

The Dutch national kilometre charge: impacts on the Dutch car market and environment

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1. Introduction

Over the last decades, mobility has continuously increased and this situation is not due to change. Accessibility, safety and the quality of the living environment are consequently and increasingly under pressure. Many policies are aimed at facilitating the growth in mobility, whilst at the same time improving accessibility, safety and the quality of the living environment. However, it has been recognized for some time that adding new capacity has its limits, certainly while the economic situation requires efficient spending of limited budgets. This calls for new policies, including ones aimed at better use of existing capacity using ITS and pricing policies in which road users pay for the total social cost of transport. This requires the implementation of pricing policies in which the user pays for scarcity of the infrastructure as well as the polluter pays for the external effects.

Since many of the problems in transport are related to the use of vehicles, usage-based charges for road vehicles (also called ‘pay-as-you-drive’, distance-based charges) are increasingly receiving interest as alternative pricing mechanisms. Some countries in Europe have already introduced usage based charges for road freight, i.e. Switzerland and Austria introduced weight-distance based heavy goods vehicle fees in 2001 and 2004, Germany launched its Toll Collect HDV system in 2005. In the United States, pilot

studies on distance-based use charges for passenger vehicles have been conducted in Oregon, Iowa and the Seattle area (see Sorensen et al., 2010, for an elaborate discussion).

In the Netherlands, road pricing was already mentioned in Dutch transport policy in the 1980ies. Policy discussions on usage-based charges started in the late 1990ies. Since 2004, however, plans gained momentum and the fourth cabinet of Balkenende developed far-fetched plans to introduce usage-based charges. The Dutch Road Pricing Act, aiming to introduce a “kilometre charge” for motor vehicles in the Netherlands, was sent for discussion in the Lower House late 2009. At the same time, motor vehicle taxes, the vehicle purchase tax for passenger cars and heavy duty vehicle tax are being abolished. The scheme is to be budget neutral totally. The scheme design chosen in the Road Pricing Act is relatively complex. The price per kilometre would consist of a base price per kilometre, differentiated by environmental performance, and an additional congestion charge depending on location and time of day. The supporting technology would include an on-board unit featuring GPS that tracks the number of kilometres driven and the rate per kilometre.

Unfortunately, the Act did not come up for discussion in the Lower House as the Balkenende cabinet fell early 2010. At the moment, the introduction of kilometre charge is very uncertain. General elections were held June 9, 2010. At the moment of writing this paper, the process of cabinet formation just started. The new cabinet will have to decide whether or not it will continue the decision making process on the existing Act, develop a different road pricing scheme or drop the plan. The outcome is very uncertain as right-wing parties who are against the kilometre charge have won the elections.

This paper has two aims. It will firstly describe the Dutch kilometre charge and overview existing appraisal studies underlying the decision making process leading to the Road Pricing Act and describe important uncertainties associated with the modelled impacts. The paper focuses on the kilometre charge for passenger cars and its impacts on car ownership and use, composition of the car fleet and CO₂ emissions. Several appraisal studies have been conducted to examine the impacts of different pricing variants, using the well-known Dutch national model system (NMS) and the national car market model Dynamo. The latter model has recently been developed and simulates yearly car ownership and car purchase behaviour of households at a detailed level (Meurs et al,

2010). Secondly, the paper examines the impact of kilometre charge variants on car ownership, car use and composition of the car fleet, using the latest model version of Dynamo. In particular, we will examine the effects of shifting taxes from ownership to kilometres travelled, and the effects of differentiation in the price by emission characteristics of the car compared with flat rates.

The rest of the paper is structured as follows. Section 2 describes the background and motivation for the Dutch kilometre charge system. Section 3 overviews existing appraisal studies on the impacts of the kilometre charge. Section 4 describes the car market model Dynamo. Section 5 describes the alternatives assessed and Section 6 the Dynamo projections of effects. Finally, Section 7 presents conclusions and discussion of results.

2. The Dutch Kilometre Charge: background and motivations

In the Netherlands, as in many other countries, the fiscal regime for passenger cars comprises fuel taxes, road taxes and car purchase taxes. Fuel taxes and purchase taxes in the Netherlands are among the highest in Europe (e.g. see for a comparison Kunert and Kuhfeld, 2007). Compared to other EU countries, terms, fixed vehicle taxes are relatively high. Under the current system, Dutch car owners pay about 14 billion Euro in taxes, more than half in fixed vehicle taxes. In the EU, only Denmark has higher purchase taxes. In 2007, the purchase tax was about 45% of the sales price, with a deduction of about 1500 Euro for gasoline cars and a premium of about 330 Euro for diesel cars. Shifting taxes from car ownership to car use has been on the political agenda in the Netherlands for more than a decade.

The idea of introducing a “kilometre charge” comes from a commission in which commercial, governmental and social organizations participated, including the ANWB Royal Dutch Touring Club, the Confederation of Netherlands Industries and Employers, the Federation of Netherlands Trade Unions and the Netherlands Society for Nature and Environment. These groups were asked in 2004 to join the commission to advise the Ministry of Transport, Public Works & Water Management on possible alternatives for

the existing car taxation system. A research group, supporting the commission, examined the costs and benefits of several pricing schemes, including fuel taxation, road tolling, area pricing, undifferentiated and differentiated usage-based charges (Besseling et al., 2005). There were strong opposing opinions on the preferred pricing scheme within the commission; some organizations preferred a congestion charge aimed at reducing congestion, others preferred usage-based charges aimed at reducing environmental impacts. Other pricing schemes, such as increasing fuel taxes, were not considered effective or feasible. Phasing out of car ownership and vehicle purchase taxes into a fuel tax would for example result almost in a doubling of Dutch fuel taxes and would require coordinated implementation among countries in Europe, otherwise the option of crossing borders will diminish the effects. In addition, fuel taxes do not allow for differentiated prices by location and time critical to capture many external effects.

The commission ultimately recommended combining a usage-based and a congestion charge. It suggested to proportionately phase out car ownership and purchase taxes and introduce a usage-based charge (called kilometre charge), differentiated according to the environmental characteristics of the vehicle and to time and place (a higher charge at congested roads during peak hours). This recommendation was included later in the Dutch Mobility Policy Document (Ministry of Transport Public Works and Water Management, 2004).

The design of the kilometre charge has four main motivations. The first, and primary, motivation is to achieve a more efficient use of road infrastructure, so reducing congestion and improving accessibility. A so-called rush-hour surcharge will be levied in addition to the base tariff at congested locations during rush hours, which is expected to lead to a dispersal of traffic on the roads at these busy places and times.

The second motivation is to reduce environmental impacts related to the use of motorised vehicles. For this reason, vehicle ownership will firstly no longer be taxed but rather its use. Such a system is expected to lead to a reduction in car use and environmental impacts. Secondly, the charges will depend on the environmental performance of vehicles. The base tariff for passenger cars will be based on CO₂ emissions. Fuel efficient cars will be financially rewarded in relation to the average tariff, while inefficient cars will be financially penalised. Cars running on diesel and LPG will

also be subject to a fuel surcharge, and diesel cars will also pay a surcharge in case of relatively high particle matter emissions. In case of heavy goods vehicles, the permitted gross vehicle weight is the basis of the base tariff, with a differentiation according to Euro class.

The third motivation is revenue neutrality. Implementation of the kilometre charge is accompanied with proportional abolition of fixed vehicle taxes/charge. This basic principle was further detailed in letters to the Dutch House of Commons late 2007 and early 2008. Revenues are transferred to the Dutch Infrastructure Fund, with proportional simultaneous reductions of the contribution from general resources to this fund. This is a trend breach in the Dutch tax regime which to date does not earmark tax revenues. Revenue-neutrality is not a universal objective or constraint for pricing schemes, e.g. discussions on introducing usage-based charges in the USA are closely tied to infrastructure expenditures and inspired by prevailing revenue shortfalls. In London, the congestion charge did not change plans for infrastructure expansions and produced additional revenues (OECD/ITF, 2010). Revenue-neutrality is also not consistent with principles of internalization of external costs, which could result in higher charges at the start and gradually decreasing kilometre charges in the long run when the environmental performance of vehicles is improved. Revenue neutrality and earmarking revenues are regarded important elements by the Dutch government to gain broad social support for the implementation of the kilometre charge.

The fourth motivation is to improve equity in transportation finance by aligning the level of taxation with the benefits derived through use of the system. It follows the 'user pays' principle. Road users who travel extensively will pay more taxes than road users who hardly ever travel. This is an important argument in gaining public acceptance for the system.

The Dutch government has set a number of preconditions in advance for the implementation of the kilometre charge (Ministry of Transport Public Works and Water Management, 2010). The preconditions originate from the Mobility Policy Document or are dictated by the wishes of the Dutch House of Commons, local governments or interest groups. The preconditions related revenue neutrality, running costs, complexity of the system and public acceptance. Some of the preconditions may become important barriers

to a successful implementation, and these are described here. Firstly, an important precondition is described in the 2007 Balkenende coalition agreement: operational costs, defined as the operational costs necessary to keep the system running, may not exceed 5% of revenues. Experiences in Singapore, London and Stockholm suggests the costs of the system represent 15 to 30% of the gross revenues and that the figure cannot be compressed to below around 10%, given their definition of costs (OECD/ITF, 2010). This precondition thus forms an important barrier to implementation.

Secondly, car purchase taxes are to be fully converted to the kilometre charge. This was a major discussion point in the decision making process. The Balkenende government decided to fully abolish car purchase taxes as this was favoured by car lobby groups. However, surveys show that high kilometre charges reduce acceptance among car drivers (Schuitema et al., 2008). Furthermore, cost-benefit analysis showed that welfare gains decrease with increasing shares of purchase taxes converted to the kilometre charge (see also Section 3).

Thirdly, in order to promote the success and acceptance of the new system, the government states it must be transparent, user-friendly and reliable for the road user. However, the design for the kilometre charge described in the Road Pricing Act is rather complex and to date it is unknown how road users would perceive its transparency and user-friendliness.

Finally, that government regards broad social support before implementation of the kilometre charge as indispensable. Results of a consultation among 400,000 members of the ANWB Royal Dutch Touring Club early 2010 show that two thirds of the members support the principle of usage-based charges, but important concerns lie with privacy issues related to GPS-based registration unit, the congestion charge (which is considered to be unfair) and the length of the transition phase¹ (Onkenhout et al., 2010). However, existence of effective congestion charging systems in Singapore, Stockholm and London shows that the tension between acceptability and welfare potential is not irredeemable, and acceptability evolves over time (OECD/ITF, 2010).

¹ The government planned for a 10 year transition phase in which the purchase tax is gradually phased out and converted into the kilometer price. During the transition phase, car owners are relatively disadvantaged as they have already paid the purchase tax at the moment of purchasing their car, and again have to pay the purchase tax in the kilometer price.

3. Overview of Dutch appraisal studies on the kilometre charge

The kilometre charge as envisioned in the Road Pricing Act implies a major tax reform and may potentially strongly affect the Dutch car market. The current tax regime affects the size of the car fleet and its composition. New car prices in the Netherlands would drop up to 30% when purchase taxes are abolished, stimulating car ownership. The purchase tax also effectively favours gasoline cars, resulting in one of the lowest share of diesel cars in the European car stock (about 20%). The tax is also progressive with regard to the fuel efficiency as purchase taxes are higher for larger, more expensive, and on typically less fuel efficient cars. Road pricing schemes with prices differentiated by time and place driven and environmental performance of vehicles are projected to have major impacts on car ownership, vehicle type choice, car use and congestion on the main motorway network.

Several appraisal studies have been conducted to examine the impacts of different pricing variants. The well-known Dutch National Transport Model (NMS) from the Ministry of Transport has been used to examine the mobility and congestion effects of at least 40 to 50 different pricing variants (e.g. 4Cast, 2006). The car market model Dynamo was the primary model to examine effects on car ownership, the car fleet and environmental effects (ECORYS and MuConsult, 2007; MuConsult, 2009). In most appraisal studies, both models have been applied jointly, using outputs from the car market model (car ownership, car costs) as input for the national transport model. The transport models outputs have also been used as input for a number of cost-benefit analyses on different variants of the kilometre charge (Besseling et al., 2008; Besseling et al., 2005; ECORYS, 2007). Some empirical studies, using Stated Preference methods, have also been conducted on the impacts of kilometre charge variants on car use (Ubbels, 2006), car ownership and vehicle type choice (de Jong et al., 2009; MuConsult, 2002). The results are typically in line with the short term model projections.

The appraisals typically show that kilometre pricing variants increase car ownership, reduce car use and congestion on the main motorway network and benefit-cost balances are positive. The effects strongly depend on:

- The average price per kilometre, which depends on assumptions on revenue neutrality and the percentage of the purchase tax to be converted to kilometre charge. Cost-benefit analysis showed welfare gains to be 20% lower (0.9 billion Euro in 2020) when the purchase tax is fully converted to the kilometre charge compared to a 25% conversion (1.1 billion euro). When a larger percentage of purchase taxes is converted it obviously results in higher kilometre charges. Higher charges however result in marginal returns in travel time benefits but increasing welfare losses due to drops in travel demand (Besseling et al., 2008).
- The environmental differentiation of the kilometre charge. The differentiation strongly effects the composition of the car fleet and related environmental impacts. Environmental effects are smaller when ‘flat’ rates are used compared to strongly environmentally differentiated prices.
- The presence and size of the congestion charge. Introducing an additional congestion charge of about 11 eurocent/kilometre has small effects on the mobility (an additional 1% decrease in car use) but effectively reduces congestion. According to NMS estimations, a kilometre charge (with a full conversion of purchase taxes) would reduce the number of vehicle hours lost on the main motorway network by about 40%, adding a congestion surcharge results in a congestion decrease by about 60-70% (4Cast, 2006).
- The time horizon. Most model estimations were conducted for the short run, i.e. the year 2020, assuming a gradual implementation in the period 2012-2016. The increase in car ownership (as projected by Dynamo) is small (up to 1%), and the NMS projections show a decrease in car use up to 17% and congestion (vehicle hours lost on the main motorway network) by 40 to 60%. In the long run, however, 10 to 15 years after introduction, car ownership is projected to increase more strongly up to 5-6%, which attenuates car use and congestion effects somewhat (10-15% reduction in car use).

The model projections from the Dutch National Model System (NMS) have been very important in the decision making process on the kilometre charge, it has been used to estimate mobility, congestion effects and travel time savings which dominate the outcome of cost-benefit analysis. Recently, the quality of NMS studies on the effects of

kilometre price, has been reviewed by Geurs and Van Wee (2010). It is concluded that the model is an appropriate instrument for analyzing the effects of kilometre charge variants, however, too little attention is paid to uncertainties in effects. There are important uncertainties and reasons for under- and over-estimates associated with both the assumed input for the pricing variants and specific model characteristics (not modelled effects). The most important uncertainty is related to non-modelled effects of lowering the fixed car costs on car use which will attenuate the effects of increased variable costs. Dynamo assumes a fixed car costs elasticity on annual mileage per vehicle of -0.04, taken from a study from De Jong et al. (1990). This small price elasticity results in significant car use effects, given the large drop in car purchase prices. Dynamo simulates an 11-12% decrease in car use by 2020, compared to a 15% decrease modelled by the NMS, for the same variant. This difference is almost entirely explained by the effect of reducing the fixed car costs (MuConsult, 2009). This is however a major uncertainty in the modelled mobility impact of the kilometre charge, and where little research has been done. The evidence base is very small, e.g. in a large international review on price elasticities in the demand for road traffic, no price elasticities for changes car kilometres per vehicle with respect to car purchase costs were found, and only three for changes in total car kilometres (Hanly et al., 2002).

Geurs and Van Wee (2010) conclude that NMS projections of the passenger mobility impacts of road pricing are thus likely to be upper bound, and taking into account major uncertainties, a bandwidth in the reduction in car use resulting from the kilometre charge from 5 to 15%, with intermediate value of 10%, seems reasonable.

The uncertainty in modelled traffic impacts is higher than for existing congestion charging schemes such as in London and Stockholm, where a fixed car taxes have not been reduced. In London, the actual traffic reductions due to the London congestion charge (16% less vehicles) exceeded the model forecast (12% fewer vehicles) (ROCOL, 2000), whereas in Stockholm the actual impacts corresponded well with the traffic model's projections (Eliasson et al., 2009).

The uncertainty in the (NMS) estimates of the congestion effects is even larger than the uncertainty in the mobility effects. Congestion levels are very sensitive to small changes in traffic volumes. De Jong and Annema (2010) compared modelled outcomes of

NMS studies since the 1980ies with actual transport developments, and concluded that modelled congestion levels, expressed in vehicle hours lost in traffic, on the main motorway network were strongly underestimated, whereas modelled car use levels were relatively accurate. This due to optimistic assumptions on road infrastructure expansions (model input) but also model characteristics. Geurs and Van Wee (2010) conclude that the travel time benefits computed using outputs from NMS and used as input for cost-benefit analysis, are relatively uncertain.

4. Description of the car market model DYNAMO

Many car ownership models have been developed in the past, e.g., see for reviews of car ownership models Tardiff (1980), Mannering and Train (1985), Bunch (2000); de Jong et al. (2004) and Potoglou and Kanaroglou (2008). The dynamic automobile market model (Dynamo) is a new extension of the model developed by Manski (1983). He formulated a model of short run equilibrium in the automobile market in Israel. The short run is a period within which new car designs and prices are fixed but used car prices adjust competitively to market forces. The magnitude and mix of new car sales, the extent of used car scrappage and the composition of used car holdings are determined in equilibrium with used car prices.

Here, we briefly describe the model, an elaborate description can be found in Meurs et al (in prep.). Dynamo is designed as a detailed and disaggregate car market model with endogenous second hand car prices, and models the size, use and composition of the car fleet as functions of household and car characteristics. The model is dynamic in a number of ways. The stock of cars in a certain year is determined by the stock in previous years and car usage in previous years. Consumers are assumed to base their decisions to buy cars not only on current prices, but on a weighted index of prices in current as well as previous years. Finally, Dynamo combines revealed preference and stated preference data to estimate the effect of price changes on car purchase behaviour and car scrappage decisions.

Dynamo is a disaggregate discrete choice model simulating demand for the number of cars by household segment and car type (71 household segments and 120 car

types) as well as usage by trip purpose. In the latest model version (Dynamo 2.2), each car type is further disaggregated into 28 CO₂ emission categories. Dynamo estimates yearly changes in the car market for the period 2003-2040, and also estimates car-use related to energy use and emissions at the national level. Figure 1 shows the main principles of the car ownership model. Changes are simulated on the basis of a good description of the car fleet and car ownership and use in the base year for different household types (in the *base matrix*). Applying the modules will lead to insight in the characteristics of the car fleet and the car ownership by household type in a following year.

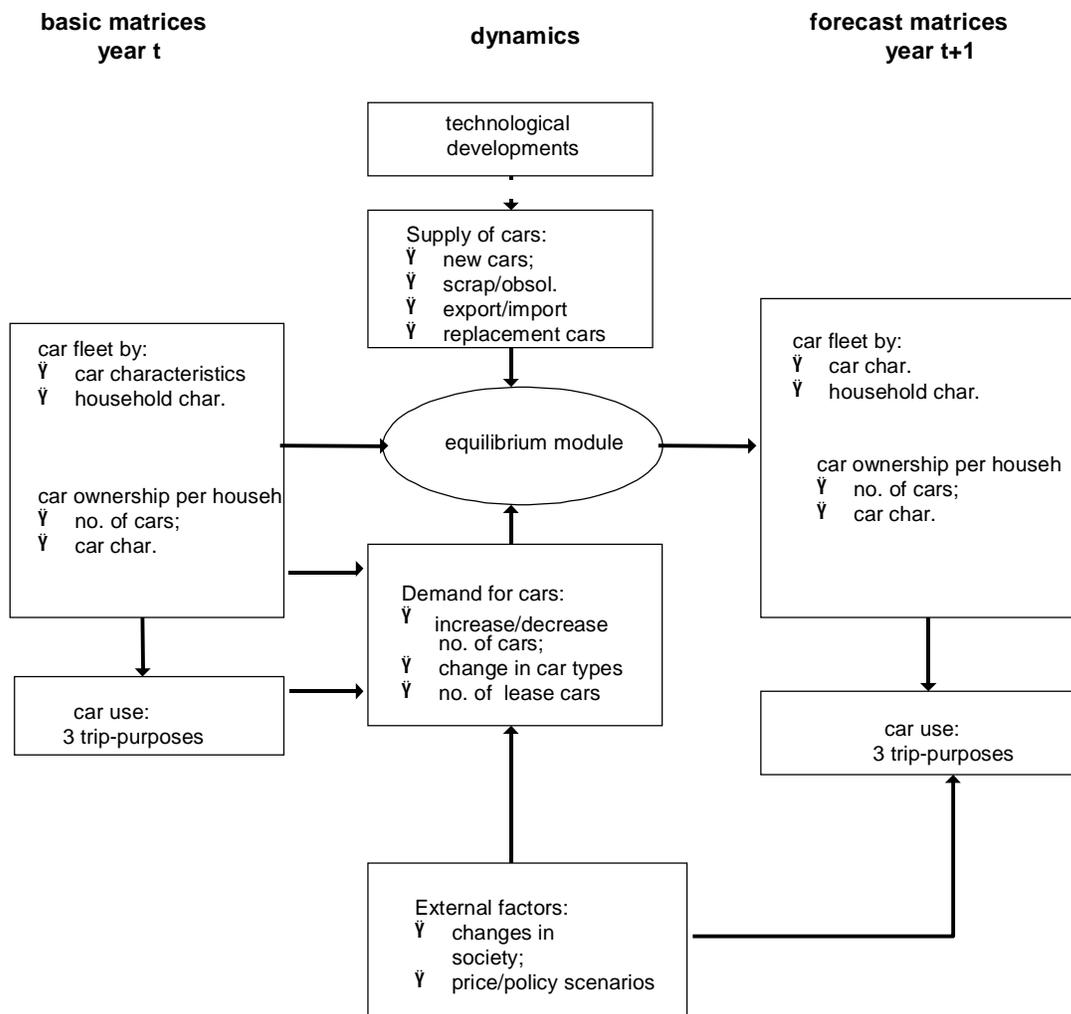


Figure 1: Conceptual model of car ownership

Changes in car ownership, the car fleet and the use of cars can be caused by the influence of external factors, such as developments in society and price/policy scenarios. These external factors influence the **demand for cars** (number of cars, types of cars) and also influence the number of kilometres driven for different purposes. An increase in income, for instance, can lead to both changes in the number of cars and in the demand for larger cars. An increase in the taxes on diesel fuel can reduce the demand for diesel-powered cars, but also the number of kilometres driven with diesel-powered cars.

Alongside this, naturally, is the **supply of cars**. Changes in this can take place by the launching of new models, by scrapping, and through export and import, and second-hand cars can be put on the market by people who are intending to change their car. Supply and demand are related to each other in the so-called **equilibrium module**. The price mechanism is used in this model to create balance between supply and demand. For example, if the petrol price goes up, less new petrol cars will be sold. At the same time people owning a petrol-powered car could decide to dispose of this earlier, which will have a depressing effect on the second-hand price of petrol-powered cars.

The new matrix of characteristics of the car fleet and the number of kilometres driven by household type, as well as the equilibrium prices of second hand cars will be represented to next year. Trends over time are obtained by repeatedly running the model. These results are incorporated into a number of environment modules that establish the effects on environment indicators (CO₂, acidifying substances, etc.).

The first model version of Dynamo (1.0) was developed in 2005 and several model extensions have been developed since. The current active version is Dynamo 2.2. The model has been applied several times in Dutch national transport and environment policy making processes to examine the impacts of socio-economic developments and fiscal measures on car ownership and vehicle type choices and environmental impacts.

5. Reference and kilometre charge scenarios

Reference scenarios

The Dutch government uses four long term business-as-usual scenarios describing population, economic and spatial developments for the period up to 2040. Here, we use

socio-economic projections from one of these scenarios, *Strong Europe* (SE), describing a modest population and employment growth. In recent years, Dutch tax plans from the Ministry of Finance has reformed car purchase taxes. Up to 2006, car purchase taxes depended almost completely on car prices but have become more and more dependent on the CO₂ and other emissions of the car. This affects the impact of kilometre charges. To compare the effects of kilometre charge variants, two reference scenarios were constructed with Dynamo: one that assumes that the structure of car costs remain similar to the 2003 structure for the whole forecast period (*SE reference*), the other that car costs are based on the actual and future expected Dutch 2009 tax plans (*SE Tax reference*). In the 2009 Dutch tax plan the first step has been taken to let the purchase tax depend only on the absolute CO₂-emissions, which has to be completed in 2013. Furthermore, since 2006 several other fines and bonuses for driving in a less or more fuel efficient car were introduced, with respect to the amount of road or purchase taxes that have to be paid, and for instance to the amount of income taxes that have to be paid for driving in a company car. In 2010 for a car that produces few CO₂-emissions (for petrol and LPG cars less than 110 gr CO₂/km driven and for diesel cars less than 95 gr CO₂/km driven) no purchase taxes and no road taxes have to be paid at all.

Road Pricing Act kilometre charge variant

The Road Pricing Act variant comprises a base level price per kilometre and a congestion charge. The Act however specified the base level road kilometre charges but not the congestion charge. In our analysis, we exclude the congestion charge from the analysis.

The price per car kilometre driven depends on a number of key elements:

- An average price of 6.7 cents per kilometre. This price level is determined by the current revenues from the car purchase taxes and a correction for the expected drop in demand and operating costs to bring the desired returns. The revenues have been determined for the year 2012 with a previous version of Dynamo (version 2.1), including the tax plan.
- Differentiation based on CO₂. The choice of CO₂ as the basis (in accordance to the 2010 purchase tax) is consistent with the broad desire to base rates on the price per kilometre to relate to the environmental performance of cars.

- Dispersion according to the existing road taxes and purchase taxes. An important consideration in shaping the distribution of rates is to stay as close as possible to reflect current tax system and thus minimize disruption of the car (both the market for used cars as new car sales).
- A price premium for particulate emissions in the case of a diesel car without particle filters (added ex-factory). The proportion of cars sold without particulate filters in the coming years will gradually decrease. The premium aims to accelerate this process and contribute to meeting air quality objectives and additional health benefits.

Figure 1 visualises the kilometre charges for 2012 by fuel type and CO₂-class, assuming road pricing is fully implemented. In practice, implementation is to be gradual over the years 2012-2018. After 2012 there is an annual adjustment of charges to correct for the decline of diesel cars sold without a particulate filter (DPF), and autonomous (technical) development in the CO₂ emissions of the entire fleet.

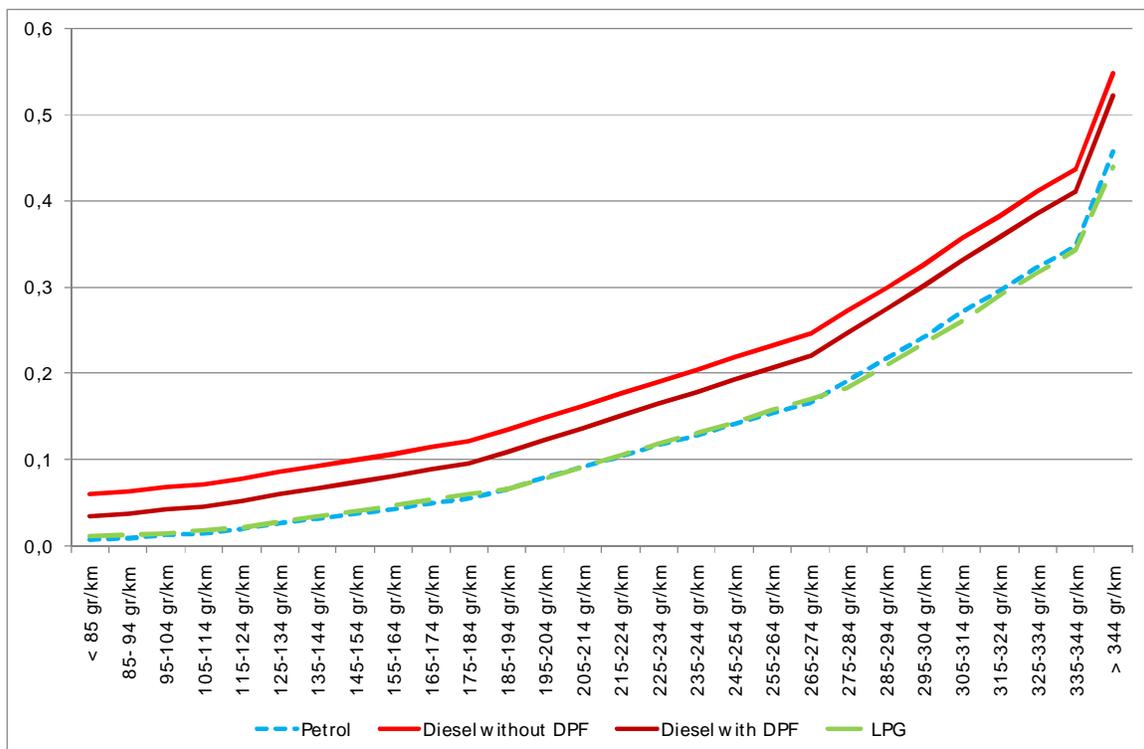


Figure 1: Kilometre charges in 2012 (euro, 2009 prices)

Kilometre charge variant without differentiation by environmental performance

To disentangle the separate effect of environmental differentiation of the kilometre charge, an alternative kilometre charge variant was developed. This variant comprises a "flat" rate which is only differentiated by fuel type, and not by environmental performance. The average rate per kilometre is equal to that of the Road Pricing Act (i.e. a full conversion of fixed car taxes) and takes the average tax burden per fuel type according to the Tax Plan into account. The effects of the environmental differentiation can be examined when the effects of the Road Pricing Act variant are compared with those from the "flat" rate variant.

Kilometre charge variants with varying proportions of purchase tax conversions

As noted earlier, the percentage of the purchase tax to be converted to kilometre charge was an important issue in the decision making process. To examine the effects of keeping a part of the purchase taxes on car ownership and use and fleet composition, four additional kilometre charge variants have been developed. The variants comprise a 0%, 25%, 50% and 75% conversion of purchase taxes to the kilometre charges, and maintain the tariff differentiation on the same principles as the Road Pricing Act variant.

6. Effects of kilometre charge variants on car ownership, use and fleet composition

6. 1 Effects of the Dutch car tax reform

The Dutch car tax plans have significant impacts on the Dutch car park. Table 1 shows the main results of the Dynamo projections for the SE and *SE Tax* reference scenarios. The tax reform, particularly the introduction of a CO₂ dependent road and purchase taxes, results in a relative large shift towards small and fuel efficient cars (the CO₂ emission of the average car is reduced by 6 grams/km) but also increases car ownership. The projected size of the car fleet grows from 9.9 million in 2030 in the "old" tax system to 10.1 million with the tax reform. Purchase and road taxes are reduced to zero for small and very fuel efficient cars (101 gr/km in 2020 for gasoline and LPG cars, 87 gr/km for diesel cars), which reduces the average car price and increases car ownership. Note that

new tax system reduces vehicle weight compared to the old system, but cars still become heavier from 2003-2030, mainly due to safety and quality improvements.

The new tax system only has a small effect of the distribution of fuel types and the total and average millage of cars. This is an expected result, since this tax-system mainly is aimed at fixed car costs (purchase and road tax) and is constructed in such a way that current difference in car costs between fuel types remain similar. However, since cars become somewhat cheaper in use (the average fuel consumption drops, as can be seen from the reduction in the CO₂-emissions/km), the total number of kilometres driven increases slightly in the *SE Tax* scenario compared to the SE scenario.

The new tax system reduces CO₂ emissions from the Dutch car park by about 4% (0.8 Mega tonne) in 2030, despite the increase in the car stock.

6.2 Effects of the Road Pricing Act kilometre charge variant

The kilometre charge variant as described in the Road Pricing Act reduces average car prices (30% relative to 2003) and increases car ownership in the long run (2030) by 4% compared to the reference scenario with the reformed tax system (from 10.1 to 10.5 million vehicles) and 6% compared to the reference scenario with the old tax system (SE reference) (see Table 1). The kilometre charge has mixed effects on the composition of the car fleet: a decrease in average vehicle age, and an increase in the proportion of diesel and the average weight of the car fleet. The latter is mainly caused by the abolition of purchase tax that for large, inefficient, cars is not fully offset by the kilometre charges if these cars are not relatively heavily used. This means that the total price incentive is spread over a longer period. This has less effect on the car purchasing behaviour than the price incentive at the time of purchase. This effect is also found in a recent Stated Preference survey on the Dutch kilometre charge (de Jong et al., 2009).

The kilometre price reduces, according to Dynamo, average car kilometres per vehicle by 13% and total car use by about 11% in 2030. The growth in car ownership attenuates the effect of the price per kilometre on car use. Note that the effects presented here do not take the congestion charge into account, which according to NMS estimations would reduce car use by an additional 1%.

Table 1: Dynamo projections of effects of kilometre charge alternatives on car use, car ownership and composition of the car fleet

Variable	SE reference			SE Tax reference			Road Pricing Act kilometre charge		“Flat” rate kilometre charge	
	2010	2020	2030	2010	2020	2030	2020	2030	2020	2030
Fleet size (million)	7.7	8.8	9.9	7.8	9.0	10.1	9.1	10.5	9.1	10.4
Millage (km)										
Average per car/year	16390	16406	16194	16323	16252	16019	14358	13948	14355	13960
Fleet total (billion)	111	127	141	111	128	142	115	127	114	127
CO ₂ emissions (g/km)										
All cars (g/km)	185	165	150	183	160	144	161	147	167	156
New cars (g/km)	171	159	140	167	152	133	157	138	168	147
New cars test value (g/km)	154	145	127	150	138	121	143	126	152	133
Total CO ₂ (megaton) [†]	20.7	21.3	21.5	20.6	20.8	20.7	18.7	19.0	19.3	20.1
Fuel mix										
Petrol	78.3%	79.7%	80.4%	78.5%	80.1%	80.9%	77.8%	76.8%	79.0%	78.7%
Diesel	19.1%	18.7%	18.3%	19.0%	18.4%	18.1%	20.7%	22.0%	19.6%	20.3%
Gas	2.6%	1.6%	1.3%	2.5%	1.4%	1.0%	1.5%	1.3%	1.4%	1.0%
Car weight										
<950 kg	22.6%	16.3%	15.6%	23.0%	19.7%	19.8%	15.8%	12.3%	15.0%	10.4%
951-1150 kg	26.7%	23.8%	23.4%	26.7%	24.4%	24.3%	22.5%	20.0%	22.1%	18.7%
1151-1350 kg	27.9%	27.1%	25.8%	27.9%	27.3%	26.5%	26.9%	25.6%	27.4%	26.2%
>1350 kg	22.9%	32.8%	35.2%	22.5%	28.6%	29.3%	34.8%	42.1%	35.5%	44.7%
Car age										
New	7.9%	7.1%	7.2%	8.2%	7.0%	7.4%	7.5%	7.5%	7.5%	7.4%
1-2 years old	13.8%	14.1%	14.2%	14.7%	14.0%	14.5%	15.0%	14.9%	14.9%	14.7%
3-5 years old	20.1%	20.6%	20.5%	20.1%	20.8%	20.5%	20.7%	21.4%	20.3%	21.2%
6-10 years old	30.2%	30.7%	29.7%	30.0%	30.8%	29.7%	30.2%	31.2%	30.2%	31.0%
>10 years old	28.1%	27.5%	28.3%	27.0%	27.4%	27.9%	26.6%	25.0%	27.0%	25.7%
Average car age (year)	7.8	8.0	8.1	7.6	8.0	8.0	7.8	7.6	7.8	7.7
Car prize (index 2003=100)	99	94	87	98	90	83	80	69	81	70

The kilometre charge increases the average emissions *per kilometre* compared to the reference with the tax plan. This is mainly due to the increase of the average weight of the car fleet. Compared to the SE scenario without the Tax Plan, average emissions per kilometre decrease. The net effect, however, is a reduction of CO₂ emissions from cars by 8% (1.7 Megaton in 2030), despite the increase in vehicle weight. The kilometre charge and the vehicle tax reform together reduce CO₂ emissions by about 12% in 2030 (2.5 Megaton). The reduction in kilometres driven per vehicle is much more important than the changes in the size and composition of the fleet. Compared to baseline with tax plan, throughout the period 2012-2020, CO₂ emissions are reduced by about 14 Megaton and up to 2030 about 32 Megaton.

6.3 Effect of the environmental differentiation in the kilometre charge

When the Dynamo projections for the Road Pricing Act kilometre charge variant are compared with the “flat” kilometre price variant, it is clear that the differentiation of charges according to the CO₂ emission of cars is an important element in the road pricing scheme. A “flat” kilometre charge leads to smaller reduction in the car age and a smaller share of diesel cars. Furthermore, it results in a heavier and therefore less fuel efficient fleet (in 2030 about 6% more CO₂ emissions/kilometre and 1.1 Megaton less reduction in total CO₂ emissions). The average CO₂ emission per kilometre is even above that of the SE tax system. The impacts on car ownership and car use are, as to be expected, very small.

6.4 Effects of varying proportions of the purchase tax

Table 2 provides the results of the Dynamo estimations of kilometre charge variants in which varying proportions of the purchase tax have been abolished. Note that road taxes are abolished in each alternative. The table shows the Road Pricing Act kilometre charge variant, with a 100% conversion of purchase taxes, three other variants representing a 75%, 50%, 25% conversion, and the SE Tax reference.

Table 2: Effects of kilometre charge variants with varying shares of purchase taxes included in the kilometre charge

Variable	Road Pricing Act variant (100%)		75% of purchase tax included		50% of purchase tax included		25% of purchase tax included		SE Tax reference	
	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
Fleet size (million)	9.1	10.5	9.1	10.3	9.0	10.3	8.9	10.1	9.0	10.1
Millage (km)										
Average per car/year	14358	13948	14563	14168	14771	14420	14982	14658	16252	16019
Fleet total (billion)	115	127	115	128	116	128	117	129	128	142
CO ₂ emissions (g/km)										
All cars (g/km)	161	147	160	146	160	145	160	145	160	144
New cars (g/km)	157	138	155	136	154	135	153	134	152	133
New cars test value	143	126	142	124	141	123	140	123	138	121
Total CO ₂ (megaton) ¹	18.7	19.0	18.8	18.9	18.8	18.9	18.9	18.9	20.8	20.7
Fuel mix										
Petrol	77.8%	76.8%	77.6%	76.1%	77.4%	75.9%	77.3%	75.5%	80.1%	80.9%
Diesel	20.7%	22.0%	20.9%	22.6%	21.0%	22.9%	21.1%	23.2%	18.4%	18.1%
Gas	1.5%	1.3%	1.5%	1.3%	1.5%	1.2%	1.6%	1.3%	1.4%	1.0%
Car weight										
<950 kg	15.8%	12.3%	16.0%	12.7%	16.2%	13.0%	16.4%	13.4%	19.7%	19.8%
951-1150 kg	22.5%	20.0%	22.5%	20.1%	22.6%	20.3%	22.7%	20.6%	24.4%	24.3%
1151-1350 kg	26.9%	25.6%	26.9%	25.5%	26.9%	25.6%	27.0%	25.8%	27.3%	26.5%
>1350 kg	34.8%	42.1%	34.6%	41.6%	34.2%	41.2%	33.9%	40.2%	28.6%	29.3%
Car age										
New	7.5%	7.5%	7.5%	7.5%	7.4%	7.4%	7.2%	7.5%	7.0%	7.4%
1-2 years old	15.0%	14.9%	14.7%	14.9%	14.5%	14.8%	14.3%	14.9%	14.0%	14.5%
3-5 years old	20.7%	21.4%	20.6%	21.4%	20.5%	21.3%	20.3%	21.2%	20.8%	20.5%
6-10 years old	30.2%	31.2%	30.4%	31.0%	30.6%	31.0%	30.7%	30.7%	30.8%	29.7%
>10 years old	26.6%	25.0%	26.8%	25.2%	27.1%	25.4%	27.4%	25.8%	27.4%	27.9%
Average car age (year)	7.8	7.6	7.8	7.6	7.9	7.6	7.9	7.7	8.0	8.0
Car prize (Index 2003=100)	80	69	82	72	84	75	87	78	90	83

Table 2 clearly shows a trade off in effects on car ownership and use and changes in fleet composition when increasing the percentage of purchase tax to be abolished. This is due to the linear relationship between price and CO₂ emissions currently implemented. When a higher share of purchase tax is taken up in the kilometre charge, the tariff increases and car use is more strongly reduced. In the long run, car use decreases by 10% when 25% of purchase tax is converted to the kilometre price and only 11% when the purchase tax is fully converted. Projected growth in car ownership and use resulting from reduced fixed car costs clearly attenuates the car use effects.

When a higher share of purchase tax is abolished, fuel efficiency of new cars and all cars decreases due to an increasing average vehicle weight. As noted earlier, explanations for effects are that households react more to present one-off car purchase costs than to recurrent variable costs, and total car costs are reduced for households with relatively low car mileages. As a result of these effects, the total CO₂ emission reduction from cars does not increase when a higher share of purchase tax is abolished. These results amplify the conclusions from the cost-benefit analysis conducted by Besseling et al. (2008), who already showed marginal returns with increasing shares of phasing out car purchase taxes.

6. Conclusions and discussion

More than half of current car related taxes in the Netherlands are fixed. Shifting taxes from car ownership to car use has been on the political agenda in the Netherlands for more than a decade, and have gained momentum since the last cabinet of Balkenende developed the Dutch Road Pricing Act, aiming to introduce a “kilometre charge” for motor vehicles in the Netherlands. At the moment of writing this paper, its introduction is very uncertain. General elections were held on June 9, 2010, and the new cabinet will have to decide whether or not it will continue the decision making process on the existing Act, develop a different pricing scheme or drop the plan.

The effects of kilometre charge variants have extensively been studied and modelled. The well-known Dutch National Transport Model (NMS) from the Ministry of Transport has been used to examine the mobility and congestion effects of at least 40 to 50 different pricing variants, and the (previous versions of the) car market model Dynamo has been used to examine effects on car ownership, the car fleet and environmental effects. The model projections from the Dutch National Model System (NMS) have been very important in the decision making process on the kilometre charge, it has been used to estimate mobility, congestion effects and travel time savings which dominate the outcome of cost-benefit analysis. The model is an appropriate instrument for analyzing the effects of kilometre charge variants, however, in appraisals too little attention is paid to uncertainties in effects. There are important uncertainties associated with both the model input and not modelled effects. The most important uncertainty in projected mobility effects is associated with the effect of lowering the fixed car costs on car use, which is not modelled in the NMS. The uncertainty in modelled traffic impacts is higher than for existing congestion charging schemes, where fixed car taxes have not been reduced. Results from Dynamo estimations presented in this paper, which account for the effects of changes in fixed car costs on car ownership and use, show that car use effects in the long run only slightly increase with the share of purchase tax converted to the kilometre price. Projected growth in car ownership and use resulting from reduced fixed car costs clearly attenuates the car use effects.

Furthermore, results from DYNAMO estimations show that abolishing existing car purchase and road taxes by a CO₂ differentiated kilometre charge has unintended consequences in the form of rising car ownership and increasing shares of diesel cars and relatively large and heavy vehicle types. Explanations for these unintended effects are that households react more to present one-off fixed costs than to recurrent variable costs, and total car costs are reduced for households with relatively low car mileages. Without the CO₂ differentiation in the kilometre charge the increase in vehicle weight and drop in fuel efficiency would be stronger. Overall environmental impacts of kilometre charges are still positive resulting from the reduction in car travel.

There are two important issues that deserve attention in further research. Firstly, the international evidence base on the price sensitiveness of changes in fixed car costs on

car use is very small. Assumptions on this price sensitivity, however, may strongly affect the effects of the Dutch kilometre charge on passenger mobility, congestion and composition of the car fleet. This is an important area for further research.

Secondly, it is assumed that decreases in the prices of new cars will be equal to the former tax, and prices on the second hand market will follow those on the market for new cars. This is probably an overestimation of the price effect. Price changes will likely not be completely passed through to consumers. International literature (Berry et al., 1995, 2004) suggests that mark ups may change as well. Goldberg and Verboven (2004) show that mark-up adjustments explain low pre-tax prices in countries with high purchase taxes. In countries with high car purchase taxes, such as Denmark and the Netherlands, most manufacturers set pre-tax list prices at a low level, arguing that this is necessary to make the after-tax prices affordable. The standard deviation of new car prices on national markets has been about 6-7% in the past years (European Commission, 2008). It is likely that pre-tax car prices in the Netherlands will increase to the EU average when purchase taxes are abolished.

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