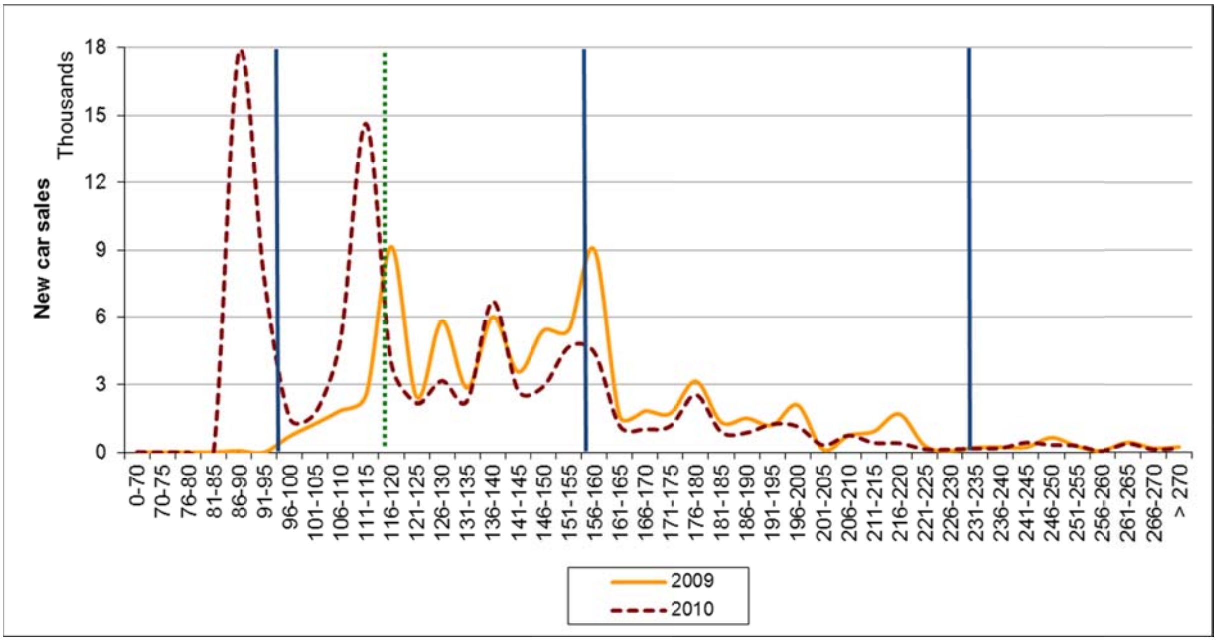

Fig.7: Distribution of new diesel cars by CO_2-emissions (gram CO_2/km), 2009-2010.

4. Impact on CO_2-emissions and tax revenues

The quantification of the isolated impact of either the tax reforms or autonomous technological improvements on car purchasing, CO_2-emissions and tax revenues, involved comparing what happened in the years after the tax change with a counterfactual baseline scenario. It was assumed that changes in the composition of car sales over the size segments and fuel types resulted from tax policy-induced changes in consumer choices. The improvements of CO_2-emissions performance within each size class and fuel type were considered to result from autonomous technological improvements by car manufacturers. The baseline scenario was constructed by taking the distribution of cars sold in 2007 as a baseline counterfactual for years in which the new fiscal polices were introduced. 2007 was chosen because the composition of the car sales was representative for pre-2007 years, it avoids distortions from the economic recession, and because the CO_2-differentiated tax reforms were not yet introduced nor announced. The distribution of base year 2007 was then linked to the actual CO_2 emissions by size segment and fuel type in 2010 to create the baseline counterfactual.

The results of this analysis, as shown in figure 8, indicate that had the composition of car sales over the size segments and fuel types not changed between 2007 and 2010, the annual reduction of the total weighted average CO_2-emissions of cars would not have been the observed 6.1% but 4.8% instead. Therefore we conclude that the impact of the CO_2-differentiated taxes have resulted in 1.3% additional reduction of CO_2-emissions over the autonomous technological improvement of 4.8% by manufacturers. Without the tax change, CO_2-emissions per km would not have dropped from 164 g/km in 2007 to 136 g/km in 2010, but instead they would have dropped only to 142 g/km in 2010.

This analysis does not take into account the effect of increasing fuel prices on the fuel efficiency of cars. Goodwin et al. (2003) found an elasticity between transport fuel prices and the efficiency of the use of fuel (by a combination of technical improvements to vehicles resulting from changes in car choices, and more fuel-conserving driving styles and driving in easier traffic conditions) of 0.15 within a year, and around 0.4 in the longer run. Gasoline and diesel retail prices increased from €1.36 and €1.02 per litre in January 2007 to €1.44 and €1.10 per litre in January 2010 (EC, 2011b). Taking the average fuel price increase of about 7% in the Netherlands combined with an elasticity of 0.15 for changes in purchasing trends toward more fuel-efficient cars results in an effect of 0.15*7% = 1.1% fuel-efficiency improvement and thus 1.1% lower weighted average CO_2-emissions from new cars in 2010. The before mentioned effects from technology (4,8%) and policy (1.3%) may in fact be overestimated when considering the fuel price effect of 1.1% which should be subtracted from these. The authors are currently preparing a more in-depth analysis of the effects for a journal paper.

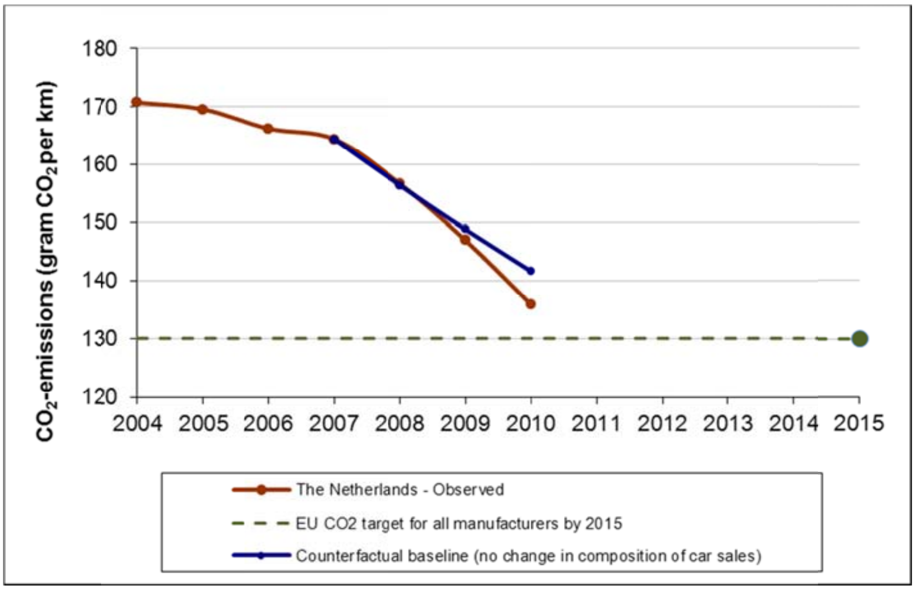

Fig.8: Impact of CO_2-differentiated taxes on average CO_2-emissions, 2007-2010.

The annual VRT government revenues used to be around € 3.0 to 3.5 billion. However, since the tax changes, as shown in figure 9, these revenues have decreased rapidly in 2009 and 2010. One of the reasons for lower revenues in 2009 is because the total number of new car sales was much lower, see table 2. Nevertheless, in 2010 when car sales recovered from the economic recession, revenues remained at a much lower level. As shown by the red line in figure 9, the average VRT per car has dropped from almost € 7,000 in 2007 to about € 5,000 in 2010. The lower VRT revenue per car is a result of the large proportion of cars, being 23% in 2010, that pay no VRT at all.

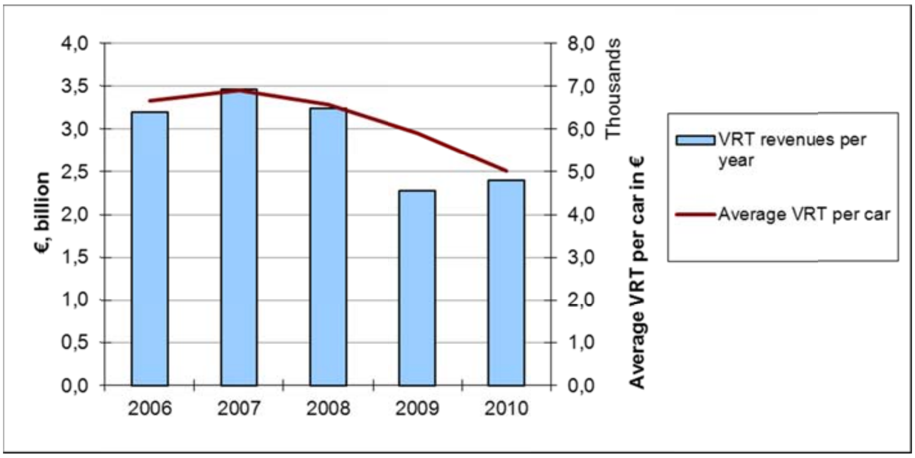

Fig.9: VRT revenues per car and total, 2006-2010.

Without the tax changes the revenue per car would have remained around € 7,000, but the total sales in 2010 would probably be lower than observed in 2010. Kok et al. (2011) has estimated that the tax changes have reduced the VRT revenues by about € 0.5 billion in 2010.

5. Conclusions and discussion

The ex-post analysis of the impact of the introduction of CO_2-differentiated car taxes in 2009 and 2010 shows that Dutch consumers are responsive to price incentives for low carbon cars. VRT-free cars in the small and compact segments A and B have witnessed an explosive growth reaching 50% market share of new car sales in 2010. Without the tax changes, weighted average CO_2-emissions of new cars would have fallen to 142 g CO_2/km in 2010 instead of the observed 136 g CO_2/km with the CO_2-differentiated car taxes. The tax changes have led to a significantly lower average VRT per car and consequently lower VRT revenues for the government.

The Dutch Ministry of Finance is currently considering new tax changes to be implemented between 2012 and 2015. One of the main concerns is that if the specification of the emission bands is kept constant to 2015, the majority of the new cars will likely fall into the VRT-free band. This way there will hardly remain an incentive to purchase the most fuel-efficient car. Analysis by Kok et al. (2011) shows that indeed according to the baseline scenario to 2015, about 62% of all new car sales will be VRT free by 2015 resulting in a dramatic government tax revenue shortfall. Based on a proposal by Kok et al., the Ministry has announced to gradually lower the CO_2-emission bands in such a way that the limit value for VRT-free car will be 82 g CO_2/km by 2015. Since by 2015 there will hardly be any environmental differences between gasoline and diesel cars due to Euro 6 standards, the existing difference in CO_2 bands for gasoline and diesel cars will gradually be reduced to become equal in 2015. The new proposal estimates a share of VRT-free cars of about 12% by 2015 and stable government tax revenues.

Whether or not the tax changes are justified from a cost-effectiveness perspective is not clear. The current analysis is based on test-values for CO_2-emissions. A correction for real world or on-road CO_2-emissions could radically change the cost-effectiveness, especially since cars with lower test-value CO_2-emissions have increasingly higher real world corrections for CO_2-values. This implicates a decreasing marginal cost-effectiveness of fiscal incentives for fuel-efficient. We recommend doing more research into the cost-effectiveness of fiscal incentives taking into account real world CO_2 correction factors.

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