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Abstract

The study concerns an assessment of the effectiveness of car purchase tax differentiation according to the CO_2-emission performance of newly sold cars as implemented in Finland. This policy instrument came into force as of 1 January 2008. The effectiveness of the instrument is assessed by means of decomposition of car sales by key features of cars and by estimation of impact relations between changes in the emission performance of newly sold cars and various explanatory variables, including the imputed tax differentiation based price differences

Key words: fuel efficiency, policy effectiveness, automobile tax reform, transport emissions

JEL classes: H23, H31, Q48, R48

Tiivistelmä

Tutkimuksessa arvioidaan vuoden 2008 autoverouudistusta, jossa vero porrastettiin hiilidioksidipäästöjen mukaan. Rekisteriaineiston avulla kartoitetaan autojen ominaisuuksien muutoksia vuosina 2006–2011 ja määritetään, miten nämä muutokset vaikuttivat uusien henkilöautojen keskimääräisiin hiilidioksidipäästöihin. Lisäksi esitetään arvio, kuinka voimakkaasti veroporrastus on vähentänyt uusien henkilöautojen hiilidioksidipäästöjä ajokilometriä kohden.

Asiasanat: polttoaineenkulutuksen tehokkuus, ohjauskeinojen vaikuttavuus, autoveron remontti, liikenteen päästöt

JEL-luokat: H23, H31, Q48, R48

Summary

As regards intensifying climate policy for the transport sector car purchase tax differentiation according to the emission level was the one of the few significant options left, which was not yet exploited and would not conflict with existing EU regulations. Finland introduced a reform of the car purchase tax at the beginning of 2008. It meant that taxes were no longer depending on the pre-tax price and/or the weight of the car, but only on the emissions per km as declared by the producer.

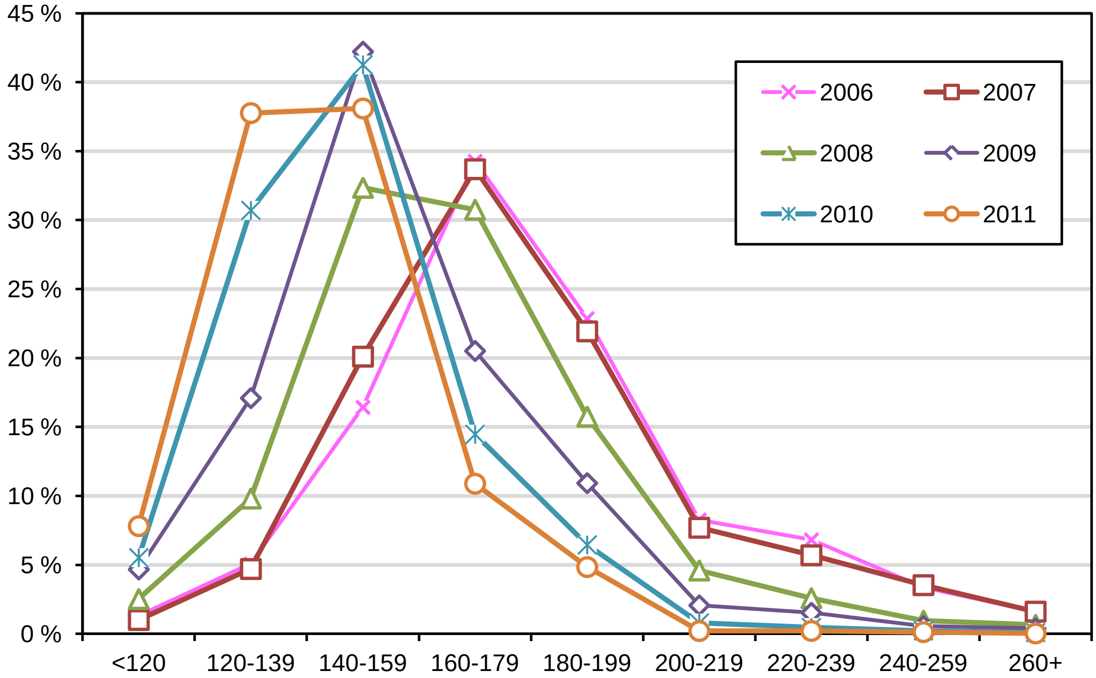
The effectiveness of the car purchase tax reform is assessed by means of decomposition of car sales by key features of cars and by estimation of impact relations between changes in the emission performance of newly sold cars and various explanatory variables, including the imputed tax differentiation based price differences. A copy of the complete motor vehicle registry was obtained from the Finnish Vehicle Administration (AKE, now Trafi), which contained micro level data about the characteristics of newly sold cars. To this data set information was added regarding monthly fuel prices, model specific price effects of the tax differentiation, inflation, wages, unemployment, and consumer confidence indicators.

The popularity of diesel cars was already increasing prior to the tax reform. Yet, in the first year of the reformed tax the reform seemed to have boosted the popularity, as fuel switch (from gasoline to diesel) was the easiest (and low cost) choice. Since 2009 however, the share of diesel cars shows some decline due to further evolution in the choices of buyers as well as due to further technical development of new cars on offer.

Apart from the fuel switch, newly sold cars tended to weigh somewhat less on average in 2008 and 2009 as compared to 2007. This is probably mainly due to the decline of sales of cars with very large engines (3000 cc and over). Indeed when comparing the average cylinder content of pre- and post-reform years a clear reduction is visible.

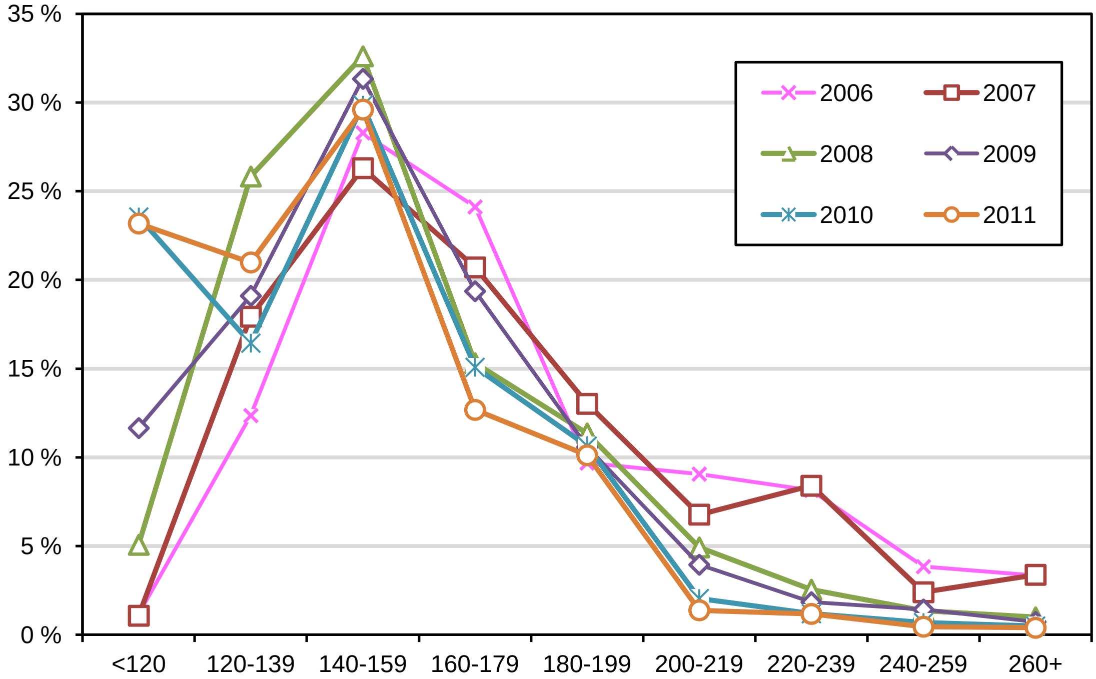
On average, gasoline cars did get smaller in 2008 and 2009 and had somewhat less engine power than in 2007. For gasoline cars this effect seemed to have been active across the various size categories and outfit levels. As a consequence the distribution of newly sold vehicles by emission level shows an overall shift to lower emissions per km. In 2006 the largest category was still 160–180 g/km. In 2008 the balance started to tilt in favor of the category 140–160 g/km, whereas in 2009 and 2010 this category had very obvious dominance. The figures for the first half of 2011 hint at a further shift making the category 120–140 g/km the largest one.

Figure S1. Changes in the distribution of emission performance of newly sold gasoline cars 2006–2011 (for 2011 up to 30.6)



For diesel cars the picture is similar as for gasoline cars, though less clear cut. The market segments of 200 g/km or more experienced a steady decline. The segment 180–199 g/km showed only modest decline, since a part of the buyers of large gasoline cars switched to buying a large diesel car. The segment (160–179 g/km) declined significantly, due to technical development and choices in favor of lower emissions per km, implying a shift to the next segment (140–159 g/km). The market segment for very low emissions (<120 g/km) grew spectacularly, showing a much larger boost than the intermediate segment of 120–139 g/km.

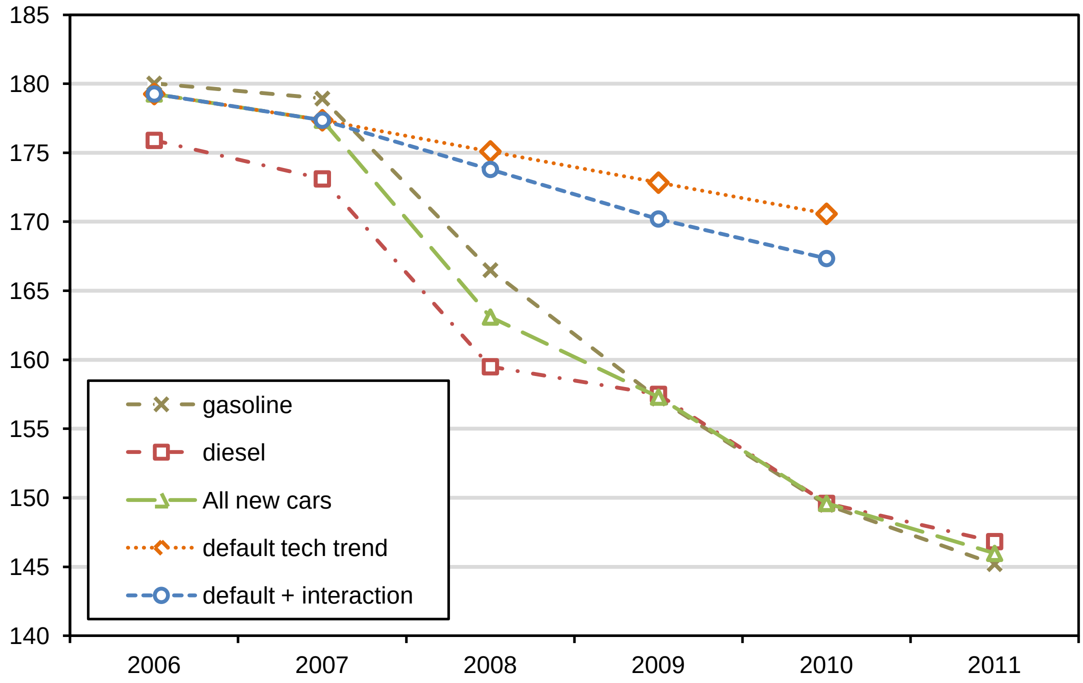
Figure S2. Changes in the distribution of emission performance of newly sold diesel cars 2006 – 2011 (for 2011 until 30.6)



The downward trend in emissions per km continues (figure S3). The average emissions per km of diesel and gasoline cars converged, with an indication that newly sold gasoline cars for the first time would have lower average emissions than diesel cars as of 2011. All in all the reduction in average emissions of new cars is truly substantial, going from almost 180 g/km in 2006 to just over 145 in 2011. The change is not just a single step event in 2008, but entails further dynamics in following years, with no signs of ending in the nearby future.

Figure S3 also provides an indication of the default (pre 2008) trend of emissions per km, which is related to technical changes in the models on offer. It indicates what would have been the average emission level of newly sold cars if no change in choices would have occurred. This trend in technological efficiency improvements reinforces somewhat in 2008 and 2009 as car suppliers in Finland adapted the model portfolio in response to the tax reform (and car makers increasingly came up with more low emission models in response to policies in many EU countries). As the actual trend in emissions shows a much stronger decline than the technical trend, other factors, such as the tax reform, must have played a role as well. From the statistical analysis can be inferred that the tax reform had and still has a statistically significant contribution to the reduction of the CO2 emissions per kilometer of newly purchased passenger cars.

Figure S3. Development of the CO_2 emissions per km for newly sold gasoline and diesel cars 2006 – 2011 (for 2011 up to 30.6)



Conclusions

The differentiation of the car purchase tax (registration tax) according to a new car's CO_2 emissions per vehicle kilometer appears to be a quite effective in terms of environmental goals as it significantly contributed to the realization of a steady reduction in emissions per kilometer of new vintages of cars compared to the default trend. For this conclusion the following observations and arguments can be brought forward:

- it has a very noticeable effect on the consumer's choice of passenger car models on offer in the sense that the choice tilts ever more towards cars with lower emissions per vehicle kilometer, whereas it also helps to raise the popularity of low emission cars;

- at the level of the overall annual new vintage of the stock the tax differentiation as implemented in the period 2008–2011 implies that 1000 euro induced priced reduction corresponds with a CO_2 emission reduction of about 7 g/km; changes in the set-up of the tax differentiation as well as significant changes in engine technology can considerably affect the responsiveness towards the differentiation and consequently parameter values would change as well;

- in addition to the effect of the car tax differentiation, the CO_2 emission per km of the average new sold car also decreases due to continued reduction of the CO_2 emission levels of car models on offer; the existence of the tax differentiation (and of comparable measures in many other EU Member countries) also reinforces the energy efficiency improvement among new car models;

- an increase in the price difference between diesel and gasoline supports a shift to cars with less CO_2 emission per km, but the significance of this effect may reduce over time (see next point);

- switching from gasoline to diesel is an important element in the buying responses, notably during the first year (2008); however, the convergence of the average emission levels of diesel and gasoline cars seems to diminish the significance of this effect;

- an increase in the share of leasing cars (or other forms of company cars) in total sales tends to raise the average emission intensity of new cars, whereas an increase in the share of rental cars has the opposite effect; it should be noted that these findings are dependent on the so far prevailing incentive structures and levels for these buyer groups; for example, company car buyers seem more inclined to purchase a low emission car than other buyers;

- the tax differentiation fits well in a long term strategy in which the passenger car stock is radically changing in terms of its technical features;

Even though effective from an environmental point of view, the chosen implementation of the tax differentiation was not particularly cost efficient for the government. The implementation in 2008 implied an equivalence point of the old and new tax structure at rather high specific emission levels, which resulted in a reduction of the car registration tax revenues. In 2008 as compared to 2007 the tax revenue per newly bought car went down by about 2400 Euro, as a consequence the emission reduction cost (per ton reduced CO_2 emission) are rather high from a public finance point of view, but entail low costs or even a net benefits for households. In the long run the reduction cost for the government are about 350~300 euro per ton CO_2, when the current incentive structure would prevail. A revision of the differentiation, e.g. such as is planned for 2012, could reduce the cost for the government. For the household sector a net average benefit of about 80 Euro per household would result, when considering a longer period (10 years).

Between 2006 and 2011 (June) the average emissions per km of newly sold cars went down from about 179 g/km to approximately 146 g/km. Of the realized reduction of approximately 33 g/km about 13 to 17 g/km seems attributable to the car purchase tax reform (in terms of car choice). Of the remainder at least 12 g/km is attributable to technological change (more efficient cars). A part of this is indirectly attributable to earlier European wide policy efforts regarding fuel efficiency of cars. Another 3 to 4 g/km is attributable to policy-technology interaction effects (supply portfolio adjustments).

Various aspects insert uncertainty to the outcomes or at least their interpretation. First, the import of used cars is rising since the introduction of the reformed car purchase tax. This constitutes a leak to the policy instrument of which the significance, persistence and drivers are not accurately known. Second, it is likely that the discrepancy between declared and actually achieved emissions per kilometer of new cars is increasing in Finland (and elsewhere). Based on preliminary explorations of data from the Netherlands there are indications that the discrepancy would have grown by about 5% and perhaps more. Applying the increased discrepancy to the assessed emission development would mean that the average CO_2 emission level per kilometer of new cars could be easily 5 grams higher (or even more) than what is currently assumed based on statistics.

Ongoing technical change necessitates a regular revision of the applied rates in the formula for establishing the car purchase tax. An unrevised scheme would gradually turn into a tax discount scheme, whereas its effect on choice making would diminish over time.

Contents

Annex 2 – Establishment of the car purchase tax and implied tax level changes for selected brands

Annex 3 – Emissions 2006 – 2009 based on model supply and car sales

Annex 4 – Estimation results

1. Introduction

Given the Finnish greenhouse gas emission reduction commitments for 2020 and the prospect of continued rigorous emission reductions in the next few decades also the transport sector has to realize significant emission reductions. About 90% of the domestic transport emissions come from road transport, of which emissions from passenger cars represent the largest share (60% of the emissions from road transport; TEM, 2008).

Large and lasting emission reductions in transport can be achieved by means of radical changes in the propulsion technology and fuel choice. The actual introduction of these innovations will be stepwise, whereas the market penetration of these innovations can be expected to reach only meaningful levels when embedded in institutional, economic and behavioral changes. Furthermore, as the market introduction of these innovations takes considerable time improvement of the fuel efficiency of cars using internal combustion engines will remain a key measure for at least the medium term (approx. 10~15 years). The prospect of getting the car stock much more fuel efficient in the short to medium turn and switching to radical innovations in the long run means that vehicle choice is becoming a significant policy variable for climate policy in the transport sector.

As regards short to medium term energy efficiency improvement it would seem obvious to raise fuel prices by means of taxation. In the Finnish case there are however various (political) limitations to this option. First, transport fuel taxes are already high, which implies that significant additional effects may be expected only when taxes are raised considerably (in absolute terms). In that case equity effects get significant, unless other taxes – such as on income – are reduced (e.g. Perrels et al 2001). Yet, even in that case various population segments, especially lower income groups in the countryside, may experience appreciably diminished access. Furthermore, the variability in oil prices weakens the incentive to buy more energy efficient cars (e.g. Greene 2011). Last but not least policy measures that are by themselves approximately tax revenue neutral have a certain advantage, in terms of policy maneuvering space, as compared to tax measures which require compensation elsewhere in the tax system in order to maintain purchasing power and preserve political support.

Tax revenue neutral policy instruments aiming at vehicle choice come mainly in three types, being (1) informational instruments such as environmental impact labeling of vehicles, (2) mandatory standards on maximum admissible vehicle emissions, and (3) tax differentiations (and closely related ‘feebates’), which favor low emission vehicles over high emission ones. In addition the granting of access privileges to low emission vehicles, such as reduced urban parking fees and lowered tariffs in road pricing systems, have gained some popularity in various countries (Pfaffenbichler and Emberger 2005) Yet, these alternatives are not necessarily tax revenue neutral. Of the aforementioned three tax neutral alternatives, option 1 can be combined with options 2 and 3 as a supportive measure, whereas options 2 and 3 are mutually exclusive. Furthermore, for all of these instruments it holds that there may be non-negligible administrative costs for the private and/or public sector depending on instrument design. It is fair to add that from a wider perspective tax neutrality is unlikely to survive without extra measures. In as far as any of these measures has noticeable impact they will reduce the tax revenue from transport fuel taxes. This could be repaired by raising the fuel tax such that the revenue loss is compensated.

Energy labeling schemes for passenger cars are already in operation within the framework of EU directive 1999/94/EC. For the entire EU voluntary agreements are in force with respect to target average emission levels of new passenger cars made by European, Japanese and South-Korean car makers. This means that country specific standards cannot be implemented. As regards informational instruments further developments would be possible, such as elaborated labeling schemes (as in the UK; UK ERC 2009), but their effectiveness remains somewhat controversial. One may therefore conclude that tax differentiation was the only option left, which was not yet exploited and would not conflict with existing EU regulations.

The present study concerns an assessment of the effectiveness of car purchase tax differentiation according to the emission performance of newly sold cars as implemented in Finland. This policy instrument came into force as of 1 January 2008. The effectiveness of the instrument is assessed by means of decomposition of car sales by key features of cars and by estimation of impact relations between changes in the emission performance of newly sold cars and various explanatory variables, including the imputed tax differentiation based price differences. A copy of the complete motor vehicle registry (situation as of 30.6.2009) was obtained from the Finnish Vehicle Administration (AKE, now Trafi[1]), which contained micro level data about the characteristics of newly sold cars. To this data set information was added regarding monthly fuel prices, model specific price effects of the tax differentiation, inflation, wages, unemployment, and consumer confidence indicators.

The report first provides a discussion in chapter 2 of experiences with the relevant policy instruments. Subsequently, a discussion of vehicle choice and stock renewal modeling is presented in chapter 3. In chapter 4 first some key statistics regarding car ownership and fuel efficiency are presented, subsequently

[1] Until 31-12-2009 the Finnish Vehicle Administration (abbreviated as AKE) was a separate agency operating under the Ministry of Transport and Communication. As of 1-1-2010 there is one integrated agency for all means of transport (ships, airplanes, road vehicles), the agency's abbreviation is Trafi.

a condensed overview of changes in car choice since 2007 is presented. Chapter 5 deals with the econometric estimation of the relation between the average emission level of newly sold cars and tax induced price differentials together with various other factors. Chapter 6 summarizes the conclusions.

2. Experiences with other instruments

2.1 Introduction

Even though in the introductory chapter was explained why the reform of the car registration tax was a plausible step, it is good to realize what the experience with other instruments has been and what has been the experience with comparable differentiation initiatives in other countries. This chapter presents a brief overview.

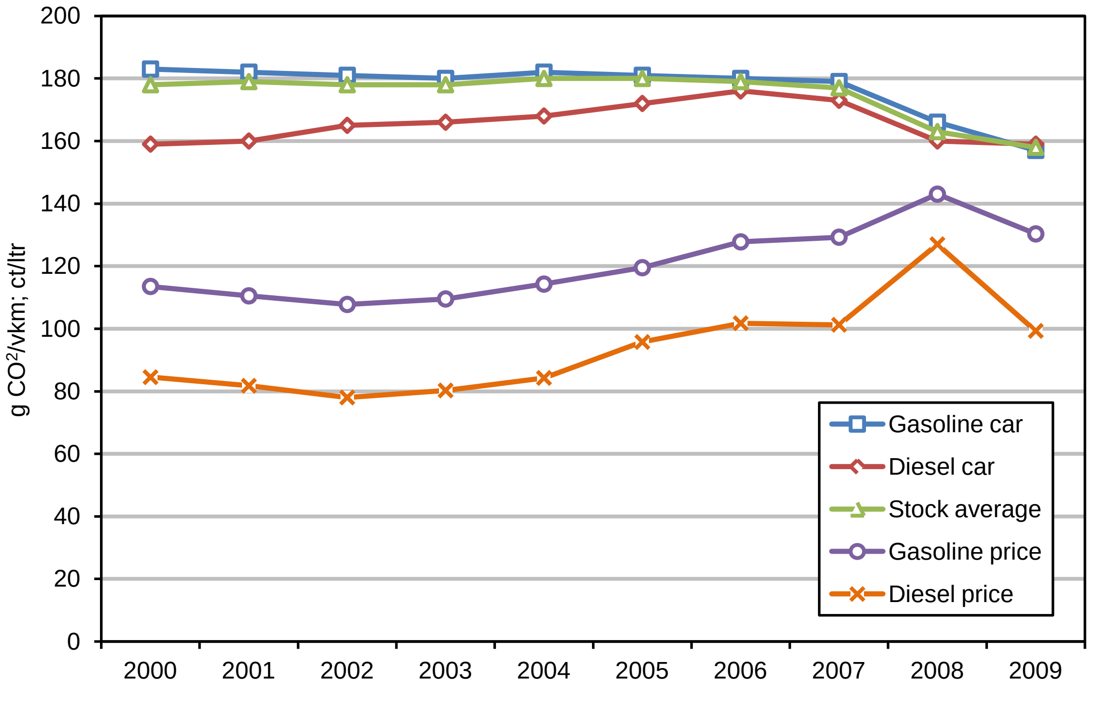
2.2 Transport fuel taxes

Arguably the taxation of automobile fuels seems a more straightforward approach for promoting fuel efficiency than fiscal incentive structures promoting purchase of fuel efficient cars. At least theoretically fuel taxation should also be more efficient than differentiating car purchase taxes by fuel efficiency (e.g. Sallee 2010). Countries with higher transport fuel taxes typically have fleets with higher average fuel efficiency (Schipper 2011). On the other hand there are indications that fuel taxation has in practice limits regarding its maneuvering space (Hammar et al 2004). Schipper (2011) hints also at the point that with increasing fuel efficiency it gets ever harder to drive up efficiency further by fuel taxation alone, as in the overall trip price for a consumer the fuel cost matter less and less. Hamar et al (2004) illustrate that fiscal regimes have an internal structural logic which also has to account for (as much as possible) keeping up purchasing power. The high positive value of the income elasticity with respect to car purchase and use (+1 and over, e.g. Storchmann, 2005) compensates to a great extent for price increases, which implies that only systematic recurrent fuel tax increases would gain more significant lasting effect. Yet, in smaller countries, like the Benelux, fuel price increases, which clearly outpace fuel price developments in neighboring countries, start create border effects. On the other hand in larger countries, like Finland or France, the marginalization effects of expensive transport fuel for countryside inhabitants often implies a political obstacle to precipitated increases in transport fuel taxes. Last but not least in countries with a significant car industry, like Germany, there are pressures towards moderation of fuel taxes, notably if the industry focuses on up-market cars. Similarly, for countries like Italy with an industry emphasizing small cars the opposite constellation can be found (Hammar et al, 2004).

With the above observations in mind the trends in fuel prices and fuel efficiency in Finland is reviewed. Between 2000 and 2007 average emissions per kilometer of newly sold cars in Finland hardly changed (fig. 2.1). As regards gasoline cars a slight reduction is visible, but apparently the average new diesel car got larger or at least got more engine power year by year, while at the same time the share of diesel cars in overall sales increased. As the number of second and third cars in households increased disproportionally, the average annual transport performance of passenger cars went down, even though current statistics cannot give a very precise answer on this (Mäkelä et al, 2008).

During the period 2000 – 2009 taxation of transport fuels barely changed in terms of percentage of the pre-tax price[2]. Observed changes in fuel prices are due to variations in market prices of crude oil and oil products. For the period 2002 – 2007 people were apparently buying equally efficient or even less fuel efficient cars than before, despite fairly steady fuel price rises (fuel prices show some fluctuation within a year). During the period 2000-2009 purchasing power has been steadily increasing. Probably the income effect on demand for (larger) cars outstripped counter effects of fuel price rises. Total car sales also did not seem to have been significantly affected by fuel prices. Car sales experienced a dip during 2001 and 2002 in association with the collapse of the IT bubble, but rebounded by and large to the late 1990s level between 2003 and 2008 (see Ch.3 figures 3.1 and 3.2).

Figure 2.1 Emissions per vehicle kilometer of newly sold cars for the period 2000–2009/6. source: AKE (now Trafi) and Statistics Finland



All in all it is highly unlikely that the reduction in emissions per km of newly sold cars in 2008 would have been caused mainly by the fuel price rises (which were occurring in the first part of 2008). Yet, the fuel price rises can still have

[2] Statistic Finland (2010) – Energy Statistics – Consumer prices of liquid fuels

had some moderating effect and possibly contributed to the gradual shift to diesel before 2008 and a more pronounced shift in 2008 (see chapters 4 & 5).

The total emissions of the passenger car fleet went down somewhat in 2008 and 2009 (Table 2.1). Yet, this was primarily attributable to a reduction in total transport performance (kilometers driven), whereas the figures are somewhat uncertain due to deficiencies in the statistic observations (Mäkelä et al, 2008). As regards the acquisition of energy efficient cars, it is as yet unsure what their eventual contribution is, among others because it is unsure whether the use of these cars shows signs of a significant rebound effect[3]. Within the framework of the KUILU project (Nissinen et al, 2012) an order of magnitude of 0.045 million ton reduction per year was estimated.

Table 2.1 Calculated total CO_2 emissions of the passenger car fleet from 2000 to 2010 (10^6 ton) source: VTT LIPASTO

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010*
6.35	6.49	6.68	6.81	6.98	7.06	7.10	7.28	7.11	6.91	6.98

*) preliminary figure

The above statements about the problematic identification of effects of fuel taxation on fuel efficiency need to be moderated to some extent. Obviously, countries with structurally low fuel taxes such the USA, and within the EU Germany, tend to have car fleets with larger cars (with higher CO_2 emissions per km; Schipper 2011). Yet, this is typically the result of a long term development in which the supply portfolio of the industry is tuned to the fiscal regime and the purchasing power of the consumers. Once such a structural trend is established it takes rather extreme measures (such as the adoption of high car tax rates in Denmark in the early eighties) to achieve changes. Furthermore, there is a risk that households respond by reducing the frequency of renewal of their cars rather than adapting to smaller cars, as has been observed in Denmark and Greece (Schipper 2011). To this can be added that if a single country, without a significant own car industry, is changing its fiscal treatments of cars, the impact on the portfolio of cars on offer is negligible. Car makers will only change the

[3] The rebound effect refers to the effect that energy efficiency improvement lowers the price of the eventual energy service (i.e. energy use per kilometer driven), provided other cost per km remained unchanged. Highly fuel efficient cars may incite their owners to drive somewhat more. The rebound effect can also refer to a more general reallocation of the financial savings caused by lower fuel cost. Other (extra) household purchases will also lead to an increase in (industrial) energy consumption. Nässen and Holmberg (2009) report a direct rebound effect on kilometers driven of 20% to 30% and a total rebound effect of 10% to 50% depending on the type and cost of change in car choice.

supply portfolio if a sufficiently large part of their markets is under similar pressures (such as happened in the past few years in the EU).

All in all fuel tax increases have a short term effect via behavior (less car kilometers, less speeding), whereas in principle their long term effect can even be larger by adding effects of car choice. The estimation results in chapter 5 hint in the same direction. Yet, with rising incomes the potentially significant long term effect of price rises can get overshadowed by the usually forceful income effect which works in the opposite direction (Storchmann, 2005), as was already mentioned at the beginning of section 2.2.

Another limitation to substantially raising transport fuel taxes relates to the fact that diesel fuel is also used for goods transportation. Hefty increases in diesel taxes would create difficulties for the road haulage sector, whereas it is practically impossible to distinguish between diesel sales by type of user. If only gasoline taxes would be raised substantially, most private car owners would start to switch to a diesel car, which in turn would create problems in the refinery sector due to technical limitations in the division between light and heavy fractions. To remedy the threat of a massive switch to diesel purchase taxes of diesel cars could be increased, but that would result in a reduction in the renewal rate of the car stock.

All in all it seems that, even though fuel taxes rate quite well from the point of view of fiscal efficiency (Gross et al, 2009), there is only limited leeway for a steady increase of transport fuel taxes, with mild (annual) increments. In the medium to long term (after 2020) more radical revisions may be inescapable, e.g. due to emergence of an electric and grid rechargeable hybrid car fleet.

2.3 Labeling, feedback and monitoring

In the past few years also energy labeling of cars was introduced in the EU, similar to the labeling which is in force for domestic appliances. The effectiveness and efficiency of this instrument for car purchases is as yet not very clear (Gross et al, 2009). The responses in the most recent survey on environmental friendly car mobility (Karetie, 2009) would hint at a rather marginal effect of this type of information, at least on Finland. On the other hand it is known from earlier review studies on energy labeling of white goods, that adequate schooling of sales personnel can make quite a difference (OECD, 2002). Indeed from the above cited survey (Karetie op cit) can also be inferred that quite some car buyers would like more and/or clearer information on fuel efficiency and emissions when they are actively looking for new cars.

In recent years a resurgence in (automated) monitoring and feedback systems is occurring, often via dedicated internet services, but for cars also by means of in-vehicle-systems, as well as via fleet management systems[4]. The cost effectiveness of the more straightforward in-vehicle options is quite good (ECMT, 2007). The expectation is that these systems will have a favorable effect mostly via driving style and route choice, but also via mode choice (selective car use) and indirectly to some extent on vehicle choice as buyers are better informed. The monitoring systems may also enhance the effect of fuel taxation as car owners get clear and regular feedback on fuel cost in relation to transport performance.

Feedback and monitoring systems are typical private initiatives and consequently the role of the public sector is in that case not so much through regulation and more via demonstration projects and public procurement. Publicly supported eco-driving information sites could step up their activity and offer more options for tailoring information to the needs and attitudes of the consumer.

In recent years there emerged some literature on tradable emission rights for road transport and a closely related so-called white certificate system for tradable energy efficiency certificates (e.g. Raux, 2010; Perrels, 2010). Overall, most authors tend to be skeptical due to the high transaction cost. Such a system may be more useful and effective in the trucking sector rather than for passenger cars.

2.4 Incentives aimed at producers – emission standards

In the USA and Canada fuel efficiency standards (CAFE – Company Average Fuel Efficiency) have been applied instead of introducing transport fuel taxation. This means that car makers should ensure that the average fuel efficiency (typically indicates as 'miles per gallon') of their total annual sales meets the target (or is even better). In addition tax credits have been applied for assisting market introduction and uptake of new green technology vehicles (e.g. hybrid and electric cars).

Fuel efficiency standards are generally regarded as a less efficient policy option (Anderson et al 2011). Reasons for the reduced effectiveness are among others the inherent rigidities and gradual erosion of the effect due to sluggish update of the norm.

For the EU as a whole the agreements with European (ACEA), Korean (KAMA) and Japanese (JAMA) car makers provide a common (soft) target for emissions per kilometer from new passenger cars. The original agreement (1998) aimed to

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[4] E.g. mandatory for public services in Canada http://www.tbs-sct.gc.ca/mm-gm/doc/gfm-ggpa/c1-04-eng.aspx (visited 12-10-2011)

reduce average CO_2 emissions from new cars to 140 g/km by 2008/2009. By 2005 it became clear that the goal would most probably not be achieved. The revised agreement (2009) has a mandatory character and aims at 130 g/km by 2015 for newly sold cars and an outlook to 95 g/km by 2015.

Another common European policy instrument is the mandatory energy labeling scheme for energy consuming products, including cars (Directive 2010/30/EU[5]). It is also implemented in Finland, where the label also provides financial information regarding expected annual fuel consumption assuming the average Finnish transport performance of 18000 km per car (European Parliament 2010).The effectiveness of the label with regard to car choice is not rigorously assessed, but is generally perceived as rather limited.

2.5 Incentives for vehicle choice in other countries

Denmark and the Netherlands have earlier applied car purchase taxes (also called 'registration tax') differentiated by emission levels. In both countries the schemes were reported to be effective, but were withdrawn for other reasons (Gross et al, 2009).

More recently Portugal, the Netherlands, and Spain introduced registration taxes in which emission intensity has a large impact on the eventual tax level. In the UK the annual circulation tax (vehicle excise duty) is related to CO_2 emission levels. Its impact on emission reduction is estimated to be rather modest (Gross et al, 2009).

Giblin and McNabola (2009) report on an ex-ante evaluation of the Irish car tax differentiation (introduced in 2008), in which both the registration tax (purchase tax) and the annual circulation tax are reformulated such as to make them dependent on the CO_2 emissions per kilometer of the car. They apply a slightly modified version of the COWI model (COWI 2002). The effect of the differentiation of the registration tax on the average emissions for new cars is estimated at approx. -2.7 g/km for gasoline and -2.3g/km for diesel cars, whereas the market share of gasoline would drop by 2%, favoring the share of diesel by the same amount.

In 2009 Germany has employed a scrapping premium to precipitate the renewal of the car fleet in conjunction with choosing a more fuel efficient (and often smaller) car. Assessment of the preliminary results suggests indeed an increased share of fuel efficient / smaller cars (Bastard, 2010). However, this effect may be followed by a slowdown in the next few years. An assessment of this measure by

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[5] See http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32010L0030%20:EN:NOT

the European Central Bank (2009) shed indeed quite some doubts on the fiscal efficiency of this measure, even in a country with a significant car industry.

Germany introduced in 2010 a new car registration tax which emphasizes low emissions per km driven (Bastard, 2010). It includes further tightening in upcoming years.

Obviously Finland is not alone in its changes in the vehicle registration tax. The varied evidence available from other countries hints at a rather favorable judgment of car purchase tax differentiated by emission per vehicle kilometer. However, depending on the eventual effect on tax revenues the cost effectiveness of the measure may be worse than expected. This depends very much on how exactly the differentiation is implemented. In Finland the implementation entailed de facto also a decrease of the (resulting) average car registration tax rate and consequently tax revenues clearly went down (see also Ch.5).

3. Vehicle choice and stock renewal

3.1 Car choice modeling

3.1.1 Findings of various empirical studies

The purchase of durable (and more expensive) consumer goods continues to be a contentious research area in economics. As regards the theme of this study, it is even more challenging, since not the binomial choice ‘buy or not’, but the much more fuzzy question ‘what model to buy’ is the issue (multinomial models). In this respect it is also important to realize that this choice is not only a function of the requirements and capabilities of the buyer, but also of the attribute combinations on offer on the car market.

For car choice modeling most common are micro-level approaches, i.e. explaining choices in favor of particular characteristic(s) in relation to characteristics of the buyer and his/her living environment (e.g. age, disposable income, household composition, and observed/expected annual mileage) and possibly also of the general economic and political environment (e.g. fuel prices, policy implementation dummies). Examples of this approach, often employing some form of discrete choice models, can be found in Fang (2008) and Bhat et al (2009). Both Fang and Bhat et al combine projected mileage with vehicle choice in a multistage discrete choice system.

Even though multinomial logit models face difficulties regarding adequate estimation a rising number of applications for the car market can be found[6]. The problem is that the data-set preferably contains sufficient attributes of *both* the car models *and* the (potential) buyers. However, such data-sets can mostly only be created by means of dedicated surveys, which are very costly. To some extent the use of mixed (multinomial) logit models is helpful as it can account for non-observed factors. Brownstone et al (2000) illustrated that it would be most helpful to use both stated preference and revealed preference survey based data-sets.

It is customary to represent car purchase as a nested choice process. In the first step the acquisition of a car as such (a binomial choice – yes/no) is considered. In a next step the type of car is considered (a multinomial choice, given the first step is ‘yes’). This step can also be subdivided in further steps (e.g. used car vs. new car, diesel vs. gasoline, and larger/luxury car vs. smaller/simpler car). Such choices maybe interlinked however. The nesting suggests a strict (unidirectional) stepwise logic, while consumers not necessarily have a strictly ordered

[6] For an overview see e.g. http://ddl.me.cmu.edu/ddwiki/index.php/Automotive_demand_models

preference set. Instead, within a certain (not entirely prefixed) budget restriction consumers may hesitate when trading e.g. guarantee (new vs. used) for space (smaller vs. larger). Among others for this reason some researchers (e.g. Fang, op. cit.) apply combined systems in which choices can be evaluated against overall intended utility levels (e.g. represented by expected mileage). Others (e.g. Golob et al, 1996) extend the analysis by differentiating between household members. It also important to realize, that the choice process for company (leasing) cars usually differs from that of private family cars.

Also macro level approaches, often based on some form of linear regression models, can be found, e.g. for assessment of changes in stock averages of certain features, such as fuel efficiency. For example, Brenkers (2005) carried out an analysis of the effects of emission reduction policies in the EU car market by using macro (market level) data.

None of the approaches is entirely satisfactory, because for a comprehensive and adequate attribution of various variables' impacts on the propensity to make a certain choice a very large variety of data is necessary, which are virtually never collected within the same survey[7]. Furthermore, to get a proper grip on effects of brand and dealer loyalty panel data are needed. The next best option would be the use of pseudo-panels, such as in Huang (2007).

In a study commissioned by the European Commission DG Environment (COWI 2002) an *ex-ante* review of impacts of fiscal measures on the CO_2-emission levels of new cars was made with the aid of a multinomial logit model embedded in a micro-simulation for nine Member States employing detailed car category data and socio-economic macro-data. This study provides a projection of the emission reduction potential per measure per Member State based on hypothesized implementation forms and side-conditions such as tax neutrality.

3.1.2 Critique

In as far as car type choices have been modeled, these models tend to assume consumers who are financially rationalizing their choices (Greene 2010a), even though particular loyalties (to brands, local dealers, etc.) can be included when accounted for in the survey. Yet, we do know from other studies (Anable et al 2009; Hoen and Geurs 2011) that such decision making is based on very diverse arguments and neither is the decision making process necessarily fully consistent, but often somewhat fuzzy. The counter argument to this is that as long as the distribution over degrees of rationality (with respect to the considered purchase

[7] One would need to collect in the same survey (non-exhaustive list): household mobility behaviour, household characteristics, number of cars and their technical characteristics, type of holdership of the cars (owning, lease, etc.), prices of transport fuels and public transport, environmental attitudes, regional/national service level indexes of road infrastructure and public transport respectively, etc.).

behavior) among the population remains by and large the same the rational choice based model still produces consistent results. That is a plausible yet somewhat precarious assumption, especially when one wishes to study impacts of policy measures that single out a so far not particularly emphasized attribute.

Greene (2010a) conducted a large review study of 28 studies regarding consumers' valuation of fuel economy when acquiring a car. The US Environmental Protection Agency (EPA), which had commissioned the study, even had this review study reviewed by other scholars (EPA 2010). The independent referees generally agreed on the main findings, which reinforces the credibility of the findings of Greene. Greene has two important interrelated messages. The first is that it seems impossible to draw generic conclusions on this issue, as the studies produced conflicting results[8] or at least highly diversified results. The second is that all these approaches have in common that they assume that the consumer applies a rational calculus in the purchase decision, even though the models may allow for some degree of market imperfections, taste differentiation, etc. In other words the current operationalisation of rationality in the purchase modeling may be simply inadequate. Greene recommends economic-psychological research to better understand purchase behavior (regarding large and valuable durables) and refers to an article by Turrentine and Kurani (2007), which aimed to open a discussion on this issue.

Greene himself produced two articles (Greene 2010b; 2011) in which he discusses uncertainty features (such as about the future fuel price), which undermine calculating behavior. On the basis of a survey and a series of structured interviews Anable et al (2009) discuss the apparent limitations of British car purchasers regarding their understanding of fuel efficiency information and its implications for future car travel cost.

From surveys and interviews can be inferred that many consumers show limitations regarding their numeracy (Anable et al, 2009). Similarly, in the most recent Finnish survey on environmental friendly car mobility (Karetie, 2009) almost half of the respondents could not indicate (from rather wide – prefixed – ranges) what amount of carbon dioxide an average eco-efficient family car would emit per vehicle kilometer. Many of the same respondents also had difficulties in identifying the most decisive factors for the environmental friendliness of a car. These numeracy limitations in combination with loss aversion and myopic inclinations regarding cost-benefit assessment results in an unduly discounting of energy efficiency in the judgment of (new) car characteristics (Greene, 2010). As indicated before even though these rationality limiting features are active, they may not crucially affect the estimated parameter values. However, the more a

[8] None of the eventually reviewed studies had major flaws in the estimation procedures or the data.

policy entails unprecedented emphasis on an attribute the more precarious this supposition gets.

All in all, it means that for private households vehicle choice tends to be a fuzzy process, in which calculated rationality (e.g. minimal operational cost), strategic rationality (e.g. dealer and/or brand loyalty), mixed intra-household (conflicting) interests and tastes, and limitations in (numerical) information processing capabilities come together. In case of sufficiently similar specifications parameter estimates for selected variables tend to stay in a reasonably narrow interval, even across countries (that notion was employed by COWI 2002 and later on by Giblin and McNaabola, 2009). Next to randomness, parameter variation within a reasonable interval can be explained – among others – by media influence (what is trendy or topical in a certain time span may receive more attention by buyers). For example, in the past five years fuel efficiency became more topical over time, but according to the most recent survey on environmental friendly car mobility (Karetie, 2009) its appreciation may have already passed the top among private car owners. On the other hand the Finnish car tax differentiation very obviously emphasizes specific emissions and makes notable price differences conditional upon differences in specific emissions (for otherwise comparable cars).

Hoen and Geurs (2011) tested the importance of positionality (perceived status) of the car for car buyers in relation policies to promote smaller cars. Not surprisingly they found positionality to be a relevant factor, which tends to reduce the willingness to reconsider the envisaged size/category of a car. In relation to this they also found indications that consumers that look for a new car have a premeditated choice range. That choice range may be loosely or more strictly defined by a varying set of attributes, depending on the buyer.

3.2 Supply side responses to demand side incentives

In response to the new emission intensity based taxation system (or any other major incentive) car suppliers will to some extent reshuffle the market positioning of their product portfolio, involving changes in relative prices over and above the taxation effect as well as changes in marketing strategies (Shiau et al, 2009; Mandell, 2009; Bastard, 2010). Furthermore, as time passes by new or renewed, that is more fuel efficient, models are introduced. This introduces further complications to the analysis with respect to distinction between consumer choice effects and supply side choice range effects.

The response of car makers will be influenced the most by public policy measures in their largest markets. As a consequence the model portfolio of one brand may be better or sooner optimized for the new Finnish fiscal circumstances than the model portfolio of some other brands. Depending on the degree of brand and dealer loyalty these differences in supply side response lags can cause interannual variation in the elasticities of vehicle choice with respect to the car tax differentiation by emission level.

It should be realized that both the EU as a whole and most EU Member States have explicit policies aiming at reducing the CO_2 emissions from passenger cars (see chapter 2, especially sections 2.3, 2.4 and 2.5). A part of those policies started already well before 2008[9], which means that the passenger car industry had already responded by starting to develop new fuel efficient models and engines by the time the Finnish car tax renovation was effectuated.

The implication is that even if Finnish car buyers were simply replacing their currently owned model by the same model with enhanced efficiency, a certain gain in energy efficiency is realized. Even if buyers would not be particularly attentive with respect to fuel efficiency, there would be a fair chance they happened to buy a model with evidently enhanced efficiency. For example, in Finland for the years 2008 and 2009 the emissions per vehicle kilometer of newly sold cars went down by 7.9% and 3.7% respectively (EkoAKE database). A decomposition analysis for the years 2006–2009 of the models on offer by cylinder content indicates that the annual technical (supply side) improvement amounted to about 1% from 2006 to 2007 and well over 2% from 2007 to 2008 and 2008 to 2009. The increase of the pace of decrease of the emissions per kilometer is probably for a good part attributable to the increasing number of European countries (including the larger ones) which are intensifying their emission reduction policy for passenger cars. This is a positive spillover effect of various Member Countries' transport climate policy for the other Member Countries. It goes beyond the scope of this report to assess those spillover effects in detail.

Observations in Finland

As regards supply side responses the following observations can be made on the basis of the technical specifications of passenger cars in 2007, 2008 and 2009 based on datasets from AKE.

In relative terms the tax reform enabled – on average – larger price reductions for diesel cars as compared to gasoline. Since the introduction of the tax reform the main car dealers have been extending the model portfolio with more fuel efficient diesel models and cutting it down with respect to gas guzzling gasoline models. In 2006 30% of all models on offer were diesel cars. In 2009 this figure had risen to 45%. Heavy weight diesel cars were less on offer, whereas the choice of light weight (<1500 kg) diesel cars, an almost empty category before 2008, was

[9] e.g. the EU wide agreement with European, Japanese and South-Korean car makers about a reduction of the emissions per vkm.

extended significantly. On the other hand the weight distribution of gasoline cars on offer didn't change to any notable extent. Also the number of diesel cars with small (< 1200 cc) engines is increasing and thereby affecting the choice range at the low end of the market.

The average tax differentiation induced price reduction of the most popular size categories of diesel cars on offer hovered between €2600 and €3200. Yet, the variation is large at individual model-version level. Virtually only in case of very sizeable diesel engines the tax differentiation caused price rises in a part of these premium categories. On the other hand the induced price reduction for the gasoline cars up to a cylinder content of 2000 cc tend to be in a bandwidth of €700~€1600 (the variation is even larger than for diesel cars of corresponding cylinder content). For gasoline cars with larger engines price rises prevail, on average of approx. €300. Yet, the spread is very large with often very substantial price hikes (over €10 000) for cars with over 3000 cc cylinder content. By inserting the price reduction per model into the car registry the resulting average tax differentiation induced price reduction varies moderately around €2700 for diesel cars and around €800 for gasoline cars, with a total average hovering around €1700 when aggregating to monthly sales data [10]. It seems that even though for individual model-versions price changes were in some cases influenced by market (re)positioning, the price reduction implied by the tax differentiation has been by and large transferred to the average sales prices.

These price changes also meant that the average price of diesel cars on offer got below the average price of all gasoline models on offer. In practice cars with emission levels (well) above 170 g/km underwent significant price rises, while significant price reductions could be noticed for cars with emission levels below 130 g/km.

3.3 Stock renewal in the Finnish passenger car stock

In the short to medium run reduction of the emissions per kilometer is mainly achieved by improving the fuel efficiency. The improvement of the fuel efficiency of the passenger car stock by promoting energy efficient choices for new cars can also be regarded as a component of a stock renewal process. By casting it as a stock renewal process it can be shown there are practical upper limits to the pace of fuel efficiency improvement of the passenger car stock, because annually only a fraction of the car stock (roughly 4%~8%) will be replaced by a new (or at least newer) car. Furthermore, replacement at the micro-level of a household does not necessarily mean replacement at the macro-level of the stock. The greater part of the replaced cars is sold on the second hand market

[10] . On the basis of the tax revenue data can be inferred that the average tax receipt per newly bought car fell by about € 2400,- when comparing the car tax revenues of 2008 to those of 2007.

to a new owner. This implies a further slowdown of the pace of fuel efficiency improvement at stock level, whereas it may also imply that the net growth of the passenger car stock is large enough to offset the emission reduction effect of the enhanced fuel efficiency development of new cars.

The Finnish passenger car stock has been relatively old as compared to stocks in many Western European countries (approx. 10 years compared to just under 8 years for the active stock). Moreover in Finland (like in Sweden and Norway) passenger cars tend to be on average somewhat larger than the EU average, whereas also the annual transport performance (approx. 18000 km) is above the EU average (approx. 16000 km).

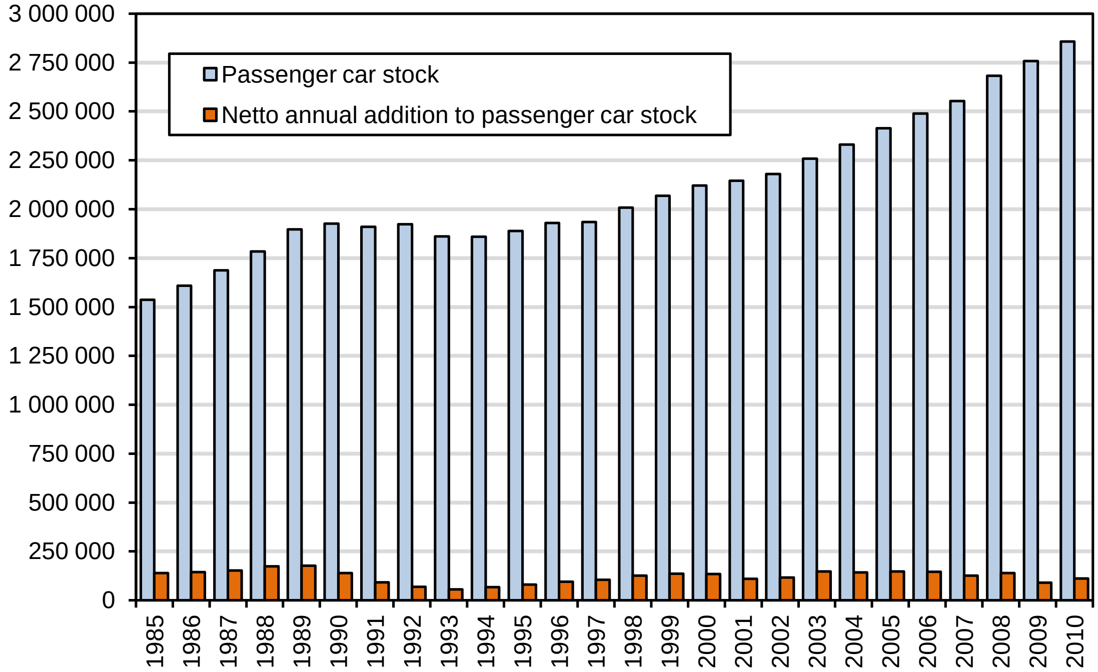
Altogether this means that Finnish cars have on average higher emissions per km, whereas the average age of the stock and the annual mileage seem to indicate appreciable leverage regarding diminishing the emissions per km of newly sold cars.

During and after the economic crisis of 1990-1992 the passenger car stock shrank slightly up to 1995 (figure 3.1). In 1996 growth resumed up to 2008. Outside the slack years 1991-1995 and 2009 the number of newly registered cars hovered between 100 000 and 150 000, meaning a renewal of 5% to 10% of the stock (see figure 2.2). The passenger car stock as of 31-12-2010 counts approx. 2.85 million cars. Annual variation in newly registered cars can be attributed to economic cycles and changes in the fiscal system for cars (figures 3.2 and 3.3). Fiscal changes either implied appreciable changes in the number of imported used cars (over 30 000 in 2002 and 2003) or forward or backward shifts in purchasing time (December ↔ January). From figure 3.3 can be inferred that there is also an intra-annual cycle, as for example company cars tend to be often renewed in the beginning of the year. Among private households there is interest in acquiring a new car before the summer holiday period.

The import numbers for used cars started to grow again in 2010 (Trafi - vehicle register, figure 3.2). The average age of cars has gone down slightly, if only active vehicles are counted. The slowdown in sales and the still appreciable number of imported used cars (approx. 22000/year) has prevented a larger reduction of the average age. Imported cars tend to be larger than average and their average age is about 8 years, when correcting for vintage cars (Trafi internet site).

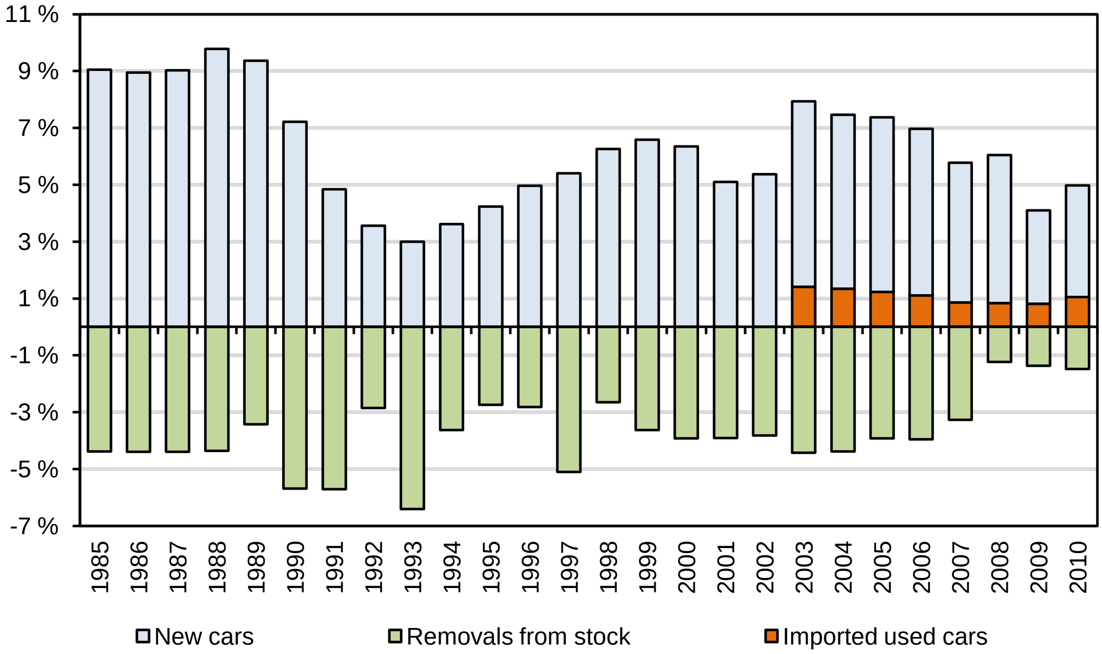
It seems that the amount of removals from the stock has diminished remarkably since 2008 (fig. 3.2), which suggests an expansion of the second hand car market. Nevertheless, the jump in the graph is at least partly caused by changes in the rules for ending registration of a vehicle (personal communication of Markku Kärkkäinen – Trafi).

Figure 3.1 *Development of the Finnish passenger car stock 1985–2010*



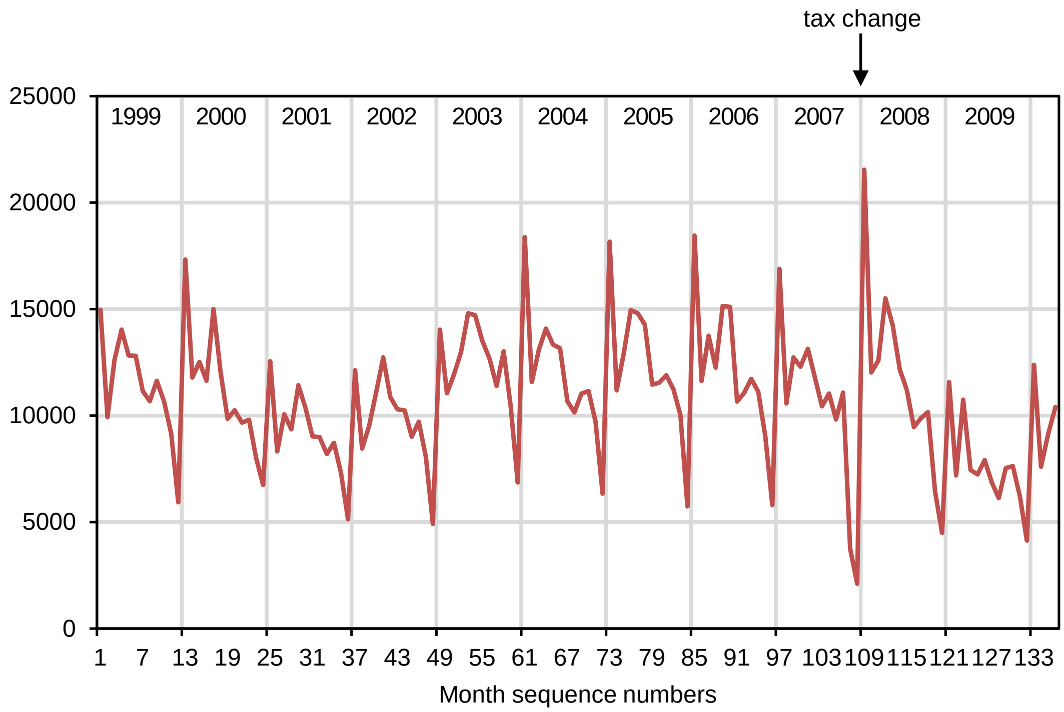
Source: Trafi

Figure 3.2 *Annual additions to and removals from the passenger car stock as percentage of the total passenger car stock (average of 2 consecutive years)*



Source: Trafi

Figure 3.3 *Monthly registrations of new cars 1999–2010/4*



Source: Trafi

3.4 Implications for modeling in this report

It is worthwhile to consider whether after all discrete choice models would be necessary in this case. In fact for judgment of the effectiveness of the tax differentiation we are not essentially interested how market shares of different model categories are moving (even though it provides interesting background information). Instead, ideal would be to relate the tax differentiation induced price change to changes in the average level of specific emissions of newly bought cars (e.g. Ryan et al, 2009). Theoretically this can be understood as modeling the demand for productivity of the (new) car stock regarding emissions in relation to variables that affect the preferred productivity (such as the fuel price). Problematic in this case is that emissions are (or at least used to be) a derived feature, implying that its performance level is to a large extent determined by other demanded attributes (e.g. space, comfort, speed). So, this approach is only valid if potential buyers have already a premeditated choice range of models among which final trade-offs between features are considered against value for money. In that case a price reduction conditional on the emission level is expected to affect eventual ranking of preferred models in as far as the considered models have undergone different degrees of specific emission reductions.

Hoen and Geurs (2011) provide support for the plausibility that every buyer has a premeditated choice range, which could be more or less susceptible to incentives such as the tax differentiation. Considering the large numbers (about 100 000 new cars per year) for the entire market for new cars it seems safe to assume that the responsiveness for the tax incentive (and other influences) is normally distributed and hence a demand model for a representative consumer can be estimated.

4. Recent changes in the Finnish car stock and newly sold cars

4.1 Introduction

The overview in this chapter is based on the dataset acquired from the Finnish Vehicle Administration (now part of the Transport Safety Agency - Trafi). The dataset concerns the vehicle registry as of 30-6-2009. In addition more recent aggregate data regarding average emissions for monthly sales and developed of the car stock were collected from the websites of Trafi and Statistics Finland. As regards the registry dataset for each vehicle is included: year of registration, year of construction, type of passenger car (sedan, hatchback, coupe, etc.), fuel type, brand, model, weight, type of ownership (private household, company car, etc.), purpose (rental, company, stock, private, etc.). The registry has been extended by adding more technical information per car model (with distinctions between construction years). Added features are among others: maximum rated engine power, emissions per vehicle kilometer, and fuel consumption. A variable list of the registry is given in Annex 1.

The formulation of the differentiated car purchase tax and indications of resulting price changes per brand from 2007 to 2008 are given in Annex 2.

As was shown in previous chapters import of used cars has some significance regarding the volume and age composition of the car stock (import of used cars is 15% to 25% of the amount of newly sold cars). In recent years the numbers stabilized just above 20 000 per year (less than 20% of the newly sold stock). However in 2010 the number of imported passenger cars rose again to 30 000. Apparently consumers have not immediately responded by importing more used (heavy powered) cars, but with some delay this leakage seems to get more important. This could however not be assessed with the available registry dataset.

It should also be realized that the economic crisis hit very hard in 2009 (see figures 3.1 and 3.3). This also may have affected model choice (cheaper and smaller models). At the same time the model supply portfolio also changed, not the least in response to climate policies in many EU countries, as shown in section 3.2.

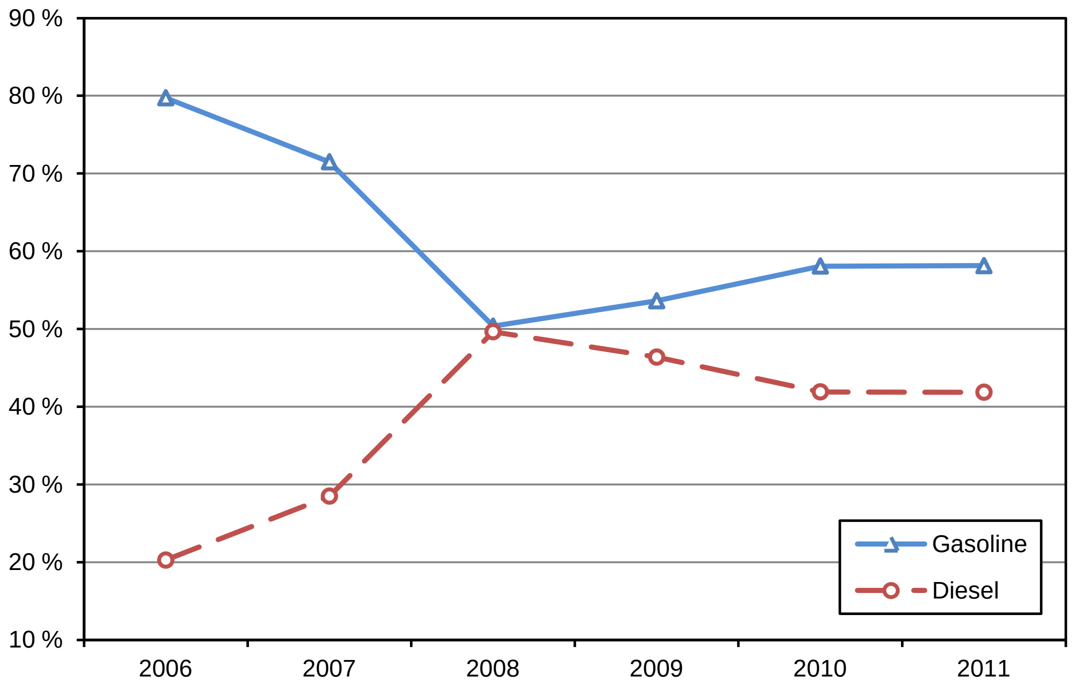
4.2 Main features of newly sold cars – changes in the market

An important factor for choosing a car is the anticipated annual mileage. A higher mileage makes it more likely to buy a diesel car, thanks to the lower operational cost per km. From the portfolio of cars on offer can be inferred that the range of choice for diesel cars is smaller than for gasoline cars. Diesel cars are typically well represented in the market segments for larger cars (cylinder content at least 1800 cc). Very small cars, very luxury cars and sports cars run almost always on gasoline, even though since 2009 the choice range for cars with small diesel engines (< 1200cc) is increasing. All in all it means that for some intended purchases potential buyers would have to accept somewhat larger trade-offs of features of the desired car, if they wish to respond to the fiscal incentive for lower emissions.

The popularity of diesel cars was already increasing prior to the tax reform. Yet, in the first year of the reformed tax the reform seemed to have boosted the popularity (fig. 4.1), as fuel switch (from gasoline to diesel) was the easiest (and low cost) choice. Since 2009 however, the share of diesel cars shows some decline due to further evolution in the choices of buyers as well as due to further technical development of new cars on offer.

Apart from the fuel switch, newly sold cars tended to weigh somewhat less on average in 2008 and 2009 as compared to 2007 (fig. 4.2). This is probably mainly due to the decline of sales of cars with very large engines (3000 cc and over). Indeed when comparing the average cylinder content of pre- and post-reform years a clear reduction is visible (fig. 4.3).

Figure 4.1 Market shares of newly sold passenger cars by fuel

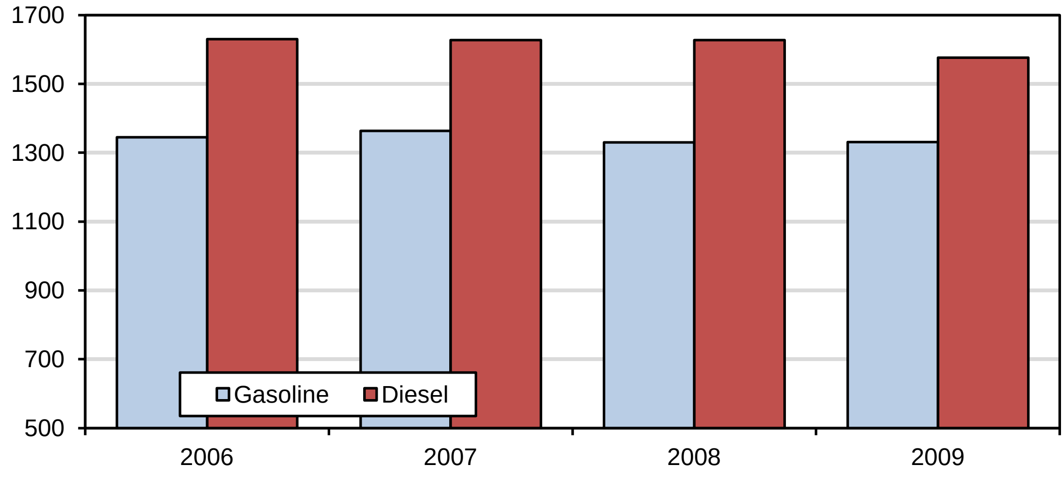


Source: Trafi passenger car registry

A compound overview of the trends in emission per km by fuel type and cylinder content from 2006 to 2009 is provided in figure 4.4.

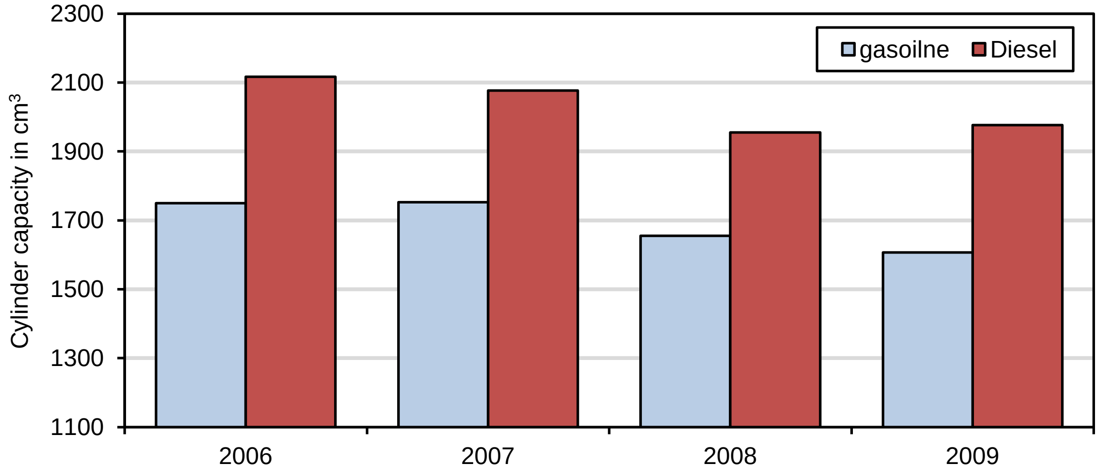
The annual composition of the buyers varies considerably over the time period considered (fig. 4.5), with an ever larger share of companies or organizations. This may be relevant as the incentive structure for both types of buyers is not the same. Furthermore, lease cars tend to have higher emissions per km (see also chapter 5).

Figure 4.2 Average weight (kg) of newly sold passenger cars by fuel type



Source: Trafi passenger car registry

Figure 4.3 Average cylinder capacity of newly sold passenger cars by fuel type 2006–2009



Source: Trafi passenger car registry

Figure 4.4 *Average emissions of newly sold cars (grams per kilometer) by market segment from 2006 to 2009 with segments defined by fuel type and cylinder content*

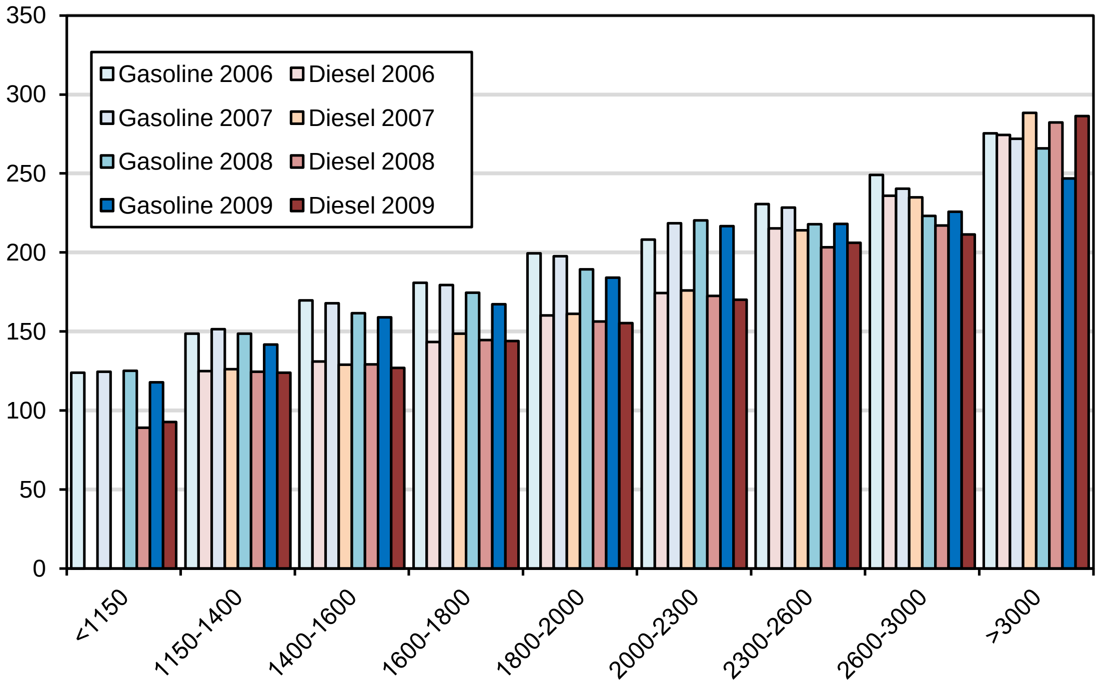
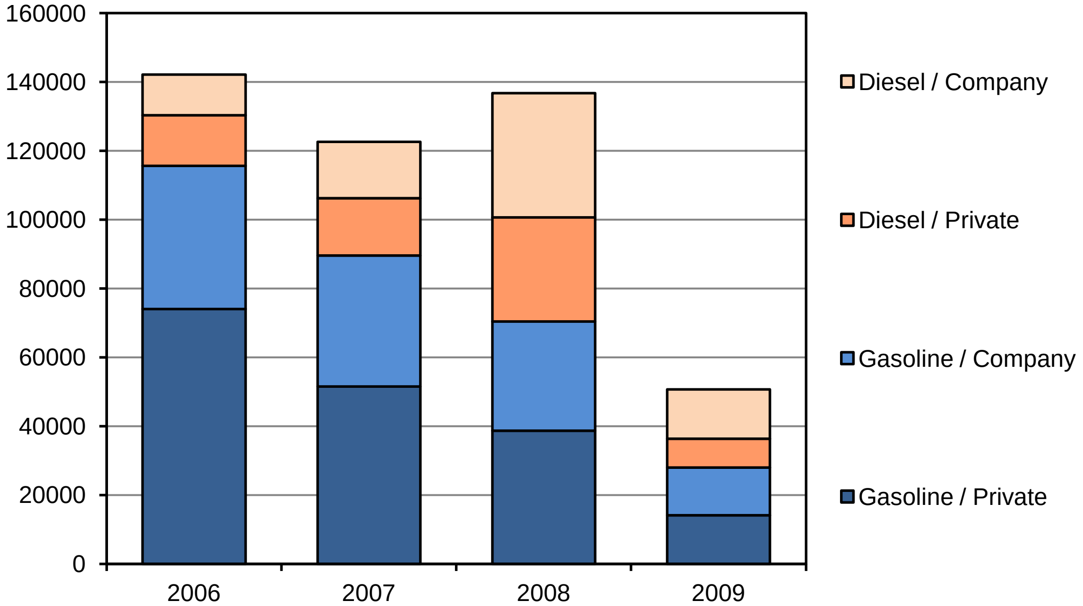


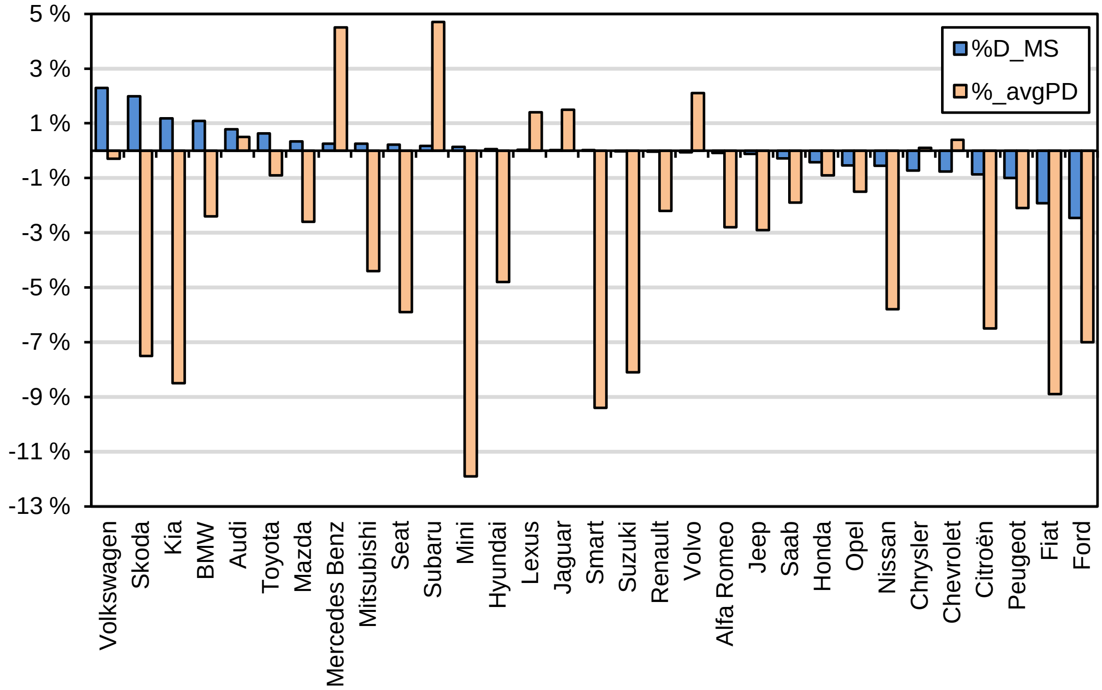
Figure 4.5 *Decomposition of sales of newly bought passenger cars by type of owner for the years 2006–2009 (January – June)*



Source: Trafi passenger car registry
Private = Household

Interestingly enough figure 4.6 indicates that the effect of the conditional price reductions does not correlate much with the changes of market shares of brands. For example, Volkswagen gained the most market share, but its sales did not entail large tax reductions. The conditionality of the price reduction (with respect to emission level) incites buyers to review necessary technical performance in contrast with brand specific features about convenience, style, etc. whereas responsiveness showed still marked variation when using relevant technical categorizations (e.g. cylinder content; see also figures 4.10 & 4.11).

Figure 4.6 Percentage change in market shares (%D_MS) and average price reduction (%_avgPD) per car brand



4.3 Trends in CO_2-emissions per kilometer by market segment

As could be seen in sections 2.2 and 4.2 the supply side and demand side responses differ between diesel and gasoline. On average, gasoline cars did get smaller in 2008 and 2009 and had somewhat less engine power than in 2007. For gasoline cars this effect seemed to have been active across the various size categories and outfit levels. As a consequence the distribution of newly sold vehicles by emission level shows an overall shift to lower CO_2-emissions per km (figure 4.7). In 2006 the largest category was still 160–180 g/km. In 2008 the balance started to tilt in favor of the category 140–160 g/km, whereas in 2009 and 2010 this category had very obvious dominance. The figures for the first half of 2011 hint at a further shift making the category 120–140 g/km the largest one.

In the case of diesel cars the picture is similar as for gasoline, but less clear cut (figure 4.8). The market segments with 200 g/km or more experienced a steady decline. However the segment 180-199 g/km showed only moderate decline, since a part of the buyers of large gasoline cars switched to buying a large diesel car. The next segment (160–179 g/km) declined significantly, due to technical development and choices in favor of lower specific emissions, which in turn favored the next segment (140–159 g/km). Last but not least the market segment for very low emissions (<120 g/km) grew spectacularly, showing a much larger boost than the intermediate segment of 120–139 g/km. Indeed, new supply of small diesel engine cars apparently did find demand.

The overall picture for all newly sold cars (fig. 4.9) looks more regular (unilateral shift to less emissions).

Figure 4.7 *Changes in the distribution of CO_2-emission performance (g/km) over emission categories of newly sold gasoline cars 2006–2011 (in 2011 up to 30.6)*

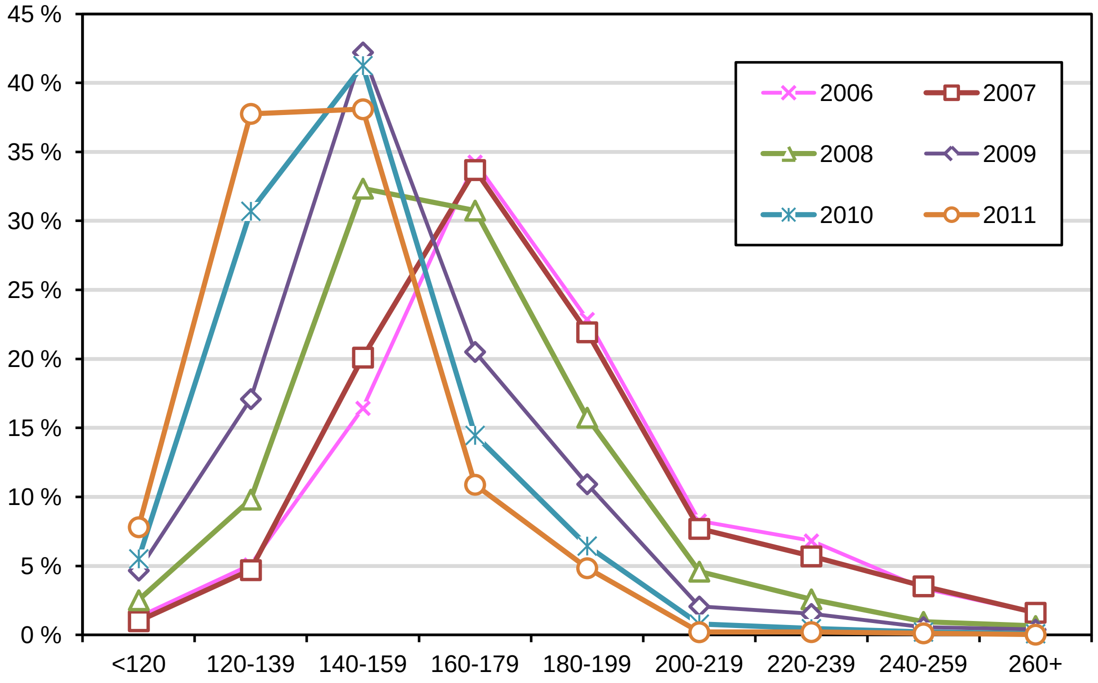


Figure 4.8 *Changes in the distribution of emission performance (g/km) over emission categories of newly sold diesel cars 2006 – 2011 (in 2011 until 30.6)*

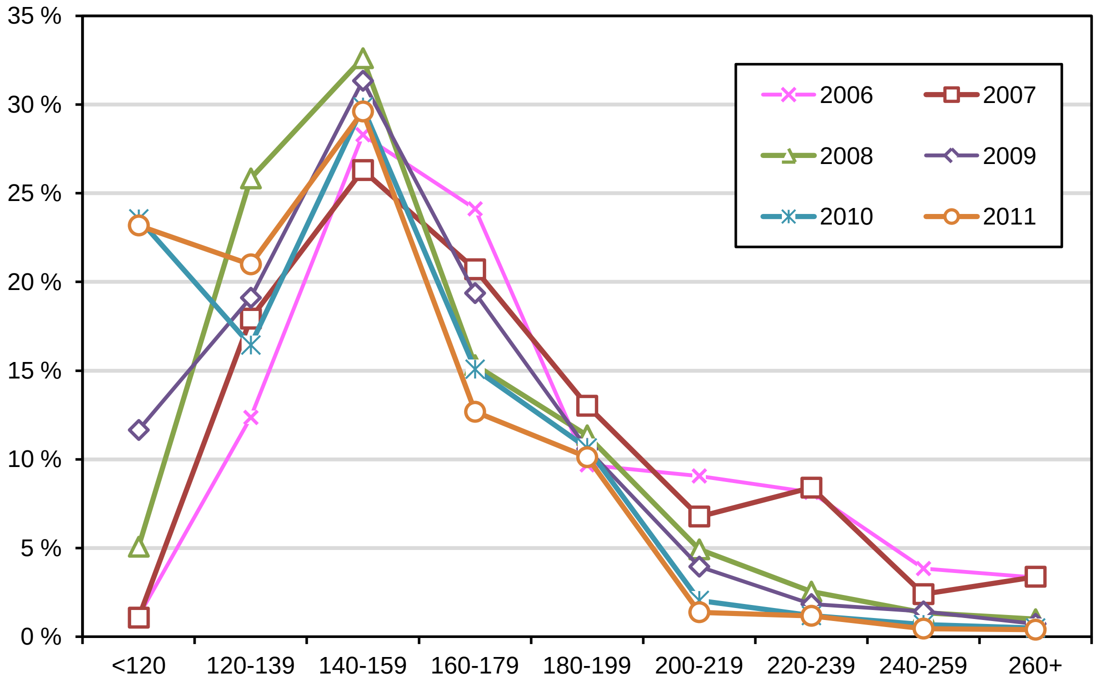
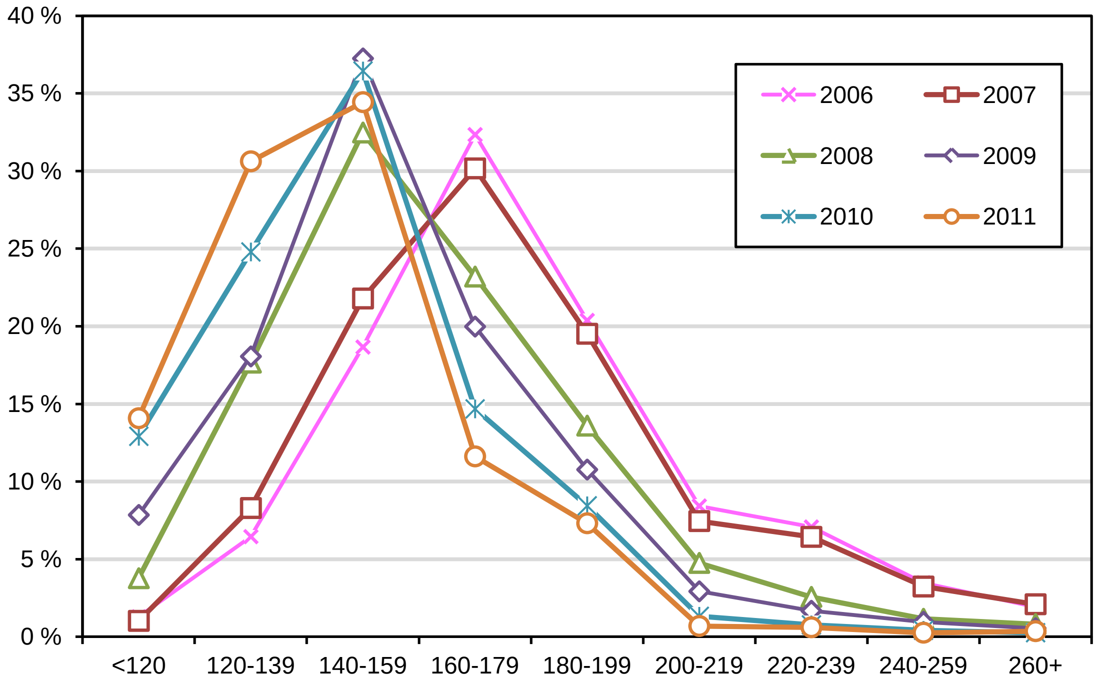


Figure 4.9 *Changes in the distribution of emission performance (g/km) over emission categories of newly sold cars (diesel and gasoline) 2006 – 2011 (in 2011 up to 30.6)*



Based on the most recent figures from Trafi it seems that the downward trend in emissions per km continues (figure 4.10). It is remarkable that average emissions per km of diesel and gasoline cars converged, with an indication that newly gasoline cars for the first time would have lower average emissions than diesel cars as of 2011. All in all the reduction in average emissions of new cars is truly substantial, going from almost 180 g/km in 2006 to just over 145 in 2011. Also when looking back over the past 10 years (e.g. compare figures 4.10 and 3.1) the change is evidently remarkable. The change is not just a single step event in 2008, but entails further dynamics in following years, with no signs of ending in the nearby future.

Table 4.1 provides a comparison of the year-on-year changes in in reported CO_2 emission levels when using supply portfolio and sales figures respectively. In 2008 and 2009 the average emission levels of sold cars reduces much more than in the previous years (as was already illustrated earlier). Yet, table 4.1 also shows that at the supply side efforts were intensified. It points at interaction between policy incentives and an intensifying of energy saving technology in subsequent vintages of car models on offer, also at the international (EU) level. When weighing the figures for the sales shares of diesel and gasoline respectively the policy response effect at the supply side is about 1%-point extra reduction in CO_2 emissions/km of the model portfolio on offer, whereas the pre-2008 default trend was just over 1% per year. Considering the developments in 2009 and 2010 the policy response may be on the rise. Annex 3 contains more detailed data for 2006–2009, underlying table 4.1.

Table 4.1 *Year-on-year percentage change in reported CO_2 emission levels based on model portfolio on offer in Finland (supply) and on cars sold (sales).*

	gasoline		*diesel*	
	model supply	**sales**	**model supply**	**sales**
2007	-1,9 %	-0,5 %	-0,4 %	0,4 %
2008	-2,7 %	-3,0 %	-1,4 %	-2,7 %
2009	-2,8 %	-3,4 %	-3,3 %	-0,6 %

Figure 4.10 also provides an indication of the default (pre 2008) trend of emissions per km, which is related to technical changes in the models on offer as summarized in table 4.1 and figures 4.11 and 4.12. It indicates what would have been the average emission level of newly sold cars if no change in choices would have occurred. This trend in technological efficiency improvements reinforces somewhat in 2008 and 2009 as car suppliers in Finland adapted the model portfolio in response to the tax reform (and car makers increasingly came up with more low emission models in response to policies in many EU countries). As the actual trend in emissions shows a stronger decline in 2008 and 2009 than the technical trend, other factors, such as the tax reform, must have played a role as well. From figures 4.1–4.3 and 4.7–4.9 can be inferred that choices of Finnish car buyers have indeed changed in favor of models with lower emissions. The tax reform provides almost certainly a principal explanation of that change. Yet, also the economic downturn and development in transport fuel prices may have contributed to that change in purchase behavior.

Figure 4.10 *Development of the CO_2 emissions per km for newly sold gasoline and diesel cars 2006–2011 (for 2011 up to 30.6)*

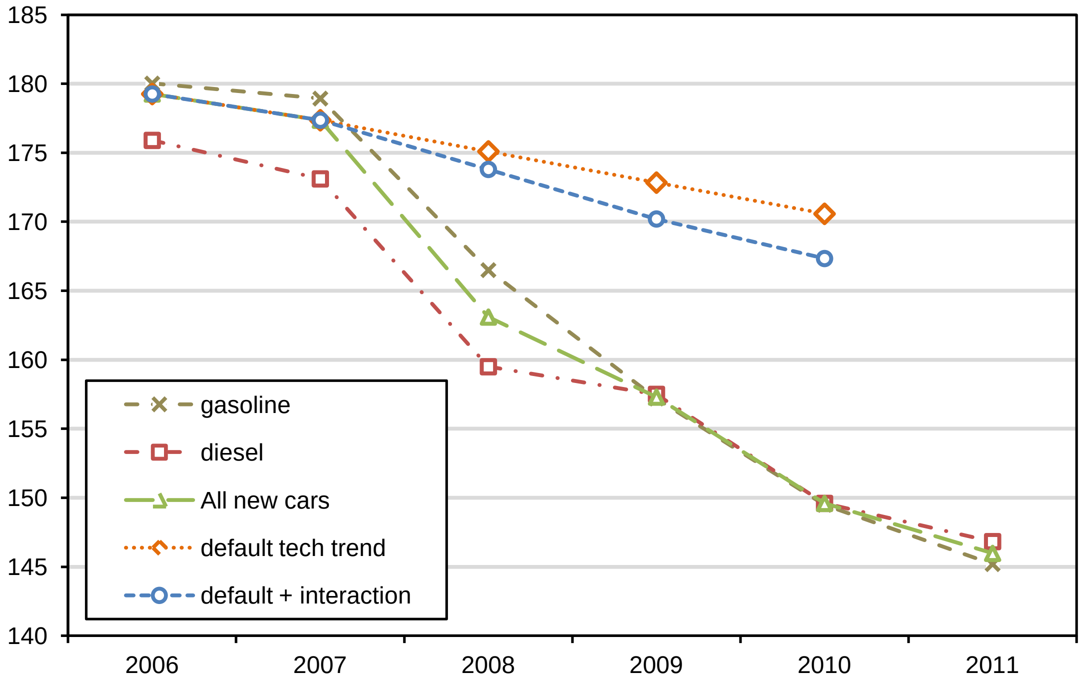


Figure 4.11 *Changes in the CO_2 emissions per kilometer in consecutive years as compared to the previous year – using unweighted averages of industry reported emissions/km for models on offer in Finland by fuel type and cylinder content*

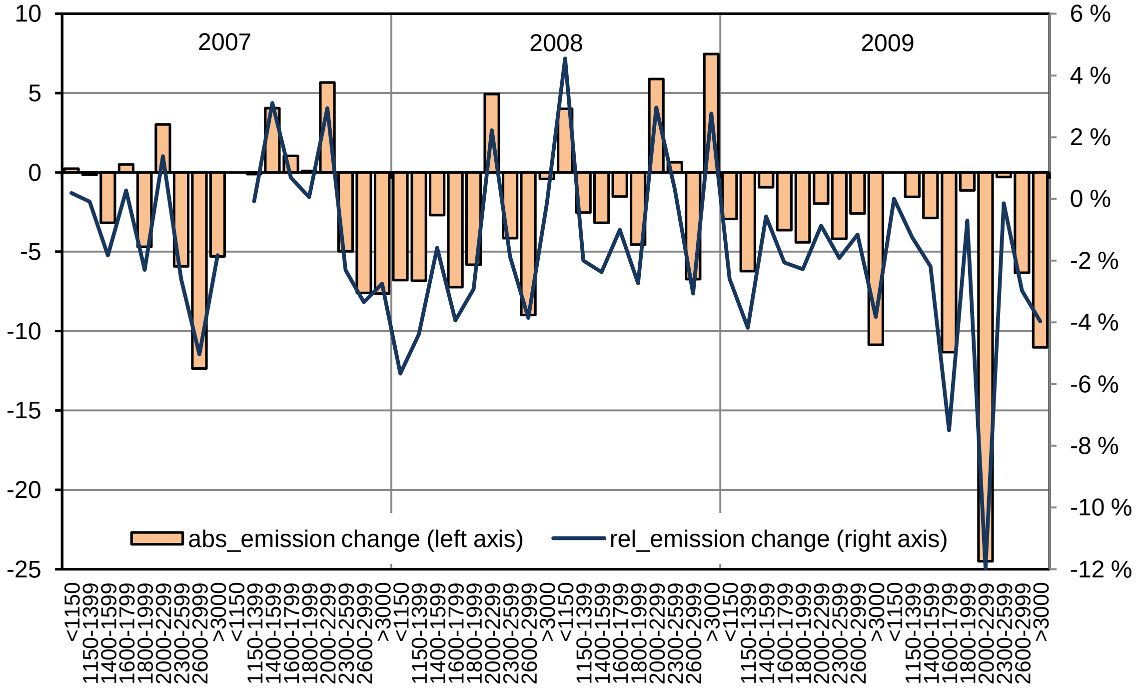
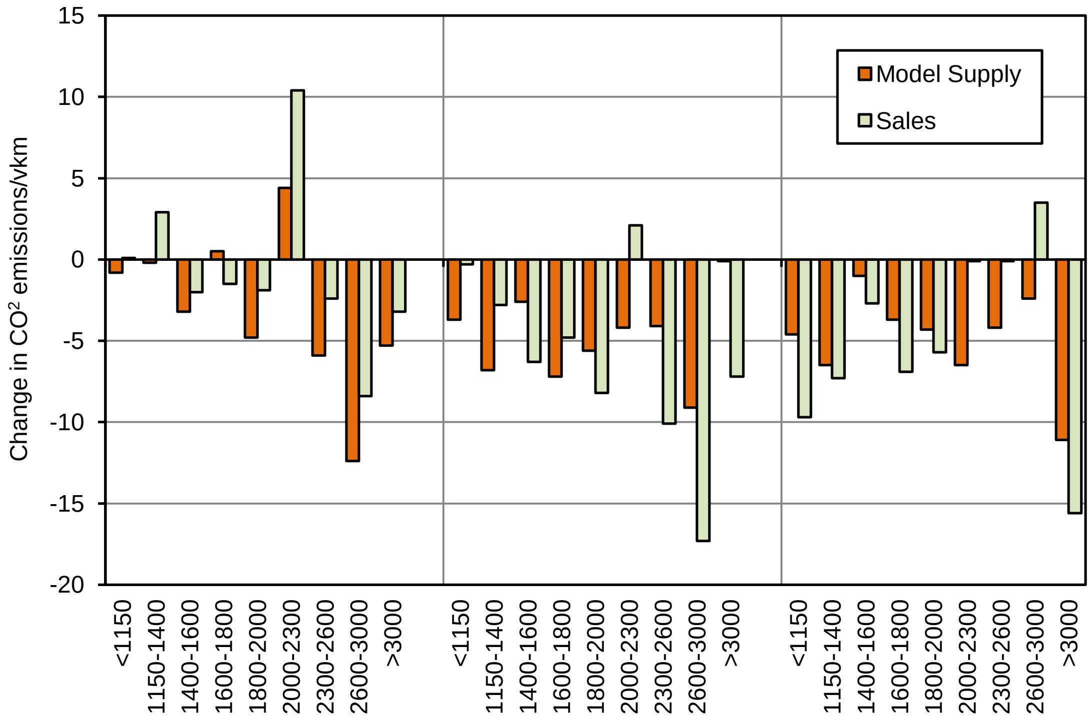
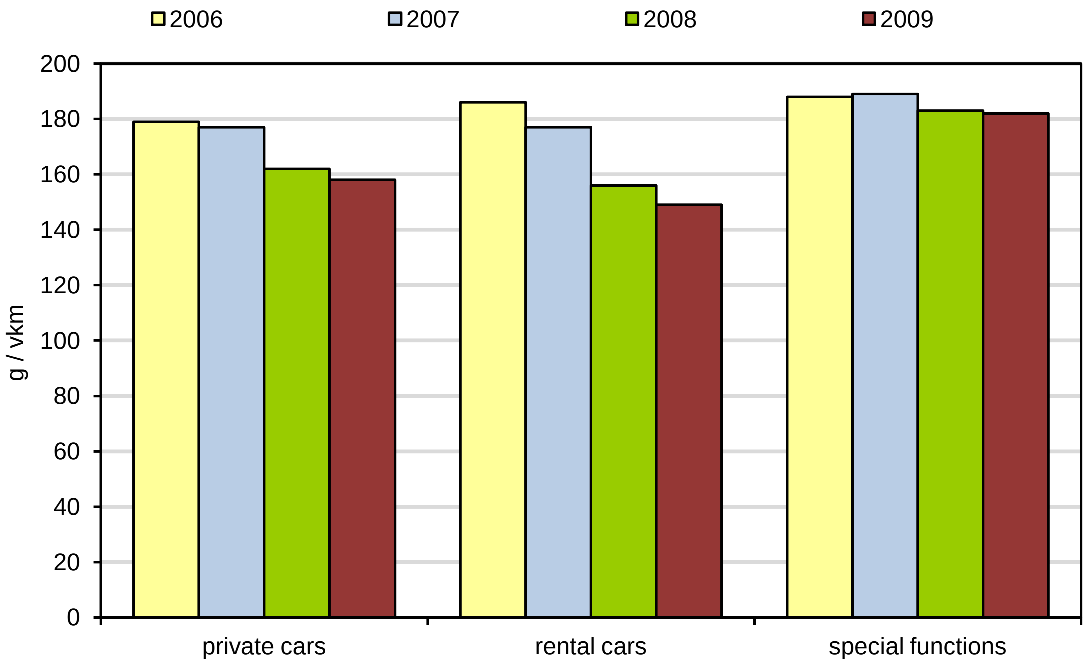


Figure 4.12 *Changes in the CO_2 emissions per kilometer for gasoline cars in consecutive years (2007–2008–2009) as compared to the previous year – comparing supply side and demand side changes per cylinder category*



Finally, figure 4.13 illustrates that sub-sets of buyers may show remarkable differences in responsiveness with respect to the tax incentive for lower emission cars. In particular new vintages of rental cars show a marked decline in emissions per kilometer. One should realize that the category ‘special functions’ often concerns cars acquired by public sector organizations. Annual acquisitions of new rental cars and special function cars are only a fraction (< 2%) of all new cars.

Figure 4.13 *CO_2 emission/km for newly sold cars by different purpose / ownership – annual averages 2006–2009*



5. Estimations of the impacts of the tax differentiation

5.1 Data

On the basis of the vehicle registry (situation as of. 30-6-2009) extended with technical data as briefly described in section 4.1 a new dataset was created which depicts monthly averages of the registered newly sold passenger cars. The period covered in the obtained data set was January 2006 – June 2009. To the technical and administrative information was added the monthly prices of gasoline and diesel, monthly consumer price index for transport expenditures, monthly wage sum, monthly unemployment rate, and average monthly income.

Also was added a calculated variable which approximates the tax induced price difference per month (as compared to the pre-reform situation in 2007). The calculation is based on the realizations (at a fairly detailed model level) and not – for example – on the relevant portfolio on offer. The ex-post observed aggregate average tax reform price reduction is not necessarily the same as the perceived price reduction of considered alternatives.

Two different models were investigated. OLS regressions were estimated with average emissions of monthly sales as dependent variable and average tax reform price difference of monthly sales as one of the explanatory variables. In addition the propensity to buy low emission cars was explored with discrete choice models (logit) using the registry dataset. In addition changes in market shares were explored. However, the level of disaggregation of market segments appeared to have major impacts on the significance of tested relations.

As explained in section 3.4 the research question can be understood as modeling the demand for productivity of the (new) car stock regarding emissions in relation to variables that affect the preferred productivity (such as the fuel price). In contrast one could also adhere to the original supposition of a choice process, for which the use of discrete choice models is appropriate. For specific though fairly broadly defined car categories is tested whether the propensity to buy a low emission car is effectively influenced by the tax change. A low emission car is defined as having emissions below a certain level.

5.2 The specification of the OLS estimations

The aim is to explain changes in specific emissions of new car sales, $I_{,t}$, (average emissions per km of all newly sold cars in period t). This can be regarded as modeling the demand for emission performance quality. The demand for the performance level is supposed to depend on factors that affect the trade-offs between prime performance factors such as space, speed, and safety. Decisive is in particular that several *external* factors can affect the price of these trade-offs, whereas the introduction of the car tax differentiation, which is conditional on the specific emission level, also provides a ‘direct price’ to the emission performance level of a car. Four types of variables can be distinguished, being:

1. those that are supposed to affect the decision makers directly, such transport fuel prices (p_{ft}), purchasing power (*income*), and the tax reform induced conditional price reduction (*PD*);

2. those that distinguish between different types of buyers (*ownership_char*; cars bought by households or company cars or rental cars), which may have marked differences in incentive strength and/or structure (the alternative would be to estimate subsets of monthly sales).

3. a technology trend variable representing the development of the emission intensity of the supply portfolio of new cars over time (*tech_trend*), in fact the month’s sequence number is used;

4. other temporal or incidental effects (*other*), in this case related to (a) the incidental peak in high emission car sales just before the tax reform, due to prior knowledge on the impending changes in taxation, and to (b) typical intra-annual cycles in car purchase and renewal, e.g. regarding company cars (this is relevant due to the use of monthly data).

In very general terms the following relation is assessed:

$$I_t = f(p_{f,t}; income_t; PD_t; ownership\_char_t; other; tech\_trend)$$

As explained earlier not all variables were available in one dataset. Eventually the following specification appeared to be feasible and produce generally satisfactory results:

where:

- I_t stands for the level the monthly average emissions expressed in gram per km of newly bought cars as compared to 12 months ago;

- p_f denotes the fuel price of fuel f in month t

    - either the model includes both the gasoline and diesel prices (*pgasoline*, *pdiesel*) in Euro, or

    - it includes the price difference between gasoline and diesel in Euro (*dpgasolinediesel*)

- $income_t$ denotes the average monthly income level in Euro in month t. (Statistics Finland) Also consumer confidence indicators were tested, but that appeared to be not useful.

- PD_t is the monthly average price difference in Euro induced by the car tax differentiation in comparison to the 2007 situation. The calculation is based on model specific price changes resulting in an average enjoyed price reduction per month. For the years 2006 and 2007 this value is set at zero. This should not be confused with an ordinary price variable as the size of the reduction is conditional upon the CO_2-emission per km of the considered model.

- *ownership_char* was operationalized by accounting for the shares of car purchases by others than households in month *t* , this implemented as:
  - share of lease cars*: $leasingcars_t$*
  - share of rental cars*; $rentalcars_t$*
- the dummy variables belonging to the group '*other*':

  - dummy_1 is represented as *priorknow.* It equals zero for most months except for November and December 2007. In the last few months prior to the introduction of the tax differentiation potential buyers got aware of the impending change, which incited some people to buy a new car with high emissions per km before 1-1-2008;

  - dummy_2 (DS1) and dummy_3 (DS2) represent the months December and January respectively. Sales in these months tends to be clearly below (Dec.) or above (Jan.) the annual monthly average and have deviating shares of company car purchases;

- the technology trend is represented by *Mnsq*, which denotes the month sequence number and functions as a proxy variable for technical development in fuel efficiency of new cars' sales portfolio. There is a fairly steady inflow of new models over the year. This variable prevents an oversized impact attribution to variable *PD* (representing the tax differentiation).

- β_i are estimated parameters for the explanatory variables; α is the intercept and ε the error term

Summarizing, subsets of the following equation are estimated:

$$I_t = \alpha + \beta_1 \cdot PD_t + \sum_{i=g,b} \beta_{2i} \cdot p_{f_i t} + \beta_3 \cdot (p_{f_g t} - p_{f_d t}) + \beta_4 \cdot income_t +$$

$$\sum_{i=l,r} \beta_{5i} \cdot ownership\_dummy_{it} + \beta_6 \cdot priorknowledge_t + \sum_{i=1,2} \beta_{7i} \cdot DS_{it} + \beta_8 \cdot Mnsq + \varepsilon_t$$

5.3 A summary of the OLS results

Alternative specifications, using first differences or relative changes instead of levels, generally produced less satisfactory results. The variable '*income*' appears to have quite limited significance and turned out to be insignificant when combined with the variables representing company car ownership shares. One would expect that income (affordability) would have some effect on model choice, but that does not seem to be the case at this aggregate level. More precisely, income has most probably still an effect on car choice, also when accounting for a given preselected bundle of characteristics. Yet, for the trade-off of emission level versus other characteristics (within a preselected market segment) income seems to have no discernible effect. Considering the variation in annual sales volume income development (and expectations) may have more influence on the timing of a purchase and on the choice between a new or a used car, but supposedly much less on model choice.

Fuel prices or more specifically the price difference between gasoline and diesel does seem to have an impact on car (engine) choice and thereby on emissions per kilometer. When the gasoline and diesel fuel prices are both included, the signs of the parameters indicate that this fuel competition effect is relevant, whereas the fuel costs as such (overall transport fuel price) matters less in this case. The inclusion of a dummy for impacts of prior knowledge also seems highly relevant. This can also be witnessed in figure 5.1. The peak in emissions/km during months 23 and 24 (November and December 2007) coincides with the time when media got wind of the reform plans. When the influence of steady technical progress (*Mnsq*) is included the remaining contribution of the tax induced price difference is statistically significant, but not very large. The results of estimations no.3-5 suggest that every 1000 euro tax deduction (as compared to the pre 2008 situation) would yield a reduction of 6 to 7 grams per km driven for the average new car during the period studied.

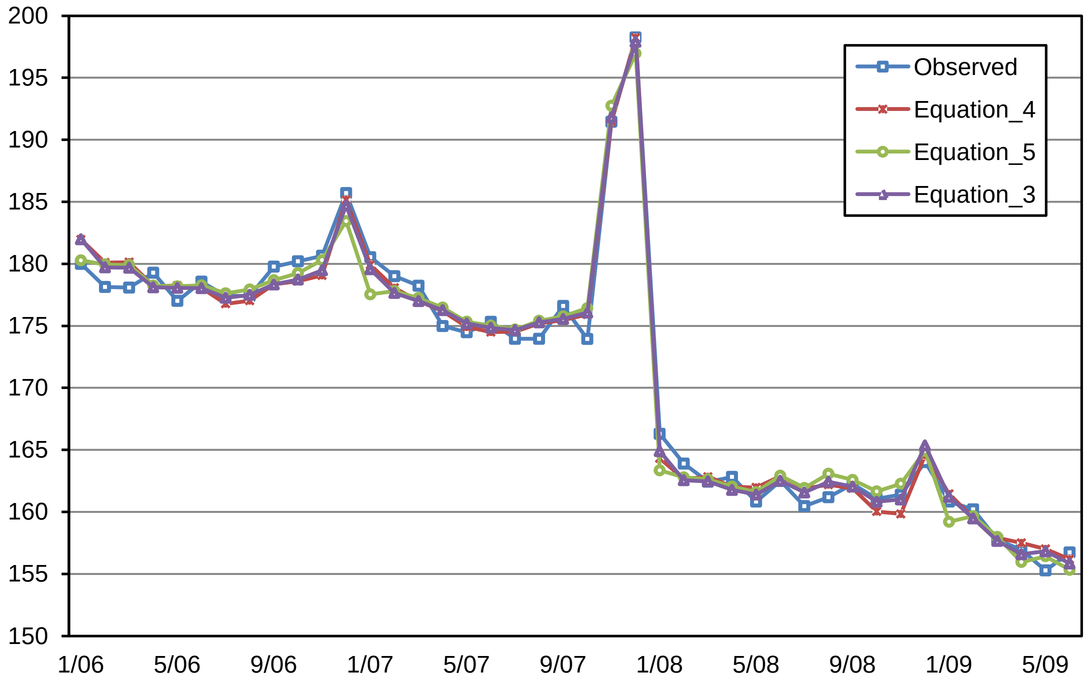
Table 5.1 Parameter values of selected models period 2006–2009

Variable / Equation no.	1	2	3	4	5
dependent (emissions - average (g/km))	171.42	171.42	171.42	171.42	171.42
intercept	132.18**	142.92**	183.99**	185.68**	184.27**
PDtx (€)	0.0137**	0.0133**	0.0065**	0.0070**	0.0062**
Pgasoline (€/liter)	-58.79**				
Pdiesel (€/liter)	62.38**				
PDgasolinediesel (€)		-61.72**	-17.04**	-21.67**	-17.71**
Income (€)	0.0228*	0.0204*			
Leasingcar (fraction)			15.12*		25.56**
Rentalcar (fraction)			-24.20 [1]		-35.59*
Priorknowledge (0/1)			13.76**	14.67**	13.35**
DS1 (0/1)			1.93**	1.45*	
DS2 (0/1)			3.52*	6.5**	
Mnsq (tech_proxy)			-0.26**	-0.19**	-0.32**
adj. R^2	0.90	0.90	0.986	0.985	0.981
N (obs = months)	42	42	42	42	42

t-value indications: * - significant at 95% level; ** - significant at 99% level
approx. 90% significance level

The calculated average monthly emissions using equations 3, 4 and 5 are compared with the realized averages in figure 5.1. The equations not only capture the large changes, but also the smaller variations quite well.

Figure 5.1 *Observed and estimated average emission levels (g/km) of newly sold cars (monthly sales basis) during the consecutive months of the period January 2006 – June 2009.*



The above estimation results imply that the contribution to the reduction of the level emissions per km during the period 2006 – 2011 can decomposed roughly as follows:

- technology trend: ~12 g – ~ 18 g *
- tax reform : ~13 g – ~ 17 g **
- technology – policy interaction: ~ 3 g – ~ 4 g ***
- other (fuel prices, income?, awareness?): ~ 0 g – ~ 3 g ****

*) Using the three parameter values from eq.3, 4, 5 of table 5.1 multiplied by the number of months lapsed produces approx. 12g, 17g, and 21g. Looking at the trends of emission levels based on the supply portfolio of cars (figures 4.10–4.12) the default technology trend contribution is probably more at the lower end (i.e. 12 g ~ 15 g).

**) The average of PD_{tx} in the study period is approximately 2100 Euro. On the basis of changes in car tax revenues and sales numbers can be inferred that in 2008 the average car tax imposed on a car was about 2400 Euro lower than in 2007. On the other hand the lower level parameter value for PD_{tx} is 0.0062 (eq.3 in table 5.1) and the higher level 0.007. This would produce four figures for the contribution of the tax reform roughly varying between 13g (0.0062 x 2100) to 17g (0,007 x 2400).

***) Based on the remaining technology effect (changes in the supply portfolio in 2008 and 2009, see also able 4.1) after subtracting trend assessed in the first point.

****) At maximum the previous aspects would explain just all of the reduction in emissions per km from January 2008 to June 2011. As can be seen in the estimations for the fuel prices or at least the price difference between gasoline and diesel have supposedly some effect on the reduction of the emissions per km (table 5.1). Possible effects of income (expectations) and awareness are not confirmed, and if nevertheless relevant these effects seem to be rather marginal at least up to now.

It should be realised that the above analysis is subject to various limitations, such as the impossibility to analyse all possibly relevant variables within one dataset. Therefore, estimates should be mainly understood as an indication of relative importance and order of magnitude. Furthermore, both the policy field and the technology responses are still under development and therefore parameter values, such as of *PD* could quite easily change.

5.4 Specification of the logit estimations

Whereas the OLS estimations dealt with a general inclination to purchase passenger cars with lower emissions per km as a result of the tax reform, the logit estimations deal with the popularity of passenger cars with emissions well below the average. In addition it was explored how the popularity of small cars (measured in terms of cylinder content) developed.

The figures 4.7 to 4.9 gave already an indication of the increasing popularity of low emission cars (< 120 g/km in figures 4.7–4.9). The category with less than 120 g/km had a next to negligible market share in 2007 (~1%). In 2011 this share has risen to 14%.

Estimations have been made for all sales together as well as for selected size classes (defined by upper and/or lower bounds of engine cylinder content). Cylinder content categories represent reasonably well the approximate categories of cars that potential buyers contemplate, i.e. reflecting the positionality concept (Hoen and Geurs 2011). The estimations have been done at the individual level, using all usable records of the registry for the entire period 2006–2009 and for the period 2008–2009. By comparing the parameter values for the two periods the stability of the effects can be reviewed.

The estimated logit models give some further insight regarding the strength of the incitements of the tax differentiation and other factors to buy cars with particularly low emissions. For the estimation of the propensity to buy a low emission car regarding all sales of medium sized and small cars in the period 2006–2009 a limit of 130 g/km has been used, implying that all cars with emissions below 130 g/km were rated as ‘low emission’. For the cylinder content class 1400–1599cc the limit was set at 130 g/km and for the class 1800–200cc at 145 g/km.

The general specification of the binomial logit model is:

$$P(selectlowemission\,\mathrm{mod}\,el) = \frac{e^{\alpha + \sum_i \beta_i \cdot X_i}}{1 + e^{\alpha + \sum_i \beta_i \cdot X_i}}$$

where X_i is a selection of explanatory variables, such as the tax reform induced price difference (*PD*), the gasoline and/or diesel price (p_f), the difference between the gasoline and diesel price (p_g-p_d), the model’s list price, ownership dummy, and a technical trend variable (*Mnsq*). Apart from the list price it concerns the same variables as used in the OLS estimations.

Please notice that in the reported estimation results the default choice modeled is the one with the largest share, which is always the non-low-emission car. This means that positive parameter values point at a discouraging effect regarding choice of a low emission car, while negative parameter values hint an encouraging effect.

5.5 A summary of the logit results

From table 5.2 can be inferred that the tax reform based conditional price reduction (PD), the diesel price and the gasoline-diesel price difference, as well as the technology trend variable Mnsq behave in a similar way as in the OLS models. On the other hand, the dummy for a company car shows the opposite effect as compared to the leasing car dummy in the OLS estimations.

The difference is due to the effect that the OLS estimate deals with the emission *level* of the average new car (per month). Since leasing cars are on average larger, a higher share of leasing cars in the monthly sales raises the average. In the logit estimations the tendency regarding a particular choice (low emission model) is modeled. Apparently company car buyers tend be somewhat more inclined to choose a low emission car than the average buyer, even though their average is still higher. In other words in the tail of the distribution the purchase behavior of company car buyers is more profiled. A reason for this may be the uptake of green fleet programs by a growing share of companies (Taloussanomat 16-10-2011).

Table 5.2 Parameter values of selected logit models for market shares of low emission cars for the entire period (eq.1-5) and the years 2008–2009 (eq.6)

Equation no. / Variable	1 all <2000cc	2 all <2000cc 08/09	3 family cars*	4 small cars*	5 cc cat. 1400-1599	6 cc cat. 1400-1599 08/09
dependent (Dlow fraction)	0.03358	0.04498	0.01037	0.05242	0.02231	0.03674
intercept	1.4251	1.8930	7.7061	2.9892	48.7648	37.1275
PDtx (€)	-0.00079	-0.00072	-0.00022	-0.00081	-0.00014	-0.00014
List price (€)	0.000018	0.000132	-0.00004	0.000106	-0.000114	-0.000115
Pdiesel (€)	0.5633	0.5306	-1.3734	0.3764	-11.3087	-7.2909
PDgasolinediesel (€)	-1.8470	-2.9860	8.4625	-1.9969	15.9645	9.5975
Company car (0/1)	-0.3146	-0.3130	-0.1929	-0.3762		
Mnsq (tech_proxy)	-0.0796	-0.0594	-0.0798	-0.0835	-0.0974	0.1473
N (registrations)	140386	75907	99605	86959	46178	25504

*) The segment 'family cars' comprises of the cylinder content categories ranging from 1400cc to 2000cc; the segment 'small cars' comprises of the cylinder content categories below 1600cc.

The effect of the price of the car ('list price') depends on the market segment considered. In case of larger generic market segments (like all cars up to 2000cc) the list price seems to function as a size and outfit indicator, meaning that larger size and/or better outfit (i.e. higher price) implies less chance of being a low emission car. However, in more profiled segments the list price seems (also) to encompass technology progress, which in recent years includes low emission solutions. As a consequence in those cases a higher price does *not* mean less chance of being a low emission car.

5.6 Cost effectiveness

Since the differentiation was rated such as to also imply a reduction of the average passenger car registration tax, a notable reduction in tax revenues resulted. The tax revenue per newly bought passenger car in 2008 was about 2400 Euro lower than in 2007 (Statistics Finland/Ministry of Finance). For 2009 the difference with 2007 is about 2100 Euro per average car.

The cost effectiveness can be regarded from various vantage points, such public finance, macro-economic, the consumer, etc. In this case the effects for public finance and for households will be discussed. Since the development of various variables over time is uncertain a plausible range, rather than a single figure will be provided.

The following assumptions are used:

- an average lifetime of passenger cars of 10 years[11] and a gradually decreasing annual transport performance (from 21000 km in year 1 to 16100 km in year 10)[12]
- a reduction effect of 7 grams CO_2 per km for every 1000 Euro average tax reduction (based on the estimated parameter value in section 5.3)
- an annual additional effect of 1 gram CO_2 per km thanks to interaction between the tax differentiation and the technology and car model portfolio on offer (lower end assumption from the decomposition on page 36)
- an average tax reduction of 2200 Euro per new car (a rough average of the 2008 and 2009 benefit) for a period of 10 years
- consumers benefiting from the tax differentiation and the resulting reduction in their fuel expenditures are reallocating the released budget to other expenditure categories
- the effect of fuel saving of new cars on the fuel tax revenues is compensated by an increase of the fuel tax
- an annual discount rate of 4% is applied
- the number of new passenger cars sold per year is 120 000

Based on these assumptions results a emission reduction per average car of 15.4 g/km in year 1 and of 25.4 g/km in year 10. Applying the gliding annual transport performance (1st assumption above) the total achieved emission reduction per average car would be 2458 kg for a car bought in year 1 and 4055 kg for a car bought in year 10.

Given an average tax reduction of 2200 Euro this would mean a gross price per ton CO_2 of 895 Euro for cars bought in year 1 from the point of view of the government budget. However, the 2200 Euro tax reduction reallocated to other expenditures produces approximately 420 Euro tax revenues and thereby lowers the price for the government to 722 Euro for cars bought in year 1. Since the interaction effect between the tax differentiation and the supply portfolio of cars adds to the emission reduction per average car in subsequent vintages, the net price per ton CO_2 decreases to 381 Euro in year 10.

Considering the various uncertainties it is better to summarize the above results in terms of price ranges. So, from a central government point of view one could

[11] The actual lifetime of passenger cars in Finland is much higher (58% reaches 20 years according to VTT LIPASTO). Yet, the transport performance gets ever smaller when the car age progresses.

[12] Based on information from VTT LIPASTO report 2008

assume a net price per ton reduced CO_2 of 700 to 750 Euro at initial stages and of around 350 Euro in later stages. However, if the car tax system would be revised such that the incentive is retained while the average tax reduction (compared to 2007) is reduced, the price per ton of reduced CO_2 emission could go down considerably (e.g. halved)[13]. The upcoming revision of the car tax system may reduce the average tax reduction by 10%~15%. (see also figure A1 in Annex 2).

From a household perspective the picture is different. A household, which buys a new car enjoys an initial benefit from the tax reduction effect plus an annual benefit from reduced fuel cost. The net present value of the initial tax reduction and the annual fuel saving over a period of 10 years is approximately 3500 Euro. At the macro level it looks differently when is assumed that the revenue loss of the car tax reduction is compensated by increases of other taxes. Than we have to assume that households have to compensate 120000 x 2200 during 10 years by other tax increases. This amounts to about 1.7 billion Euro (at net present value). On the other hand the net present value of the aggregate benefits for households during the same period amounts to approximately 2.1 billion Euro. Spread out over the 10 year period this would amount to 81 Euro benefit per household per year[14]. Also after correction for slightly increased fuel tax (approx. 250 million NPV over 10 years; to compensate for revenue loss due to energy saving) there remains a net benefit for the sector households as a whole.

5.7 Non-clarified aspects

Within the framework of this study two aspects could not be studied in depth, being:

A. import of used cars

B. differences in declared and on-the-road fuel efficiency and emissions

The import of used cars has been going up after the car tax reform (see section 3.3). Imported used cars are on average larger cars than the average newly sold car, whereas they lack the latest energy saving technology (average age is ~8 years (TRAFI website)). Considering these features it can be assumed that an increasing share of imported used car in the annual addition to the car stock implies a deterioration of the intended improvement of the fuel efficiency and specific CO_2 emission level of the car stock. A closer inspection of this impact in

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[13] It would mean that the parameter 7 g/km per 1000 Euro tax reduction would go up, thanks to a more pronounced incentive structure.

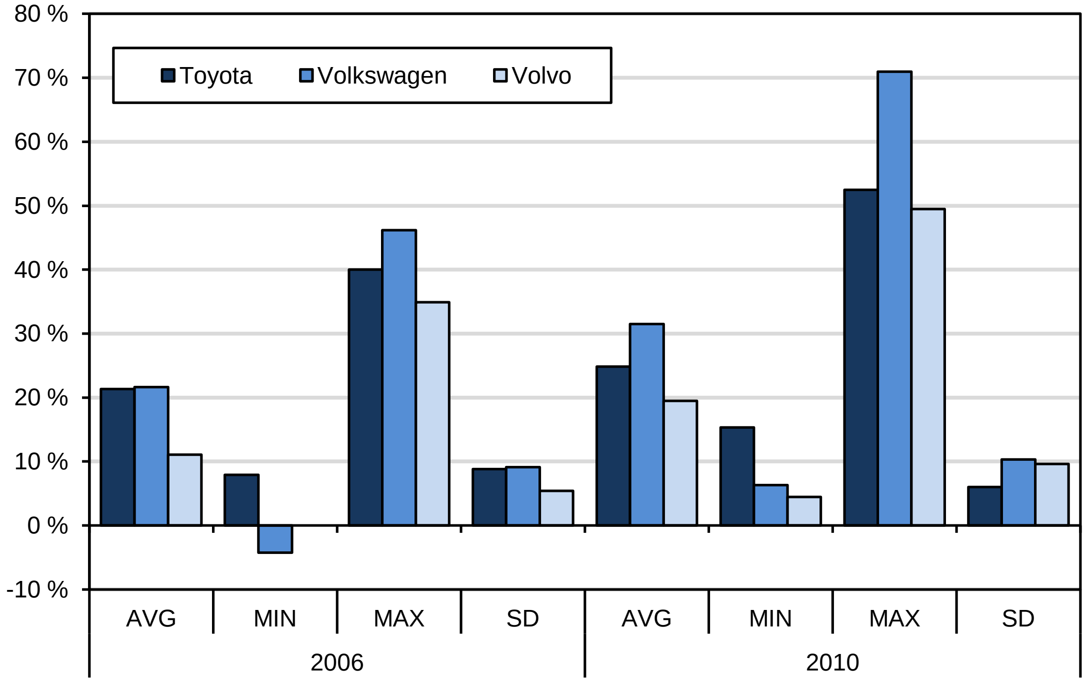
[14] All households which do not buy (or hold) a new car during the ten year period probably end up having a net reduction of purchasing power, whereas all other households (‘the buyers’) have a significantly larger net benefit than € 81.

terms of its significance, persistence and drivers (e.g. also income effects next to taxation effects?) seems recommendable.

It is well known that the actual (on-the-road) fuel performance of cars does not attain the test value efficiency levels of the same models (ECMT 2005). However, there are indications that more energy efficient car models tend to suffer from larger discrepancies between declared and practically attained levels (Ligterink and Bos 2009). Furthermore, even more disconcerting is that according to a large fuel consumption tracking dataset in the Netherlands based on multi-year lease car fleet's performance (http://www.werkelijkverbruik.nl/) the discrepancy is increasing. A preliminary check of the database with respect to a selection of the most popular models in Finland (figure 5.4) hints at widening of the gap of 5% or more. If these trends are also valid in Finland it would mean that the actually achieved decrease of the emission levels of recent vintages of new cars is appreciably smaller than what is displayed in figure 4.10. For example, it would mean that in 2010 the average emissions per km of newly sold cars in Finland would be about 156 g/km and not 149 g/km. These trends would also affect the monitoring and projection of transport emissions at national level.

Ligterink and Bos (2009) indicate that the larger differences between observed and reported (ideal) fuel consumption and emission levels are to a certain extent attributable to larger sensitivity to non-optimal driving behavior. If this is indeed a significant source of deviation from ideal fuel consumption levels, it hints at an increased significance of eco-driving courses.

Figure 5.4 *Differences (in %) between declared and practically observed emissions per km in 2006 and 2010 for three popular brands in Finland (based on a Dutch leasing car fleet database)*



The models included in the comparison were (including varieties per model):

- Toyota: Corolla, Avensis, Yaris, RA4V
- Volkswagen: Golf, Passat
- Volvo: V70, V50

6. Conclusions

The differentiation of the car purchase tax (registration tax) according to a new car's CO_2 emissions per vehicle kilometer appears to be a fairly effective policy instrument in Finland regarding the realization of a steady reduction in emissions per kilometer of new vintages of cars compared to the default trend. For this conclusion the following observations and arguments can be brought forward:

- it has a very noticeable effect on the consumer's choice of passenger car models on offer in the sense that the choice tilts ever more towards cars with lower emissions per vehicle kilometer, whereas it also helps to raise the popularity of low emission cars;

- at the level of the overall annual new vintage of the stock the tax differentiation as implemented in the period 2008 – 2011 implies that 1000 euro induced priced reduction corresponds with a CO_2 emission reduction of about 7 g/km; changes in the set-up of the tax differentiation as well as significant changes in engine technology can considerably affect the responsiveness towards the differentiation and consequently parameter values would change as well;

- in addition to the effect of the car tax differentiation, the CO_2 emission per km of the average new sold car also decreases due to continued reduction of the CO_2 emission levels of car models on offer; the existence of the tax differentiation (and of comparable measures in many other EU Member countries) also reinforces the energy efficiency improvement among new car models;

- an increase in the price difference between diesel and gasoline supports a shift to cars with less CO_2 emission per km, but the significance of this effect may reduce over time (see next point);

- switching from gasoline to diesel is an important element in the buying responses, notably during the first year (2008); however, the convergence of the average emission levels of diesel and gasoline cars seems to diminish the significance of this effect;

- an increase in the share of leasing cars (or other forms of company cars) in total sales tends to raise the average emission intensity of new cars, whereas an increase in the share of rental cars has the opposite effect; it should be noted that these findings are dependent on the so far prevailing incentive structures and levels for these buyer groups; for example, company car buyers seem more inclined to purchase a low emission car than other buyers;

- the tax differentiation fits well in a long term strategy in which the passenger car stock is radically changing in terms of its technical features;

Even though effective from an environmental point of view, the chosen implementation of the tax differentiation was not particularly cost efficient for the government. The implementation in 2008 implied an equivalence point of the old and new tax structure at rather high specific emission levels, which resulted in a reduction of the toal car registration tax revenues. In 2008 as compared to 2007 the tax revenue per newly bought car went down by about 2400 Euro, as a consequence the emission reduction cost (per ton reduced CO_2 emission) are rather high from a public finance point of view, but entail low costs or even a net benefits for households. In the long run the reduction cost for the government are about 350 ~ 300 euro per ton CO_2, when the current incentive structure would prevail. A revision of the differentiation, e.g. such as is planned for 2012, could reduce the cost for the government. For the household sector a net average benefit of about 80 Euro per household would result with the system in place since 2008 and when considering a longer period (10 years).

Between 2006 and 2011 (June) the average emissions per km of newly sold cars went down from about 179 g/km to approximately 146 g/km. Of the realized reduction of approximately 33 g/km about 13 to 17 g/km seems attributable to the car purchase tax reform (in terms of car choice). Of the remainder at least 12 g/km is attributable to technological change (more efficient cars). A part of this is indirectly attributable to earlier European wide policy efforts regarding fuel efficiency of cars. Another 3 to 4 g/km is attributable to policy-technology interaction effects (supply portfolio adjustments).

Various aspects insert uncertainty to the outcomes or at least their interpretation. First, the import of used cars is rising since the introduction of the reformed car purchase tax. This constitutes a leak to the policy instrument of which the significance, persistence and drivers are not accurately known. Second, it is likely that the discrepancy between declared and actually achieved emissions per km of new cars is increasing in Finland (and elsewhere). Based on preliminary explorations of data from the Netherlands there are indications that the discrepancy would have grown by about 5% and perhaps more. Applying the increased discrepancy to the assessed emission development would mean that the average CO_2 emission level of new cars in 2011 is not 146 g/km, but rather 156 g/km.

Ongoing technical change necessitates a regular revision of the applied rates in the formula for establishing the car purchase tax. An unrevised scheme would gradually turn into a tax discount scheme, whereas its effect on choice making would diminish over time.

For a complete analysis of all supply and demand factors affecting car choice and stock renewal a very diverse and large dataset would be necessary which combines at micro-level registery information with car model's technical information, purchase motivation information, and general macro-economic background information on fuel prices, purchasing power development, etc.

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Annex 1 – variables in the datasets

Variables in the passenger car registry (as far as used in this study)

variable name	comment
• gasoline price (95E) (€/liter.)	monthly average price level
• diesel price (€/liter)	monthly average price level
• length of vehicle	in millimeters
• width of vehicle	in millimeters
• use category	1: private; 2: under permit; 3: drive training; 4: car rental; 5: sales stock)
• status of contact person	owner; user
• day of first entry in car registry	
• type of ownership / holdership	private car; business car; lease car;
• cylinder content	in cm3
• number of passenger seats	
• vehicle code number in registry	
• day of first of use of the car	
• type of fuel	gasoline, diesel, CNG, natural gas, electricity, hydrogen, methanol, hybrid (NB! only gasoline and diesel used; hybrid added to gasoline, other fuels extremely rare)
• car body model	sedan, station, hatchback, coupe, cabriolet, 4WD
• CO2 emissions	g/km
• fuel consumption - main road	liters/100 km
• fuel consumption - urban	liters/100 km
• fuel consumption - overall	liters/100 km
• municipality of current owner	municipality number
• name of car model (official)	
• name of car model (as usually referred to in sales)	
• car brand (make)	
• weight of car	kg
• number of doors	
• postal code of postal address of current owner	
• car's registery number (number plate)	
• maximum rated power	kW

- number of cylinders
- max. allowable gross weight kg
- curb weight kg
- gears 4, 5, 6, automatic
- colour
- self imported car YES /NO

Variables in the passenger cars technical specification registry

- model name and version
- fuel type (gasoline, diesel, natural gas, other)
- brand
- CO2 emissions/km according to industry
- fuel consumption (ltr/100km) - overall
- fuel consumption (ltr/100km) - main roads
- fuel consumption (ltr/100km) - urban area
- cylinder content (cm3)
- rated engine power (kW)
- number of gears
- kind of gearbox (manual / automatic)
- number of passenger places
- number of doors
- curb weight (kg)
- maximum allowable weight (kg)
- drive wheels (front, rear, 4-weel drive)
- brakes fitted with anti-blocking system
- CO emissions/km according to industry
- HC emissions/km according to industry
- NOx emissions/km according to industry
- particle emissions/km according to industry
- noise production stationary (dbA)
- noise production when passing by (dbA)
- car body model (sedan, hatchback, station, coupe, cabriolet, other)
- list price (€)
- model year (2006, 2007, 2008, 2009)

The above two datasets were merged, while dropping duplicate variables and adding the tax induced price difference PD (difference between 2008 and 2009 prices and the 2007 price per (sub)model.

Variables in the monthly new cars sales dataset (OLS)

• month	1 (January) ….12 (December)
• year	2006, 2007, 2008, 2009
• Mnsq	month sequence number (2006/1 = 1 … 2009/6 = 42)
• Dtax	dummy to indicate months in which new tax is valid
• Danticip (DS1)	dummy for months in which anticipation effect assumed to be valid due to prior knowledge
• Ddec-jan (DS2/3)	dummy to indicate months December and January, having typically higher and lower sales respectively
• pbensin	price of gasoline (€/litre)
• pdiesel	price of diesel (€/litre)
• wpfuel	average fuel price (gasoline : diesel 0.5:0.5)
• dpbensindiesel	difference between gasoline and diesel price
• KHI_liikenne	consumer price index for transport expenditures, 2005=100
• registered	number of newly registred passenger cars
• registered_bensin	number of newly registred gasoline passenger cars
• registered_diesel	number of newly registred diesel passenger cars
• car stock	total car stock at the end of the year
• holder	holder of the car is not the owner
• sholder	share of monthly car sales for which holder other than the owner
• dpayroll	monthly change in total payroll
• dpayroll_seasonal	monthly change in total payroll, seasonal adjusted
• payroll index	monthly total payroll cost index (2005 = 100)
• meanincome	average monthly income (by year quarter)
• unemployment	unemployment rate (%)
• employment	employment rate (%)
• s_unemployment	seasonally adjusted unemployment rate
• cb_confidence	consumer confidence in national economy
• cb_owneconomy	consumer confidence in own economy
• cb_carbuyaim	intention to buy a car within 12 months
• KHI	consumer price index (monthly) 2005=100
• inflation	change in consumer price index (monthly) 2005=100
• N_bensin	number of gasoline cars

- N_diesel — number of diesel cars
- diesel_share — share of diesel cars in sales per month
- Emissions — average CO_2 emission/km of cars sold (in a month)
- Emissions_bensin — average CO_2 emission/km of gasoline cars sold (in a month)
- Emissions_diesel — average CO_2 emission/km of diesel cars sold (in a month)
- Emissions_expensive — average CO_2 emission/km of expensive cars sold (in a month) (expensive: price $\geq$ € 26000)
- Emissions_cheap — average CO_2 emission/km of cheap cars sold (in a month) (cheap: price < € 26000)
- rentalcars — share of sales meant for use as rental car
- warehousecars — share of sales meant for commercial stocks
- leasingcars — share of sales meant for use as lease car
- companycars — share of sales meant for use as company car
- Price — average monthly sales weighted price of new car
- totalmass — average monthly sales weighted total weight of new car
- ownmass — average monthly sales weighted curb weight of new car
- totallength — average monthly sales weighted length of new car
- capacity — average monthly sales weighted cylinder content of new car
- maxpower — average monthly sales weighted rated power of new car
- PD — average monthly sales weighted tax induced price reduction of new car (2007 price as reference level)
- PD_bensin — average monthly sales weighted tax induced price reduction of new gasoline car (2007 price as reference level)
- PD_diesel — average monthly sales weighted tax induced price reduction of new diesel car (2007 price as reference level)
- PD_expensive — average monthly sales weighted tax induced price reduction of new car costing at least € 26000 (2007 price as reference level)
- PD_cheap — average monthly sales weighted tax induced price reduction of new car costing less than € 26000 (2007 price as reference level).

On the next two pages the OLS dataset is reproduced, without some variables not used in the analysis.

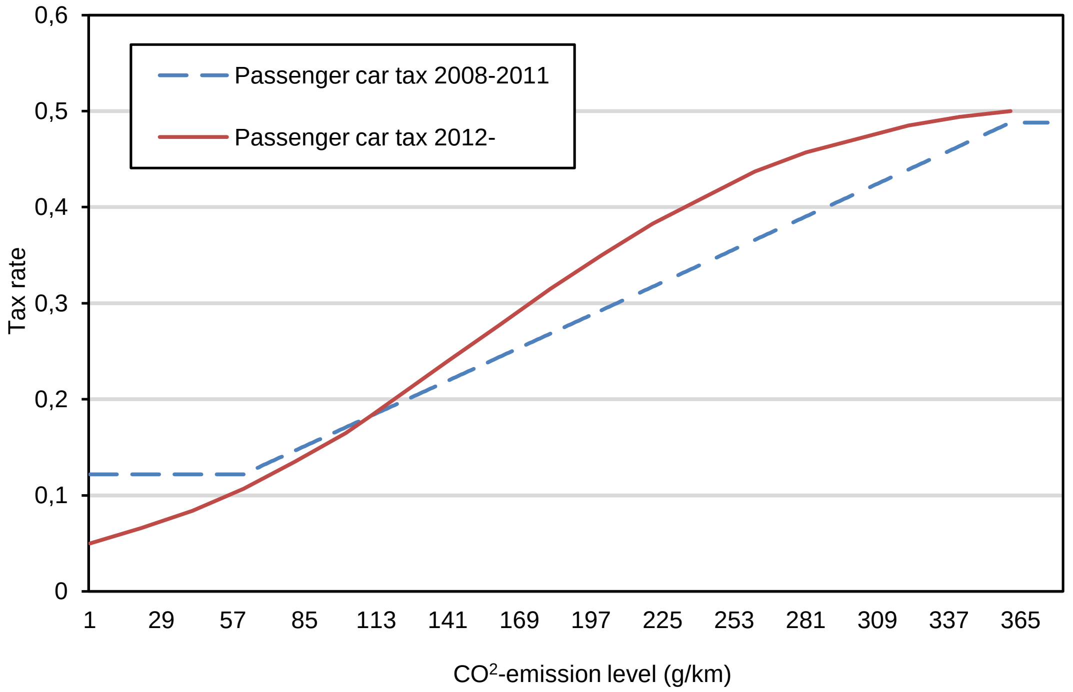
time	month	year	new tax	new tax anticipation dummy	Emissions	Emissions _bensin	Emissions_ diesel	pgasoline	pdiesel	wpfuel	dpgasoline diesel	KHI_liikenne	dmonth _payroll	dyear_payroll _seasonal	payrollindex	incomelevel _index	meanincome	cb_confidence	cb_owneconomy	cb_carbuyaim	KHI	inflation
1/2006	1	2006	0	0	179,99	181,55	173,8	1,24	1,01	1,125	0,23	100,3	-9,43	4,5	94,1	101,3	2 531	13,7	10,1		99,9	0,8
2/2006	2	2006	0	0	178,13	178,88	174,35	1,26	1,02	1,14	0,24	101,1	3,72	5,3	97,6	101,3	2 531	17,0	12,4		100,7	0,9
3/2006	3	2006	0	0	178,08	178,64	175,4	1,25	1,02	1,135	0,23	101,2	6,76	5,4	104,2	101,3	2 531	12,6	11,3		101	0,9
4/2006	4	2006	0	0	179,28	179,71	177,24	1,34	1,03	1,185	0,31	103,3	-4,99	0,9	99	102,3	2 553	9,4	11,0	19 %	101,5	1,3
5/2006	5	2006	0	0	177,01	177,46	174,82	1,35	1,05	1,2	0,3	103,2	2,02	3,6	101	102,3	2 553	13,9	11,1	19 %	101,6	1,7
6/2006	6	2006	0	0	178,56	178,64	178,26	1,34	1,04	1,19	0,3	103,8	26,14	9,1	127,4	102,3	2 553	16,6	12,4	17 %	101,7	1,7
7/2006	7	2006	0	0	177,41	178,18	173,74	1,4	1,05	1,225	0,35	105,4	-7,77	3,5	117,5	103,8	2 592	14,4	9,1	18 %	101,5	1,9
8/2006	8	2006	0	0	177,41	178,06	174,72	1,38	1,05	1,215	0,33	104,3	-12,34	5,2	103	103,8	2 592	14,4	8,2	19 %	101,9	1,9
9/2006	9	2006	0	0	179,77	181,06	174,6	1,28	1,02	1,15	0,26	102,3	0,68	3,2	103,7	103,8	2 592	16,1	10,2	18 %	102	1,5
10/2006	10	2006	0	0	180,2	181,32	175,8	1,23	0,99	1,11	0,24	101,7	-3,95	5,3	99,6	104,4	2 605	14,9	9,7	18 %	102,3	1,8
11/2006	11	2006	0	0	180,65	181,68	177,19	1,21	1	1,105	0,21	100,4	0,70	5,0	100,3	104,4	2 605	17,9	12,9	19 %	102,3	2,1
12/2006	12	2006	0	0	185,7	188,25	176,6	1,21	0,99	1,1	0,22	100,3	8,57	5,5	108,9	104,4	2 605	18,2	10,9	16 %	102,4	2,2
1/2007	1	2007	0	0	180,53	182,21	175,88	1,18	0,96	1,07	0,22	100,1	-8,54	5,3	99,6	105,1	2 620	18,3	12,3	18 %	102,2	2,3
2/2007	2	2007	0	0	179	180,42	174,81	1,2	0,97	1,085	0,23	100,4	3,41	6,0	103	105,1	2 620	16,8	14,1	19 %	102,9	2,2
3/2007	3	2007	0	0	178,23	180,11	172,3	1,26	0,99	1,125	0,27	102,4	7,38	6,3	110,6	105,1	2 620	16,5	12,2	18 %	103,6	2,6
4/2007	4	2007	0	0	174,98	176,27	170,76	1,29	0,99	1,14	0,3	102,9	-5,15	5,6	104,9	105,4	2 626	17,9	12,4	19 %	104,1	2,6
5/2007	5	2007	0	0	174,48	175,73	170,36	1,34	0,99	1,165	0,35	103,5	2,57	6,6	107,6	105,4	2 626	17,7	10,7	19 %	104	2,4
6/2007	6	2007	0	0	175,32	176,57	171,8	1,35	0,99	1,17	0,36	104,2	23,23	4,1	132,6	105,4	2 626	20,4	12,2	18 %	104,2	2,4
7/2007	7	2007	0	0	173,95	175,42	170,38	1,36	1,01	1,185	0,35	104,7	-7,54	4,7	122,6	105,7	2 635	18,5	11,4	17 %	104,1	2,6
8/2007	8	2007	0	0	173,95	175,62	170,07	1,32	1,01	1,165	0,31	103,8	-9,46	7,6	111	105,7	2 635	20,3	11,7	19 %	104,2	2,3
9/2007	9	2007	0	0	176,6	178,58	172	1,31	1,02	1,165	0,29	103,2	-4,23	3,3	106,3	105,7	2 635	18,5	10,2	17 %	104,7	2,6
10/2007	10	2007	0	0	173,94	176,42	168,6	1,29	1,03	1,16	0,26	103,1	-0,85	5,1	105,4	109,4	2 730	17,3	12,1	19 %	105	2,7
11/2007	11	2007	0	1	191,45	190,69	193,33	1,35	1,14	1,245	0,21	103,2	3,80	8,9	109,4	109,4	2 730	14,5	12,7	21 %	105,3	2,9
12/2007	12	2007	0	1	198,25	206,33	185,34	1,33	1,14	1,235	0,19	102,4	6,95	7,4	117	109,4	2 730	14,0	10,4	18 %	105,1	2,6
1/2008	1	2008	1	0	166,29	171,03	160,92	1,42	1,22	1,32	0,2	104,6	-8,21	7,5	107,4	110,2	2 755	13,1	9,7	19 %	106,2	3,8
2/2008	2	2008	1	0	163,89	168,92	158,83	1,4	1,2	1,3	0,2	104	6,15	9,7	114	110,2	2 755	10,1	9,6	21 %	106,7	3,7
3/2008	3	2008	1	0	162,43	167,54	157,53	1,42	1,25	1,335	0,17	105,2	2,72	7,1	117,1	110,2	2 755	12,9	9,8	18 %	107,6	3,9
4/2008	4	2008	1	0	162,82	168,7	156,92	1,42	1,26	1,34	0,16	105,2	-1,71	9,5	115,1	111,4	2 784	12,6	9,3	19 %	107,8	3,5
5/2008	5	2008	1	0	160,83	165,2	156,28	1,48	1,33	1,405	0,15	106,4	2,43	9,8	117,9	111,4	2 784	11,1	6,6	18 %	108,4	4,2
6/2008	6	2008	1	0	162,49	165,95	158,72	1,57	1,44	1,505	0,13	108,7	18,74	5,8	140	111,4	2 784	10,2	5,8	16 %	108,8	4,4
7/2008	7	2008	1	0	160,46	163,34	157,17	1,58	1,44	1,51	0,14	109,2	-5,71	7,5	132	112,3	2 806	6,5	4,6	16 %	108,6	4,4
8/2008	8	2008	1	0	161,18	163,12	159,01	1,51	1,37	1,44	0,14	107,3	-11,29	6,5	117,1	112,3	2 806	8,7	3,2	16 %	109,1	4,7
9/2008	9	2008	1	0	162,23	165,07	158,93	1,5	1,33	1,415	0,17	107,6	-2,82	6,4	113,8	112,3	2 806	8,1	6,3	17 %	109,6	4,7
10/2008	10	2008	1	0	161,05	163,3	158,52	1,41	1,22	1,315	0,19	106,2	1,93	9,3	116	115,2	2 911	-0,2	5,3	15 %	109,6	4,4
11/2008	11	2008	1	0	161,38	161,72	161,09	1,25	1,11	1,18	0,14	101,5	-2,76	3,7	112,8	115,2	2 911	-4,5	3,1	15 %	109,1	3,6
12/2008	12	2008	1	0	164,01	166,44	162,24	1,16	1,03	1,095	0,13	99,6	6,38	1,6	120	115,2	2 911	-6,5	3,2	14 %	108,7	3,5
1/2009	1	2009	1	0	160,83	160,52	161,17	1,16	0,99	1,075	0,17	98,8	-6,17	5,0	112,6	115	2 905	-3,9	3,5	16 %	108,5	2,2
2/2009	2	2009	1	0	160,2	159,22	161,38	1,2	0,98	1,09	0,22	99,9	0,09	-1,0	112,7	115	2 905	-3,9	3,0	15 %	108,6	1,7
3/2009	3	2009	1	0	157,76	156,89	158,88	1,2	0,94	1,07	0,26	100	1,86	-1,8	114,8	115	2 905	-1,5	3,4	15 %	108,6	0,9
4/2009	4	2009	1	0	156,92	156,81	157,1	1,23	0,95	1,09	0,28	100,4	1,22	0,8	116,2	116,3	2 942	1,0	3,4	14 %	108,6	0,8
5/2009	5	2009	1	0	155,28	156,26	153,98	1,3	0,98	1,14	0,32	101,8	-1,20	-2,1	114,8	116,3	2 942	7,2	5,6	17 %	108,4	0
6/2009	6	2009	1	0	156,73	156,09	157,56	1,36	1	1,18	0,36	103,4	21,08	-0,8	139	116,3	2 942	8,4	7,1	16 %	108,7	-0,1

time	month	year	registered _total	registered_ bensin	registered _diesel	diesel_ share	diesel_ share_ cheap	diesel_s hare_ex pensive	rental cars	warehouse cars	holder	Leasing cars	company cars	curb weight	cylinder content	rated power	Emissions _expensi ve	Emissions _cheap	PD	PD_gaso line	PD_ diesel	PD_exp ensive	PD_cheap
1/2006	1	2006	18446	14462	3686	20,3 %	4,0 %	33,9 %	0,09 %	0,10 %	27,7 %	1,72 %	0,42 %	1418,2	1859,1	94,4	192,63	162,31	0	0	0	0	0
2/2006	2	2006	11615	9452	1945	17,1 %	3,6 %	29,9 %	0,08 %	0,04 %	29,4 %	2,37 %	0,43 %	1401,9	1812,4	91,8	193,46	160,28	0	0	0	0	0
3/2006	3	2006	13748	11105	2357	17,5 %	2,5 %	31,9 %	0,06 %	0,19 %	29,7 %	2,73 %	0,39 %	1391,9	1806,1	91,3	194	160,2	0	0	0	0	0
4/2006	4	2006	12250	9884	2097	17,5 %	3,6 %	30,5 %	0,06 %	0,18 %	28,8 %	3,03 %	0,44 %	1412,3	1849,2	94,3	196,06	160,38	0	0	0	0	0
5/2006	5	2006	15142	12278	2526	17,1 %	3,2 %	30,4 %	0,07 %	0,17 %	28,5 %	3,38 %	0,53 %	1389,1	1811,5	91,5	193,71	159,36	0	0	0	0	0
6/2006	6	2006	15098	12092	2516	17,2 %	2,7 %	30,9 %	0,13 %	0,12 %	31,6 %	5,03 %	0,61 %	1400,5	1834,3	93,3	195,35	159,81	0	0	0	0	0
7/2006	7	2006	10663	8572	1823	17,5 %	3,6 %	31,5 %	0,03 %	0,13 %	33,3 %	7,11 %	0,58 %	1407	1838,8	94,4	193,57	161,21	0	0	0	0	0
8/2006	8	2006	11068	8740	2109	19,4 %	4,1 %	34,0 %	0,09 %	0,11 %	35,6 %	8,27 %	0,44 %	1423,9	1854,2	95,8	192,72	160,92	0	0	0	0	0
9/2006	9	2006	11729	9056	2302	20,3 %	3,8 %	34,7 %	0,07 %	0,10 %	34,4 %	7,60 %	0,72 %	1437,5	1891,0	97,3	195,07	161,69	0	0	0	0	0
10/2006	10	2006	11122	8694	2265	20,7 %	5,2 %	34,1 %	0,09 %	0,09 %	38,1 %	9,76 %	0,74 %	1437,8	1886,9	97,1	198,15	160,6	0	0	0	0	0
11/2006	11	2006	9031	6926	1966	22,1 %	6,4 %	35,6 %	0,11 %	0,11 %	41,8 %	13,02 %	0,85 %	1448,4	1894,7	97,0	198,54	160,61	0	0	0	0	0
12/2006	12	2006	5788	4402	1241	22,0 %	5,8 %	31,4 %	0,34 %	0,11 %	54,0 %	27,61 %	1,20 %	1481,8	1968,1	102,3	199,8	162,85	0	0	0	0	0
1/2007	1	2007	16893	12269	4619	26,6 %	8,9 %	41,4 %	0,30 %	0,13 %	32,7 %	5,71 %	0,56 %	1461,9	1898,5	98,7	193,03	157,78	0	0	0	0	0
2/2007	2	2007	10574	7764	2805	25,3 %	7,7 %	40,2 %	0,36 %	0,13 %	35,6 %	8,80 %	0,71 %	1455,4	1880,2	97,7	192,6	157,05	0	0	0	0	0
3/2007	3	2007	12735	9468	3264	24,2 %	7,3 %	39,1 %	0,08 %	0,10 %	37,2 %	10,25 %	0,66 %	1455,9	1871,4	98,6	191,21	156,78	0	0	0	0	0
4/2007	4	2007	12295	9204	3091	23,5 %	6,0 %	41,5 %	0,12 %	0,12 %	37,3 %	10,62 %	0,57 %	1420,4	1810,0	94,5	188,89	155,85	0	0	0	0	0
5/2007	5	2007	13130	9808	3319	23,4 %	6,6 %	40,2 %	0,35 %	0,27 %	38,3 %	11,20 %	0,65 %	1422,2	1817,7	94,3	189,4	154,99	0	0	0	0	0
6/2007	6	2007	11780	8453	3321	26,3 %	10,3 %	41,1 %	0,68 %	0,17 %	40,3 %	12,35 %	0,75 %	1444,5	1854,6	96,5	189,71	153,53	0	0	0	0	0
7/2007	7	2007	10435	7217	3208	29,1 %	9,1 %	46,0 %	0,59 %	0,20 %	41,3 %	11,59 %	0,79 %	1435,9	1838,5	95,4	186,16	153,75	0	0	0	0	0
8/2007	8	2007	11025	7594	3428	29,9 %	9,7 %	46,8 %	0,44 %	0,18 %	40,8 %	12,65 %	0,64 %	1442,9	1842,1	96,3	186,35	154,38	0	0	0	0	0
9/2007	9	2007	9821	6743	3076	30,2 %	8,0 %	46,3 %	0,42 %	0,22 %	43,3 %	13,88 %	0,78 %	1456,5	1881,7	98,2	189,27	154,5	0	0	0	0	0
10/2007	10	2007	11079	7426	3644	31,7 %	11,6 %	48,1 %	0,41 %	0,25 %	45,1 %	15,61 %	1,06 %	1458,2	1876,2	98,2	186,45	153,12	0	0	0	0	0
11/2007	11	2007	3753	2609	1148	29,0 %	11,1 %	40,3 %	1,34 %	0,30 %	55,1 %	26,32 %	1,55 %	1550,3	2071,1	109,7	208,01	156,21	0	0	0	0	0
12/2007	12	2007	2097	1234	859	39,3 %	10,8 %	46,0 %	0,93 %	0,00 %	65,9 %	42,13 %	3,12 %	1613,6	2164,0	115,6	202,77	156,57	0	0	0	0	0
1/2008	1	2008	21544	11322	10210	46,9 %	28,6 %	64,3 %	0,64 %	0,28 %	39,5 %	12,49 %	0,97 %	1460,8	1839,0	95,8	178,17	150,4	-1970,0	-922,9	-3062,0	-2300,2	-1531,5
2/2008	2	2008	12019	5925	6080	49,9 %	29,6 %	67,8 %	0,65 %	0,22 %	38,9 %	11,64 %	1,11 %	1453,3	1827,1	94,5	175	148,52	-1973,1	-864,9	-3001,3	-2348,4	-1446,2
3/2008	3	2008	12577	6039	6514	51,1 %	32,6 %	67,9 %	0,77 %	0,47 %	39,8 %	11,39 %	1,00 %	1447,2	1822,6	93,9	172,87	147,97	-2015,3	-915,1	-2994,9	-2376,4	-1518,2
4/2008	4	2008	15512	7558	7938	49,9 %	32,3 %	66,7 %	1,08 %	0,44 %	40,9 %	13,01 %	0,90 %	1455,5	1827,5	94,9	173,1	148,62	-2133,9	-1008,3	-3169,6	-2492,4	-1628,3
5/2008	5	2008	14235	7099	7123	48,9 %	30,4 %	67,7 %	3,25 %	0,60 %	42,7 %	15,12 %	0,87 %	1435,3	1802,8	92,9	171,78	148,23	-2146,0	-980,9	-3275,5	-2550,1	-1638,0
6/2008	6	2008	12152	6142	5988	47,8 %	25,7 %	66,8 %	3,29 %	1,40 %	46,1 %	17,90 %	1,03 %	1435,4	1799,0	92,9	173,34	149,94	-2049,4	-1022,1	-3146,7	-2438,1	-1553,2
7/2008	7	2008	11192	5787	5392	46,7 %	23,8 %	65,0 %	2,66 %	0,80 %	43,7 %	17,18 %	0,83 %	1439,8	1794,7	93,1	170,09	148,49	-2135,4	-1130,3	-3292,5	-2471,4	-1702,0
8/2008	8	2008	9458	4885	4566	47,0 %	25,0 %	63,3 %	1,10 %	1,12 %	48,6 %	19,05 %	0,99 %	1449,7	1799,6	93,8	170,7	148,97	-2064,7	-1059,3	-3204,2	-2436,9	-1543,4
9/2008	9	2008	9871	5180	4675	46,2 %	25,2 %	62,9 %	2,28 %	1,86 %	49,6 %	20,19 %	1,61 %	1452,1	1808,4	94,5	172,51	149,58	-1987,1	-976,7	-3171,7	-2322,4	-1545,1
10/2008	10	2008	10164	5276	4881	46,7 %	24,8 %	64,6 %	1,61 %	1,75 %	50,1 %	22,63 %	1,65 %	1452,1	1797,8	94,0	171,75	147,06	-2164,5	-1154,0	-3290,8	-2575,3	-1602,3
11/2008	11	2008	6452	3173	3267	49,5 %	20,7 %	70,1 %	1,55 %	1,11 %	52,9 %	26,57 %	1,79 %	1468,7	1825,2	95,4	170,25	148,64	-2321,1	-1097,9	-3587,7	-2989,7	-1353,4
12/2008	12	2008	4488	1853	2613	57,3 %	28,3 %	71,4 %	1,55 %	1,12 %	66,9 %	43,71 %	2,35 %	1504,7	1880,0	99,3	170,69	147,53	-2576,4	-1277,8	-3585,7	-2943,3	-1816,2
1/2009	1	2009	11566	5717	5816	49,5 %	19,3 %	70,1 %	3,15 %	5,18 %	43,7 %	17,21 %	1,03 %	1461,1	1803,2	94,5	167,42	148,72	-2150,0	-1269,6	-3074,3	-2499,0	-1649,8
2/2009	2	2009	7185	3816	3354	45,6 %	17,1 %	64,9 %	2,72 %	2,78 %	46,8 %	20,40 %	1,03 %	1469,5	1806,5	95,2	166,5	148,01	-2038,3	-1108,3	-3159,0	-2319,4	-1634,3
3/2009	3	2009	10739	5874	4847	44,2 %	16,1 %	70,6 %	11,32 %	4,91 %	55,4 %	31,74 %	0,94 %	1419	1743,5	90,9	166,67	147,73	-2115,9	-1328,5	-3019,2	-2478,3	-1654,8
4/2009	4	2009	7445	4250	3179	40,9 %	16,0 %	65,6 %	3,52 %	2,21 %	42,6 %	14,91 %	0,86 %	1431,2	1748,1	93,1	164,84	146,8	-2087,2	-1367,5	-3056,7	-2405,6	-1715,7
5/2009	5	2009	7236	4036	3184	42,3 %	21,0 %	59,6 %	1,63 %	2,76 %	43,1 %	16,14 %	1,55 %	1435,4	1753,5	93,8	163,32	145,65	-2005,6	-1140,0	-3188,2	-2419,3	-1489,5
6/2009	6	2009	7909	4320	3582	43,6 %	18,6 %	61,1 %	4,22 %	3,18 %	45,9 %	18,70 %	1,78 %	1457,8	1791,9	95,1	165,35	145,38	-1974,0	-956,2	-3309,0	-2212,7	-1632,6

Annex 2 – Establishment of the car purchase tax and implied tax level changes for selected brands

The tax percentage applied to the pre-tax price defined by the manufacturer is calculated by using the carbon dioxide emissions as grams per kilometer reported by the manufacturer. The tax rate is rising linearly between 60g/km and 360g/km (fig. A1), and has a minimum of 12.2% and a maximum of 48.8%. Rates will be adapted in 2012 such as to reinforce the incentive to choose a low emission vehicle (figure A1).. Probably the average tax receipt per sold car will rise under the revised system.

Figure A1. Tax rates by emission level of a passenger car – period 2008–2011



Source: Nissinen et al, 2012

Figures A2 and A3 illustrate that the developments of emission intensity and to a lesser extent those of price change are not a matter of steady improvement. Partly, these results may also be affected by revisions of given technical details of the car models on offer, whereas on the other hand introduction of new very successful models may contribute surprisingly strongly to overall changes. Also typical cycles for renewing company cars and lease cars may affect the developments (see also figure 2.3).

Figure A3 shows the significant differences in realized price discounts between brands. Apparently the share of diesels in the portfolio has a large influence. It is also noticeable that only two of the five brands (Renault and Ford) show a fairly systematic further gain in the price discount as time goes by. For the other brands the level of the discount does not change much after the introduction of the tax reform in January 2008.

Toyota shows even a positive price differential. This could be regarded as a first mover premium, as Toyota is the brand that took the lead in producing and marketing innovative low emission cars (hybrids).

Figure A2. *Changes in average emissions/km of monthly sales by brand (difference with level of same month in previous year)*

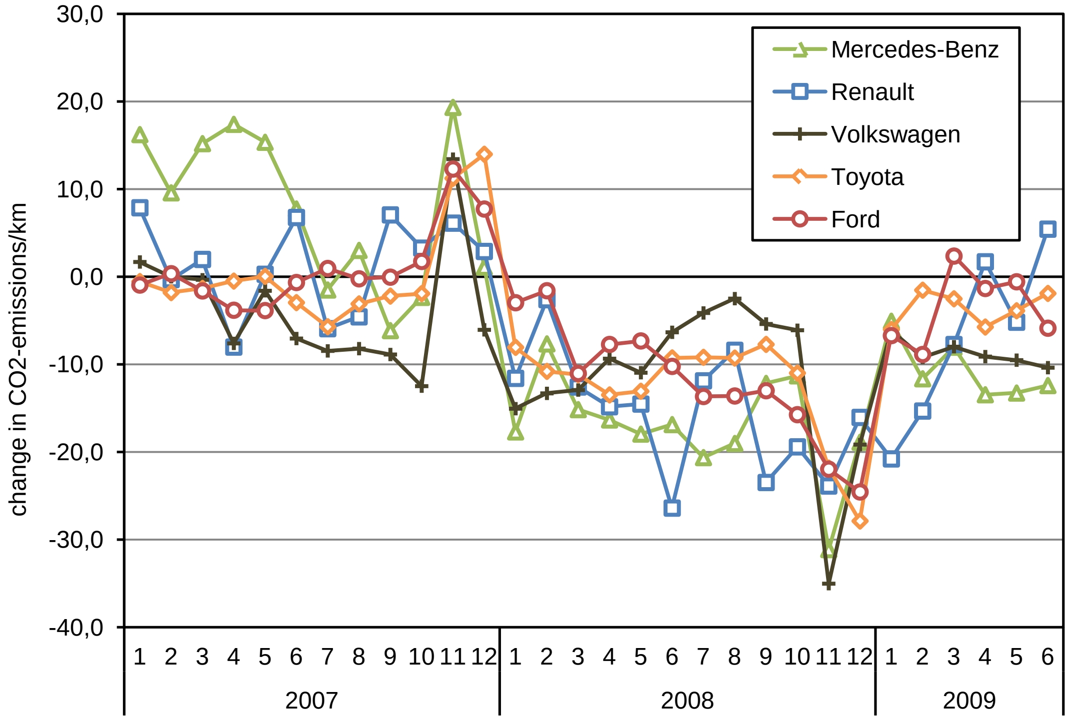
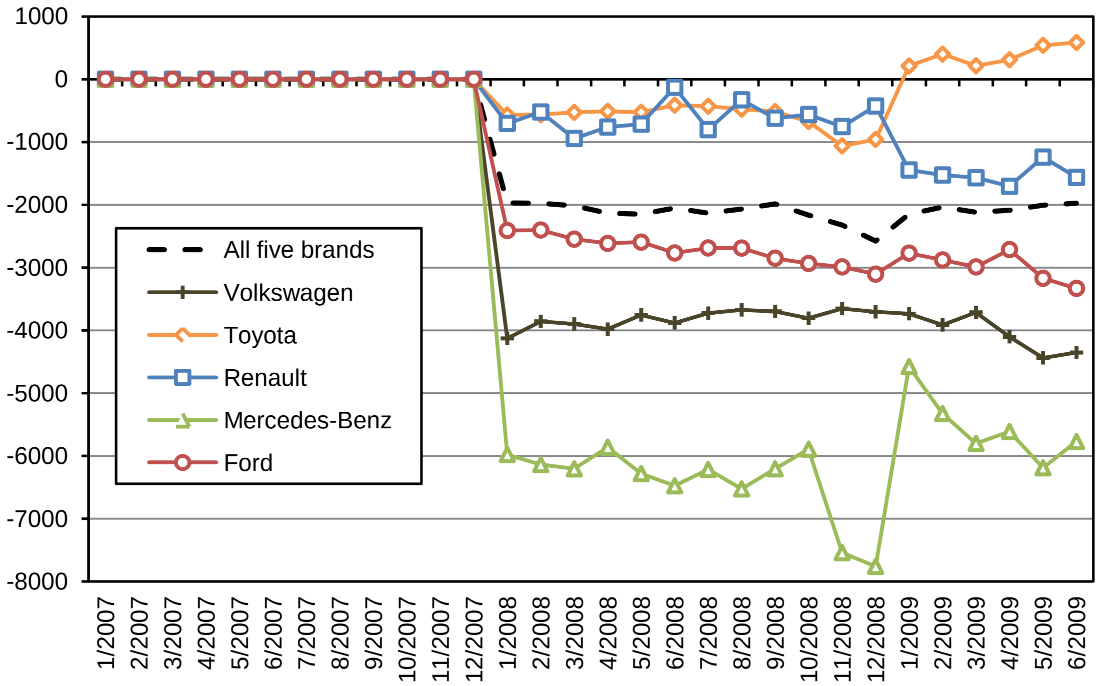


Figure A3. *Calculated evolution of tax reform induced average price changes by brand*



Annex 3 – Emissions 2006 – 2009 based on model supply and sales

Model supply figures are based on the AKE (now Trafi) database of technical specifications of models on offer by year. Sales figures are based on the car registry data.

GASOLINE			model supply	sales	
VUOSI	cylinder class	N models	*Mean* CO2/vkm	*Mean* CO2/vkm	N sales
2006					
1	<1150	66	126,2	125,9	4055
2	1150-1400	315	156,3	148,5	19783
3	1400-1600	453	172,8	169,7	38684
4	1600-1800	368	183,3	180,9	16272
5	1800-2000	882	204,1	199,5	23055
6	2000-2300	146	215,2	208,0	2063
7	2300-2600	455	227,9	230,6	8435
8	2600-3000	187	245,2	249,0	1644
9	>3000	315	289,9	276,9	1672
2007					
1	<1150	73	125,4	126,0	2723
2	1150-1400	371	156,1	151,4	17324
3	1400-1600	634	169,6	167,7	28981
4	1600-1800	489	183,8	179,4	12276
5	1800-2000	1045	199,3	197,6	17992
6	2000-2300	274	219,6	218,4	1163
7	2300-2600	440	222	228,2	6374
8	2600-3000	236	232,8	240,6	987
9	>3000	349	284,6	273,7	1727
2008					
1	<1150	72	121,7	125,7	2766
2	1150-1400	421	149,3	148,6	19582
3	1400-1600	472	167	161,4	23278
4	1600-1800	383	176,6	174,6	9303
5	1800-2000	789	193,7	189,4	11337
6	2000-2300	83	215,4	220,5	489
7	2300-2600	326	217,9	218,1	2285
8	2600-3000	208	223,7	223,3	755
9	>3000	428	284,5	266,5	615
2009					
1	<1150	81	117,1	116,0	805
2	1150-1400	363	142,8	141,3	10840
3	1400-1600	468	166	158,7	7495
4	1600-1800	396	172,9	167,7	4338
5	1800-2000	707	189,4	183,7	3573
6	2000-2300	61	208,9	220,4	83
7	2300-2600	318	213,7	218,0	415
8	2600-3000	182	221,3	226,8	270
9	>3000	328	273,4	250,9	201

			model	sales	
			supply		
DIESEL	cylinder class	N models	*Mean*	*Mean*	N sales
2006			**CO2/vkm**	**CO2/vkm**	
2		41	126,6	124,9	978
3		121	130	130,9	2089
4		20	151,5	143,1	168
5		548	166,4	160,6	11875
6		164	193,2	174,7	4847
7		256	215,2	215,4	3749
8		187	226,6	235,4	3063
9		15	278,1	273,0	64
	2007				
1		6	88	88,0	3
2		50	126,8	126,4	1299
3		201	133,3	129,1	3754
4		33	152,5	148,2	602
5		1002	166,5	161,9	15734
6		219	198,9	177,0	4373
7		320	210,2	213,5	3669
8		212	219	234,4	3609
9		23	270,4	286,8	261
	2008				
1		7	92	89,1	50
2		74	124,5	124,8	3260
3		254	130	129,2	10864
4		46	151	144,5	2769
5		1243	161,8	157,0	34396
6		318	204,7	172,8	6759
7		364	210,9	204,4	5057
8		228	212,2	217,4	3134
9		29	277,9	282,7	155
	2009				
1		7	92	92,3	13
2		98	122	124,6	1043
3		268	127,8	126,6	3313
4		43	139,7	144,0	860
5		1110	160,8	156,1	11241
6		352	180,2	171,7	3477
7		341	210,6	206,9	1822
8		227	205,9	213,2	910
9		39	266,9	284,7	29

Annex 4 – Estimation results

OLS estimates

all years

The REG Procedure

Model: MODEL1

Dependent Variable: EMISSIONS

Number of Observations Read	42
Number of Observations Used	42

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	3883.97461	970.99365	82.55	<.0001
Error	37	435.19649	11.76207		
Corrected Total	41	4319.17110			

Root MSE	3.42959	R-Square	0.8992
Dependent Mean	171.42024	Adj R-Sq	0.8883
Coeff Var	2.00069		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	132.18555	28.62750	4.62	<.0001
PBENSIN	1	-58.78898	10.87627	-5.41	<.0001
PDIESEL	1	62.38439	9.88783	6.31	<.0001
PD	1	0.01369	0.00146	9.40	<.0001
MEANINCOME	1	0.02278	0.00984	2.31	0.0263

all years

The REG Procedure

Model: MODEL2

Dependent Variable: EMISSIONS

Number of Observations Read	42
Number of Observations Used	42

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3879.29803	1293.09934	111.71	<.0001
Error	38	439.87306	11.57561		
Corrected Total	41	4319.17110			

Root MSE	3.40229	R-Square	0.8982
Dependent Mean	171.42024	Adj R-Sq	0.8901
Coeff Var	1.98477		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	142.92212	22.83008	6.26	<.0001
DPBENSINDIESEL	1	-61.72151	9.75354	-6.33	<.0001
PD	1	0.01328	0.00130	10.25	<.0001
MEANINCOME	1	0.02038	0.00901	2.26	0.0294

all years

The REG Procedure

Model: MODEL3

Dependent Variable: EMISSIONS

Number of Observations Read	42
Number of Observations Used	42

Analysis of Variance

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	8	4272.06856	534.00857	374.13	<.0001
Error	33	47.10254	1.42735		
Corrected Total	41	4319.17110			

Root MSE	1.19472	R-Square	0.9891
Dependent Mean	171.42024	Adj R-Sq	0.9865
Coeff Var	0.69695		

Parameter Estimates

Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	183.98683	1.31724	139.68	<.0001
DPGASOLINEDIESEL	1	-17.03673	4.62409	-3.68	0.0008
PD	1	0.00650	0.0005746	11.31	<.0001
Monsqn	1	-0.26175	0.05457	-4.80	<.0001
PRIORKNOWLEDGE	1	13.75965	1.23115	11.18	<.0001
DS1	1	1.93273	0.69010	2.80	0.0085
DS2	1	3.51809	1.62414	2.17	0.0376
LEASINGCARS	1	15.12377	7.24652	2.09	0.0447
RENTALCARS	1	-24.19957	14.76400	-1.64	0.1107

all years

The REG Procedure

Model: MODEL4

Dependent Variable: EMISSIONS

Number of Observations Read 42
Number of Observations Used 42

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	4265.14784	710.85797	460.54	<.0001
Error	35	54.02326	1.54352		
Corrected Total	41	4319.17110			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	185.68006	1.11206	43031	27878.7	<.0001
DPGASOLINEDIESEL	-21.66649	4.28275	39.50438	25.59	<.0001
PD	0.00699	0.00055031	249.21039	161.46	<.0001
Monsqn	-0.18812	0.03933	35.31968	22.88	<.0001
PRIORKNOWLEDGE	14.67279	1.18139	238.09736	154.26	<.0001
DS1	1.44806	0.67640	7.07432	4.58	0.0393
DS2	6.50235	0.83224	94.22365	61.04	<.0001

all years

The REG Procedure

Model: MODEL5

Dependent Variable: EMISSIONS

Number of Observations Read 42
Number of Observations Used 42

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	4248.68677	708.11446	351.62	<.0001
Error	35	70.48433	2.01384		
Corrected Total	41	4319.17110			

Root MSE	1.41910	R-Square	0.9837
Dependent Mean	171.42024	Adj R-Sq	0.9809
Coeff Var	0.82785		

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	184.26563	1.36904	36482	18115.7	<.0001
DPGASOLINEDIESEL	-17.70766	5.15473	23.76487	11.80	0.0015
PD	0.00624	0.00065747	181.39623	90.07	<.0001
Monsqn	-0.32212	0.05300	74.39096	36.94	<.0001
PRIORKNOWLEDGE	13.34820	1.42118	177.65187	88.22	<.0001
LEASINGCARS	25.56386	4.10157	78.23056	38.85	<.0001
RENTALCARS	-35.59094	15.56421	10.53051	5.23	0.0284

Logit estimates

MODEL 1: logistic model CC_class1_to_5

The LOGISTIC Procedure

Model Information

Data Set	REK.CARSTOCKPRICE3
Response Variable	Dlow
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	380722
Number of Observations Used	140386

Response Profile

Ordered Value	Dlow	Total Frequency
1	0	135825
2	1	4561

Probability modeled is Dlow=0.

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	40233.947	31179.045
SC	40243.800	31248.010
-2 Log L	40231.947	31165.045

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	9066.9025	6	<.0001
Score	7533.9701	6	<.0001
Wald	6573.1669	6	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	1.4251	0.2502	32.4539	<.0001
Dprice	1	-0.00079	0.000015	2611.7887	<.0001
HINTA	1	0.000176	2.917E-6	3658.8822	<.0001
gasodiediff	1	-1.8470	0.3151	34.3541	<.0001
dieselhinta	1	0.5633	0.1494	14.2048	0.0002
asiakaslaji1	1	-0.3146	0.0322	95.5544	<.0001
Monsqn	1	-0.0796	0.00189	1773.4489	<.0001

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
Dprice	0.999	0.999	0.999
HINTA	1.000	1.000	1.000
gasodiediff	0.158	0.085	0.292
dieselhinta	1.756	1.310	2.354

asiakaslaji1	0.730	0.685	0.778
Monsqn	0.924	0.920	0.927

Association of Predicted Probabilities and Observed Responses

Percent Concordant	81.7	Somers' D	0.652
Percent Discordant	16.5	Gamma	0.664
Percent Tied	1.8	Tau-a	0.041
Pairs	619497825	c	0.826

MODEL 2: logistic model CC_class1_to_5 2008-2009

The LOGISTIC Procedure

Model Information

Data Set	REK.CARSTOCKPRICE3
Response Variable	Dlow
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	162337
Number of Observations Used	75907

Response Profile

Ordered Value	**Dlow**	**Total Frequency**
1	0	72493
2	1	3414

Probability modeled is Dlow=0.

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	**Intercept Only**	**Intercept and Covariates**
AIC	27851.987	22517.713
SC	27861.224	22582.374
-2 Log L	27849.987	22503.713

Testing Global Null Hypothesis: BETA=0

Test	**Chi-Square**	**DF**	**Pr > ChiSq**
Likelihood Ratio	5346.2741	6	<.0001
Score	4345.0953	6	<.0001
Wald	3965.7414	6	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	1.8930	0.3714	25.9724	<.0001
Dprice	1	-0.00072	0.000015	2395.8973	<.0001
HINTA	1	0.000132	3.079E-6	1827.0608	<.0001
gasodiediff	1	-2.9860	0.4097	53.1121	<.0001
dieselhinta	1	0.5306	0.1861	8.1269	0.0044
asiakaslaji1	1	-0.3130	0.0373	70.4928	<.0001
Monsqn	1	-0.0594	0.00563	111.2022	<.0001

Odds Ratio Estimates

Effect	**Point Estimate**	**95% Wald Confidence Limits**	
Dprice	0.999	0.999	0.999
HINTA	1.000	1.000	1.000
gasodiediff	0.050	0.023	0.113
dieselhinta	1.700	1.180	2.448
asiakaslaji1	0.731	0.680	0.787
Monsqn	0.942	0.932	0.953

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	79.0	Somers' D	0.591
Percent Discordant	19.9	Gamma	0.598
Percent Tied	1.1	Tau-a	0.051
Pairs	247491102	c	0.796

MODEL 3: logistic model family cars

The LOGISTIC Procedure

Model Information

Data Set	REK.CARSTOCKPRICE3
Response Variable	Dlow
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	295844
Number of Observations Used	99605

Response Profile

Ordered Value	Dlow	Total Frequency
1	0	98572
2	1	1033

Probability modeled is Dlow=0.

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Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	11496.277	10378.324
SC	11505.786	10444.887
-2 Log L	11494.277	10364.324

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	1129.9533	6	<.0001
Score	1167.1227	6	<.0001
Wald	914.9210	6	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	7.7061	0.5281	212.9607	<.0001
Dprice	1	-0.00022	0.000019	135.8203	<.0001
HINTA	1	-0.00004	3.272E-6	119.7544	<.0001
gasodiediff	1	8.4625	0.8077	109.7612	<.0001
dieselhinta	1	-1.3734	0.2692	26.0272	<.0001
asiakaslaji1	1	-0.1929	0.0635	9.2133	0.0024
Monsqn	1	-0.0798	0.00530	226.9979	<.0001

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
Dprice	1.000	1.000	1.000
HINTA	1.000	1.000	1.000
gasodiediff	>999.999	971.975	>999.999
dieselhinta	0.253	0.149	0.429
asiakaslaji1	0.825	0.728	0.934

Monsqn	0.923	0.914	0.933

Association of Predicted Probabilities and Observed Responses

Percent Concordant	77.4	Somers' D	0.591
Percent Discordant	18.3	Gamma	0.617
Percent Tied	4.3	Tau-a	0.012
Pairs	101824876	c	0.795

MODEL 4: logistic model small cars

The LOGISTIC Procedure

Model Information

Data Set	REK.CARSTOCKPRICE3
Response Variable	Dlow
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	203851
Number of Observations Used	86959

Response Profile

Ordered Value	Dlow	Total Frequency
1	0	82401
2	1	4558

Probability modeled is Dlow=0.

.

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	35753.810	29676.310
SC	35763.184	29741.923
-2 Log L	35751.810	29662.310

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	6089.4999	6	<.0001
Score	6488.2694	6	<.0001
Wald	5342.0484	6	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	2.9892	0.2617	130.5118	<.0001
Dprice	1	-0.00081	0.000016	2713.2917	<.0001
HINTA	1	0.000106	3.497E-6	927.1202	<.0001
gasodiediff	1	-1.9969	0.3234	38.1371	<.0001
dieselhinta	1	0.3764	0.1518	6.1477	0.0132
asiakaslaji1	1	-0.3762	0.0325	133.6457	<.0001
Monsqn	1	-0.0835	0.00193	1881.2680	<.0001

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
Dprice	0.999	0.999	0.999
HINTA	1.000	1.000	1.000
gasodiediff	0.136	0.072	0.256
dieselhinta	1.457	1.082	1.962
asiakaslaji1	0.686	0.644	0.732

Monsqn	0.920	0.916	0.923

Association of Predicted Probabilities and Observed Responses

Percent Concordant	78.3	Somers' D	0.576
Percent Discordant	20.7	Gamma	0.582
Percent Tied	1.1	Tau-a	0.057
Pairs	375583758	c	0.788

MODEL 5: logistic model low emission cars CC_class_3

The LOGISTIC Procedure

Model Information

Data Set	REK.CARSTOCKPRICE3
Response Variable	Dcc3_low
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	118973
Number of Observations Used	46178

Response Profile

Ordered Value	Dcc3_low	Total Frequency
1	0	45148
2	1	1030

Probability modeled is Dcc3_low=0.

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	9872.919	3265.461
SC	9881.659	3317.902
-2 Log L	9870.919	3253.461

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	6617.4585	5	<.0001
Score	5605.4645	5	<.0001
Wald	1682.1251	5	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	48.7648	1.4546	1123.8875	<.0001
Dprice	1	-0.00140	0.000060	539.6812	<.0001
HINTA	1	-0.00114	0.000029	1591.5858	<.0001
gasodiediff	1	15.9645	1.1520	192.0334	<.0001
dieselhinta	1	-11.3087	0.5067	498.1963	<.0001
Monsqn	1	-0.0974	0.00735	175.6921	<.0001

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
Dprice	0.999	0.998	0.999
HINTA	0.999	0.999	0.999
gasodiediff	>999.999	>999.999	>999.999
dieselhinta	<0.001	<0.001	<0.001
Monsqn	0.907	0.894	0.920

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	95.3	Somers' D	0.943
Percent Discordant	1.0	Gamma	0.979
Percent Tied	3.7	Tau-a	0.041
Pairs	46502440	c	0.971

MODEL 6: logistic model low emission cars CC_class_3 2008-2009

The LOGISTIC Procedure

Model Information

Data Set	REK.CARSTOCKPRICE3
Response Variable	Dcc3_low
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	45261
Number of Observations Used	25504

Response Profile

Ordered Value	Dcc3_low	Total Frequency
1	0	24567
2	1	937

Probability modeled is Dcc3_low=0.

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Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	8032.668	2611.680
SC	8040.815	2660.560
-2 Log L	8030.668	2599.680

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	5430.9879	5	<.0001
Score	4239.9306	5	<.0001
Wald	1639.3177	5	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	37.1275	1.4206	683.0710	<.0001
Dprice	1	-0.00140	0.000060	549.1765	<.0001
HINTA	1	-0.00115	0.000029	1580.6924	<.0001
gasodiediff	1	9.5975	1.4647	42.9356	<.0001
dieselhinta	1	-7.2909	0.5415	181.2901	<.0001
Monsqn	1	0.1473	0.0160	84.5076	<.0001

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
Dprice	0.999	0.998	0.999
HINTA	0.999	0.999	0.999
gasodiediff	>999.999	834.422	>999.999
dieselhinta	<0.001	<0.001	0.002
Monsqn	1.159	1.123	1.196

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	94.8	Somers' D	0.933
Percent Discordant	1.5	Gamma	0.969
Percent Tied	3.7	Tau-a	0.066
Pairs	23019279	c	0.967

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