TØI report 1463/2016

Christian Steinsland
Vegard Østli
Lasse Fridstrøm

Institute of Transport Economics
Norwegian Centre for Transport Research

Equity effects of automobile taxation

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Author(s):	Christian Steinsland Vegard Østli Lasse Fridstrøm	**Forfattere:**	Christian Steinsland Vegard Østli Lasse Fridstrøm
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Summary:

With a focus on equity effects, three CO_2 abatement measures bearing on automobile taxation have been studied by means of network travel demand models and a discrete choice model for vehicle purchase. The commuter tax credit in effect in Norway helps equalize welfare between low and high income communities. Revoking it would be a strongly regressive tax measure. Increasing the fuel tax would have similar, although not quite so strongly regressive effects. Higher toll rates and ferry fares also affect different population segments unequally, but in a way that has less to do with income than with geography per se. The vehicle purchase tax, on the other hand, is an effective instrument for long-term greenhouse gas reduction, without having obvious regressive effects. The same is true of the value added and purchase tax exemptions for battery electric vehicles. These tax incentives have allowed Norwegian consumers a large new assortment of relatively affordable vehicles – cars that are also quite economical in use, since battery electric vehicles are three to four times more energy efficient than conventional cars.

Sammendrag:

Bilavgiftenes fordelingsvirkninger er studert ved hjelp av etterspørselsmodeller for korte, henholdsvis lange reiser i Norge og ved hjelp av en hierarkisk logit-modell for bilkjøp. Reiseutgiftsfradraget ved skattelikningen utjevner inntekt og velferd mellom lavinntekts- og høyinntektsområder. Å fjerne fradraget bidrar til større ulikhet. Også drivstoffavgiftene virker ulikhetsskjerpende, men den regressive virkningen er ikke fullt så sterk som om reiseutgiftene ikke kunne føres til fradrag. Bompenger og fergetakster gir ulike utslag i ulike deler av landet, men disse er i liten grad inntektsrelatert. Menn rammes hardere av reiseutgiftsendringer enn kvinner, og personer mellom 25 og 60 år rammes mer enn de yngre eller eldre. Det er forholdsvis liten forskjell mellom hushold av ulik størrelse eller sammensetning. Engangsavgiften for personbiler virker i hovedsak progressivt, ved at avgiften er høyest for de dyreste bilene, også relativt. Avgiftsfritakene for elbiler har gitt betydelige prisfordeler for kjøpere av enkelte dyre modeller. Men den viktigste fordelingsvirkningen er trolig at kjøperne har fått et større utvalg av biler i de lavere prisklasser.

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Institute of Transport Economics
Gaustadalleen 21, 0349 Oslo, Norway
Telefon 22 57 38 00 - www.toi.no

Transportøkonomisk Institutt
Gaustadalleen 21, 0349 Oslo
Telefon 22 57 38 00 - www.toi.no

Preface

The BISEK research programme is a joint Swedish-Norwegian endeavour to reveal the economic and social significance of the automobile – **BI**lens **S**ociala och **EK**onomiska betydelse.

This report, commissioned by BISEK, examines the equity effects of various automobile taxation measures as applied in Norway. A parallel report, focusing on Swedish tax rules, is being produced by CTS/KTH in Stockholm.

The project manager at the Institute of Transport Economics (TØI) has been Lasse Fridstrøm. Christian Steinsland has carried out and documented the simulations run on the DOM Intercity and NTM6 network models of travel demand. Vegard Østli has estimated and operated the BIG discrete choice model for automobile purchase. Berit Grue has produced the maps showing geographic income disparities. Trude Rømming has been responsible for the final editing and layout. Harald Minken has been in charge of the quality assurance.

Thanks are due to Björn Carlén of the Swedish National Institute of Economic Research (Konjunkturinstitutet), to Erik Hernes of the Norwegian Ministry of Finance, and to Harald Thune-Larsen of TØI for their insightful comments, which helped improve the present report substantially. Thanks are also due to the Board of BISEK for their generous funding and for their inspiring comments and suggestions during the research process.

Oslo, February 2016
Institute of Transport Economics (TØI)

Gunnar Lindberg	*Kjell Werner Johansen*
Managing Director	*Head of Department*

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The commuter tax credit in effect in Norway helps equalize welfare between low and high income communities. Revoking it would be a strongly regressive tax reform, affecting people in low income areas much more than in affluent ones. Increasing the fuel tax would have similar, although not quite so strongly regressive effects. Higher toll rates and ferry fares also affect different population segments unequally, but this variation has little to do with income and more to do with geography per se. In choosing among these three policy measures, there is a clear conflict between equity and efficiency, in that the most cost efficient measure for greenhouse gas abatement is also the most regressive, while the least efficient measure is least regressive.

The Norwegian vehicle purchase tax, on the other hand, is an effective instrument for long-term greenhouse gas abatement, without having obvious regressive effects. The same is true of the value added and purchase tax exemptions for battery electric vehicles. These tax incentives have allowed Norwegian consumers a large new assortment of relatively affordable vehicles – cars that are also quite economical in use, since battery electric vehicles are three to four times more energy efficient than conventional cars.

Affecting travel behaviour – three policy options

State-of-the-art travel demand models for Norway have been run with the aim of revealing the equity effects of selected policy measures for greenhouse gas (GHG) abatement. The Oslo Intercity Regional Model, comprising roughly 43 per cent of Norway's five million population, was used to study trips shorter than 100 km one way in southeastern Norway, i. e. in and around the capital city of Oslo. The NTM6 model for domestic, long distance travel was used to analyze trips longer than 70 km one way. Both of these are network models of travel demand, predicting trip frequency, destination choice, mode choice and route choice under user specified input assumptions.

The following three policy options have been studied:

1. Tripled toll rates and ferry fares everywhere in Norway
2. A NOK 0.20 (= € 0.024)[1] per vehicle km road charge or higher fuel tax
3. Abolishment of the commuter tax credit

In 2014, the commuter tax credit applied to all workers travelling more than 10 000 km per annum between their home and their job, with a standard rate of NOK 1.50 per km, regardless of travel mode. Given a 28 per cent marginal income tax rate, the

[1] As of 1 July 2014, NOK 1 = SEK 1.09 = US$ 0.162 = € 0.119.

credit gave rise to a tax cut of NOK 0.42 per km travelled in excess of the annual 10 000 km threshold, enough to cover just about half the average motorist's fuel bill.

The three measures result in comparable CO_2 abatement effects, on short as well as long distance trips (Figs. E.1 and E.2).

For short distance trips, the only mode of interest in our policy context is the private car. For other modes the changes in CO_2 emissions are negligible. The three policy measures considered all result in emissions reductions between 80 000 and 120 000 tonnes of CO_2 (tCO_2) per annum within the area covered by the Oslo intercity model. The relative reduction is 2.8 to 4.2 per cent compared to the reference scenario emissions of 2.89 million tonnes of CO_2 on short-haul trips.

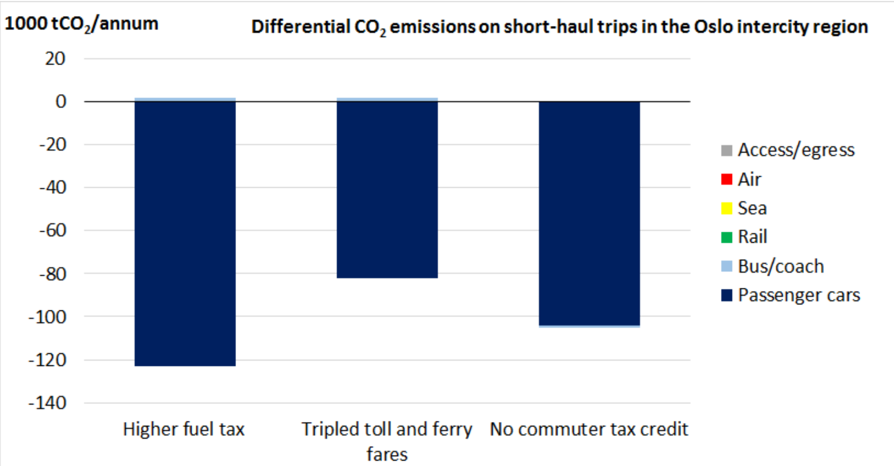

Fig. E.1. Policy impact on short-haul trips in Oslo intercity region. Absolute changes in annual CO_2 emissions, by policy measure and travel mode.

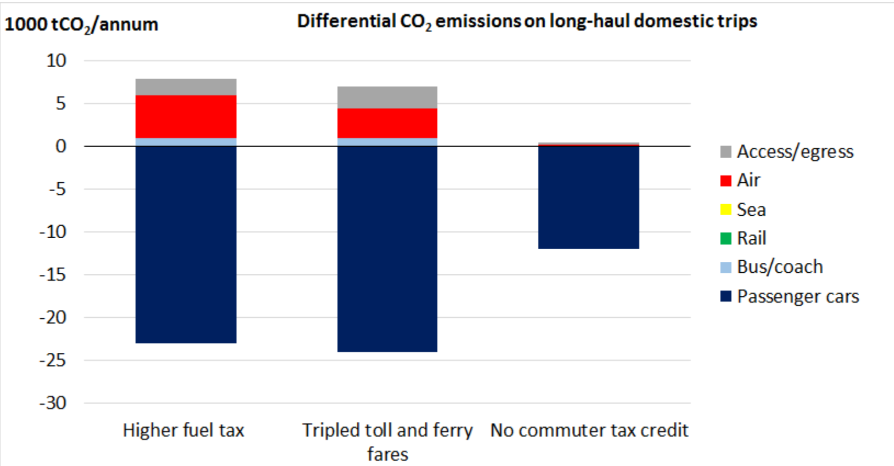

Fig. E.2. Policy impact on long-haul domestic trips. Absolute changes in annual CO_2 emissions, by policy measure and travel mode.

In the long distance travel market, the pattern is a bit more complex. Part of the emissions reductions from automobiles will be counteracted by increased emissions from air travellers, as the air mode becomes more competitive vis-à-vis private cars, also resulting in more airport access and egress trips. The net annual emissions reduction estimated is between 12 000 and 17 000 tCO_2 in all three cases, or between 0.5 and 0.7 per cent compared to the 2.55 million tonnes benchmark.

Each policy option inflicts costs on the travellers, in the form of higher cash expenditure, increased travel time and/or foregone trips. We calculate these losses by means of standard cost-benefit appraisal methods, more precisely by means of the well-known 'rule-of-the-half', which measures changes in aggregate consumer surplus as one moves up or down the demand curve.

To provide a full picture of the social welfare impact, changes in external costs and benefits must be taken into account. These externalities mean that private economic costs, as perceived by the individual household or person, may differ from the costs incurred by society at large.

The calculated cost efficiency of the respective three policy measures exhibits nothing like the relatively uniform pattern obtained for aggregate CO_2 emissions. While the tripled toll rate and ferry fares option inflicts large welfare costs on society, the fuel tax increase and the revocation of the commuter tax credit are shown to have negative net economic costs, when due account is taken of external effects, including the prescribed 20 per cent incremental value attributed to public funds (Fig. E.3).

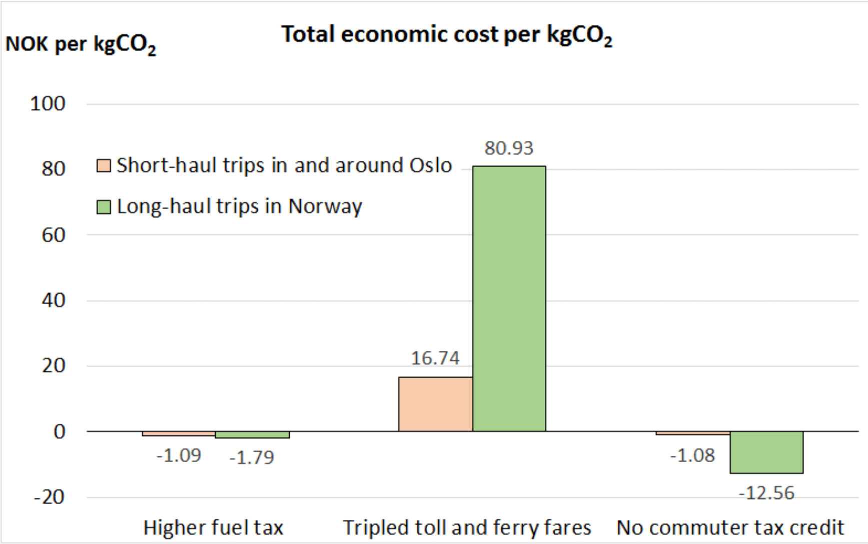

Fig. E.3. Calculated net economic cost per avoided kg CO_2 under three policy scenarios, according to the Oslo Intercity Regional Model for short-haul trips and the NTM6 model for long-haul trips.

These two measures are, in other words, socially profitable before GHG abatement benefits. According to the travel demand models, revoking the commuter tax credit results in a net social *gain* before GHG abatement benefits of € 100-120 per tonne CO_2 in the short-haul market around Oslo and € 1 200-1 500 in the long-haul domestic market. These estimates do not, however, take account of the possible productivity loss resulting from a contracted labour market, when the recruitment area of employers shrinks and workers no longer find it worthwhile to commute long distances for a better paid job.

The NOK 0.20 per km increased fuel tax option results in very similar benefits in the short-haul market, but smaller benefits in the long distance market: € 180-220 per tonne CO_2.

The by far least efficient option is to raise the toll rates and ferry fares. Here, CO_2 abatement comes at a *cost* a € 1 700-2 000 and € 8 000-10 000 on short, resp. long distance trips. Note, however, that most Norwegian toll roads have nothing to do with congestion charging or marginal cost pricing. Their purpose being road financing, the toll rates are, with few exceptions, invariant across time and across all types of passenger cars.

In terms of equity rather than efficiency, the ranking of the three options is completely reversed.

As shown in Fig. E.4 for the commuter tax credit revocation, the extra tax burden inflicted on residents in the least affluent neighbourhoods, having less than NOK 175 000 per capita income in 2001, is roughly 4.5 times higher in absolute terms than in the top income communities.

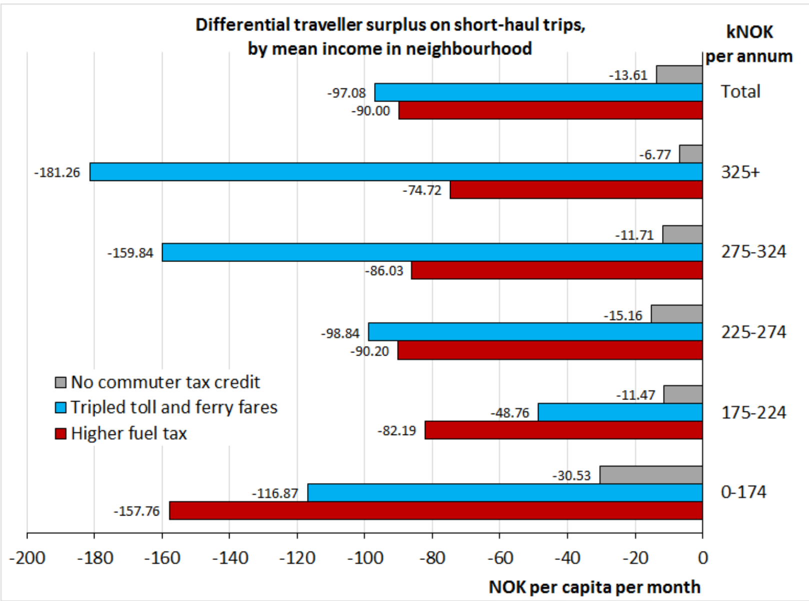

Fig. E.4. Calculated per capita changes in traveller surplus on short-haul trips in the Oslo intercity region, under three policy scenarios, by mean income in neighbourhood in 2001.

An increased fuel tax policy would be somewhat less regressive, with a ratio of roughly 2 between the bottom and top income neighbourhoods.

The tripled toll rate and ferry fares scenario has less distinct equity effects.

Traditionally, the distinction between progressive and regressive taxes is done, not on the basis of *absolute* changes in welfare, as shown in Fig. E.4, but from changes *relative* to the initial income level. A tax is progressive only if it withdraws a higher *percentage* of value from high income earners than from low income households. When we convert the absolute changes shown in Fig E.4 to percentages of mean income in each income bracket, the ratio of low to top income tax burden becomes 14.7 for the abolished commuter tax credit, 6.9 for the higher fuel tax option, and 2.1 for the tripled toll rates and ferry fares policy. All options are, according to this argument, regressive. Abolishing the commuter tax credit is the worst.

It may seem surprising that the inhabitants of the low-income neighbourhoods have the highest fuel bill and the longest commute by car. But they do. This is no doubt a reflection of the well-known rent gradient phenomenon, by which housing rents and land values decrease gradually as one moves away from the city centre, as does also the wage and income levels. Inhabitants of low income areas incur long commutes, since most jobs are located in or near the city.

Fig. E.4 deals with short distance travel in and around Oslo. An analogous picture for long distance trips nationwide is given in Fig. E.5.

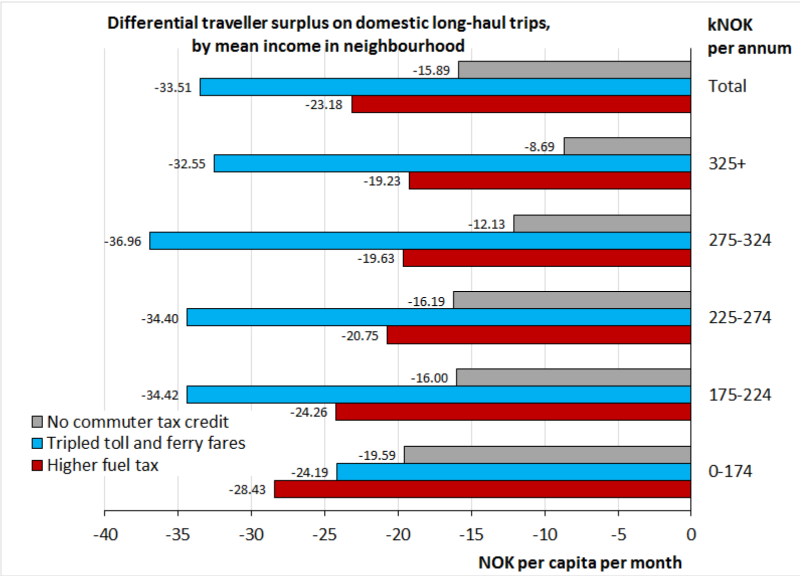

Fig. E.5. Calculated per capita changes in traveller surplus on long-haul domestic trips, under three policy scenarios, by mean income in neighbourhood in 2001.

Again the commuter tax credit revocation and the higher fuel tax policy are seen to be clearly regressive, even when judged by *absolute* changes in welfare. When correction is made for varying initial income, the *relative* burden ratio between low and high income areas comes out at 5.3 in the case of abolished commuter tax credit, at 3.5 in the case of more expensive fuel, and at 1.8 in the tripled toll rates and ferry fares case. All options are regressive, although less so than in the short-haul travel market.

Equity effects may be measured along a number of different dimensions other than income. In this study, effects have also been computed by age, gender, county of residence, household type, and household car ownership.

While the latter two dimensions are found to exhibit few interesting differences, certain clear patterns of inequality do emerge in terms of age, gender and geography.

Males are generally more seriously affected by increased fuel tax and reduced commuter tax credit. This is true in the short-haul as well as in the long-haul market (Figs. E.6 and E.7). Persons in the economically most active ages (25-59/66) are more seriously affected than the younger or older.

Geographic differences are shown in Figs. E.8 and E.9. The three CO_2 abatement policies will affect the population in different counties unequally. This is true in particular of the tripled toll and ferry fares scenario, since toll roads and ferry crossings are unevenly spread across the counties.

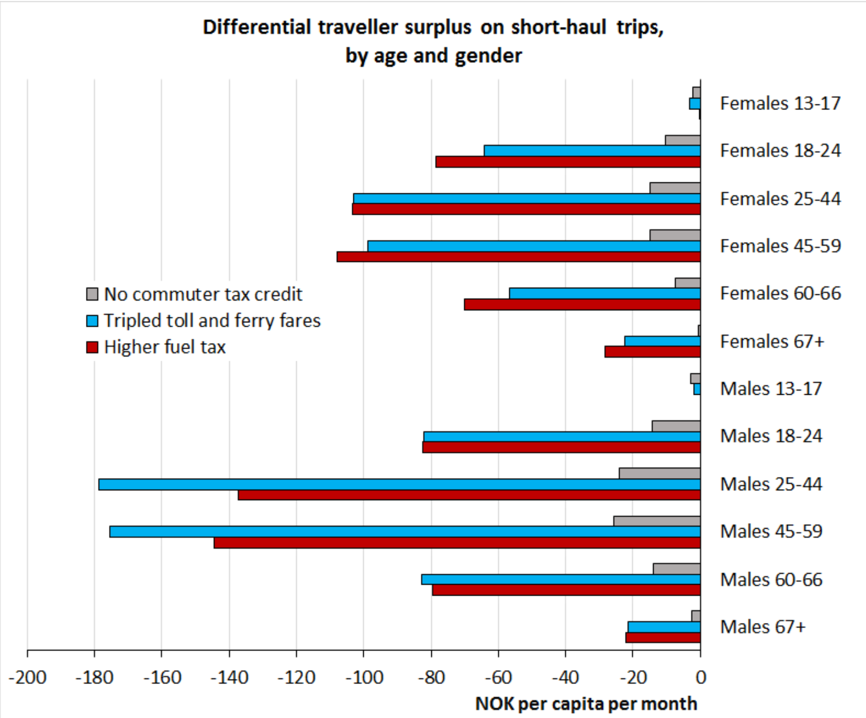

Fig. E.6. Calculated per capita changes in traveller surplus on short-haul trips in the Oslo intercity region, under three policy scenarios, by age and gender.

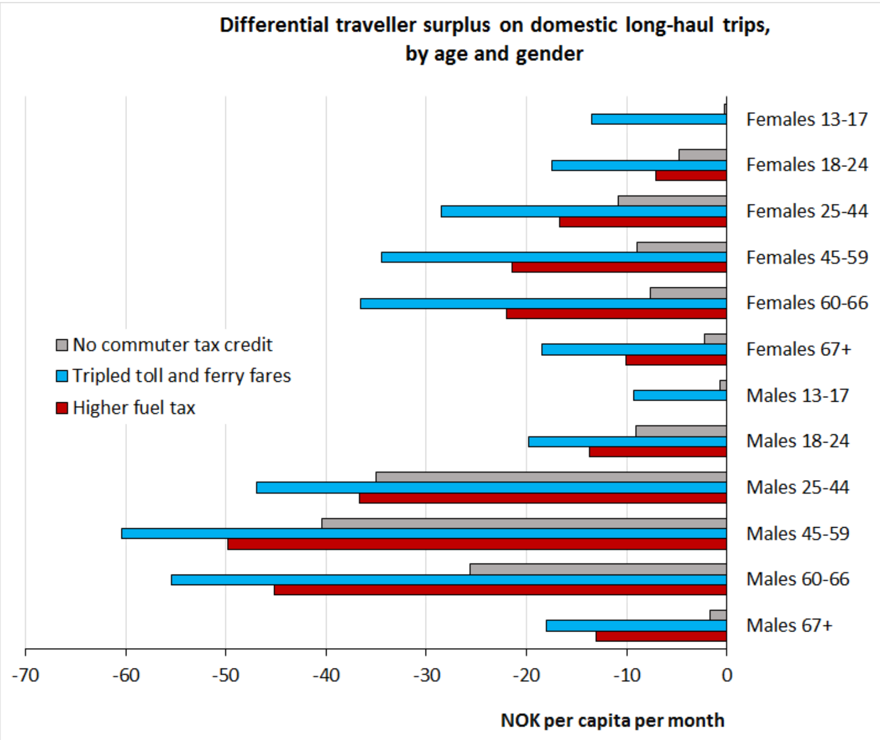

Fig. E.7. Calculated per capita changes in traveller surplus on long-haul domestic trips, under three policy scenarios, by age and gender.

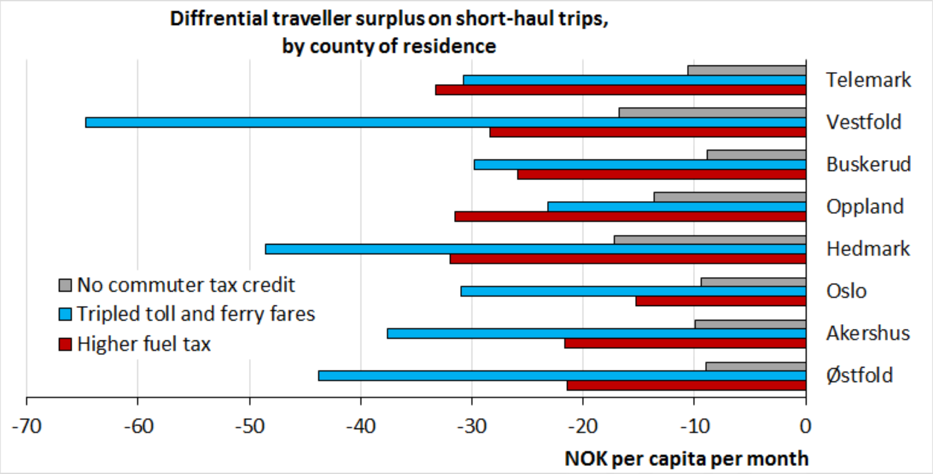

Fig. E.8. Calculated per capita changes in traveller surplus on short-haul trips in the Oslo intercity region, under three policy scenarios, by county of residence.

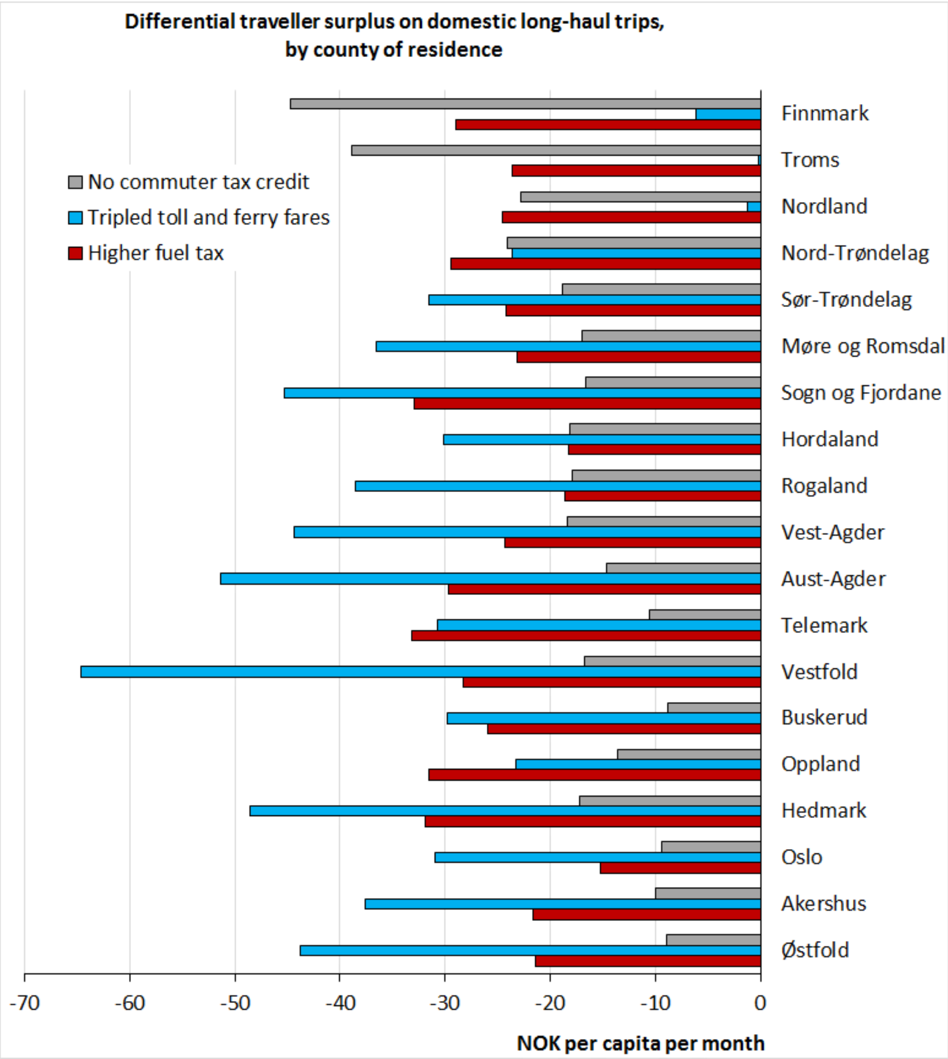

Fig. E.9. Calculated per capita changes in traveller surplus on long-haul domestic trips, under three policy scenarios, by county of residence.

The small county of Vestfold, on the west side of the Oslo fjord, appears to be more severely hit by increased toll and ferry fares than any other county in south-eastern Norway. Residents of the three northernmost counties, on the other hand, are hardly affected at all by an increase in toll and ferry fares.

The fuel cost increase is seen to affect the highly urbanised county of Oslo least and the less densely populated counties most.

The commuter tax credit revocation also hits harder in the sparsely populated counties. In the northernmost county of Finnmark, the per capita traveller surplus loss on long-haul trips is nearly five times higher than in Oslo.

In summary, when policy makers are to choose among the above three options, the traditional contradiction between equity and efficiency is as present as ever. Abolishing the commuter tax credit would be the most profitable of the three policy options considered, but also the most regressive. The opposite – high cost and low regressivity – is true of tripled toll rates and ferry fares.

In principle, however, the final equity effect will depend crucially on how the public revenue from tax, toll or ferry fares is used. For some policy options, it might be possible to redistribute the increased public revenue in such a way that the final distributional effect would become progressive. At least this would be true of policies affecting travellers more or less in general, such as a fuel tax increase, where a reduced VAT on food would probably do the trick. It might be harder to design redistribution schemes to compensate the relatively few affected by an abolished commuter tax credit, or the relatively haphazard set of travellers hit by higher toll rates or ferry fares.

Affecting vehicle choice behaviour – six policy options

Automobiles are more heavily taxed in Norway than in almost any European country, with the possible exception of Denmark. Private cars meant for passenger transport are subject to purchase tax (‘engangsavgift’) upon their first registration.

The vehicle purchase tax for passenger cars is a sum of four independent components, calculated on the basis of curb weight, engine power, and type approval CO_2 and NO_X emissions, respectively. All but the small, linear NO_X component are distinctly convex curves, i. e. they bend upward and become gradually steeper.

For vehicles equipped with an internal combustion engine (ICE), the four purchase tax components taken together typically add 50 to 100 per cent on top of the import value – or even more for the largest and most powerful vehicles.

For plug-in hybrid vehicles (PHEVs), certain special rules apply. The electric motor is not considered part of the tax base for engine power. Also, so as to leave the standardized weight of the battery pack and the electric powertrain out of the tax calculation, the taxable curb weight of PHEVs is reduced, as of our base year 2014, by 15 per cent. In 2015, this deduction was raised to 26 per cent.

Since the CO_2 component is negative for cars emitting less than 105 g/km (as of 2014), light-weight PHEVs may come out with zero of near-zero purchase tax. The purchase tax cannot, however, become negative, as in the French feebate (bonus-malus) system.

Battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs) are altogether exempt of purchase tax. Most of these vehicles would, however, be subject to zero purchase tax even if the exemption were lifted, as the engine power and NO_X components would be zero, while the negative CO_2 component would more than offset the positive weight component, except for the heaviest vehicle models.

BEVs and FCEVs are also exempt of value added tax (VAT). Other vehicles are subject to a 25 per cent VAT as calculated on the retail price exclusive of purchase tax.

By means of the BIG discrete choice model of automobile purchase we have simulated six different policy options bearing on the automobile purchase tax. These are

1. A 10 per cent increase in all purchase tax components.
2. A 10 per cent increase in the CO_2 component
3. A 10 per cent increase in the curb weight component
4. A 10 per cent increase in the engine power component
5. A revocation of the purchase tax exemption for BEVs
6. A revocation of the VAT and purchase tax exemptions for BEVs.

Results in terms of changes in the mean type approval CO_2 emission rate of new passenger cars are shown in Fig. E.10. The reference situation is the observed car sales and the tax regime in effect in 2014.

A uniformly 10 per cent higher purchase tax will reduce the mean type approval emission level by 2.4 gCO_2/km, or about 2.2 per cent. Increasing the CO_2 or weight component leads to a 1.1 gCO_2/km decrease in average emissions, while an increase in the power component will have very little effect on the CO_2 level.

Introducing a purchase tax for BEVs, identical to the one in effect for PHEVs, will lead to a moderate, 0.56 gCO_2/km increase in the average emission level of new cars.

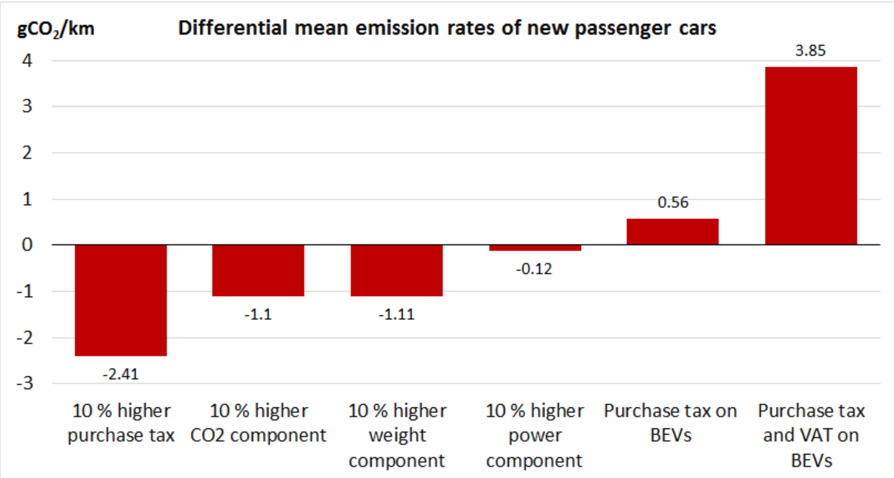

Fig. E.10. Absolute changes in mean type approval CO_2 emission rates of new passenger cars, compared to reference case, under six fiscal policy scenarios.

If, however, both the VAT and the purchase tax exemptions are lifted, the result will be an estimated 3.85 gCO_2/km higher level of emissions. The VAT effect alone can be calculated as 3.85 – 0.56 = 3.3 gCO_2/km.

The left-most and right-most policy options shown in Fig. E.10 differ by 6.3 gCO_2 per km. This difference corresponds to roughly 2.5-3 ml/km lesser fuel consumption by the type approval test. For a car running 200 000 km before scrapping, the total fuel savings are 7-800 litres over the vehicle's lifetime, when considering that the real-world, on-the-road fuel consumption of the 2014 cohort of cars is about 40 per cent higher than according to the EU type approval test. For the entire 2014 cohort of Norwegian registered cars, the lifetime CO_2 emissions difference is around 250 000 tonnes.

Public revenue impacts are shown in Fig. E.11. A 10 per cent overall increase in the purchase tax rates will generate an estimated NOK 742 million extra revenue for the public treasury, when behavioural changes on the part of car buyers are taken into account. VAT revenue goes slightly down, as more buyers choose VAT-exempt BEVs or FCEVs.

Increasing only the CO_2 component by 10 per cent will have comparatively small effects on the purchase tax revenue. The same is true of the engine power component. The weight component, however, is a potent one. Most of the revenue increase obtained by a uniform 10 per cent increase in all tax components is due to the weight factor.

Interestingly, the purchase tax exemption for BEVs reduces public revenue by only NOK 200 million – a small amount compared to large numbers featured in multiple media announcements on the 'cost' of the electric vehicle incentives. Note, however, that our point of reference is a tax regime in which low and zero emission vehicles already enjoy very much lower tax rates – especially if they are equipped with an electric motor – than do fuel guzzlers.

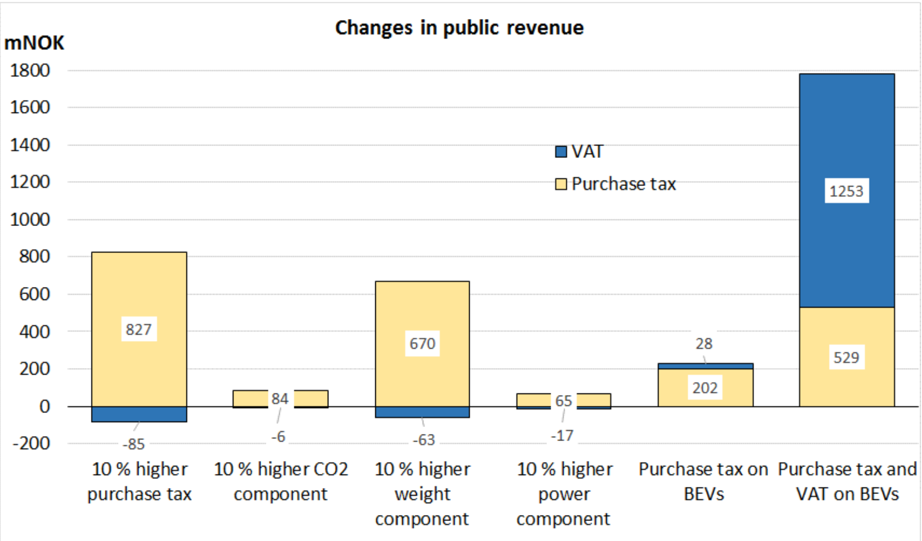

Fig. E.11. Differential annual VAT and purchase tax revenue under six fiscal policy scenarios.

A much larger increase in public revenue would take place if the VAT exemption were lifted as well. In such a case, some car buyers would shift from BEVs to ICE vehicles, whereby the purchase tax revenue would increase, not by NOK 200 million, but by more than NOK 500 million. An even larger revenue increase would come from the VAT system. The total public revenue increase is estimated at NOK 1.782 billion.

In Figs. E.12 to E.15, we show, in somewhat greater detail, how the same two fiscal policy options would affect the market for cars in different fuel, weight, price and CO_2 emission categories. In all of these calculations, it has been assumed that tax increases are passed on 100 per cent to the buyers, translating into proportional retail price increases.

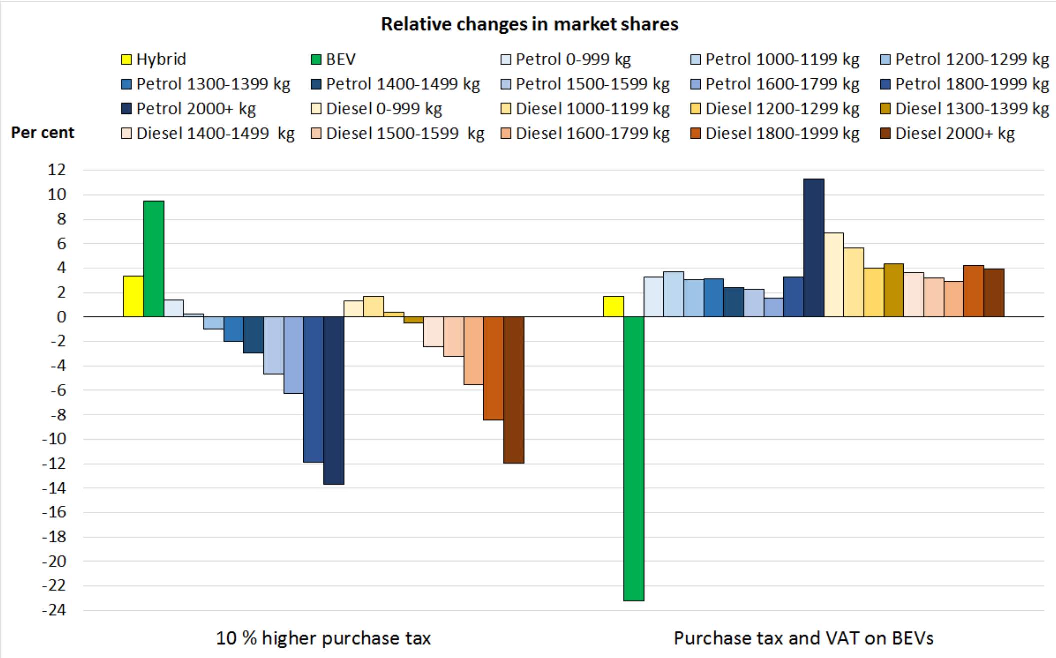

Fig. E.12. Relative changes in fuel and weight segments' market shares under two fiscal policy scenarios.

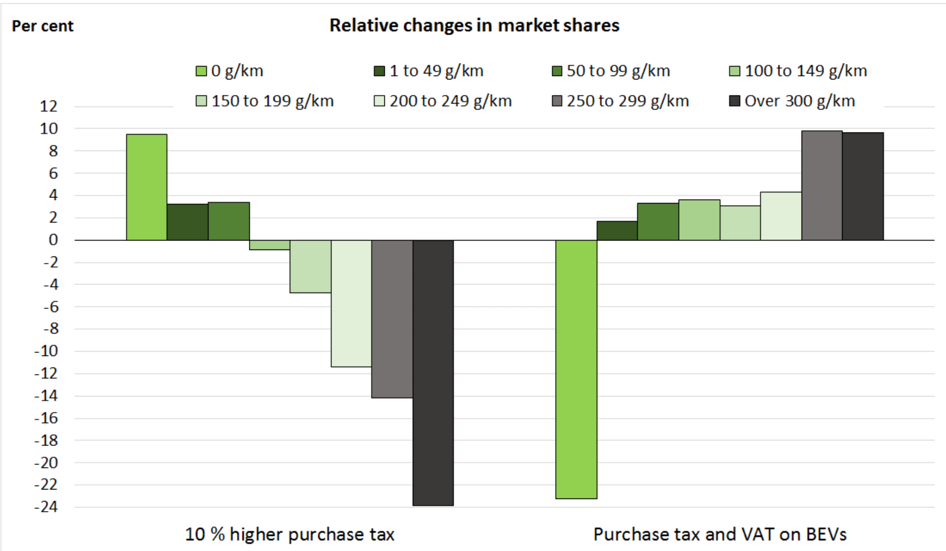

Fig. E.13. Relative changes in market shares under two fiscal policy scenarios, by type approval CO_2 emission interval.

A uniformly 10 per cent increased purchase tax would enhance the sales of hybrid and battery electric vehicles, and also of the smaller petrol and diesel driven cars (Fig. E.12). The largest ICE cars would, however, have their market drop by 12-14 per cent. Increasing sales would take place for cars with less than 100 gCO_2/km type approval emission rates, while the least climate friendly vehicles would sell about 24 per cent less (Fig. E.13). In terms of price segments, sales would increase only in the two most inexpensive categories, while the most expensive segments of models would have their sales reduced by about 10 per cent (Fig. E.14). The demand impact is more or less a mirror image of the respective changes in price (Fig. E.15), although in such a way that vehicle categories undergoing comparatively small price increases will have their market shares grow.

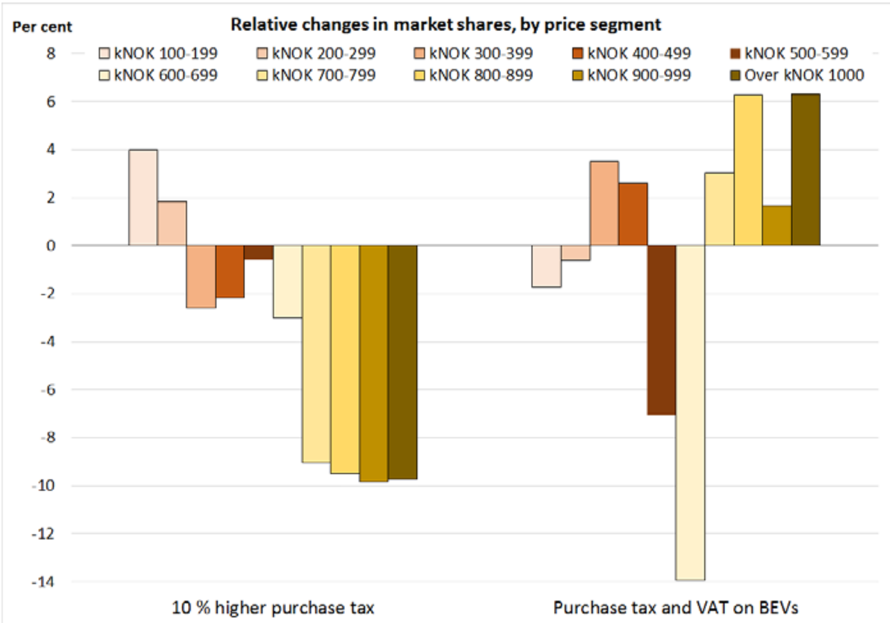

Fig. E.14. Relative changes in automobile market shares under two fiscal policy scenarios, by vehicle price bracket (kNOK 2010).

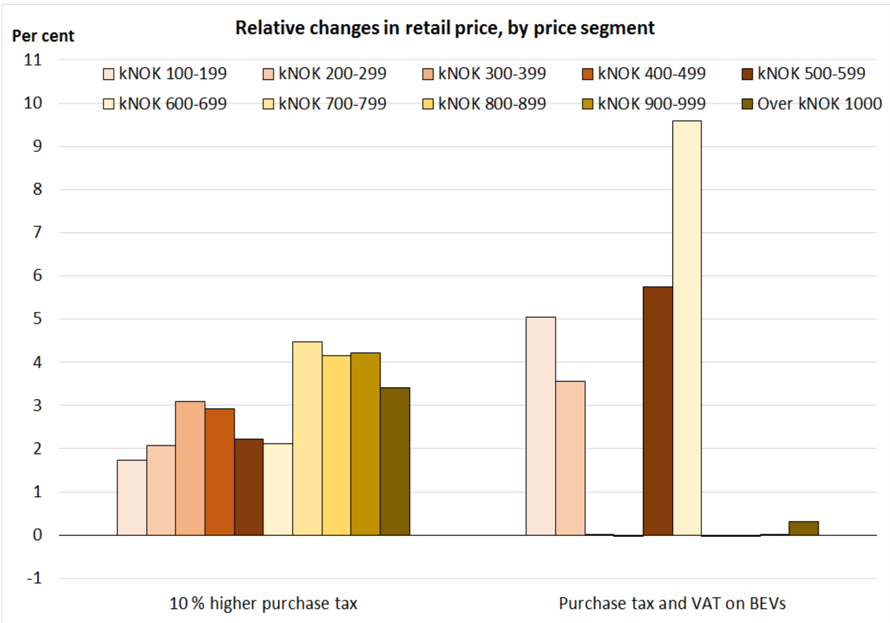

Fig. E.15. Relative changes in automobile prices under two fiscal policy scenarios, by vehicle price bracket (kNOK 2010).

The revocation of the VAT and purchase tax exemptions for BEVs would, if implemented in 2014, have reduced the BEV sales by an estimated 23 per cent (Fig. E.12). All other vehicle classes would gain market shares. The demand for fuel guzzlers would go up by 10 per cent (Fig. E.13). Average prices would go up and aggregate sales would drop in the two most inexpensive price segments, where most BEVs are, and also in the upper-mid-price segment (kNOK 550-770 000 when adjusted for inflation until November 2015), where the Tesla models are (Figs. E.14 and E.15).

In terms of equity, the uniform 10 per cent increase in purchase tax rates is seen to affect the more expensive vehicle segments more strongly than the less costly. Relative price increases are, by and large, higher the higher is the initial price (Fig. E.15). The demand response is also stronger in the uppermost price segments. This is a clear sign that the vehicle purchase tax, and any proportional increase in it, is progressive. People buying the more expensive cars are, by and large, more affluent than those buying cheaper vehicles.

The revocation of the VAT and purchase tax exemptions for BEVs has more mixed distributional effects. The largest average price increase and the sharpest relative drop in demand will occur in the upper-mid-price segments, where Teslas hold a considerable market share. The second most important impact will take place within the two lowermost price segments. BEVs in this price range represent around 80 per cent of the BEVs sold in Norway in 2014. Hence, if and when VAT and purchase tax is reintroduced for BEVs, the numerically most dominant effect will be that consumers have a more limited choice in the low-price vehicle segments. A number of comparatively inexpensive cars will become generally less affordable. Although we cannot tell for sure who gain or lose by this, chances are that the less affluent car buyers will lose more, relatively to their income, than the wealthy.

The BEV tax exemptions are, in such a case, progressive rather than regressive, and their revocation could be a regressive fiscal measure. Here, there is no apparent contradiction between equity and GHG abatement, since the BEV exemptions are also quite effective in bringing down the mean CO_2 emission rate of new cars.

Sammendrag:

Fordelingseffekter av endret bilbeskatning

TØI rapport 1463/2016
Forfattere: Christian Steinsland, Vegard Østli og Lasse Fridstrøm
Oslo 2016 65 sider

Reiseutgiftsfradraget ved skattelikningen utjevner forskjellene mellom høy- og lav-inntektsområder. Å avvikle fradraget, som foreslått av grønn skattekommisjon, vil gi størst velferdstap i distriktskommunene, siden disse har størst andel sysselsatte med lang arbeidsreise. En liknende, men ikke fullt så sterk fordelingseffekt vil oppstå dersom en øker drivstoffavgiftene. Økte bompenger og fergetakster rammer mer usystematisk, dvs. uten klar sammenheng med inntektsnivået. Men vurdert som klimatiltak blir rangeringen mellom disse tre strategiene helt motsatt. Klimapolitikk og fordeling står altså i motsetning til hverandre. Effektivitet i klimapolitikken kan også stå i motsetning til produktivitet i arbeidslivet. Særlig gjelder dette fjerning av reisefradraget, som retter seg mot de lange arbeidsreisene. Å øke reisekostnadene for de ansatte er på sett og vis det motsatte av regionforstørring.

Engangsavgiften for personbiler har stor betydning for hvilke nye biler vi kjøper, og i det lange løp for hele bilparkens sammensetning. Avgiftens innretning, med progressivt stigende avgiftssatser på CO_2-utslipp, vekt og motorkraft, samt fritak for elbiler, har bidratt til at CO_2-utslippet fra nye biler registrert i Norge er gått betydelig ned. Ved at elbilene er fritatt for moms og engangsavgift har norske kjøpere fått et stigende antall relativt rimelige biler å velge blant. Elbilene har også ekstra lave drifts-kostnader, siden de er tre til fire ganger så energieffektive som bensinbiler. Selv om fritakene fra moms og engangsavgift også gir fordeler for noen elbilmodeller i det øvre prissjiktet, er den tallmessig dominerende virkningen at utvalget av forholdsvis billige biler er blitt større. Det synes derfor ikke som om det, i utformingen av engangs-avgiften, er noen sterk motsetning mellom klima- og fordelingspolitiske mål.

Utslippskutt gjennom endret reiseatferd

Ved hjelp av to nettverksmodeller for reiseatferd har vi studert følgende tre potensielle strategier for å redusere klimagassutslippene fra transport:

1. Økt drivstoffavgift eller kilometeravgift tilsvarende 20 øre per personbilkilometer
2. Tredoblede bompengesatser og fergetakster
3. Avvikling av reiseutgiftsfradraget

Reiseutgiftsfradraget

Beregningene er gjort per år 2014. Dette året gjaldt følgende regler for reiseutgifts-fradraget: Alle som reiser mer enn 10 000 km årlig mellom bolig og arbeidssted, kan føre den overskytende distansen til fradrag på selvangivelsen med kr 1,50 per km, opp til 50 000 km per år. Mellom 50 000 og 75 000 km er satsen 70 øre per km. For et arbeidsår på 230 arbeidsdager svarer 'terskelen' på 10 000 km til en daglig arbeidsreise på minst 22 km hver veg.

Fradraget gis uansett hvilken reisemåte som anvendes, og uten annet krav til dokumentasjon enn adressene for bolig og arbeidssted. Siden marginalskatten på slike fradrag i 2014 var 28 prosent, gav hver km arbeidsreise utover 10 000 km per år 42 øre (= 150 x 0,28) lavere inntektsskatt. Dette er omtrent nok til å dekke halve drivstoffutgiften for en gjennomsnittlig bilist.

Ifølge skattestatistikken var det i 2013 snaut 11 prosent av skattyterne som hadde ført slike reiseutgifter til fradrag, med i gjennomsnitt kr 15 700.

Grønn skattekommisjon (NOU 2015:15) har foreslått å avvikle reisefradraget. For likningsåret 2016 er betydningen av fradraget redusert, ved at terskelen er hevet fra 10 000 til 14 667 km, samtidig som den relevante marginalskatten er senket til 25 prosent.

Utslippsvirkninger

Doseringen av hvert virkemiddel er i våre analyser satt slik at de tre alternativene skal gi noenlunde samme klimagassreduksjon. Det gjør de også (Fig. S.1 og S.3).

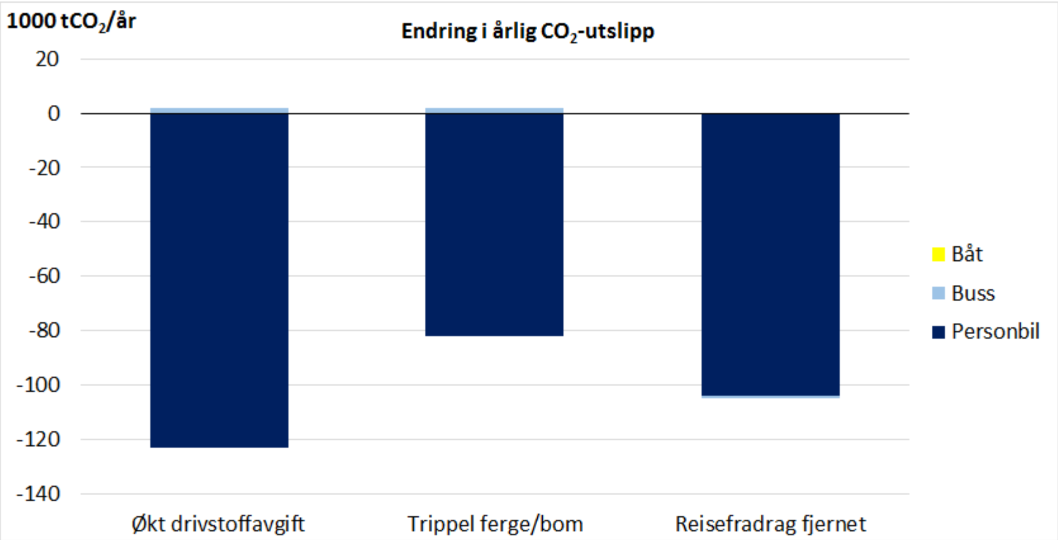

Fig.S.1. Endring i CO_2-utslipp på korte reiser på det sentrale Østlandet, etter type tiltak og reisemiddel.

Utslippene på korte reiser på det sentrale Østlandet er beregnet ved hjelp av den såkalte Delområdemodellen (DOM) Intercity, som dekker fylkene Oslo, Akershus, Østfold, Vestfold og Telemark, samt deler av Hedmark, Oppland og Buskerud (Fig.

S.2). Med korte reiser mener vi i denne rapporten reiser som er mindre enn 100 km én veg.

Når drivstoffavgiften øker tilsvarende 20 øre per km, beregnes utslippene på korte turer på Østlandet å gå ned med ca. 120 000 tonn CO_2 (tCO_2) per år, dvs. med 4,2 prosent. Tredoblede bom- og fergetakster gir en nedgang på ca. 80 000 tCO_2, mens fjerning av reiseutgiftsfradraget leder til drøyt 100 000 tCO_2 redusert utslipp. Praktisk talt alle utslippskuttene på korte reiser skriver seg fra personbiler.

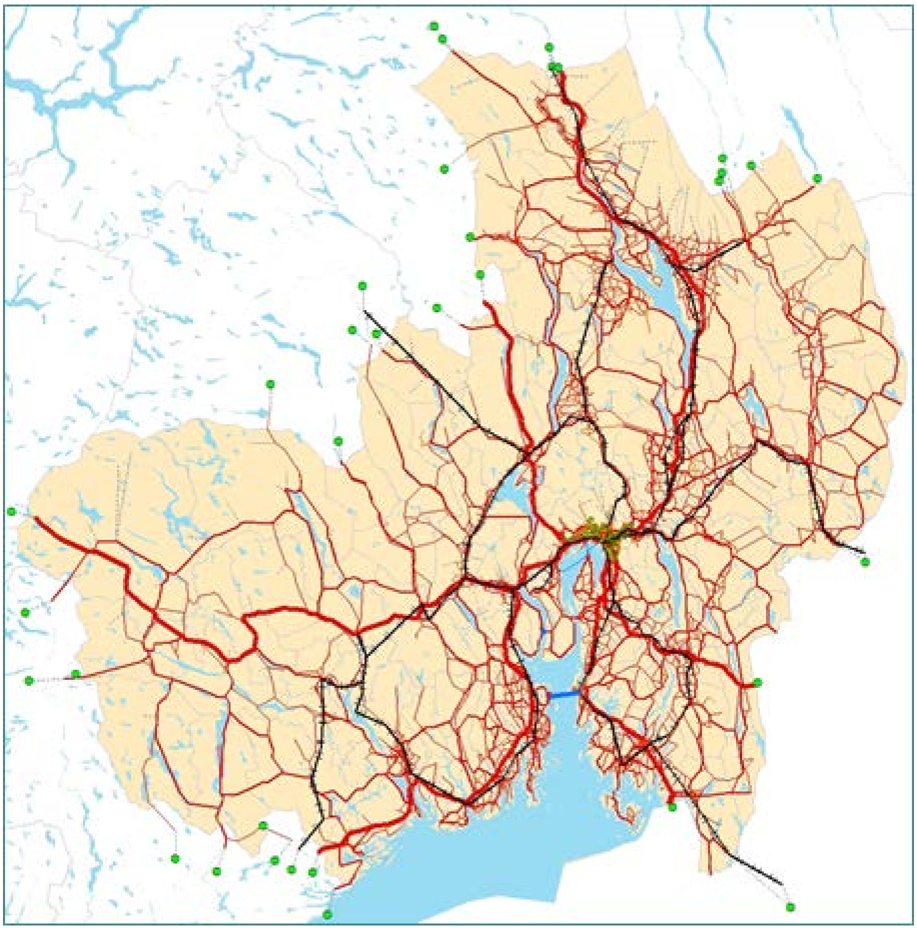

Fig. S.2. Kart over området dekket av DOM Intercity. Veger markert i rødt, jernbaner i svart og båtruter i blått.

Når utslippene går ned, skyldes det at folk tilpasser seg skatte- og prisendringene ved å reise kortere, sjeldnere eller med andre transportmidler. I tilfellet med fjernet reisefradrag, som kun gjelder arbeidsreiser, er den underliggende mekanismen at det blir mer kostbart – og dermed mindre vanlig – å bo i lang avstand fra arbeidsplassen. Utslippsreduksjonen kommer med andre ord gjennom at noen personer flytter, bytter jobb, begynner å reise kollektivt eller slutter å arbeide.

De lange reisene (over 70 km én veg) er studert ved hjelp av den nasjonale persontransportmodellen NTM6. Når drivstoffavgiften øker, blir de lange bilreisene færre og/eller kortere, og utslippet fra biler går ned med ca. 23 000 tCO_2 per år (Fig. S.3). Men buss- og flyturene blir flere, og det samme gjelder tilbringertransportene til og fra flyplasser. Netto årlig utslippsreduksjon på lange reiser i Norge blir ca. 15 000 tCO_2, eller 0,6 prosent.

I alternativet med tredoblede bom- og fergetakster anslår modellen at utslipps-reduksjonen på lange reiser blir ca. 17 000 tCO_2, dvs. 0,7 prosent. Fjernet reisefradrag gir noe mindre effekt: snaut 12 000 tCO_2 redusert utslipp hvert år.

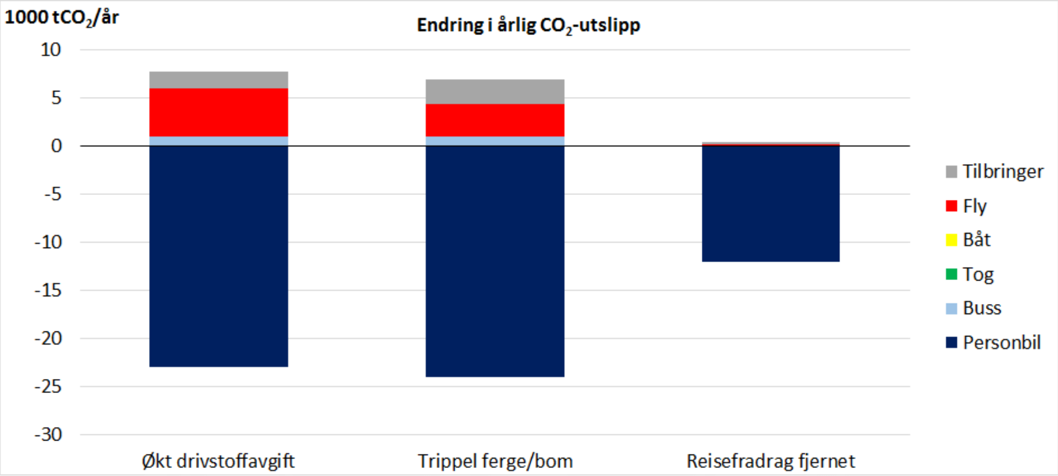

Fig.S.3. Endring i CO_2-utslipp på lange reiser i Norge, etter type tiltak og reisemiddel.

Samfunnsøkonomisk effektivitet

Enten den reisende tilpasser seg ved å betale en høyere pris, ved å innstille reisen eller ved å reise på en annen måte eller til et annet sted enn før, oppstår det et nyttetap på den reisendes hånd. Dette nyttetapet beregner vi på samme måte som i standard nyttekostnadsanalyse, i sum for alle innbyggere. I tillegg beregner vi virkningen for offentlig økonomi og for omfanget av eksterne kostnader. Summen av alle disse postene utgjør netto samfunnsøkonomisk overskudd. Resultatene er vist i Fig. S.4 og S.5.

Alternativet med økt drivstoffavgift er i modellberegningene ekvivalent med innføring av en generell kilometeravgift på 20 øre – en flat pris på vegbruk. Dette gir et nyttetap for trafikantene på korte turer på Østlandet beregnet til 2 238 millioner kroner per år, eller rundt kr 1 100 per innbygger i alderen 13 år og oppover.

En vesentlig del av dette nyttetapet – 1 898 millioner kroner – er penger betalt i drivstoffavgift. Dette er ikke samfunnsøkonomiske kostnader – bare en omfordeling fra private til offentlige kasser. Når en skal beregne netto samfunnsøkonomisk kostnad, må dette beløpet trekkes fra. Vi må dessuten ta med i regnestykket at trafikknedgangen gir noe reduserte driftsinntekter for bom- og fergeselskapene, med rundt 83 millioner. På den annen side vil trafikknedgangen medføre lavere eksterne kostnader i form av vegslitasje, kø, ulykker, støy og lokal forurensning. Dessuten skal fordelen ved økte inntekter til det offentlige tas med i nyttekostnadsregnskapet med 20 prosent av skattebeløpet. Alt i alt gir økt drivstoffavgift tilsvarende 20 øre per personbilkilometer en samfunnsøkonomisk gevinst på 149 millioner kroner per år, før en tar hensyn til verdien av reduserte klimagassutslipp (Fig. S.6).

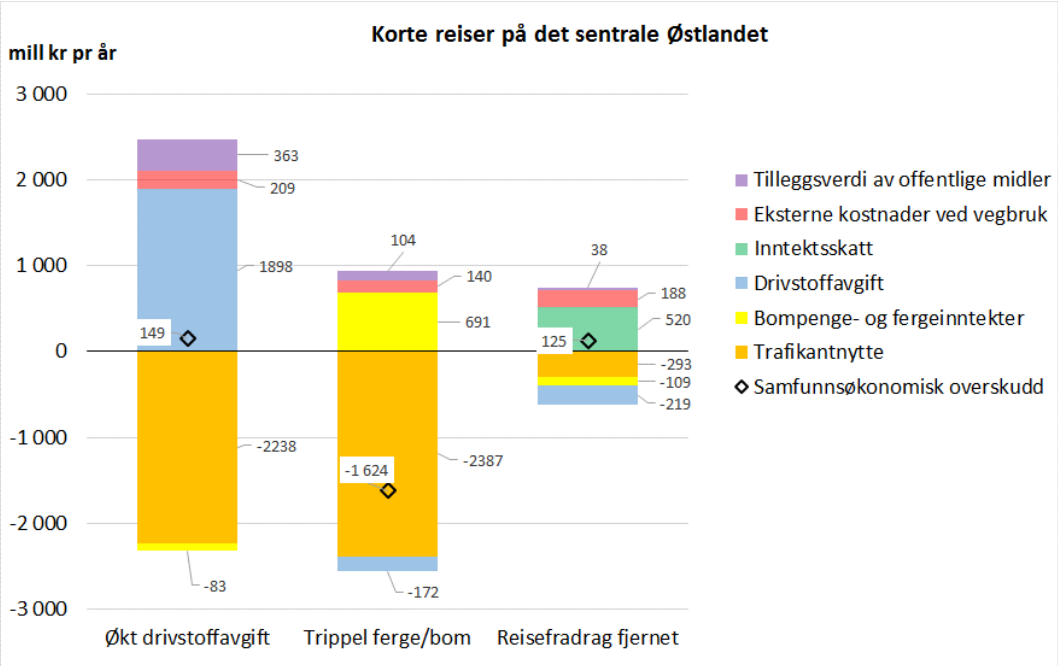

Fig. S.4. Nyttekostnadsregnskap for tre strategier for kutt i klimagassutslippene på korte reiser på det sentrale Østlandet.

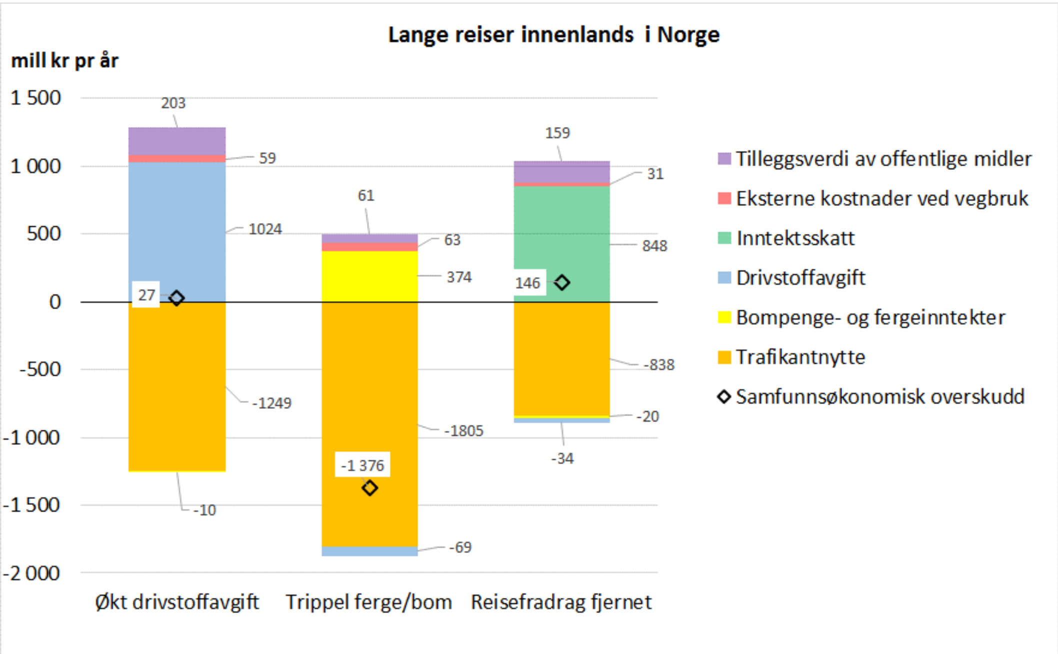

Fig. S.5. Nyttekostnadsregnskap for tre strategier for kutt i klimagassutslippene på lange reiser innenlands i Norge.

Tredoblede bompenge- og fergetakster gir et nyttetap for trafikantene på Østlandet på 2 387 millioner kroner per år og 172 millioner kroner mindre inntekt fra drivstoff-avgift. Til gjengjeld får bom- og fergeselskapene en økt driftsinntekt på 691 millioner. Tiltaket medfører likevel et underskudd på 1 624 millioner kroner per år. Når økte bompenger kommer såpass dårlig ut, er det fordi de kreves opp med forholdsvis store beløp, men på bare en liten del av vegnettet, og uten at en differensierer etter kø, utslipp, ulykkesrisiko, vegslitasje eller liknende. Slike bompenger har ingenting med vegprising eller køprising å gjøre.

Å fjerne reisefradraget medfører ifølge beregningene en årlig samfunnsøkonomisk gevinst i markedet for korte reiser på Østlandet på 125 millioner kroner. Tiltaket gir ikke full uttelling i offentlige kasser, fordi en vesentlig del av økningen i inntektsskatt vil bli motsvart av mindre proveny fra drivstoffavgift, bompenger og fergebilletter.

I markedet for lange reiser i Norge gir de samme tre tiltakene årlige samfunns-økonomiske resultat på pluss 27, minus 1 376 og pluss 146 millioner kroner, henholdsvis (Fig. S.5).

Forskjellene i samfunnsøkonomisk lønnsomhet kommer fram i Fig. S.6, der kostnadene er regnet i kroner per unngått kg CO_2-utslipp.

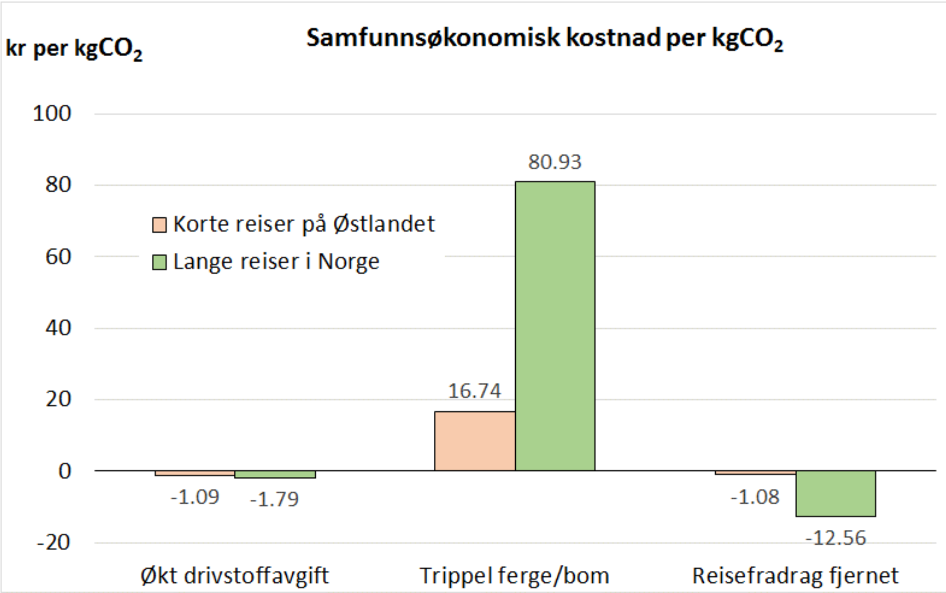

Fig. S.6. Samfunnsøkonomisk kostnad per unngått kg CO_2 på korte, henh. lange reiser, i tre scenarier.

Økt drivstoffavgift og fjernet reisefradrag gir samfunnsøkonomisk gevinst. Det betyr at tiltakskostnaden er negativ. I markedet for korte reiser på Østlandet blir gevinsten per unngått tonn CO_2 like stor – ca. én krone per kg CO_2 – enten en øker drivstoff-avgiften eller fjerner reisefradraget. I markedet for lange reiser er den siste strategien mest lønnsom.

Når to av strategiene er samfunnsøkonomisk lønnsomme, skyldes det at en har tatt eksterne kostnader, herunder tilleggsverdien av offentlige midler, med i regnestykket. Uten disse postene er alle tiltakene ulønnsomme.

Beregningene tar ikke hensyn til virkninger utenfor transportsektoren. Slike virkninger kan i prinsippet ha stor betydning. Avvikling av reisefradraget kan betraktes som det motsatte av regionforstørring. Den økonomiske avstanden mellom hjemsted og arbeidssted vil for mange arbeidstakere øke. Det gjør arbeidstakerne mindre tilbøyelige til å reise langt for å oppnå en jobb med høyere lønn og høyere produktivitet. Dermed går produktiviteten i arbeidslivet antakelig ned.

Fordelingsvirkninger

Tiltakene vil ha ulike virkninger på de forskjellige befolkningsgruppene. I Fig. S.8-S.9 har vi satt opp nyttetapet for personer bosatt i fem ulike typer grunnkretser, rangert etter gjennomsnittlig personinntekt i grunnkretsen i 2001. Det er ca. 14 000 grunnkretser i Norge, med et gjennomsnittlig innbyggertall på under 400. I byene består hver grunnkrets gjerne av noen få kvartal. Det er altså en forholdsvis liten geografisk enhet. I Fig. S.7 vises de 5 532 grunnkretsene i transportmodellen for det sentrale Østlandet, med fargesjattering i henhold til inntektsnivået[1].

Å fjerne reisefradraget gir klart størst ulempe for personer bosatt i lavinntekts-områdene, med drøyt kr 30 per innbygger per måned (Fig. S.8). Dette gjennomsnittet er regnet over alle innbyggere over 13 år, ikke bare dem som benytter seg av fra-draget. Om andelen fradragsberettigede i lavinntektsgrunnkretsene er som på lands-basis, altså 11 prosent, utgjør nyttetapet snaut kr 4 000 per år i gjennomsnitt for dem det gjelder, når vi inflasjonsjusterer til 2015. I høyinntektskretsene blir det tilsvarende tallet kr 870. Tiltaket rammer således 4,5 ganger så hardt i lavinntektssonen. Om vi tar hensyn til at inntektsnivået er 3,3 ganger så høyt i høyinntektskretsene som i lavinntektskretsene, finner vi at tiltaket rammer 15 ganger (= 4,5 x 3,3) hardere, regnet i forhold til inntekten, i nederste del av inntektsstigen enn i øverste.

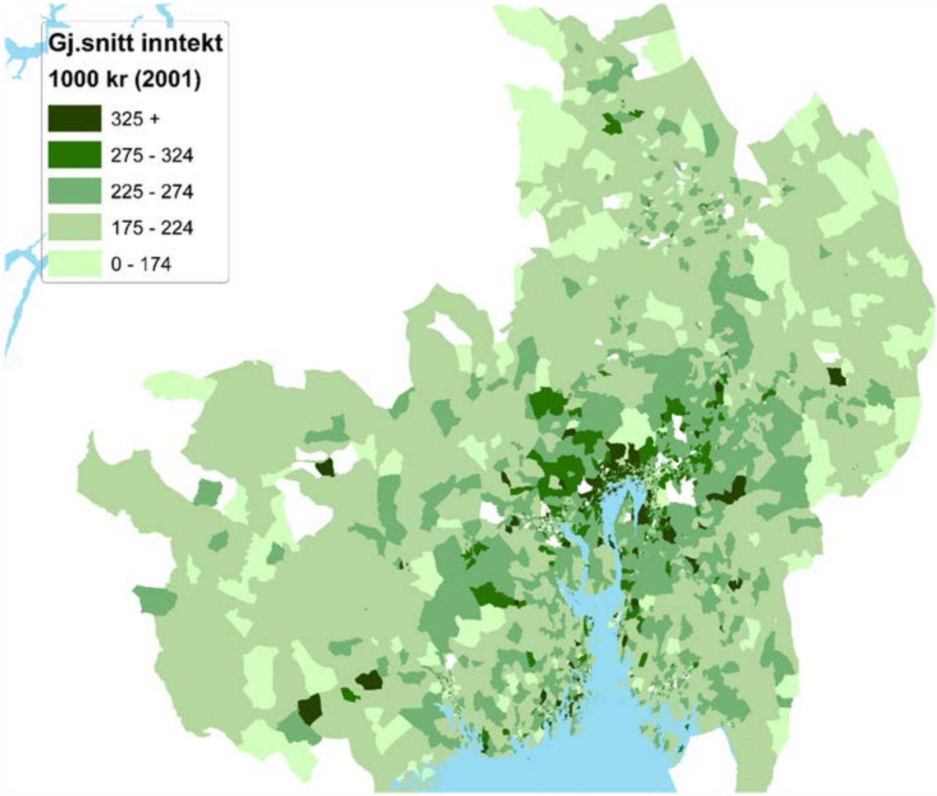

Fig. S.7. Grunnkretsene i DOM Intercity-modellen, etter gjennomsnittsinntekt i 2001.

[1] Beløpene er regnet i 2001-kr. For å korrigere for prisstigning fram til 2015, må en multiplisere med 1,285. Nedre inntektsgrense på kr 175 000 per 2001 svarer til kr 225 000 i 2015. Øvre grense på kr 325 000 svarer til kr 418 000 i 2015.

Økningen i drivstoffavgift slår ut på omtrent samme måte, selv om forskjellene i henhold til lokalt inntektsnivå her er noe mindre. Økte bompenger og fergetakster gir utslag som ikke synes å variere like systematisk med grunnkretsens inntektsnivå.

Det kan synes overraskende at drivstoffavgift og reisefradrag slår mest ut i lav-inntektssonene. Men forklaringen er logisk nok. Lønnsnivå, eiendomsverdier og husleie er høyest i og nær bysentra. For å få tilgang til godt betalte jobber, må personer bosatt i utkanten reise lenger enn personer bosatt i byen. Distrikts-befolkningen må til en viss grad velge mellom kort arbeidsreise og høy inntekt.

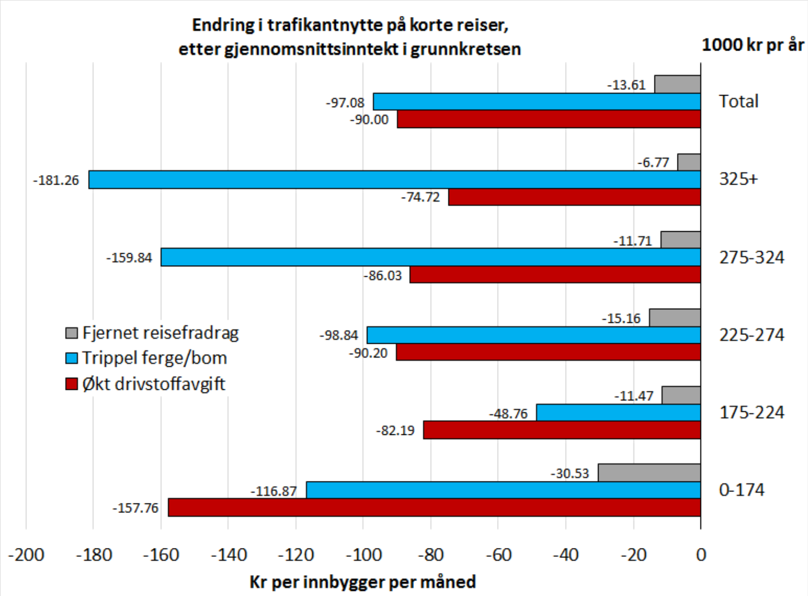

Fig. S.8. Endring i trafikantnytte på korte reiser på det sentrale Østlandet, etter grunnkretsens inntektsnivå i 2001, i tre scenarier.

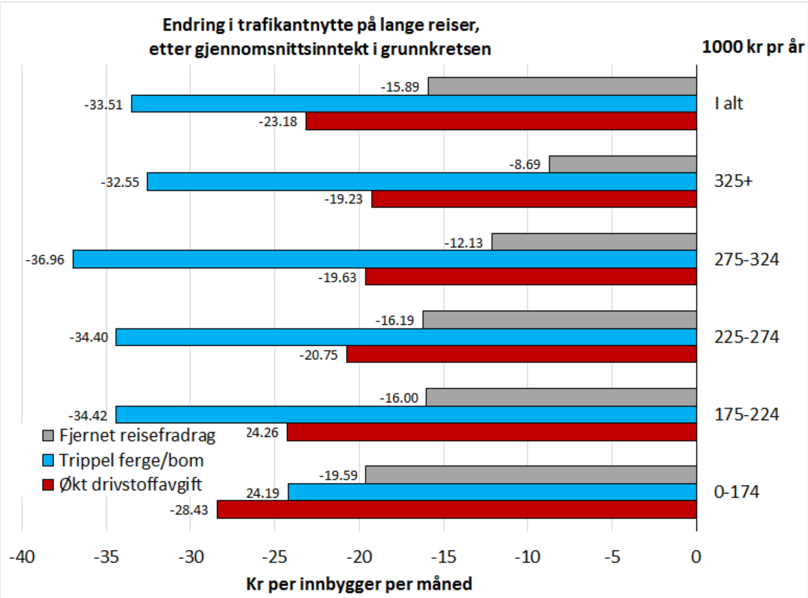

Fig. S.9. Endring i trafikantnytte på lange reiser i Norge, etter grunnkretsens inntektsnivå i 2001, i tre scenarier.

Figur S.8 gjelder korte reiser på Østlandet. I modellen for lange reiser finner vi tilsvarende, men ikke fullt så skarpe forskjeller mellom inntektssonene (Fig. S.9).

I Fig. S.10-S.11 vises fordelingsvirkningene etter fylke.

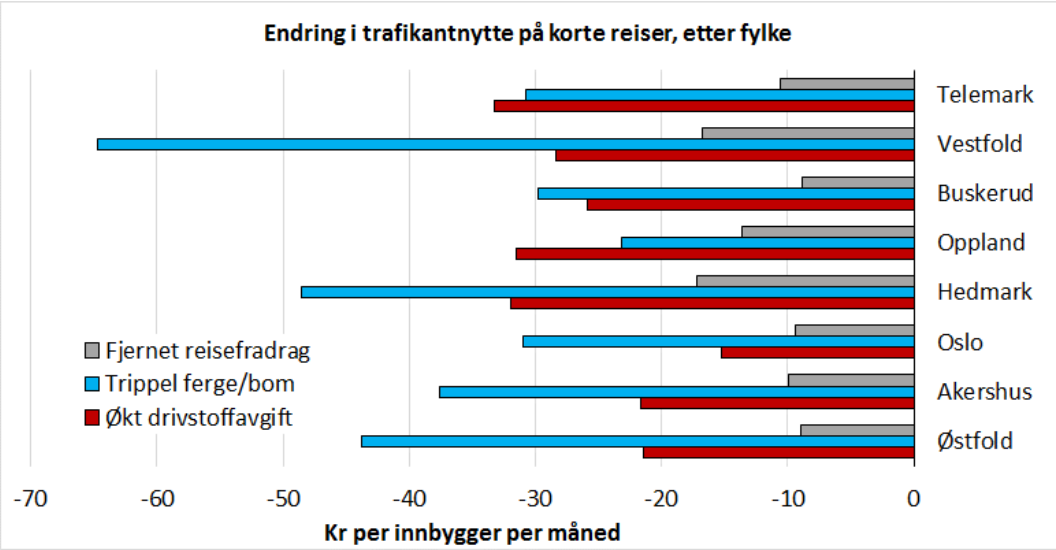

Fig. S.10. Endring i trafikantnytte på korte reiser på det sentrale Østlandet, etter fylke, i tre scenarier.

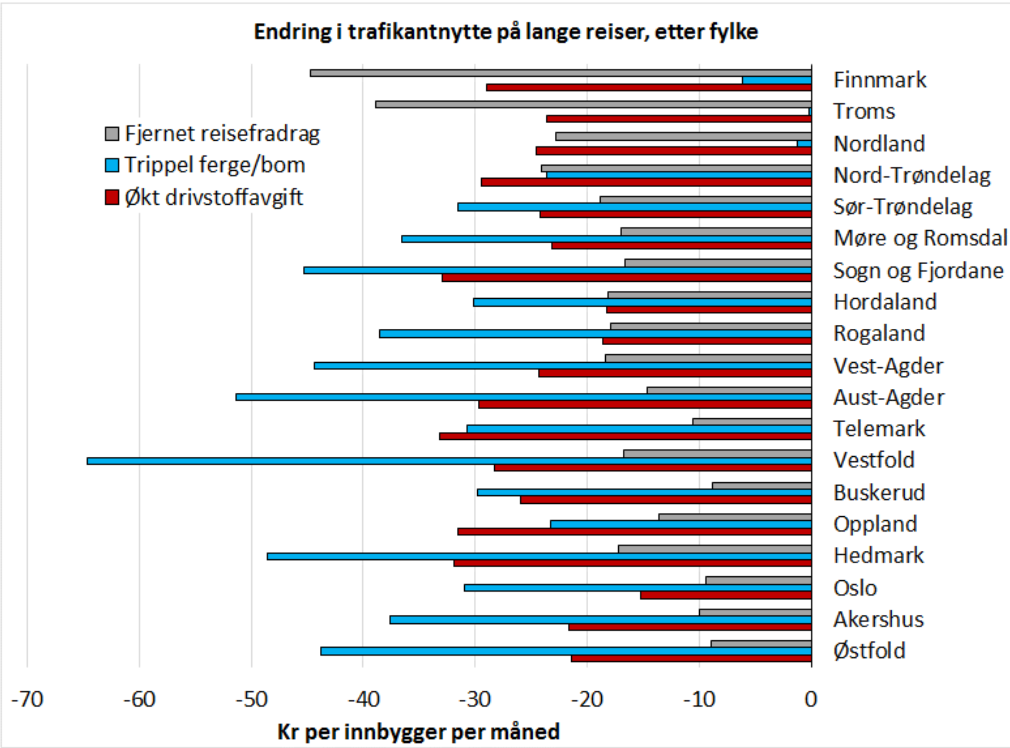

Fig. S.11. Endring i trafikantnytte på lange reiser i Norge, etter fylke, i tre scenarier.

Blant østlandsfylkene slår bom- og fergetakstene hardest i Vestfold. Vi har ikke beregninger som viser korte turer i andre deler av landet enn på Østlandet, men mønstret for lange turer viser at Vestfold 'leder' også der, mens de tre nordligste fylkene slipper 'billigst'.

Med hensyn til reisefradraget er mønstret nærmest omvendt. Å fjerne det vil ramme Finnmark fem ganger hardere enn Oslo, og nesten tre ganger hardere enn Vestfold, når vi ser kun på lange reiser. Drivstoffavgiften slår minst i Oslo og mest i Sogn og Fjordane, Telemark, Hedmark og Oppland – forholdsvis lite urbaniserte fylker.

Til sist presenterer vi, i Fig. S.12-S.13, fordelingsvirkninger etter kjønn og alder.

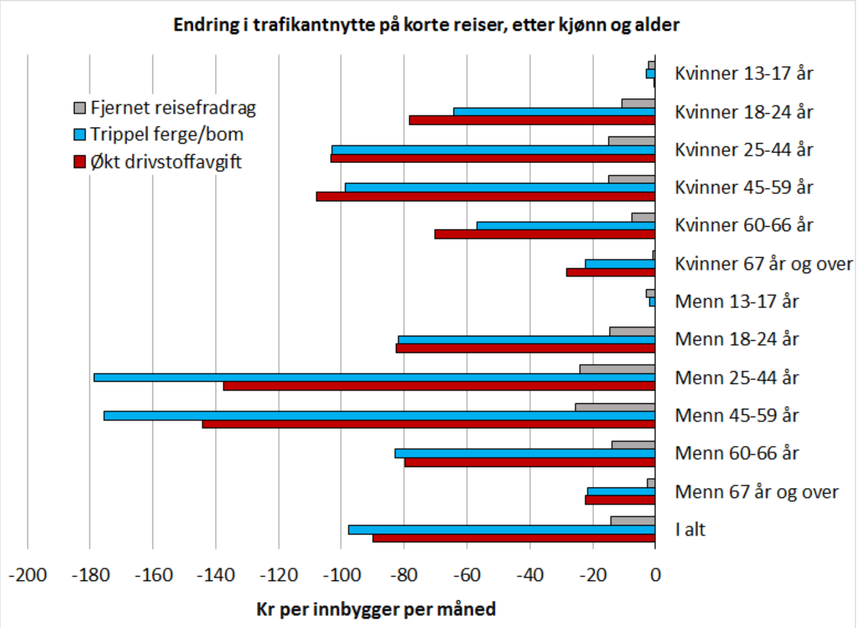

Fig. S.12. Endring i trafikantnytte på korte reiser på det sentrale Østlandet, etter kjønn og alder, i tre scenarier.

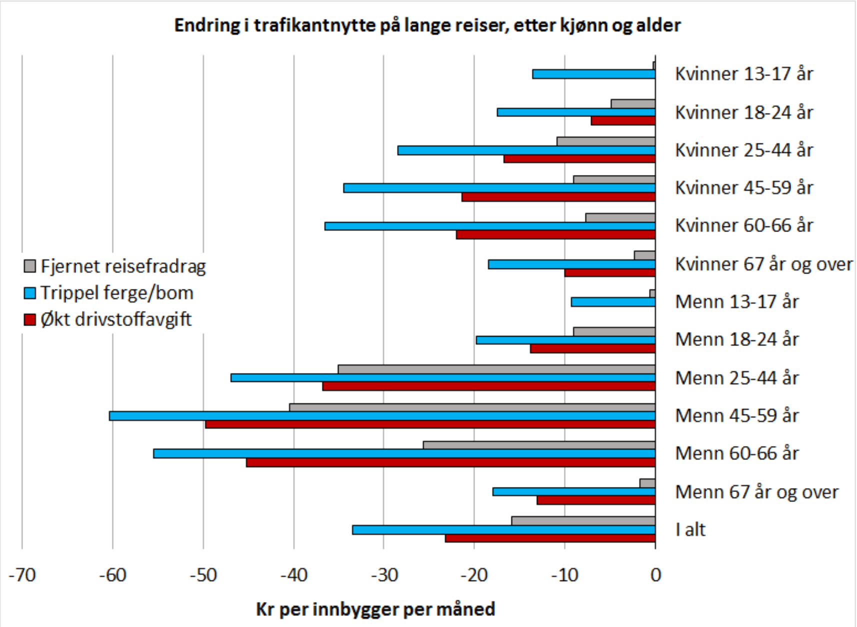

Fig. S.13. Endring i trafikantnytte på lange reiser i Norge, etter kjønn og alder, i tre scenarier.

Uansett hvilket tiltak vi ser på, kommer menn dårligere ut enn kvinner. De reiser mer, særlig med bil, og vil tape mer enn kvinnene på økt drivstoffavgift, fjernet reisefradrag eller økte bom- og fergetakster.

For begge kjønn gjelder det at personer i den mest yrkesaktive alderen, 25-59 eller 25-66, får større nyttetap enn både yngre og eldre, dersom noen av de tre tiltakene gjennomføres.

Utslippskutt gjennom endrede bilkjøp

Engangsavgiften for personbiler består av fire komponenter, basert på henholdsvis egenvekt, motoreffekt, CO_2-utslipp og NOx-utslipp. Motoreffektkomponenten gjelder bare for forbrenningsmotorer. Vektkomponenten er i 2016 26 prosent lavere for ladbare hybridbiler. I 2014 var denne 'rabatten' 15 prosent. Batterielektriske biler er helt fritatt for engangsavgift, og også for moms. Det samme gjelder brenselscelle-biler drevet av hydrogen.

Bortsett fra disse unntakene har engangsavgiften siden 2007 vært tilnærmet teknologinøytral. Det er samme regler for diesel- og bensinbiler. Dieselmotoren er mer energieffektiv enn bensinmotoren. Dette er grunnen til at dieselbilene fikk økt markedsandel i 2007 og fram til 2011.

Ved hjelp av bilgenerasjonsmodellen BIG har vi beregnet endringene i nybilsalget per 2014 under seks hypotetiske endringer i engangsavgiften:

1. 10 prosent høyere engangsavgift på alle nivå
2. 10 prosent høyere CO_2-komponent
3. 10 prosent høyere vektkomponent
4. 10 prosent høyere motoreffektkomponent
5. Innføring av engangsavgift på elbiler
6. Innføring av moms og engangsavgift på elbiler.

Beregningene er gjort per 2014, dvs. vi tar utgangspunkt i de skattereglene som gjaldt dette året.

Hvert av de seks alternativene leder ifølge modellen til en bestemt endring i kjøps-atferden. Siden bilene i ulike grad er belagt med engangsavgift, gir dette også utslag i samlet avgiftsinngang (proveny) til statskassen. Virkningene er vist i Fig. S.14.

Om hver av komponentene i engangsavgiften ble 10 prosent høyere, ville provenyet øke med anslagsvis 827 millioner kroner. Men momsinntektene ville gå litt ned, siden enda flere ville velge det momsfrie alternativet – elbil. Samlet provenyøkning fra moms og engangsavgift beregnes dermed å bli 742 millioner kroner.

En 10 prosents økning i kun CO_2-komponenten ville selvsagt gi mindre proveny-effekt – bare 78 millioner kroner, ifølge modellen. Enda mindre ville effekten være av 10 prosent høyere avgift på motorytelsen: 48 millioner. Det er vektavgiften som slår. En 10 prosents økning her ville gi en samlet provenyøkning på anslagsvis 607 millioner kroner.

Det femte beregningsalternativet gjelder innføring av engangsavgift på elbiler. Vi forutsetter da at elbilene får samme avgiftsregler som ladbare hybrider per 2014, dvs. negativ CO_2-komponent, 15 prosent fradrag i vektkomponenten og null avgift på ytelsen i den elektriske motoren. Provenyeffekten beregnes i dette tilfellet til 230 millioner kroner i løpet av ett enkelt år.

Kan vi tolke dette beløpet som skatteinntektstapet knyttet til det någjeldende avgifts-fritaket for elbiler? Ja, i en viss forstand kan vi det. Men det er påvirket av hva vi sammenlikner med. Når beløpet ikke blir større, er det fordi vi tar utgangspunkt i et system der engangsavgiften allerede er vesentlig redusert for lavutslippsbiler, særlig når en del av motorytelsen skriver seg fra en elektromotor.

Det siste alternativet, der elbilene blir belagt med både engangsavgift og moms, gir et økt proveny fra engangsavgiften på anslagsvis 529 millioner kroner – betydelig høyere enn dersom en ikke samtidig opphever momsfritaket (202 millioner). Det skyldes at når elbilene får moms, vil flere kjøpere velge bensin- eller dieselbiler, og disse vil være belagt med høyere engangsavgift enn elbilene. Den største økningen i avgiftsinngang kommer likevel i form av moms, med 1 253 millioner kroner i året.

Momsfritaket er altså betydelig viktigere for elbilenes konkurranseevne enn fritaket fra engangsavgift.

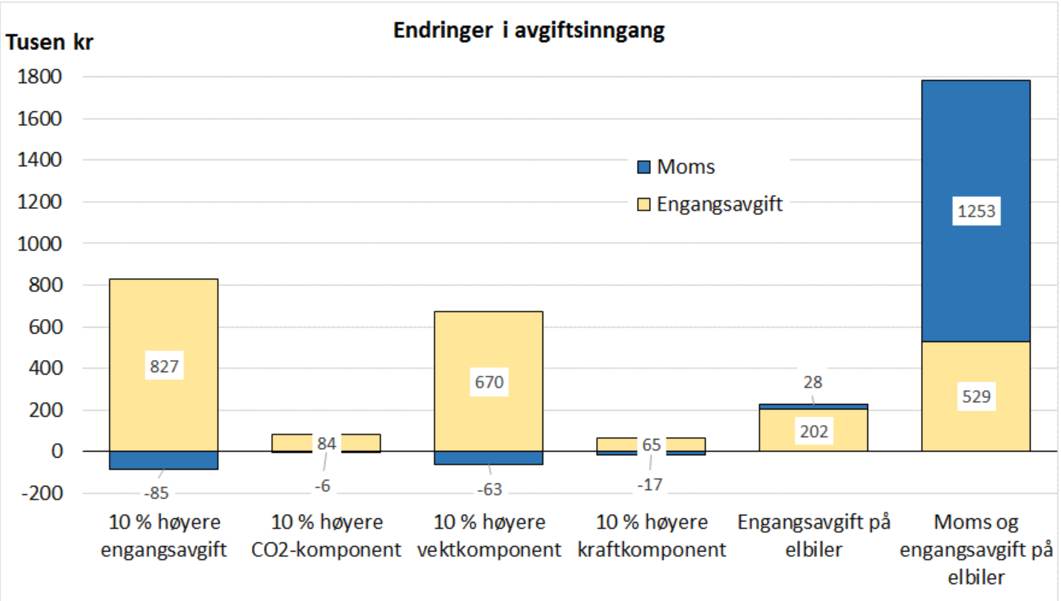

Fig. S.14. Endring i avgiftsinngang i seks ulike alternativ for avgiftsomlegging, regnet per 2014.

Målt etter bilenes gjennomsnittlige CO_2 utslipp er de seks avgiftsstrategiene svært ulike. Mens 10 prosent høyere engangsavgift beregnes å føre til 2,41 gCO_2/km lavere gjennomsnittlig typegodkjent utslipp fra nye biler, gir innføring av moms og engangs-avgift på elbiler en økning på 3,85 gCO_2/km (Fig. S.15). Forskjellen er 6,3 gCO_2/km, eller rundt 5,5 prosent, svarende til en kvart million tonn mindre CO_2-utslipp fra 2014-årskullet av personbiler i løpet av kjøretøyenes levetid. Da har vi regnet med at hver bil tilbakelegger 200 000 km, og at det virkelige utslippet i trafikken er 40 prosent høyere enn ifølge typegodkjenningen, som er basert på laboratorietester.

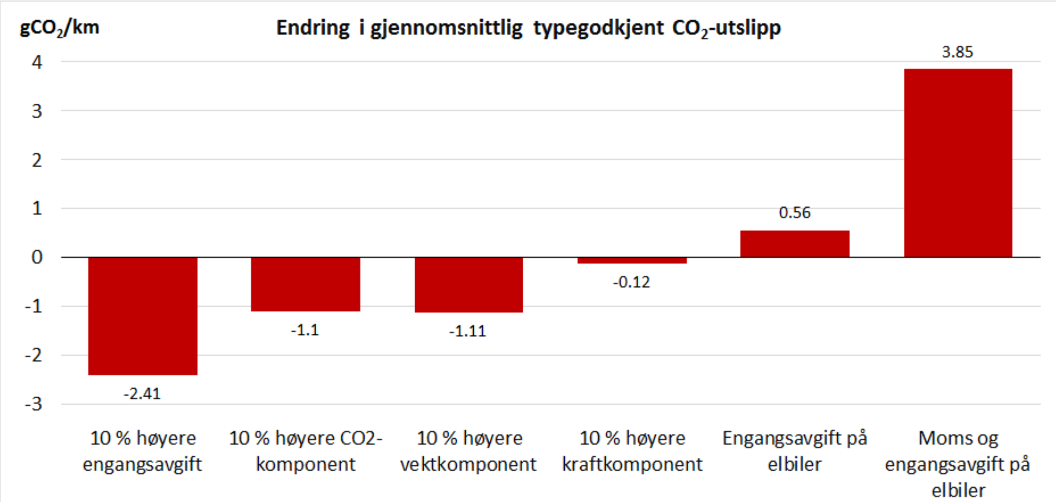

Fig. S.15. Absolutte endringer i gjennomsnittlig typegodkjent CO_2-utslipp fra nye personbiler, i seks ulike alternativ for avgiftsomlegging per 2014.

Hva ligger bak denne forskjellen? I Fig. S.16 viser vi hvordan de to avgiftsendringene vil forskyve salget mellom biler i ulike vekt- og drivstoffklasser. 10 prosent økt engangsavgift vil gi merkbart større salg av elbiler, og dessuten økende markedsandeler for hybrider og for de mindre bensin- og dieselbilene. De større bilene med kun forbrenningsmotor vil tape terreng.

Innføring av moms og engangsavgift på elbiler, vist til høyre i Fig. S.16, vil ha nesten diametralt motsatt effekt. Salget går opp i alle bilsegment unntatt for elbiler.

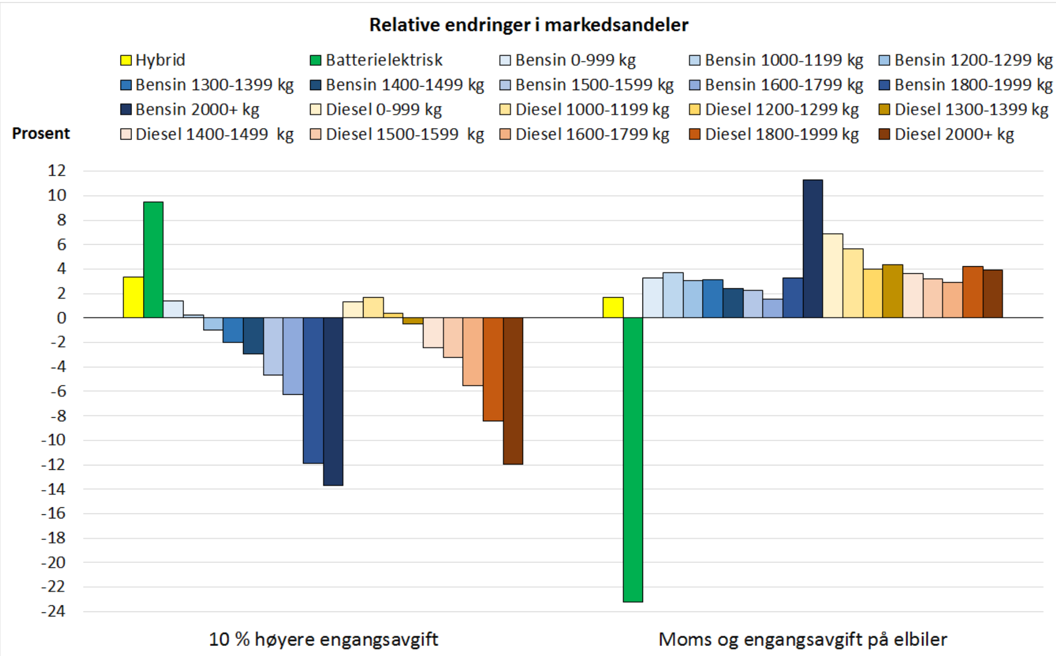

Fig. S.16. Relative endringer i markedsandeler, etter drivstoff og vektklasse, i to ulike alternativ for avgiftsomlegging per 2014.

Om vi i stedet segmenterer bilene etter CO_2-utslipp (i henhold til typegodkjennings-testen), får vi et bilde som vist i Fig. S.17. Økt engangsavgift gir økt salg av lavutslippsbiler og redusert salg av høyutslippsbiler. Moms og engangsavgift på elbiler gir derimot økt salg i alle bilsegment med CO_2-utslipp større enn null.

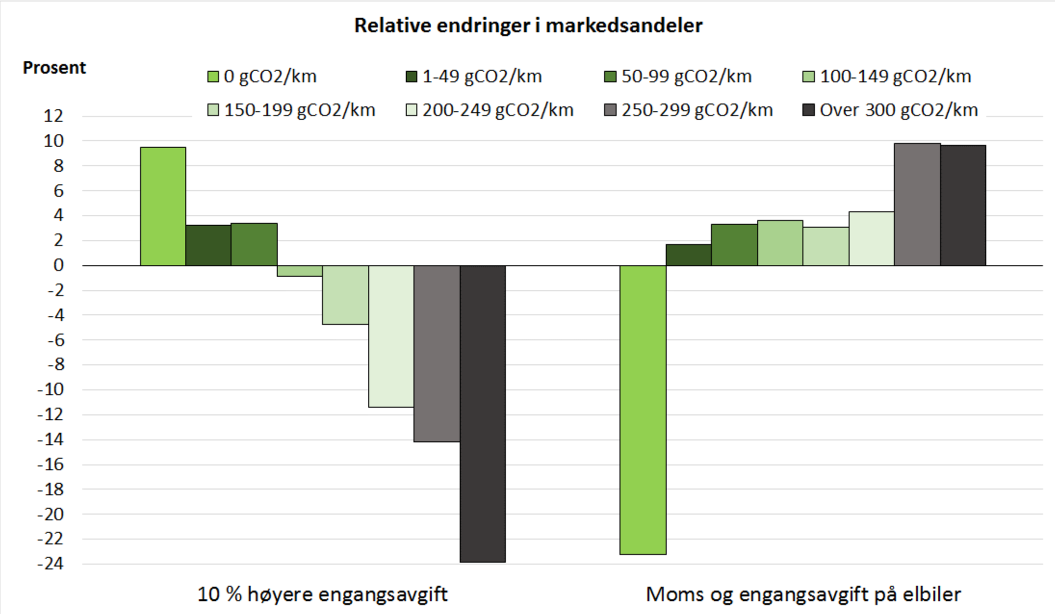

Fig. S.17. Relative endringer i markedsandeler, i intervall for gjennomsnittlig typegodkjent CO_2-utslipp, i to ulike alternativ for avgiftsomlegging per 2014.

Fordelingseffektene av de samme to motstridende avgiftsstrategiene er forsøkt belyst i Fig. S.18 og S.19[2]. Siden modellen vår ikke inneholder opplysninger om bilkjøperne, kan vi ikke knytte salgs- og prisvirkningene direkte til de ulike kjøpergrupper, inndelt f. eks. etter inntekt. Det beste vi kan gjøre er en mer indirekte betraktning, der vi legger til grunn at valget av mellom en billig og dyr bilmodell har nær sammenheng med kjøperens økonomiske ressurser. Prisavslag på billige biler kan antas å komme lavinntektsgruppene til gode, mens prisavslag på dyre modeller først og fremst er til fordel for de mer velstående.

Ut fra dette resonnementet kan vi antyde at en 10 prosents økning i engangsavgiften i første rekke vil være til belastning for de mer velstående bilkundene. Prisen øker mer i høyprissegmentene, og salget her faller, mens det øker noe i lavpriskategoriene. Slik sett kan dette alternativet tolkes som en progressiv – dvs. inntektsutjevnende – skatteendring.

Moms og engangsavgift på elbiler vil ha mindre tydelige fordelingseffekter. Prisene stiger og salget faller i 'Tesla-segmentet', mellom 550 og 770 tusen kroner regnet per november 2015[3]. Slik sett rammes kjøperne i dette segmentet. Men rundt 80 prosent av elbilene befinner seg i lavprissegmentet, så de fleste som 'straffes' når avgifts-fritakene oppheves, er kjøpere av relativt rimelige biler – opp til 330 tusen kroner regnet per november 2015.

[2] Beløpene er i figurene regnet i 2010-kr. For å korrigere for prisstigning fram til november 2015 kan en legge på 10 prosent, dvs. multiplisere med 1,1.

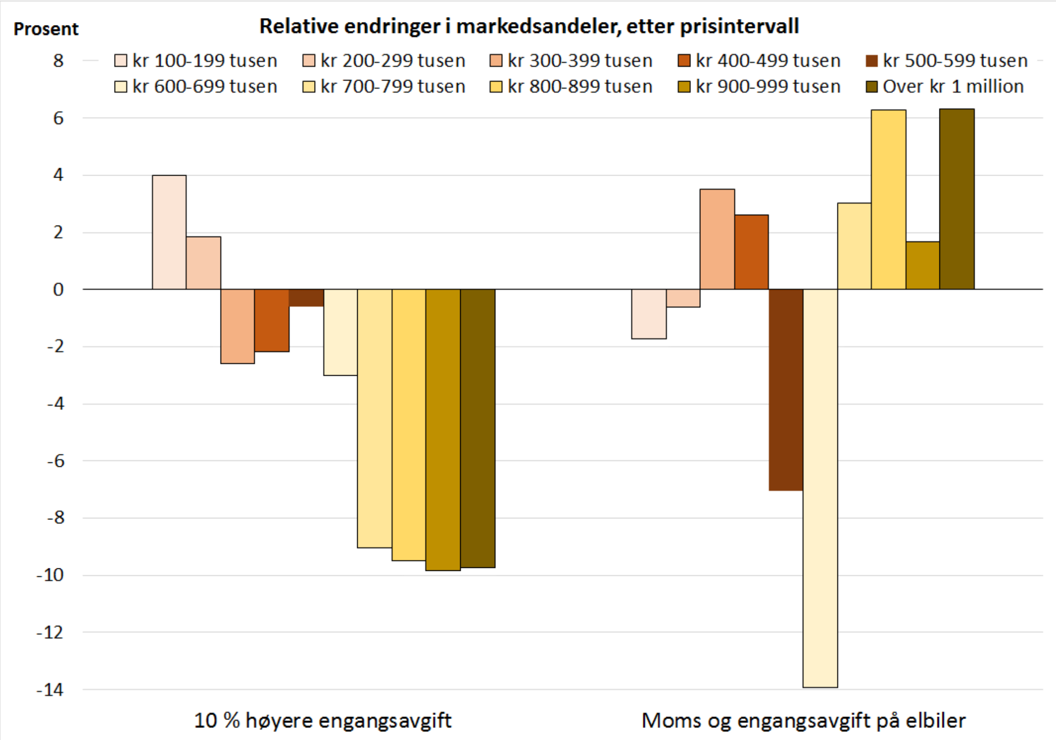

Fig. S.18. Relative endringer i markedsandeler, etter prisintervall regnet i 2010-kroner, i to ulike alternativ for avgiftsomlegging per 2014, forutsatt 100 prosent avgiftsoverveltning i prisen.

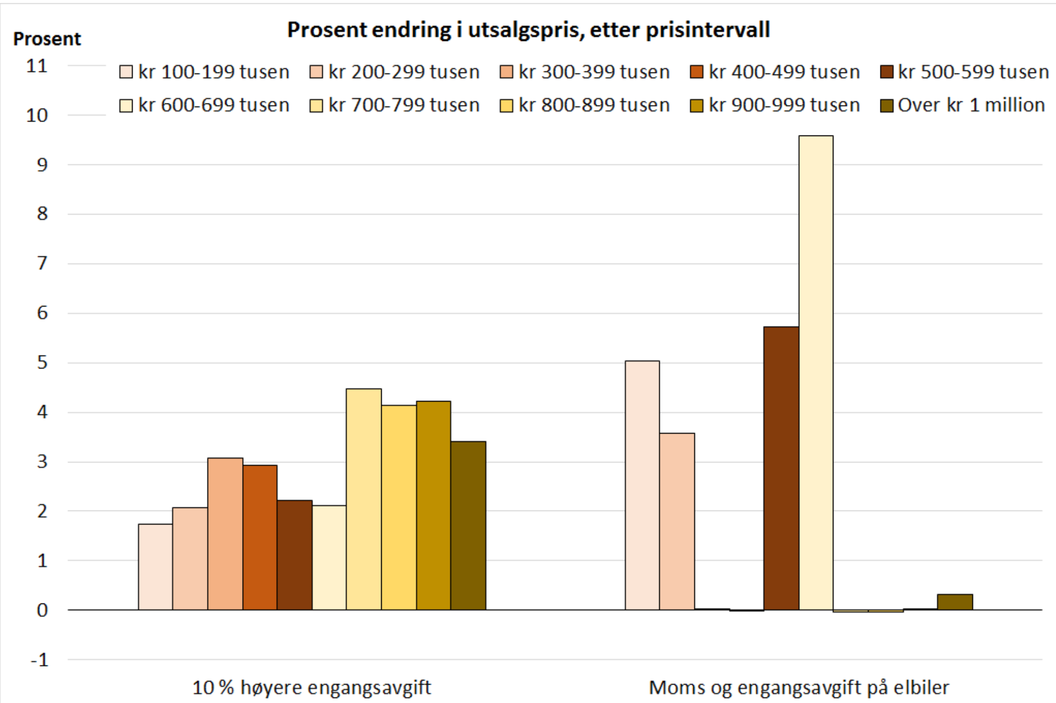

Fig. S.19. Relative endringer i utsalgspris, etter prisintervall regnet i 2010-kroner, i to ulike alternativ for avgiftsomlegging per 2014, forutsatt 100 prosent avgiftsoverveltning i prisen.

Det er således lite trolig at innføring av moms og engangsavgift på elbiler virker progressivt. Det er mer nærliggende å anta det motsatte.

En kan innvende at sju av åtte norske hushold kjøper bruktbil og slik likevel kommer betydelig billigere fra det enn det som følger av prisene på nye biler. Det er sant. Men prisforskjellene for nye biler vil gjenspeiles i bruktbilprisene så lenge bilene er på vegen. Engangsavgiften skaper således tilsvarende prisforskjeller i bruktbilmarkedet som i markedet for nye biler.

Effektivitet og rettferdighet

Motsetningen mellom samfunnsøkonomisk lønnsomhet og jevnest mulig fordeling er en klassiker. Våre analyser antyder at motsetningen er til stede i fullt monn på noen områder av bilavgiftspolitikken, men i mindre grad på andre.

Skatte- og avgiftstiltak rettet mot reiseetterspørselen synes gjennomgående å gi skjevere fordelingseffekter jo mer kostnadseffektive de er. Å fjerne reisefradraget ved skattelikningen gir samfunnsøkonomisk gevinst, når vi ser bort fra virkninger utenfor transportsektoren. Til gjengjeld er fordelingsvirkningene svært ugunstige. Økt drivstoffavgift gir nesten like stor gevinst som å fjerne reisefradraget, og er nesten like problematisk fra inntektsfordelingssynspunkt. Fordelingsvirkningene har også en regional dimensjon, målt langs den klassiske sentrum-periferi-aksen.

Motsetningen synes betydelig mindre i tilfellet med engangsavgift på personbiler, slik avgiften – og fritakene fra denne – er utformet i Norge. En jevn prosentvis økning i engangsavgiften vil gi størst prisendring i de øvre prissjikt. Det samme gjelder stort sett dersom en skjerper bare én av komponentene. Dette er en refleks av at alle de tre store komponentene i engangsavgiften er progressivt utformet, dvs. at avgiften stiger stadig brattere når CO_2-utslippet, vekten eller motorytelsen øker.

Skattefritakene for elbiler innebærer betydelige fordeler for kjøperne av de mest eksklusive elbilmodellene. Men disse er i mindretall. Det store gross av elbilkjøpere – og av bilkjøpere generelt – beveger seg i de nedre prisintervallene. Skattefritakene for elbiler har utvidet utvalget av noenlunde rimelige personbiler.

Samtidig som engangsavgiften generelt og elbilfritakene spesielt bidrar sterkt til å senke de nye bilenes gjennomsnittlige utslipp, og slik er klimapolitisk effektive, synes fordelingsprofilen å være i hovedsak utjevnende.

1 Introduction

Policy measures to reduce the climate and environmental impact of transport are being considered world-wide. One major concern relates to the equity effect of the respective measures in question. Will the measure(s) affect different segments of the population in unfair or unreasonable ways? Is it possible to provide quantitative assessments of the various distributional effects produced? The aim of this report is to shed light on these issues, in the context of automobile taxation measures as applied in Norway.

Four different types of policy instruments have been studied:

A. Increased fuel tax or kilometre charge
B. Higher toll rates and ferry fares
C. Abolishment of the commuter tax credit
D. Changes to the vehicle purchase tax rates

Equity effects may be measured along a number of different dimensions. Most commonly, the focus is on (changes in) the *income* distribution. Other dimensions may, however, also be of interest in a political context. These dimensions include *age, gender, geographic region,* and *type of household*.

For quantitative assessment one needs a quantitative behavioural model. In this report, three different models have been used:

- The Oslo Intercity Regional Model for short trips in south-eastern Norway
- The NTM6 model for long-distance domestic travel in Norway
- The BIG discrete choice model for automobile purchase

All of these models have their limitations. Results are subject to uncertainty, and in some cases the models can only provide rough indications of how equity is affected by a given policy measure.

As our main criterion for benefit assessment, we use the relative changes in consumer surplus as calculated for various policy measures, travel distances and population segments. A simplified method of calculation, based on the so-called rule-of-the-half, is applied. Results are interpretable as policy effects as of 2014.

In the case (D) of the vehicle purchase tax, the model used (BIG) contains no information on vehicle owners. Only vehicle characteristics enter the model. Thus the best we can do is to calculate effects separately for different vehicle price segments. Since vehicle choice is correlated to personal income, one may consider the former as a proxy for the latter.

In chapter 2, we explain the main automobile tax rules in effect in Norway. In chapter 3, our modelling apparatus is described. Chapter 4 sets out the main principles of equity analysis applied. Results are shown in chapters 5 and 6. A discussion is offered in chapter 7, while conclusions are drawn in chapter 8.

2 Automobile[1] taxation in Norway

2.1 Fuel tax

In Norway as of 2014, petrol was subject to a 'road use' tax amounting to NOK[2] 4.87 per litre, a 'CO_2' tax of NOK 0.93 per litre, and a general value added tax (VAT) of 25 per cent, calculated on the retail price including the road use and CO_2 taxes. Diesel was subject to corresponding tax rates of NOK 3.82, NOK 0.62 and 25 per cent VAT. Needless to say, one NOK of 'road use' tax has the exact same behavioural and distributional effect as one NOK of 'CO_2' tax, regardless of how the two are labelled.

Biodiesel was in 2014 subject to a 'road use' tax of NOK 1.91 per litre. No 'CO_2' tax was levied on biofuel. Since October 2015, even the 'road use' tax on biodiesel has been abolished.

In our model simulations, we shall examine the case where the fuel cost per car km increases by NOK 0.20 (= € 0.024). Given the average fuel mileage of the Norwegian passenger car fleet (about 30 mpg[3]), this corresponds to an about 20 per cent higher fuel price, or an almost 40 per cent higher fuel tax.

There is no km charge in effect for Norway. However, our simulated fuel price increase corresponds to a NOK 0.20 per km road charge, as implemented, e. g., through a GPS surveillance system like the one considered for the Netherlands (Meurs et al. 2013).

2.2 Ferries and toll roads

As of January 2014, some 60 toll cordons or toll collection points were in operation in Norway (Fig. 2.1). With few exceptions, the toll rates are time invariant, their purpose being road financing rather than congestion charging. The rates vary from NOK 11 to NOK 150.

In many cases, toll collection is used as a means to finance bridges and subsea tunnels that replace previous ferry crossings. There are, however, still some 120 ferry crossings left in the Norwegian road network, of which only a few are shown in Fig. 2.1. Ferry voyages are not, as in Sweden, usually free of charge. In this study, we simulate a 200 per cent increase in all toll rates and ferry fares, i. e. tripled rates.

[1] In this report we use the terms 'car', 'private car', 'passenger car' and 'automobile' as synonyms, encompassing all light-duty, four-wheel vehicles meant for passenger transport by road, including sport-utility vehicles (SUVs) and mini-vans.

[2] As of 1 July 2014, NOK 1 = SEK 1.09 = US$ 0.162 = € 0.119. As of 20 January 2016, the NOK value has fallen to SEK 0.96 = US$ 0.113 = € 0.104.

[3] 30 miles per gallon, corresponding to 184 g CO_2 per km for a petrol driven car and 212 g/km for a diesel car.

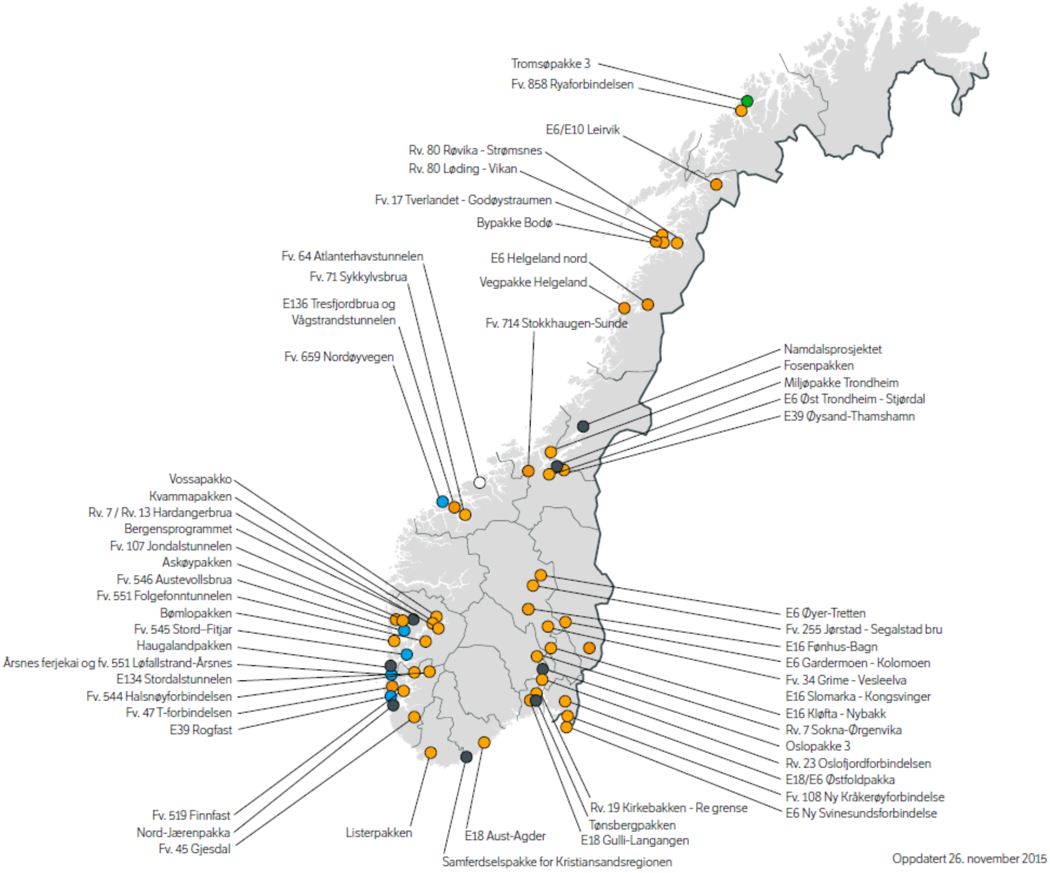

Fig. 2.1. Toll roads (yellow), toll cordons (grey), toll ferries (blue), local fuel tax (green), and manual toll collection (white). November 2015. Source: Norwegian Public Roads Administration.

2.3 Commuter tax credit

As of 2014, commuters were allowed to deduct their travel expenses on their tax declaration, at a rate of NOK 1.50 per km in excess of 10 000 km annual travel distance between home and workplace, up to 50 000 km. Between 50 000 and 75 000 km the rate is NOK 0.70. The 50 000 km threshold corresponds to an about 44 km daily round trip through a 230-day working year. As of 2014, the NOK 1.50 per km deduction translates into a NOK 0.42 per km tax credit, the marginal applicable tax rate being 28 per cent[4].

The deduction is given no matter what mode of travel is actually used, and without any need to document travel expenses, as long as the home address and the job address are sufficiently far apart. If preferred, the taxpayer is free to use his private car, in which case the tax credit is typically sufficient to cover just about half his petrol or diesel cost. For battery electric vehicle users, the tax credit is more than sufficient to offset the entire energy cost.

In 2013, approximately 11 per cent of the taxpayers were eligible for the commuter tax credit. Their mean deduction was NOK 15 700. As averaged over all taxpayers,

[4] As of 2016, the threshold has been raised to NOK 22 000, corresponding to 14 667 annual kilometres travelled, and the marginal tax rate has been lowered to 25 per cent.

the deduction was NOK 1 700 (Table 2.1). In this study, we examine the effect of abolishing the commuter tax credit, as proposed recently by the 'green tax commission' (NOU 2015:15).

Table 2.1. Commuter tax credit statistics for 2013. Source: Statistics Norway (Statistikkbanken)

	Taxpayers 17 and older	Amount (mNOK)	Average among eligible (NOK)	Overall average (NOK)
Gross income	4 007 559	1 648 731	411 400	407 100
Commuter costs above kNOK 15	430 054	6 738	15 700	1 700
Income tax payable	3 602 597	418 262	116 100	103 300

2.4 Vehicle purchase tax

Automobiles are more heavily taxed in Norway than in almost any European country, with the possible exception of Denmark. Private cars meant for passenger transport are subject to purchase tax ('engangsavgift') upon their first registration. Imported second hand cars are subject to a graduated purchase tax depending on the age of the vehicle.

The vehicle purchase tax for passenger cars is a sum of four independent components, calculated on the basis of curb weight, engine power, and type approval CO_2 and NO_X emissions, respectively. All but the NO_X component are distinctly convex curves, i. e. they become gradually steeper (Fig. 2.2).

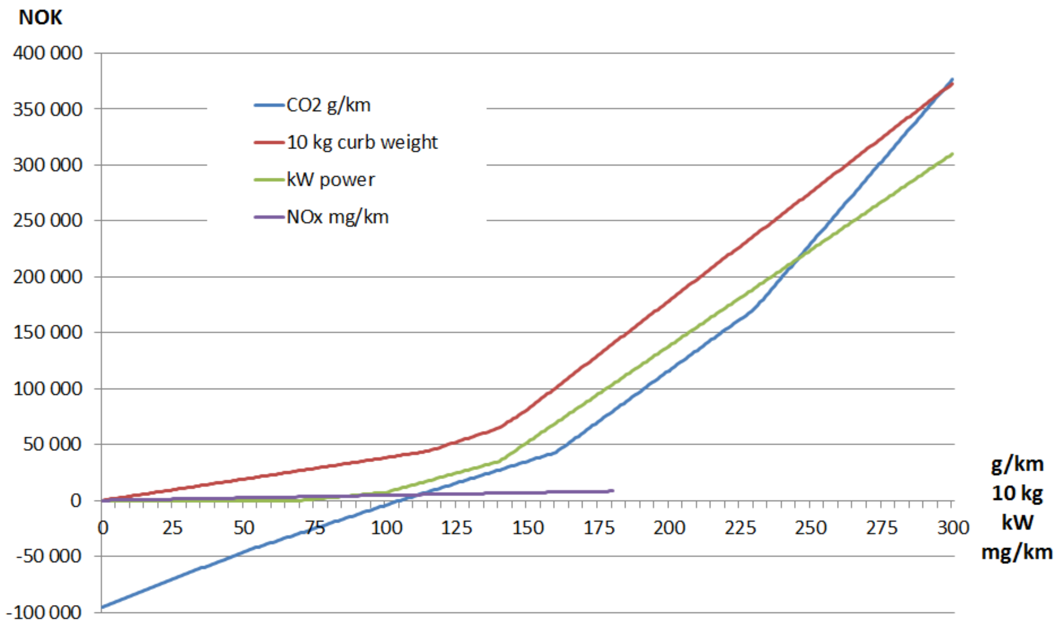

Fig. 2.2. Vehicle purchase tax as a function of curb weight, engine power, and type approval CO_2 and NO_X emission rates, in Norway 2014. Source: Fridstrøm et al. (2014)

For vehicles equipped with an internal combustion engine (ICE), the four purchase tax components taken together typically add 50 to 100 per cent on top of the import value – or even more for the largest and most powerful vehicles.

For plug-in hybrid vehicles (PHEVs), certain special rules apply. The electric motor is not considered part of the tax base for engine power. Also, so as to leave the standardized weight of the battery pack out of the tax calculation, the taxable curb weight of PHEVs is reduced, as of 2014, by 15 per cent[5].

Since the CO_2 component is negative for cars emitting less than 105 g/km, light-weight PHEVs may come out with zero of near-zero purchase tax. The purchase tax cannot, however, become negative, as in a feebate (bonus-malus) system.

Battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs) are altogether exempt of purchase tax, as well as of value added tax (VAT).

2.5 Other taxes on automobile ownership and use

In Norway, the fiscal rules bearing on automobile ownership and use also include an annual circulation tax, a reregistration tax, a scrap deposit tax, and an income tax on company cars. Although even these taxes may have certain environmental effects, they are not analysed in this report. For the sake of completeness, however, we do offer a brief description and explanation.

2.5.1 Annual circulation tax

The annual circulation tax ('årsavgift') applies to vehicles weighing less than 7 500 kg and equipped with a license plate. The general fee in 2014 was NOK 2 995 per annum for passenger cars. Diesel driven cars without a factory mounted particle filter were charged NOK 3 490, while motorcycles were charged NOK 1 835. For taxis, vintage cars (older than 30 years) and battery electric vehicles the charge was NOK 425.

Heavier vehicles are subject to a circulation tax which depends on the vehicle's weight and suspension system (hydraulic or other).

2.5.2 Reregistration tax

Whenever a vehicle is resold and reregistered in Norway, a lump-sum tax is due, depending on the vehicle's class, age and weight. The fee decreases with age and increases with weight. As of 2014, passenger cars that were first registered in 2013 or 2014 were subject to a reregistration fee of NOK 6 772 if weighing less than 800 kg, NOK 9 249 between 800 and 1200 kg, NOK 13 299 between 1200 and 1600 kg, and NOK 17 223 above 1600 kg. For cars dating from 2003 through 2010, the corresponding fees were NOK 2 508, 3 580, 4 977 and 6 438. Cars from 2011 and 2012 were charged something in between the 2013 and 2010 levels, while cars from the year 2002 or before were all charged NOK 1 535.

Obviously, the reregistration tax as applicable in 2014 discouraged the second hand sales of large and relatively new passenger cars. Its rationale was fiscal rather than environmental. In 2015, the reregistration tax was considerably simplified and reduced, leading to tax rates of maximally NOK 3 800 for cars lighter than 1 200 kg and maximally NOK 5 800 for heavier cars. For 2016, these new rates have simply been adjusted for inflation.

[5] In 2015, the deduction was raised to 26 per cent.

2.5.3 Scrap deposit

When a new car is registered, the buyer is charged a vehicle scrap deposit reimbursable when the car is delivered to an authorized vehicle scrapping facility. The deposit is meant as an incentive not to leave car wrecks in the street or in the open environment. As of 2014, the deposit payable on new cars was NOK 2 400. The 'reimbursement' collected at scrapping was, however, NOK 3 000.

The potential use of the scrap deposit tax as a climate policy instrument was studied by Fridstrøm et al. (2013). A temporarily increased car scrappage premium was found to hardly affect the life-cycle climate footprint of the Norwegian passenger car fleet. It was found more likely than not that such a policy measure would be counter-productive. Similarly discouraging results were reached by ITF (2011) and van Wee et al. (2000).

2.5.4 Income tax on company cars

The private use of a company owned car is considered part of the employee's salary and is hence subject to ordinary income tax. The tax burden incurred by any single beneficiary depends on his/her marginal income tax rate. In Norway as of 2014, the maximal marginal tax rate on a person's salary was 47.2 per cent.

The annual benefit of using a company owned car is, generally speaking, valued at 30 per cent of the (new) vehicle's list price up to NOK 280 100 (as of 2014), and at 20 per cent of the price exceeding NOK 280 100. However, for cars more than three years old as of 1 January, or if the annual distance travelled in the company's service exceeds 40 000 km, the taxable benefit is reduced by 25 per cent. Also, for electric vehicles the taxable benefit is reduced by 50 per cent.

3 Modelling apparatus

3.1 General network modelling approach

State-of-the-art travel demand models exist for short distance trips within several Norwegian regions, as well as for long distance travel nationwide. The Oslo Intercity Regional Model predicts short distance trips in an area stretching 100-200 km out from the capital city. Here, by definition, short distance trips are less than 100 km one way. Long distance travel demand is predicted by means of the so-called NTM6 model, which covers all domestic trips longer than 70 km one way.

To study the GHG abatement effect of various policy options, we generate a set of potential policy scenarios and compare these to a reference scenario. Since model results are to be understood as end-of-chain equilibrium solutions, the logic of comparison between the reference scenario and any given policy scenario is that of comparative statics (Hicks 1939): We compare different, hypothetical equilibria, without concerning ourselves with the path between these situations, or with the time needed to get from one equilibrium to another.

Travel demand as predicted by the Oslo Intercity and NTM6 models is conditioned by household licence holding and car ownership and by the location of residences, jobs and other nodes of attraction. The models predict travel demand response in terms of trip frequency, destination choice, mode choice and route choice, all of these being endogenously determined by the relative generalised costs of the respective travel options. The generalised costs are composed of out-of-pocket expenditure as well as of in-vehicle time, waiting time, transfer time and access/egress time.

The models do not distinguish between different types of automobiles. There is one representative per kilometre rate of out-of-pocket expenditure applicable to all car trips, covering fuel, tyres, maintenance and other variable costs. Thus the models cannot technically distinguish between a hypothetical NOK 0.20 kilometre charge and a corresponding increase in the average fuel cost.

CO_2 emissions follow from the travel demand output through the application of per person kilometre emission rates. Since these rates vary by mode and occupancy (Borken-Kleefeld et al. 2013; Aamaas et al. 2013), certain mode-specific average rates are used. These assumptions are set out in Table 3.1.

Only direct emissions (pump-to-wheel) are accounted for. Electrically driven means of transport are assumed to generate zero emissions. This assumption can be justified, either by the fact that Norwegian electricity supply is almost 100 per cent hydropower based, or by the fact that all EEA[6] power plants are covered by the European cap-and-trade system (EU ETS).

[6] EEA = European Economic Area, i. e. the EU plus Norway, Iceland and Liechtenstein.

Table 3.1. Input CO_2 emission rates by mode

Mode	gCO_2/PKM
Diesel driven trains	80
Coach/bus	92
Air	198
Speed boat	904
Ferry	621
Car driver - urban	202
Car driver - rural	149
Car passenger	0

Greenhouse gases other than CO_2 are disregarded. The inaccuracy caused by this simplification is small, except perhaps for the air mode, where the high altitude emissions of particles and water vapour do have a significant climate impact, through the formation of contrails and cirrus clouds (Borken-Kleefeld et al. 2010).

Public transport vehicle kilometres – and hence CO_2 emissions – are assumed to respond to demand according to Mohring's (1972) square root law of optimal supply. That is, when demand increases by x per cent, vehicle kilometres increase by a factor given by the square root of $(100 + x)/100$. This applies even to the air mode.

Travel demand model output is produced in the form of tables showing trip generation and person kilometres travelled, by travel purpose and mode. For the purpose of our equity analysis, repeated runs were made with the Oslo Intercity and NTM6 models, so as to capture travel behaviour responses within selected subgroups of the population. The details of this modelling exercise and its output are described by Steinsland (2015).

3.2 The Oslo Intercity Regional Model

The coverage of the Oslo Intercity Regional Model is shown in Fig. 3.1. Travel demand is modelled to and from 5566 zones based on data from the national travel behaviour survey 2001 (Denstadli & Hjorthol 2002) and network level-of-service (LOS) data for all modes of transport as of 2014. For the purpose of our analyses, the model was calibrated against aggregate flow data for December 2013. The model encompasses 43 per cent of the nation's about five million resident population (Rekdal et al. 2013; Madslien et al. 2005; Steinsland 2009, 2011, 2014).

Travel demand flows between zone pairs are generated through a nested logit model structure predicting trip frequency, destination choice, mode choice and route choice. The main modes are car driver, car passenger, public transport (PT), bicycle and pedestrian. The PT network consists of boat, bus, railway, tramway and subway (metro) lines. Separate algorithms are run for five different travel purposes: commuting, business, shopping, visits and other.

Short-haul trip generation and travel demand in the reference scenario are shown in Figs. 3.2 and 3.3, respectively.

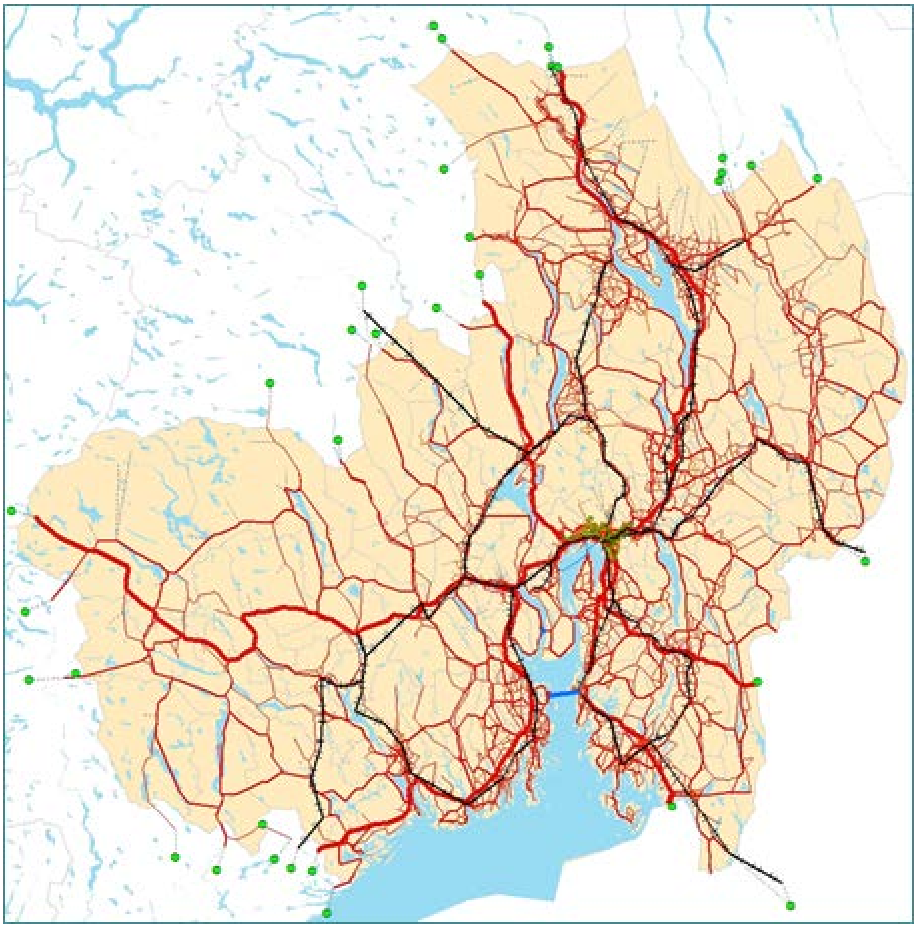

Figure 3.1. The Oslo Intercity Regional Model network for short distance trips. Roads are shown in red, railroads in black and sea routes in blue.

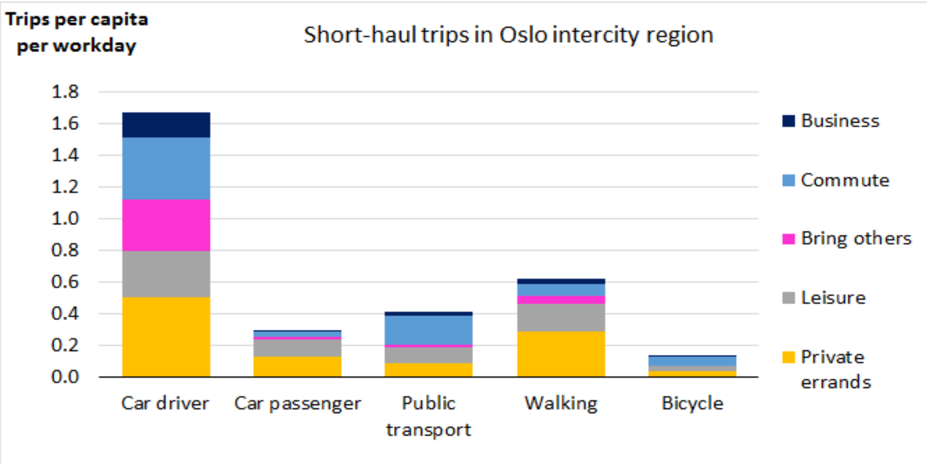

Fig. 3.2. Benchmark short-haul trip generation in the Oslo intercity model region, by travel purpose and mode.

Some 68 per cent of the person kilometres travelled are made by car drivers. When passengers are included, the car share is 79 per cent. Public transport (PT) has a 17 per cent share. Among commuters, the PT share is 28 per cent.

The private car accounts for 95 per cent of the CO_2 emissions from short-haul travel in the Oslo intercity region (Fig. 3.4).

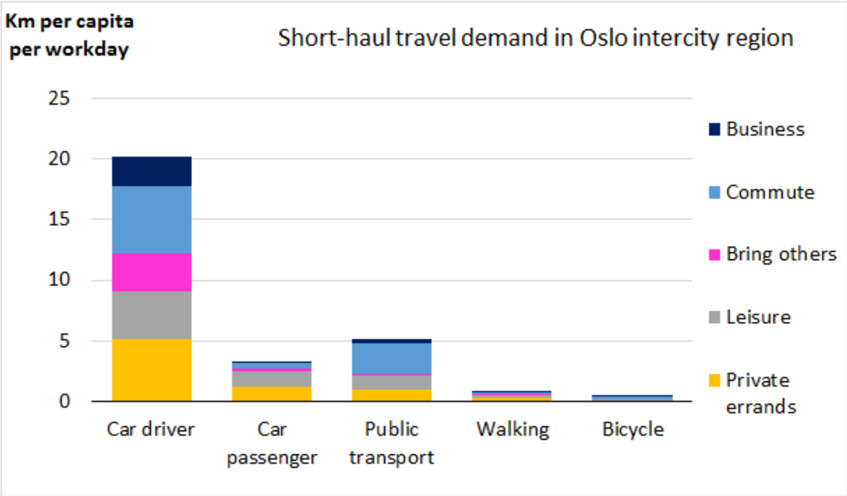

Fig. 3.3. Benchmark short-haul person kilometres in the Oslo intercity model region, by travel purpose and mode.

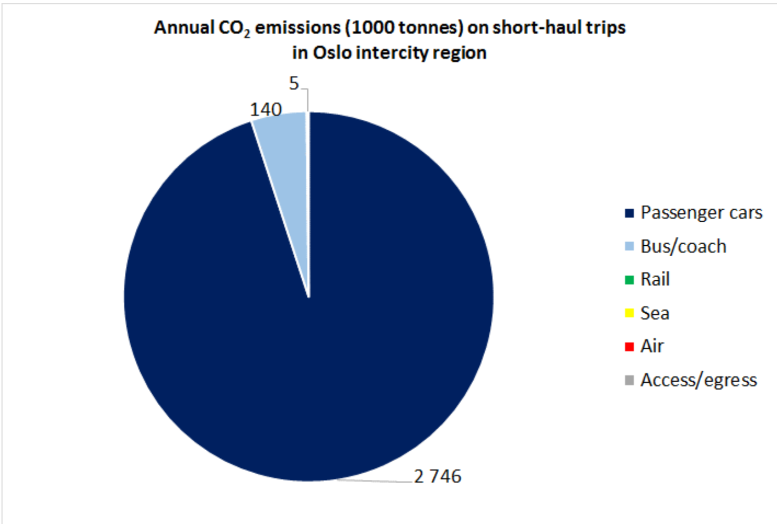

Fig. 3.4. Benchmark CO_2 emissions on short-haul trips in Oslo intercity region, by mode.

3.3 The NTM6 model

The network used in the NMT6 long distance travel demand is shown in Fig. 3.5. Since, for some origin-destination (OD) pairs in Norway, the shortest connection passes through Sweden and/or Finland, the network includes some border crossing links.

Containing 1428 zones, the model defines six different modes: car driver, car passenger, bus/coach, rail, sea and air. The NTM6 model is based on travel behaviour data from 2009 and network data from 2013 (Rekdal et al. 2014).

Figure 3.5. The NTM6 long distance travel demand model network. Roads are shown in red, railroads in black, air routes in grey and sea routes in blue.

Long-haul domestic trip generation and travel demand in the reference scenario are shown in Figs. 3.6 and 3.7, respectively.

Just about 50 per cent of the long-haul person kilometres are made by car (drivers and passengers). The air mode has a 32 per cent share. The public transport (PT) category comprises the bus/coach, rail and sea modes.

Almost one half (48 per cent) of the CO_2 emissions on long-haul domestic trips are due to aviation (Fig. 3.8). The car as a main mode of travel accounts for about 39 per cent. The access-egress 'mode', which also to a large extent consists of car trips, accounts for an additional 7 per cent.

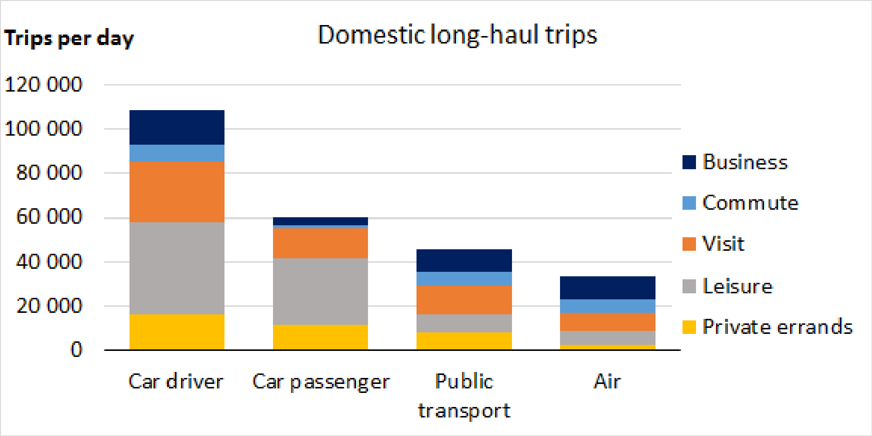

Fig. 3.6. Benchmark domestic long-haul trip generation, by travel purpose and mode.

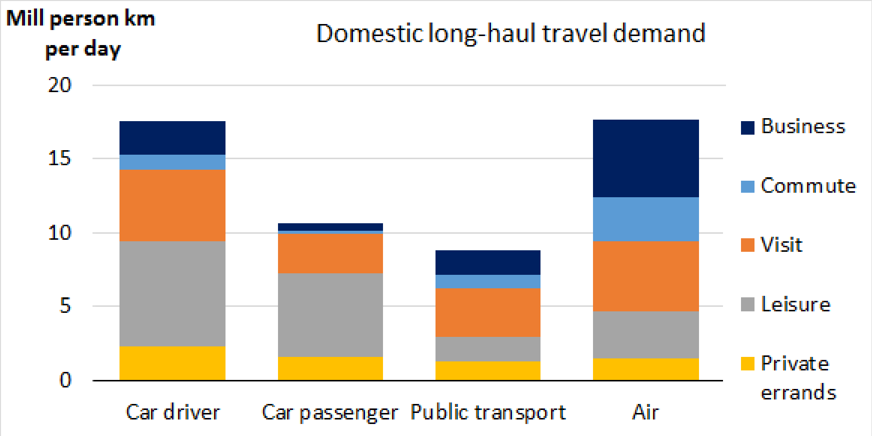

Fig. 3.7. Benchmark domestic person kilometres on long-haul trips, by travel purpose and mode.

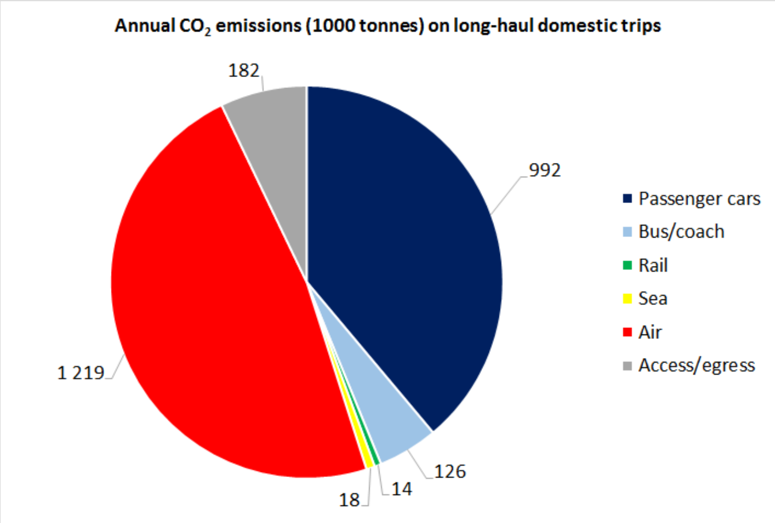

Fig. 3.8. Benchmark CO_2 emissions on long-haul domestic trips, by mode.

3.4 The BIG model

To study the composition of new car sales under differing fiscal assumptions, we make use of a nested logit model – called BIG[7] – estimated on the basis of exhaustive, disaggregate passenger car sales data covering the period between January 1996 and July 2011 (see Østli et al. 2015). A total of 38 468 different vehicle models were identified and their annual sales recorded. Independent variables include the retail list price, tax, fuel type, make (brand), type approval fuel mileage, curb weight, utility load, engine power, width, length, traction, and number of doors and seats. As a proxy for all those quality attributes that are not explicitly accounted for, we use the share of the retail price that does *not* consist in purchase tax or VAT.

Since the model is supposed to predict the market share of potential new car models with known or assumed attributes, care was taken to specify the model as a generic one. There are no alternative specific coefficients, other than the dummies capturing the vehicles' make (brand).

Extensive testing was done in order to find the appropriate nest structure. Somewhat surprisingly, the only nest structure compatible with a priori assumptions (scale parameters larger than unity) was one in which each vehicle make forms one nest. Thus, there are 21 such nests in the model, the last one being a residual nest assembling 'all other makes'. Fig. 3.9 illustrates the model's nest structure.

The BIG model differs from virtually all other vehicle demand models reported in the literature in that it contains quite exhaustive vehicle data, but no information on the vehicle owners or their households. Hence the model cannot predict the effect of changes occurring to the car *owners*, such as increased income, rather than to the vehicles themselves. The benefit of this approach, however, is one of considerable simplification, leaving room for a more detailed, more complete and wholly disaggregate description of the vehicles. Also, it means that no input is required on such variables as household structure, population and income growth, or transport infrastructure and prices, in order for the model to produce a forecast.

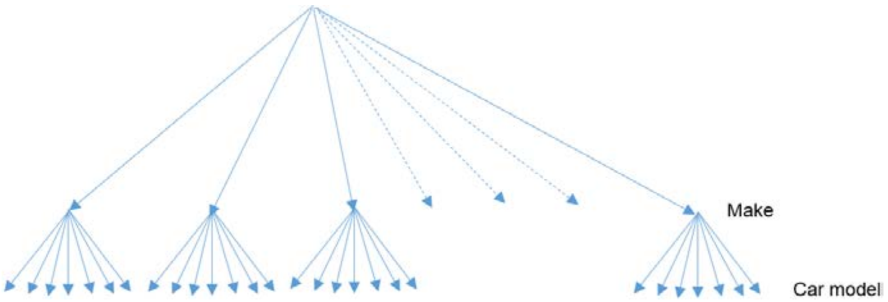

Fig. 3.9. Nest structure in BIG automobile purchase model. Source: Østli et al. (2015).

The model predictions are sensitive to changes in the purchase tax. Since the discrete choice model is entirely generic, we may use it to predict the demand for hypothetical new car models, in particular the demand for low and zero emission vehicles, such as BEVs and PHEVs.

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[7] An acronym for 'bilgenerasjonsmodell', or 'car cohort model'.

In Figs. 3.10-3.12 we show model calculated market shares for new passenger cars registered in Norway 2014. We shall use these market shares as our reference scenario (benchmark).

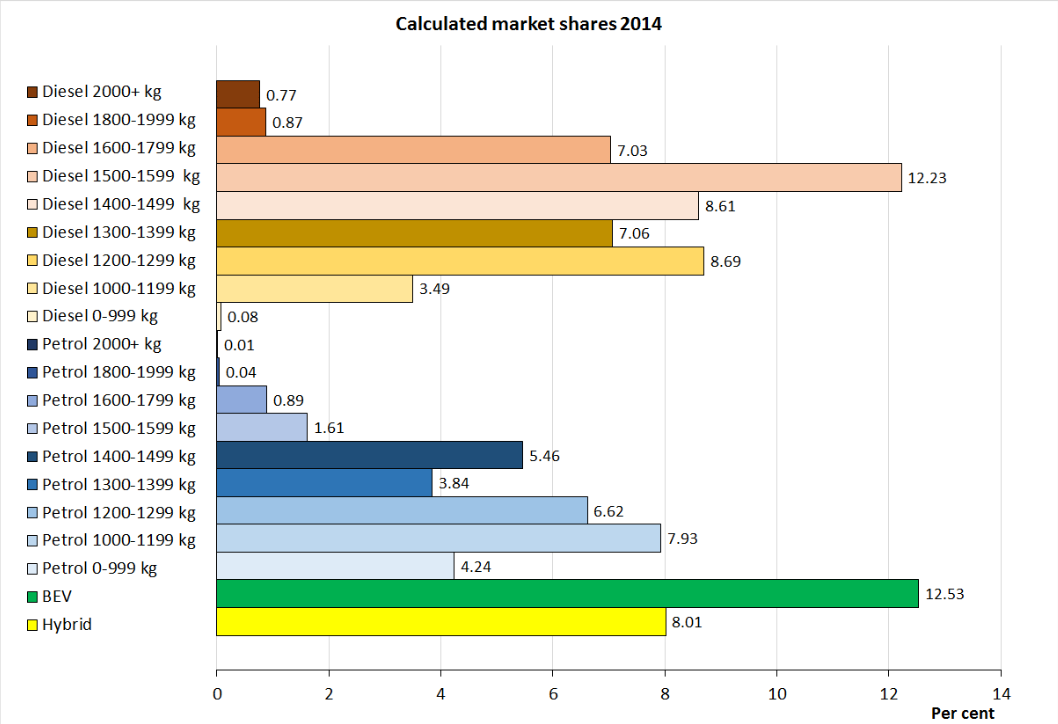

Fig. 3.10. Calculated automobile market shares for 2014, by energy carrier and curb weight.

BEVs had a 12.5 per cent market share in 2014 – 18 090 vehicles out of 144 202. Among these, 4 042 were of the Tesla make – a 2.8 per cent market share.

Hybrid electric vehicles had an 8 per cent market share. This includes PHEVs as well as non-chargeable hybrids.

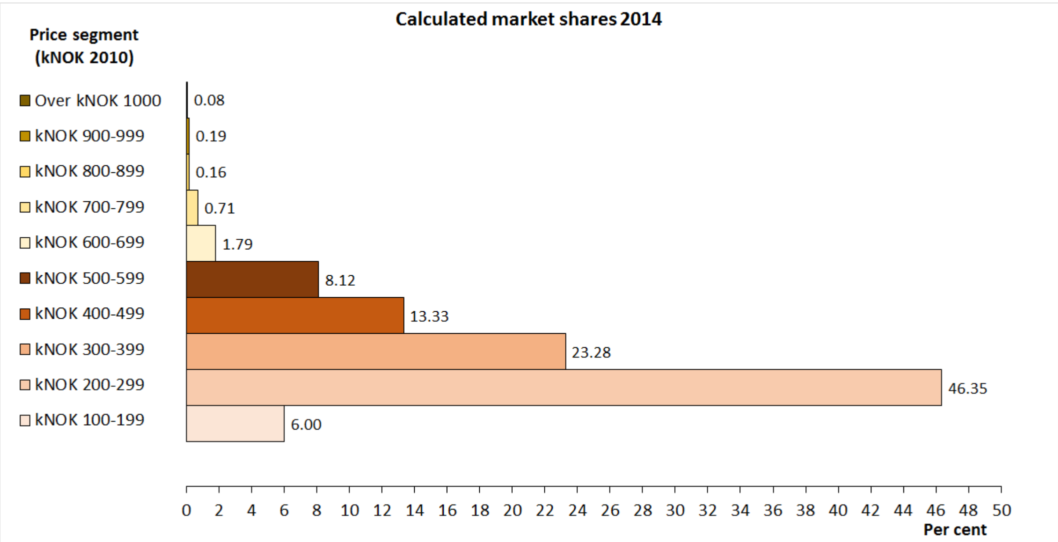

Fig. 3.11. Calculated automobile market shares for 2014, by price segment.

Almost half the cars sold cost between NOK 200 000 and NOK 299 000 (in NOK 2010, corresponding to NOK 220-330 000 at the November 2015 price level).

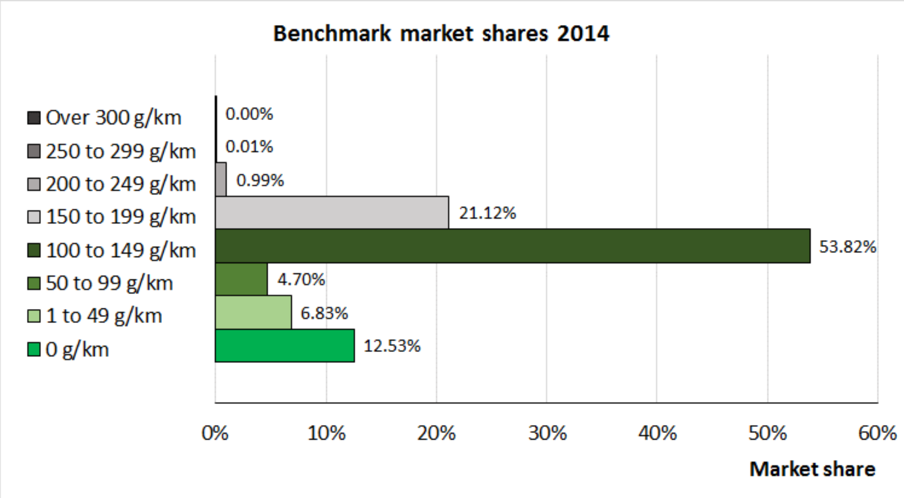

Fig. 3.12. Calculated automobile market shares for 2014, by type approval CO_2 emission bracket..

In terms of emission rates, more than half the cars emit between 100 and 149 gCO_2/km by the type approval test. About 11.5 per cent emit more than 0 gCO_2/km, but less than 100 gCO_2/km.

The average type approval CO_2 emission rate of all new passenger cars sold in Norway in 2014 was 110 g/km (see www.ofv.no). The BIG model prediction for 2014 is a little above the mark, with 113.33 g/km on average. To ensure comparability with other scenario predictions, we shall use the value predicted by the model, rather than the empirically observed mean, as our benchmark (reference).

The average retail prices and purchase tax components within the respective fuel and weight segments are shown in Fig. 3.13. One notes that for the largest and most expensive vehicle models, the VAT and purchase tax represent more than half the price. For smaller vehicles the purchase tax is less dominant.

The average retail price of BEVs sold in 2014 was NOK 320 000 (in NOK 2010, corresponding to NOK 352 000 as of November 2015). When the Teslas are left out, the average price of BEVs is NOK 241 000 (NOK 265 000 as of November 2015), lower than for the third smallest class (1200-1299 kg) of petrol or diesel driven cars. Thanks to the VAT and purchase tax exemptions, most BEVs come out relatively inexpensive compared to ICE vehicles.

For hybrid vehicles, the CO_2 component comes out negative and deductible from the sum of the weight, power and NOx components (confer Fig. 2.2). A small CO_2 deduction is seen to apply even to the smallest class of diesel vehicles.

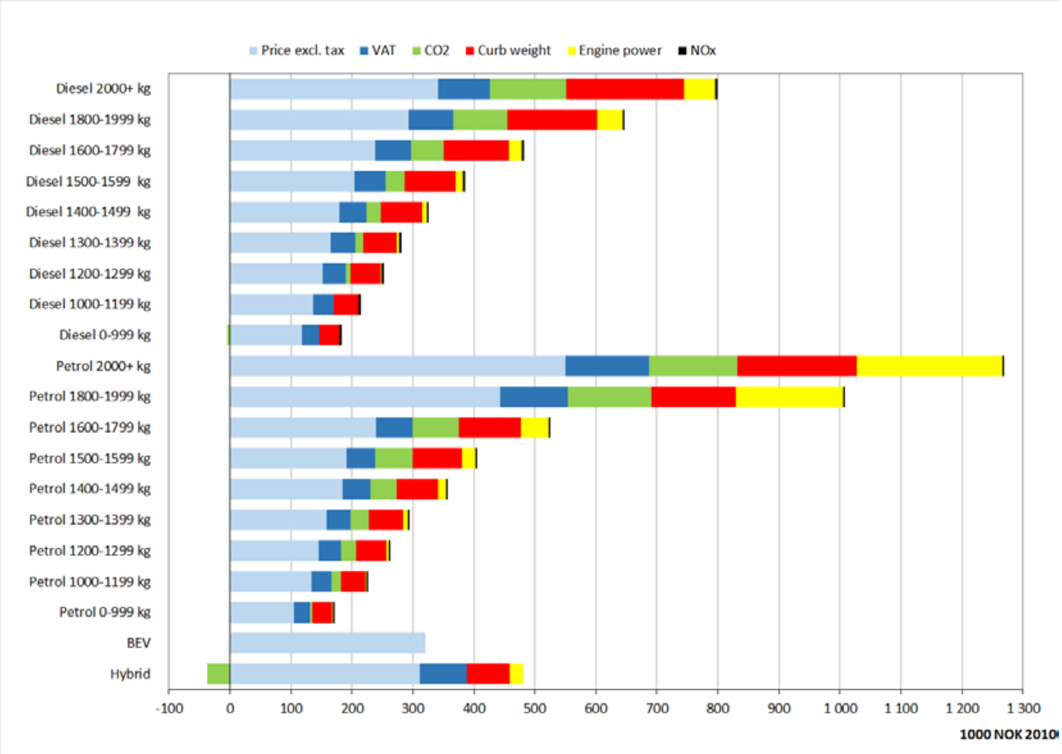

Fig. 3.13. Estimated automobile retail price and purchase tax components, by energy carrier and curb weight, as of 2014. Source: Fridstrøm et al. (2015)

4 Assessment principles

4.1 Consumer surplus changes

Assume that in the initial situation travellers by a certain mode, say by private car, perform an amount of travel denoted by v_0, at a generalised cost k_0. Imagine that under some alternative policy scenario, the cost is raised to k_1, and demand falls to v_1. The change in consumer surplus, calculable by the formula

$$N = \frac{(k_1 - k_0)(v_1 + v_0)}{2},$$

known as the 'rule-of-the-half', is shown as the blue area in Fig. 4.1. The little triangle forming the right-most part of the blue area has become known as the *'deadweight loss'*.

To assess the welfare costs incurred by private travellers, we shall apply this well-known rule, which measures the change in consumer surplus as one moves up or down the demand curve.

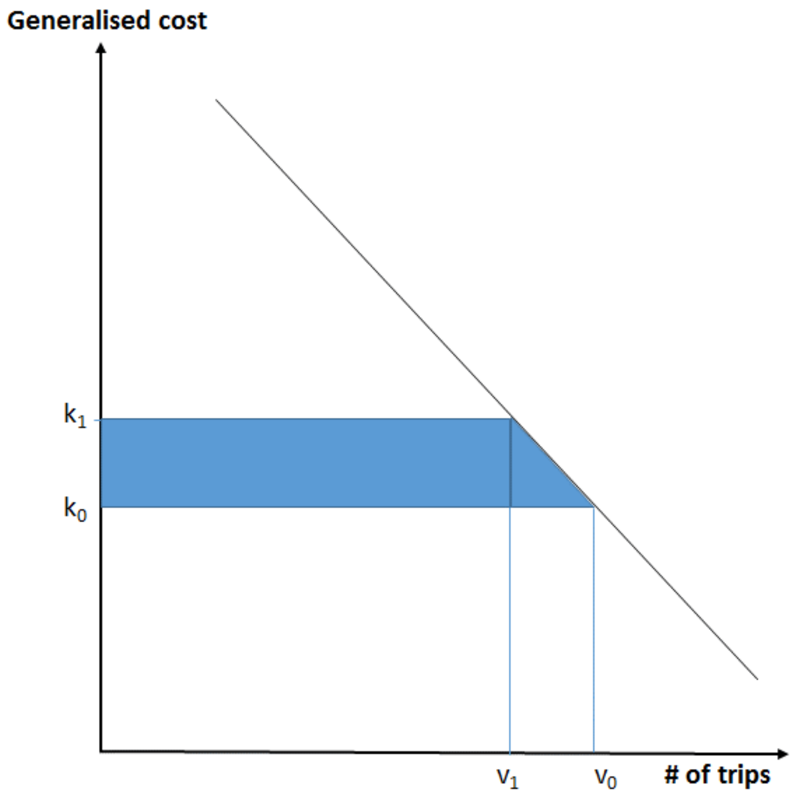

Fig. 4.1. The travel demand curve and the rule-of-the-half for changes in consumer surplus.

This rule applies to every single origin-destination (OD) pair in the geographic area considered. For each OD pair, the generalised cost consists of out-of-pocket expenditure (fares, fuel, toll, etc.), travel time, headway, walking distance, as well as other elements of (dis)utility perceived by the travellers.

To obtain an overall estimate of the consumer surplus change one sums through all OD pairs affected.

When the generalised cost changes for one mode only, it is sufficient to calculate the changes along that particular mode-specific demand curve, even if some travellers switch to another mode. If, however, the generalised cost changes for more than one mode, such as when mode-switching generates congestion in the receiving mode, one must calculate the consumer surplus changes mode by mode and sum through all modes.

The rule-of-the-half is an approximation suitable for small changes. Its accuracy is affected negatively if the changes in demand are large and (i) the demand curve is not nearly linear over the interval considered, and/or (ii) the alternative scenario studied involves large shifts in demand between modes of transport, affecting their respect-tive generalised costs. In such a case, the approach developed by Huw Williams (1977) is more accurate. It is, however, unattractive on account of its computational complexity. We shall therefore stick to the simpler, but more approximate approach given by the rule-of-the-half.

4.2 Income distributional effects

The equity impact of a given policy measure could, in principle, be studied along a number of different dimensions. The classical and most common dimension considered is income.

4.2.1 Definitions

A tax or policy measure is said to be *regressive* if it imposes a heavier burden on low-income households than on their more affluent counterparts. In the opposite case, we refer to the tax as *progressive*.

To use this definition for practical, empirical analysis one has to decide what is to be meant by ‘a heavier burden’. To make the concept operational, it has become common to compute the tax expenditure or welfare loss incurred by each household as a percentage of their current income. If this percentage is a decreasing (increasing) function of income, when households are grouped into income deciles or similar, the tax is regressive (progressive).

Although this may seem like a straightforward way of deciding on regressivity or progressivity, certain ambiguities remain. Vickrey (1947, 1949, 1987) points out that since most households adapt their level of expenditure to their lifetime income expectancy, or to some more ‘permanent’ income measure, rather than to a single year’s earnings, it would be more appropriate to view income in a long-term perspective.

One way to circumvent this problem is simply to group households by their total annual expenditure rather than by their current income. This procedure has been used in a number of empirical studies. It turns out, however, that a given tax tends to come out as less regressive when judged along the expenditure scale than according to an income scale – see, e. g., Ahola et al. (2009) or the review article by Kosonen (2012).

4.2.2 Literature review

During the last couple of decades, a large number of studies have been made on the equity effect of environmental taxes and other fiscal instruments for market correction. Poterba (1991) starts out by referring to 'the long-standing view that excise taxes such as the gasoline tax are regressive'. He finds, however, that the outlay on petrol ('gasoline') represents a much smaller share of income in the low-income deciles than in the middle-income deciles, which – in turn – do not differ much from the high-income deciles. The petrol tax is, in other word, progressive, at least over the lower half of the income spectrum. The main reason seems to be that poor families cannot generally afford a car, hence their average petrol expenditure is quite low.

Santos & Catchesides (2005) find that the British petrol tax is strongly regressive when only car-owning households are considered, but when all households are taken into account, the middle income households are the most seriously affected.

Kosonen (2012) reviews a number of studies from the Nordic countries. Tuuli (2009) finds that the motor fuel budget share increases up to the sixth to eighth expenditure decile, before levelling out. This is due, mainly, to the fact that low-income families own fewer cars than households in the middle-income range. He concludes that the fuel tax is not regressive in Finland, however represents a higher burden in rural areas than in the cities. Ahola et al. (2009) find a very similar pattern for Sweden, provided that households are grouped according to expenditure rather than income. Klinge Jacobsen et al. (2001) find that, in Denmark, taxes on energy and pollution are typically neutral or mildly regressive, but the transport-related taxes (on vehicles and fuel) are clearly progressive, even when related to income, and even more so when related to expenditure. One possible explanation for this is the high level of automobile taxation, which makes the car into more of a luxury good than e. g. in Sweden. Berri et al. (2014) confirm that the fuel and vehicle taxes are progressive in Denmark, but not in France or Cyprus, where the fuel tax is found to be regressive. Basing their analysis on Engel elasticities[8], Aasness & Larsen (2003) find that in Norway during 1986-94, the fuel tax was regressive.

Several studies make the important point that the final distributional effect of a tax depends crucially on if and how the tax revenue is redistributed. Studying the Stockholm congestion charging scheme, Eliasson & Mattson (2006) state that 'if revenues are spent on public transport, this will primarily benefit low-income groups, while proportional tax cuts will naturally benefit high-income groups'. Callan et al. (2009) remarks that 'A carbon tax is regressive […]. However, if the tax revenue is used to increase social benefits and tax credits, households across the income distribution can be made better off without exhausting the total carbon tax revenue'. Bureau (2011) states that 'Carbon tax is regressive before revenue recycling', but that 'recycling additional revenues from the carbon tax either in equal amounts to each household or according to household size makes poorest households better off'. Gonzalez (2012) concludes that a carbon tax is 'regressive[...] when the revenue is

[8] The Engel elasticity measures the percentage change in spending on a certain good when total expenditure expands by one per cent. It is larger than one for 'luxury' goods and distinctly smaller than one for 'necessities'.

recycled as a manufacturing tax cut and progressive[...] when it is recycled as a food subsidy'.

Now, redistributing revenue in a progressive way is perhaps easier in theory than in practice. Ahola et al. (2009) seem, however, to have pointed to a quite reliable and practicable method, in suggesting that revenue be recycled through a lower VAT rate on comestibles. This will indeed make the tax scheme more progressive, since low-income families spend a larger than average share of their budget on food.

Samakovlis et al. (2015), studying carbon taxation in Sweden, demonstrate how the equity effect of recycling will differ considerably between a lowered VAT (i) on public transport, (ii) on services in general, or (iii) an all consumer goods. They find that the geographic dimension, contrasting urban to rural communities, is at least as significant for equity as the income dimension.

4.2.3 The AFFORD study

If the tax percentage does not vary monotonously with income or expenditure, no definite conclusion can be drawn about regressivity/progressivity. How can we then proceed?

The *Lorenz curve*, due to Lorenz (1905) and described well by Kakwani (1987), constitutes a concise, formalised way of summarising the degree of income inequality between the various members of society. Relating the cumulative proportion of income units, measured on the horizontal axis, to the cumulative proportion of income received, measured the vertical axis, the curve takes the form of a straight line through the origin with slope 1 (45-degree angle) if and only if all units in the population receive the same income. In all other cases the curve is a monotonously increasing, upward-bending line located beneath the straight line with a 45-degree angle. The lower the Lorenz curve, the more income is concentrated in the upper income brackets, and the less 'equitable' is the distribution.

One way to summarize the information contained in the Lorenz curve is by way of the *Gini* coefficient, due to Gini (1912). Equal to twice the area between the 45-degree straight line and the Lorenz curve, the *Gini* coefficient is bounded between zero and one. The higher the *Gini* coefficient, the larger is the 'gap' between the actual and the maximally equitable distribution, and the less 'equitable' is – in a sense – the distribution at hand.

In the AFFORD project for the European Commission, Fridstrøm et al. (2000) exploited this apparatus to study the income distributional effects of marginal cost pricing of travel in the greater Oslo area. They computed changes in the Lorenz curve and in the Gini coefficient, as defined in terms of household income per consumption unit, under various first or second best marginal cost pricing packages and revenue redistribution schemes. The equity effect was shown to be strongly dependent on how the revenue from peak-load pricing and congestion charging was used. If the revenue is recycled to the taxpayers in the form of poll transfer, i. e. with an equal amount to every adult, equity was seen to improve. When no recycling takes place, or when revenue is recycled in the form of a proportional tax relief, the pricing scheme was found to be regressive.

4.2.4 A simplified modelling approach

The AFFORD exercise was possible thanks to the availability of disaggregate household income data coupled with a detailed network travel demand model. In the present project, we are less fortunate. The Oslo Intercity and NTM6 models do not contain income data at the individual or household level. The best proxy one can obtain is the average personal income among residents in each zone of origin, as measured at the level of the basic statistical unit (BSU, 'grunnkrets'). These figures are summarised in Table 4.1. There are approximately 14 000 BSUs in Norway, with an average population of less than 400. In the urban areas, the BSUs have fairly small extension, typically just a few blocks. In this report, we shall refer to the BSUs as 'neighbourhoods'.

Table 4.1. Resident population and mean income in local per capita income brackets, according to the network models for short, resp. long distance trips.

	Per capita income in neighbourhood (NOK 2001)					
	0-174	175-224	225-274	275-324	325+	Total
			Oslo Intercity Regional Model			
Population aged 13 and above	148 552	776 938	662 695	265 208	199 455	2 052 848
Per cent of population	7.2	37.8	32.3	12.9	9.7	100.0
Average per capita local income	126 605	204 194	245 551	296 016	413 615	
Income ratio	1	1.61	1.94	2.34	3.27	
			NTM6 Long-Distance National Model			
Population aged 13 and above	410 459	2 192 136	1 224 516	259 760	162 232	4 249 103
Per cent of population	9.7	51.6	28.8	6.1	3.8	100.0
Average per capita local income	156 774	203 140	245 143	294 343	369 738	
Income ratio	1	1.30	1.56	1.88	2.36	

Since the choice of residential location is strongly income dependent, rents and real estate values varying markedly between local communities, the mean neighbourhood income proxy is thought to capture a large part of the cross-sectional variation in household earnings. Some caution is, however, in order when these figures are interpreted, since the latest available local income data refer to the year 2001.

In Fig. 4.2, we show how per capita local income varies among the neighbourhoods comprised by the Oslo Intercity Regional Model for short-haul trips. There is a visible tendency for income levels to decrease as one moves away from the capital city. Neighbourhoods west of downtown Oslo tend to be more affluent than on the eastern side.

When travellers in the Oslo intercity region are sorted by mode and neighbourhood income, one notes that the lowest income communities exhibit, in fact, the highest travel demand (Fig. 4.3). Somewhat surprisingly, they also drive farther by car than people in the more affluent communities.

A similar pattern is found for domestic long distance trips (Fig. 4.4).

Note that income brackets are defined in terms of NOK 2001. To correct for inflation until November 2015, multiply by 1.30.

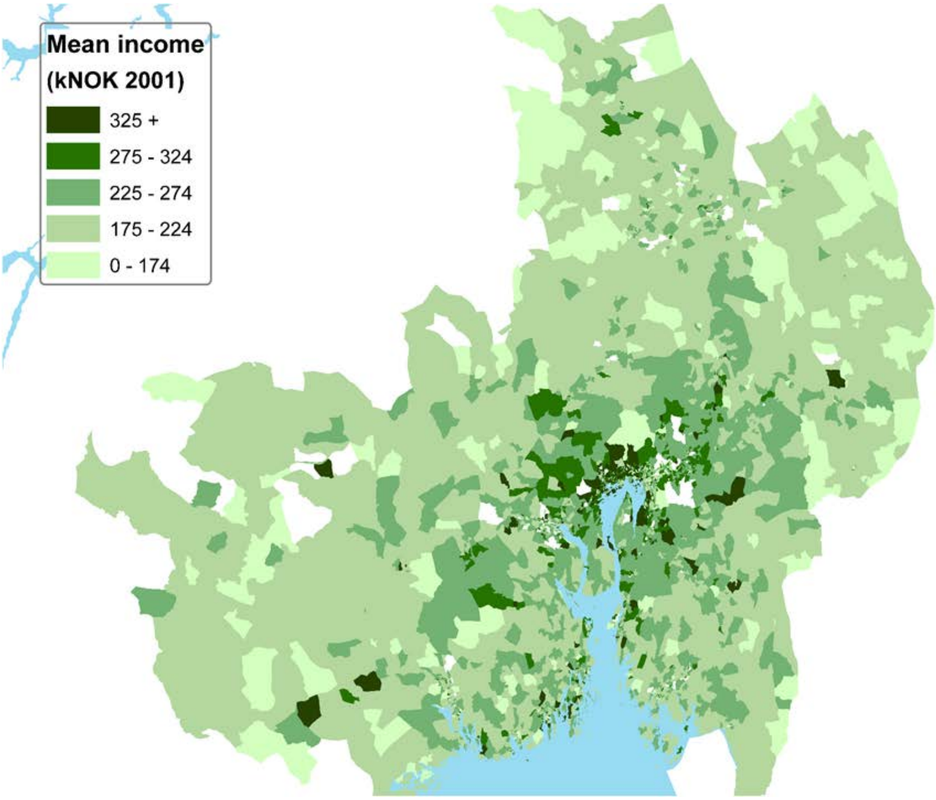

Fig. 4.2. Neighbourhoods (BSUs) comprised by the Oslo Intercity Regional Model, by mean income in 2001.

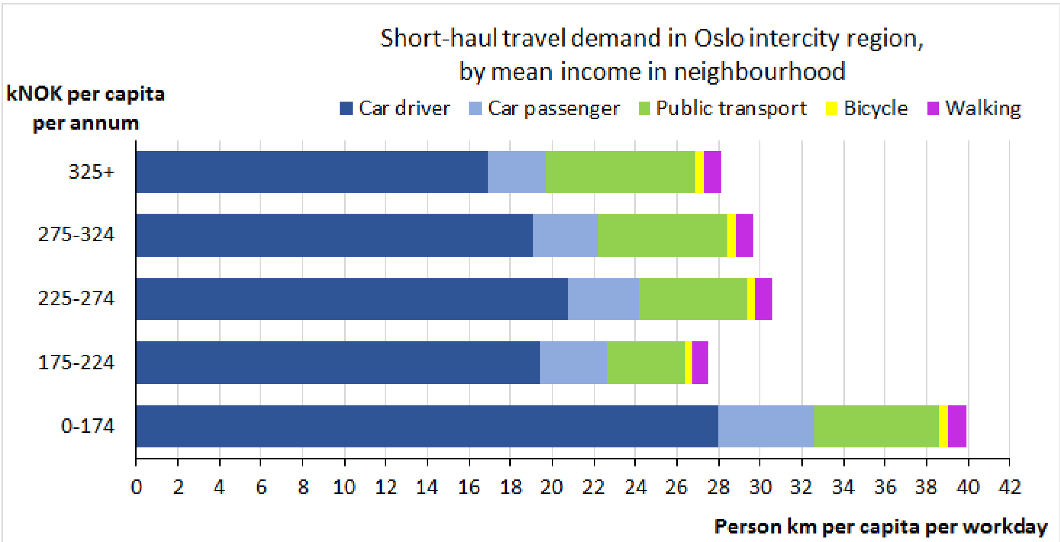

Fig. 4.3. Benchmark short distance travel demand according to the Oslo Intercity Regional Model, by mode and mean income in residential neighbourhood.

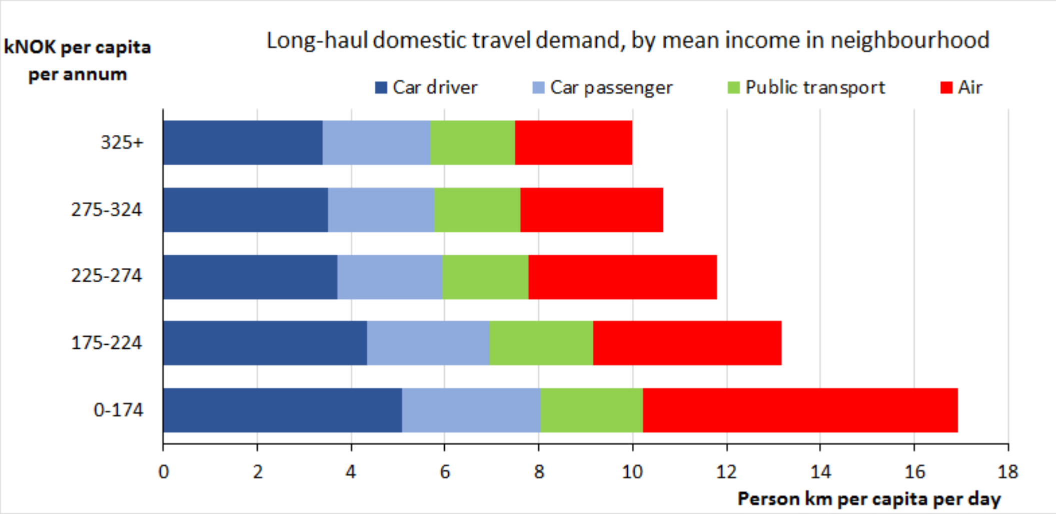

Fig. 4.4. Benchmark domestic long distance travel demand according to the NTM6 model, by mode and mean income in residential neighbourhood.

4.3 Socio-demographic effects

Another angle under which one might want to study equity is the household structure. Are the policy effects fair to families with children, to persons living alone, or to the most crowded households?

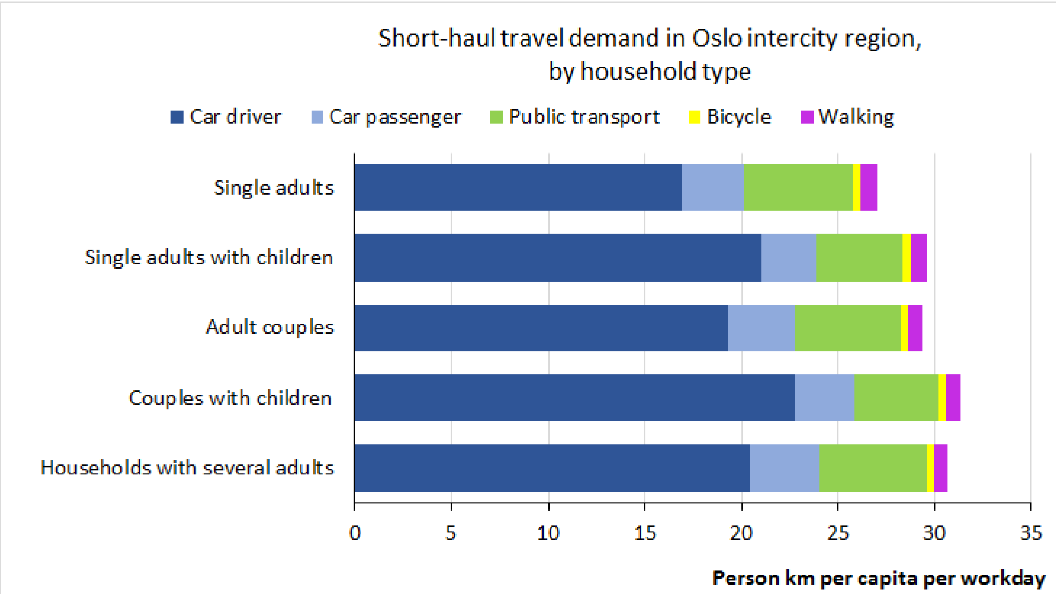

Fig. 4.5. Benchmark short distance travel demand according to the Oslo Intercity Regional Model, by mode and household type.

The reference situation in the Oslo intercity region is shown in Fig. 4.5. The differences between household types appear to be moderate. Larges families exhibit slightly higher short-trip mobility than smaller ones. Persons living in couples travel somewhat more than singletons.

Long distance travel seems to be clearly more prevalent among couples than for single adults with or without children (Fig. 4.6).

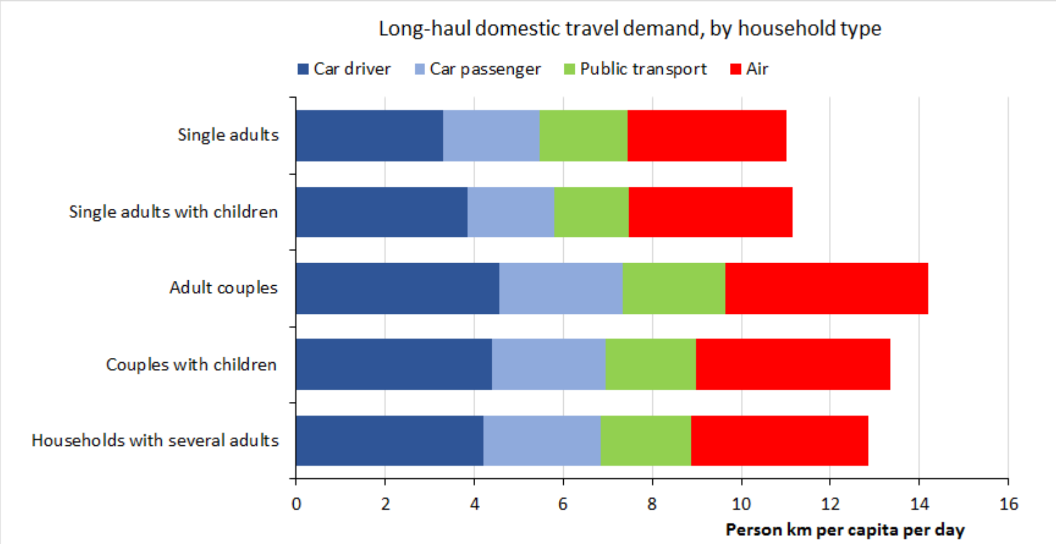

Fig. 4.6. Benchmark domestic long distance travel demand according to the NTM6 model, by mode and household type.

A third way to look at equity is by age and gender. Here, the differences in terms of mobility are pronounced (Figs. 4.7 and 4.8). Males travel more than females, especially as car drivers, and middle aged people travel more than the teenagers and the elderly. This is true for short as well as for long distance trips.

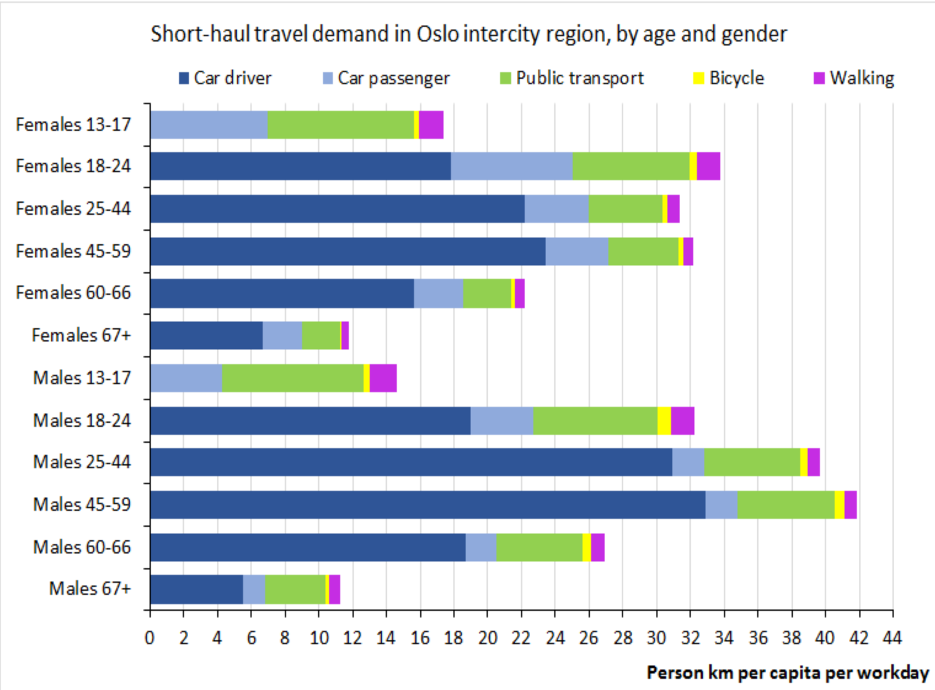

Fig. 4.7. Benchmark short distance travel demand according to the Oslo intercity model, by mode, gender and age.

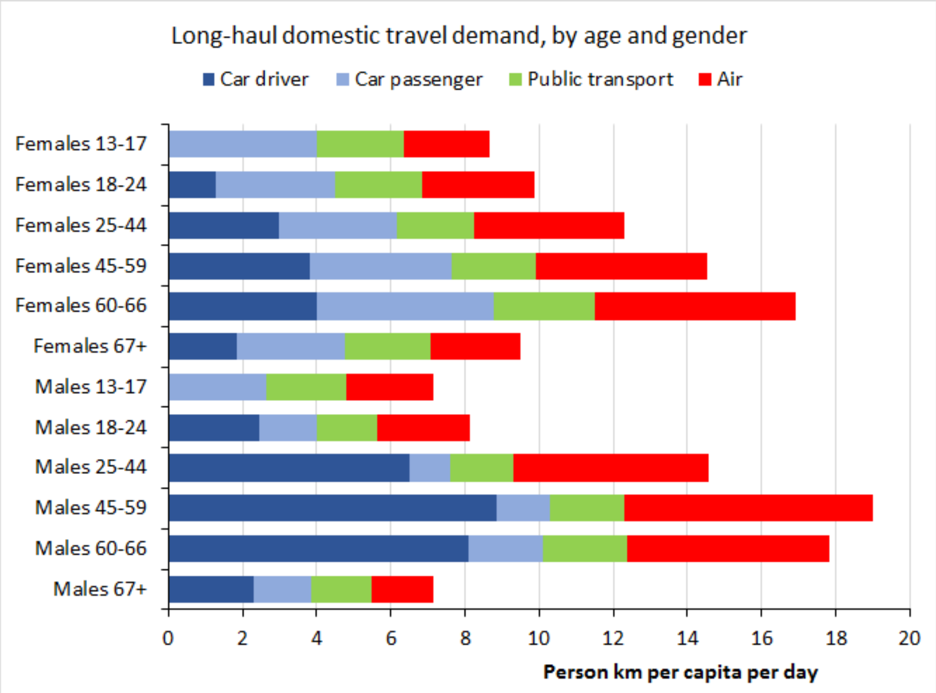

Fig. 4.8. Benchmark domestic long distance travel demand according to the NTM6 model, by mode, gender and age.

4.4 Geographic effects

The fourth equity dimension considered here is geography, or – more precisely – county of residence.

Among the counties covered by the Oslo Intercity Regional Model, per capita short-haul car travel demand is lowest in Oslo and highest in Akershus – the surrounding county (Fig. 4.9).

Long-distance travel demand is highest, as reckoned per capita, in the two northernmost counties (Fig. 4.10). Here, the air travel mode is the most common for trips longer than 70 km. The three counties at the south-east corner of the country have the lowest long-distance travel incidence. Recall, however, that these statistics do not include international trips, which are more frequent among residents of Oslo, Akershus and Østfold than elsewhere (Hjorthol et al. 2014: 24).

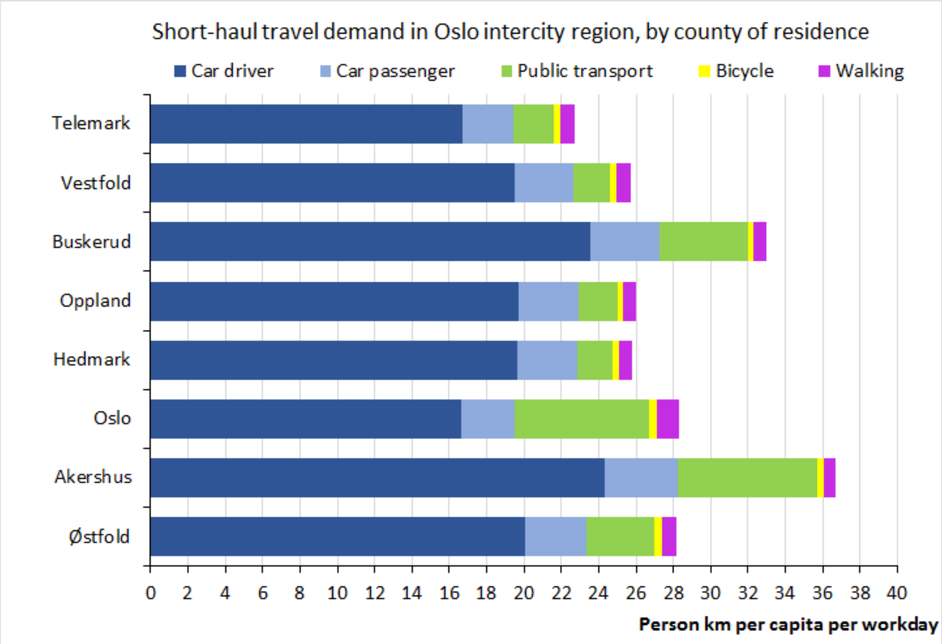

Fig. 4.9. Benchmark short distance travel demand according to the Oslo Intercity Regional Model, by mode and county of residence.

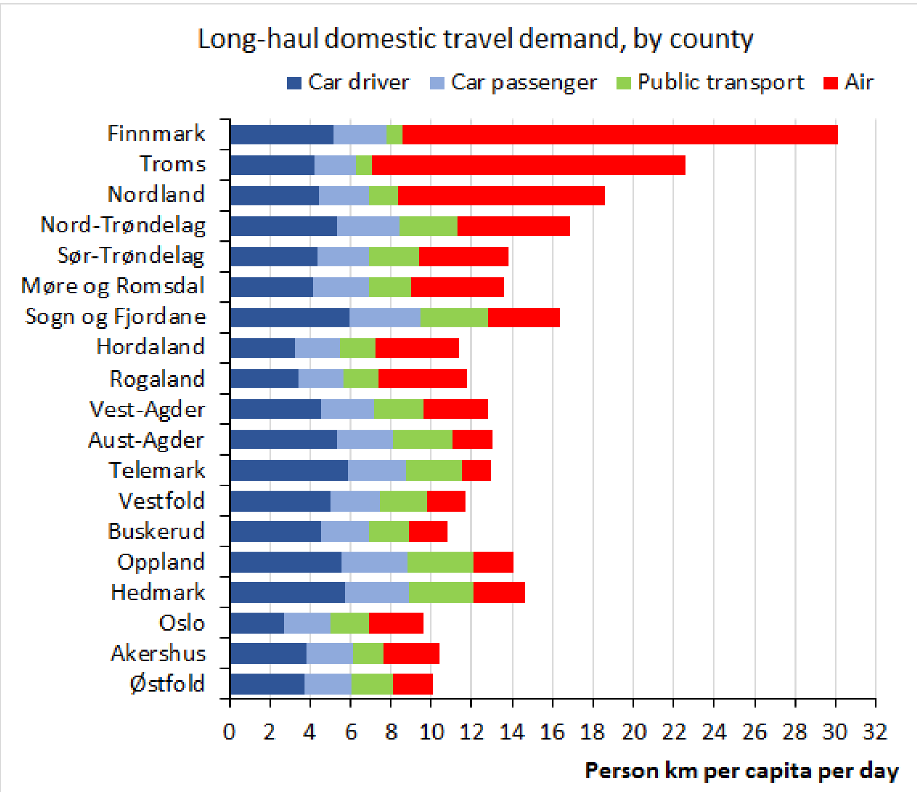

Fig. 4.10. Benchmark domestic long distance travel demand according to the NTM6 model, by mode and county of residence.

5 Network modelling results

5.1 Travel demand

Figs. 5.1 and 5.2 show travel demand effects of the three policy measures studied by means of short- and long-haul travel demand models.

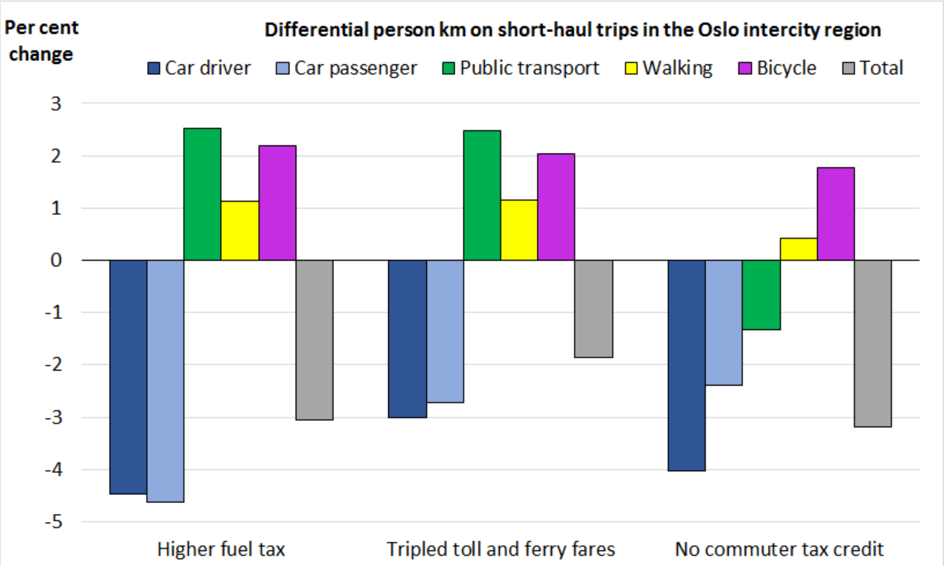

Fig. 5.1. Policy impact on short-haul travel demand in Oslo intercity region. Per cent change in person km travelled, by policy measure and mode.

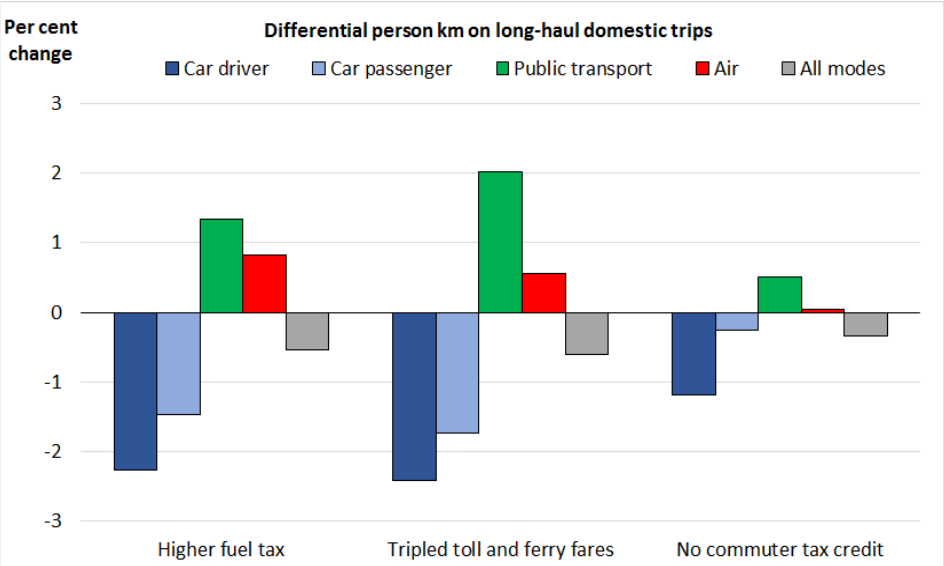

Fig. 5.2. Policy impact on long-haul domestic travel demand. Per cent change in person km travelled, by policy measure and mode.

A NOK 0.20 increase in per km car travel cost, brought about by a new km charge or by an escalated fuel tax, will lead to an estimated 4-5 per cent decrease in short-haul car kilometres and an about 2 per cent decrease in long-haul car travel demand. Short distance public transport demand expands by 2-3 per cent, while long distance air and public transport demand expands by around 1 per cent. Total travel demand shrinks by an estimated 3 per cent for short-haul trips and by one half per cent for long-haul trips.

According to the model simulations, tripled toll rates and ferry fares would have comparable effects on long-haul trips, but somewhat smaller effects on short trips in the Oslo intercity region.

The abolishment of the commuter tax credit would lead to an even larger overall travel demand effect on short-haul trips than the fuel tax increase considered. This policy measure affects all modes of transport, yielding reduced demand even for short-haul public transport. At longer distances, however, air and public transport will experience slight increases in demand, as the car mode becomes comparatively less competitive.

5.2 CO_2 emissions

In terms of CO_2 emissions, the three policy measures have comparable effects – 80 to 120 000 tCO_2/annum – as far as short-haul trips in and around Oslo are concerned (Fig.5.3). The relative reduction is 2.8 to 4.2 per cent compared to the reference scenario emissions of 2.89 million tonnes of CO_2 on short-haul trips.

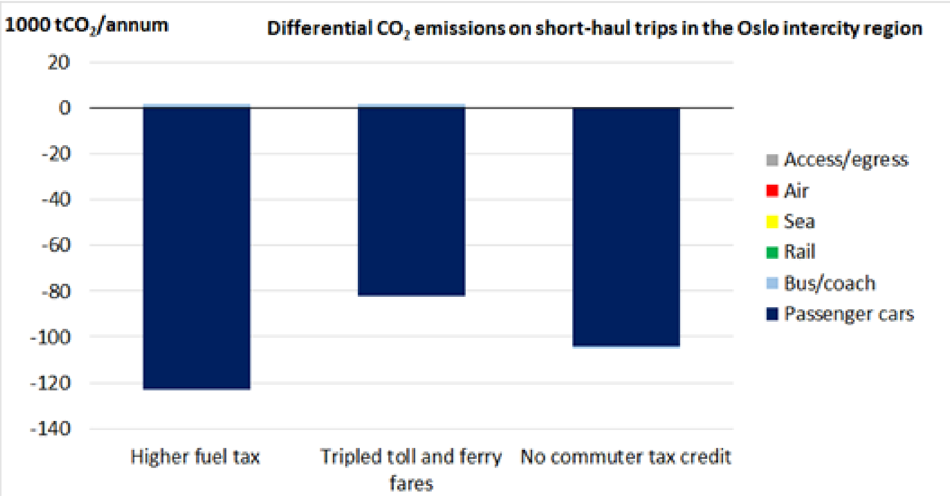

Fig. 5.3. Policy impact on short-haul trips in Oslo intercity region. Absolute changes in CO_2 emissions, by policy measure and mode.

On longer distances, the commuter tax credit reform is seen to have only half as large an impact on emissions from private cars as the other two strategies (Fig. 5.4). However, since tripled toll and ferry fares as well as increased fuel tax shift travel demand from cars to the air and bus/coach modes, generating increased emissions from these, the overall CO_2 impact on long-haul trips is of the same order of magnitude – 12 to 17 000 tCO_2/annum, or 0.5 to 0.7 per cent down from 2.55 million tonnes – in all three policy scenarios.

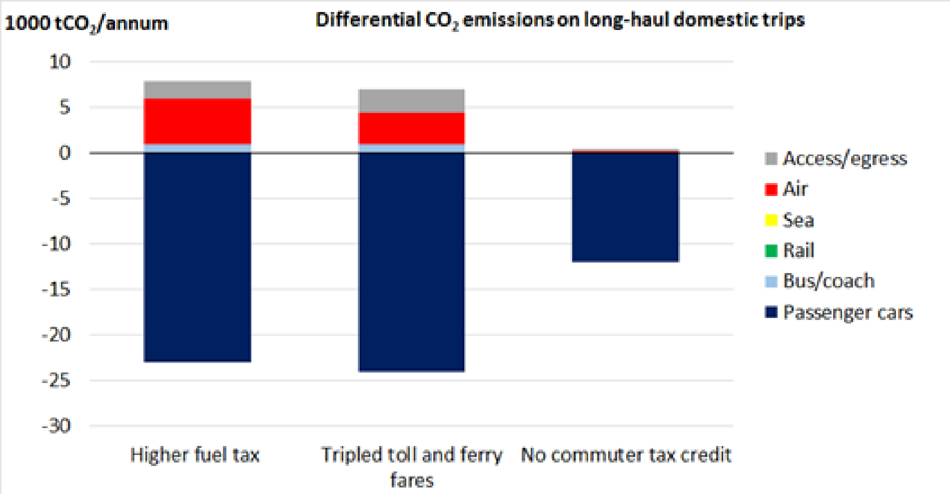

Fig. 5.4. Policy impact on long-haul domestic trips. Absolute changes in CO_2 emissions, by policy measure and mode.

5.3 Economic costs and benefits

Certain costs and benefits arising under the three policy scenarios are shown in Figs. 5.5 and 5.6.

The increased fuel tax option comes out with a positive net annual economic *benefit* of NOK 149 million in the short-haul Oslo intercity market, and at NOK 27 million in the long-haul domestic market. The abolished commuter tax credit also comes out as socially profitable, with net annual *benefits* of NOK 125 and 146 million, respectively, in the two markets. Tripling the toll rates and ferry fares is, however, strongly unprofitable, with net annual *costs* of NOK 1 624 and 1 376 million.

The net economic benefit, as calculated here, is the sum of six elements: the traveller surplus change, the differential external cost of road use, the changes in public revenue from fuel tax, income tax, toll and ferry fares, and the economic value attached to additional public revenue[9] (the ‘cost of funds’).

In Fig. 5.7, we present a diagram for the short-haul market, where all of the revenue flows in the increased fuel tax scenario have been drawn to scale, with colour codes corresponding to those of Figs. 5.5-5.6. Since we are not concerned with the absolute level of welfare in the initial situation, only with the *changes* brought about by the policy measure in question, the zero point on the vertical axis of Fig. 5.7 can be set arbitrarily, without loss of generality. We have set it at the point corresponding to a zero fuel tax. Hence the grey area shown represents the fuel tax revenue obtained by applying the ‘old’ fuel tax rate to the ‘new’ travel demand, in other words the fuel tax

[9] According to the guidelines of the Norwegian Ministry of Finance (2014), a NOK 1 incremental revenue for the public treasury is to be valued at NOK 1.20, i. e. at a 20 per cent ‘premium’ compared to private funds, since taxes are in general distortionary, and hence public revenue comes at a price in terms of reduced allocative efficiency throughout the economy (Pigou 1948).

revenue previously collected from the road users that remain in the market after the policy intervention. We refer to this as 'stable fuel tax revenue'.

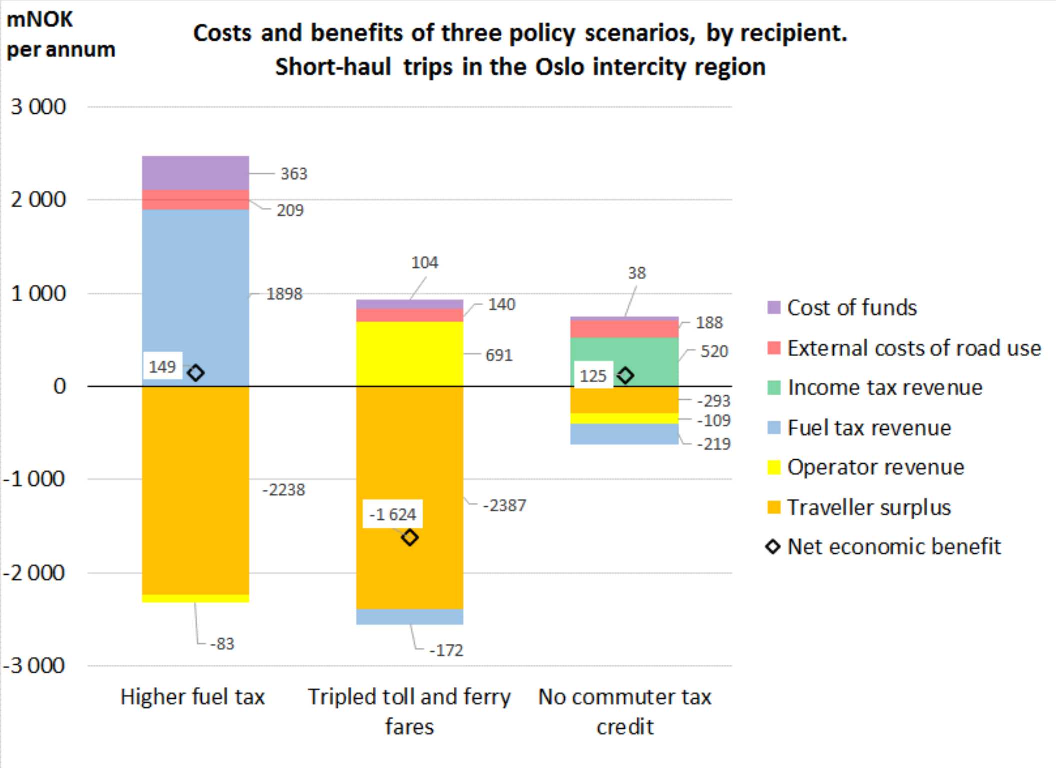

Fig. 5.5. Differential costs and benefits calculated for short-haul trips in the Oslo intercity region, under three policy scenarios.

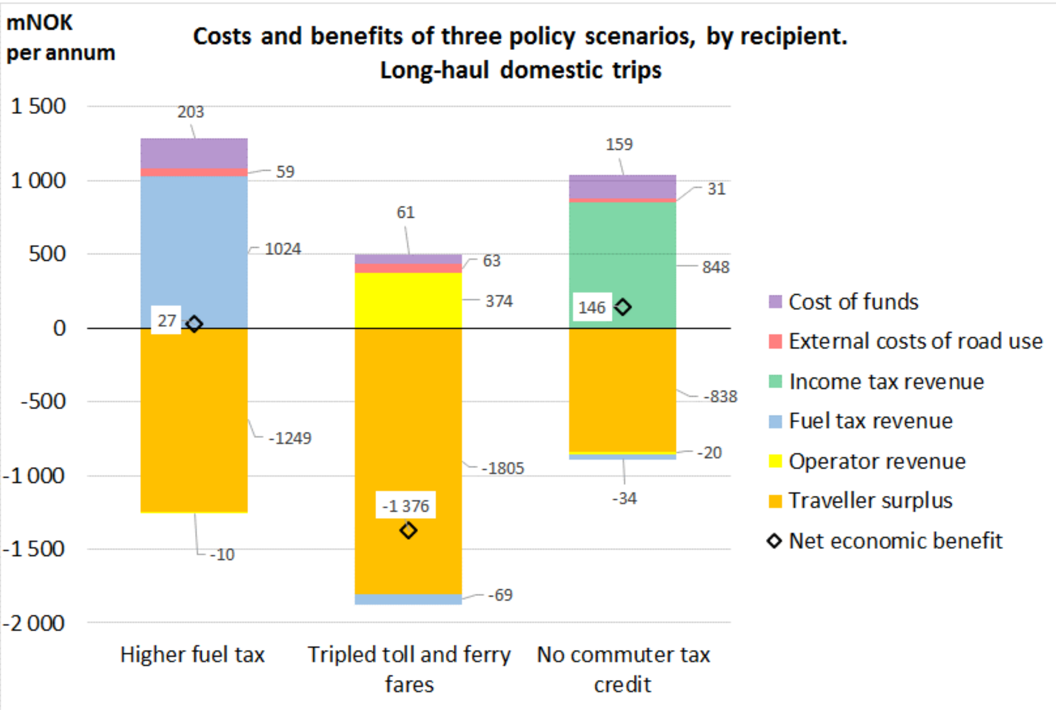

Fig. 5.6. Differential costs and benefits calculated for domestic long-haul trips, under three policy scenarios.

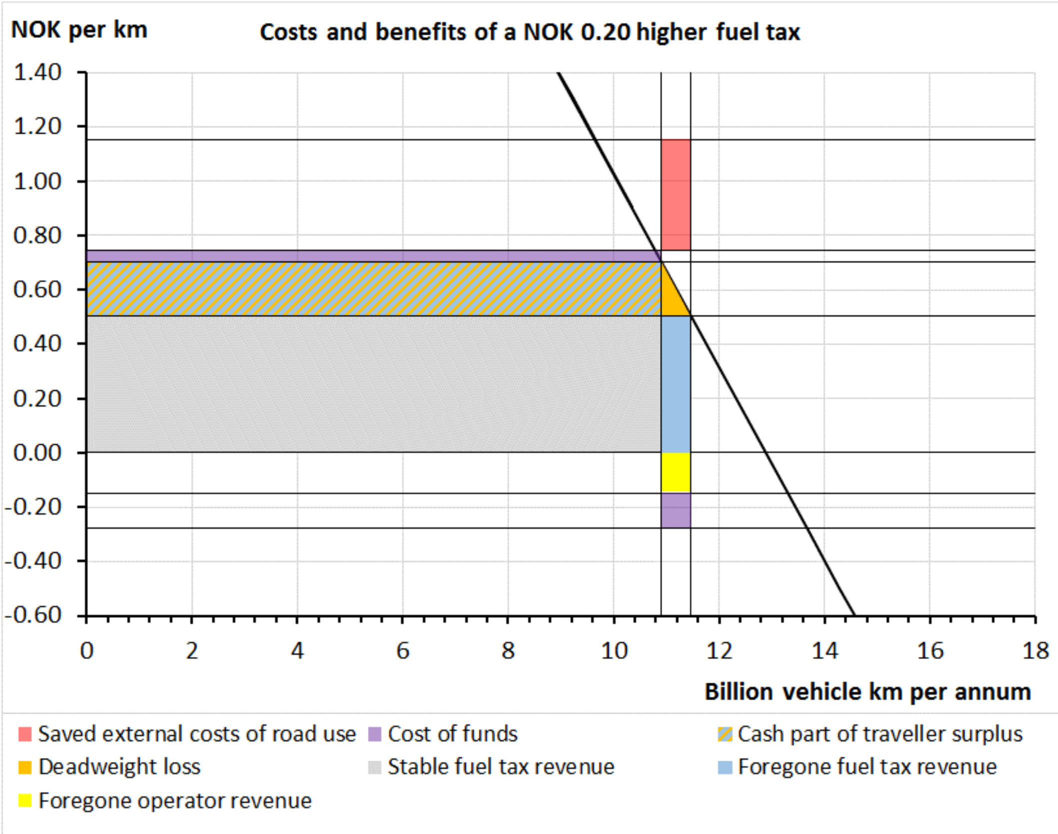

Fig. 5.7. Market response to a NOK 0.20 higher per km fuel tax, calculated for short-haul trips in the Oslo intercity region. Coloured areas are proportional to cost/benefit/cash flow involved.

Note that cash flows between private households and the public sector, or between different segments of the private sector, are not economic costs – only redistributive transfers. Thus, the greater part of the ochre coloured area shown in Fig. 5.5, representing traveller surplus loss, consists in a mNOK 2182 cash expenditure, which has an exact counterpart in the form of extra fuel tax revenue for the public treasury. In the cost-benefit account, these two items cancel each other out, as suggested by the hatched, blue-and-ochre rectangle in Fig. 5.7. What is left as a real welfare economic cost is just the mNOK 56 deadweight loss, represented by the ochre triangle in Fig. 5.7. This is the benefit foregone by road users travelling less frequently or to less distant destinations than before.

Now, in practice the additional net public revenue will not be quite as large as the hatched blue-and-ochre area, since the public treasury will lose out (i) on the fuel tax, previously collected on a larger number of vehicle kilometres travelled (mNOK 284 blue area in Fig. 5.7), and similarly (ii) on previously collected toll and ferry fares (mNOK 83 yellow area). These losses, representing a negative 'rebound effect' for the public treasury, must also taken into account.

On the other hand, when the number of vehicle kilometres travelled goes down, so do their external costs. The size of this benefit (mNOK 209) is shown by the pink areas in Figs. 5.5 and 5.7. To calculate this benefit, we have applied average marginal external cost rates as derived by Thune-Larsen et al. (2014, revised 2016), amounting to around NOK 0.40 per km for passenger cars. Since not all external costs are strictly proportional to the vehicle kilometres travelled, this is an approximation.

Finally, the cost of funds are taken into account, with a premium valued at 20 per cent of the additional public revenue generated, and an equally large share of public revenue foregone on account of reduced travel demand. Thus, the mauve area in Fig. 5.5 is the balance between the upper (mNOK 436) and the lower (mNOK 73) mauve areas shown in Fig. 5.7.

One notes that the premium value of public revenue and the reduced amount of external costs are sufficient, taken together, to more than offset the deadweight loss and the reduced revenue from fuel tax, toll and ferry fares. But this conclusion hinges crucially on the assumed premium value of public funds and on the unit rate of external costs. We revert to this question in Section 7.3.2.

While the three policy strategies considered have comparable effects in terms of CO_2 abatement (Figs. 5.3 and 5.4), they are remarkably different as judged by their economic costs (Fig. 5.8).

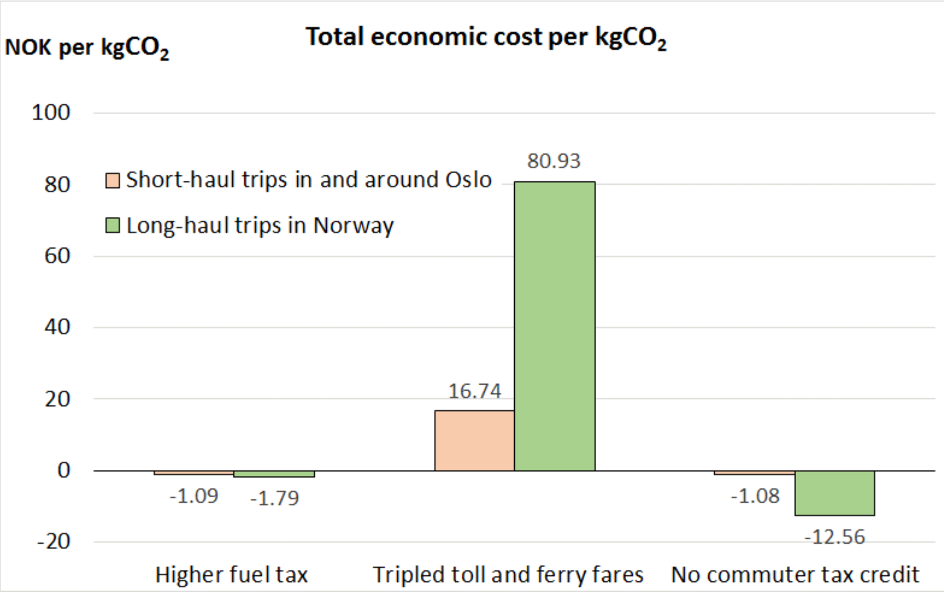

Fig. 5.8. Calculated net economic cost per avoided kg CO_2 under three policy scenarios, according to the Oslo Intercity Regional Model for short-haul trips and the NTM6 model for long-haul trips.

Considered as a GHG abatement measure, abolishing the commuter tax credit has a negative economic cost – i. e. it is socially profitable even before we consider GHG abatement effects. In the long-haul domestic travel market, the estimated benefit is as high as NOK 12.56 per $kgCO_2$. A more moderate benefit is derived in the short-haul market – NOK 1.08 per $kgCO_2$.

The incremental revenue obtained by the public treasury is, however, not nearly as large as one might expect. In the short-haul market, more than half the mNOK 520 extra revenue from income tax is counterbalanced by reduced revenue from fuel tax (mNOK 219), toll and ferry fares (mNOK 109) – a most significant fiscal 'rebound effect'. In the long-haul market, the travel demand response is much smaller, and so is also the reduction in toll and fuel tax revenue.

Increasing the fuel tax is also shown to be socially profitable, on account of reduced external costs and the premium value attached to public revenue. In the long-haul market, the estimated benefit is somewhat bigger (NOK 1.79 per kgCO_2) than in the short-haul market (NOK 1.09 per kgCO_2).

In this context, the tripled toll and ferry fares strategy is like the odd man out, with abatement costs reaching almost NOK 81 per kgCO_2 in the long distance market and almost NOK 17 in the short distance market, corresponding to € 9 600 and € 2 000 per tonne CO_2, respectively. Note, however, that the increased toll rates considered have nothing to do with congestion charging or marginal cost pricing. What we have modelled is essentially a tripling of fundraising toll on highways that are already in a free-flow state of demand, i. e. without significant delays.

5.4 Equity

5.4.1 Effects by local income level

In Figs. 5.9 and 5.10, calculated changes in traveller surplus under the three policy scenarios have been broken down by per capita income brackets as defined for the travellers' respective zones of residence[10], which we subsequently refer to as their 'neighbourhoods'.

For the tripled toll and ferry fares policy, no striking distributional pattern of effects is seen.

Under the increased fuel tax scenario, however, a relatively clear, regressive pattern emerges. Losses are higher, even in absolute terms, for travellers living in low income neighbourhoods. In the short-haul travel market, *absolute* per capita losses are more than twice as high for individuals living in neighbourhoods with a per capita income of less than kNOK 175 in 2001 than for travellers in the uppermost local income bracket (kNOK 325+).

In the long-haul domestic travel market, the tendency is the same, although weaker.

An even more regressive pattern is found for the revocation of the commuter tax credit, which, on short-haul trips, affects people from the least affluent communities 4.5 times (= 30.53/6.77) more strongly – in *absolute* terms – than most well-to-do neighbourhoods. In the long-haul market, the corresponding ratio is about half as high: 2.25 (= 19.59/8.69).

The absolute amounts of benefit lost when the commuter tax credit is revoked may appear small. However, since the commuter tax credit affects only 11 per cent of the taxpayers (Table 2.1), the average impact on the persons affected is roughly nine times higher than shown in the graph. Also, recall that prices have risen by about 30 per cent since 2001. When both of these facts are taken account of, the monthly NOK 30.53 figure derived for low income neighbourhoods corresponds to roughly NOK 4 000 over an 11-month working year, as evaluated at the 2015 price level.

[10] More precisely, the zones coincide with the 'basic statistical units' (BSUs), see Section 4.2.4.

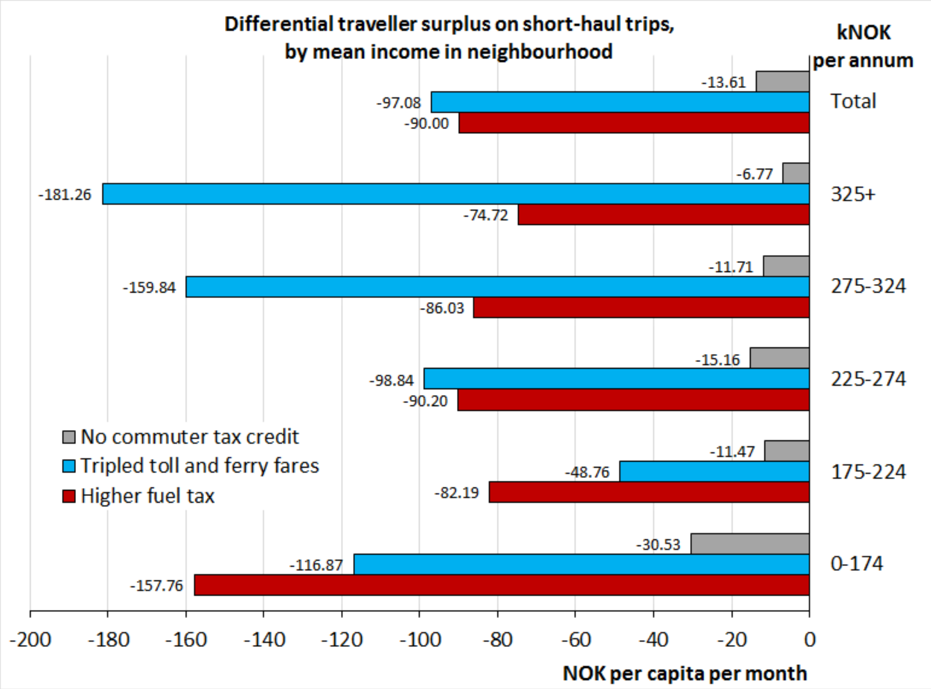

Fig. 5.9. Calculated per capita changes in traveller surplus on short-haul trips in the Oslo intercity region, under three policy scenarios, by mean income in neighbourhood in 2001.

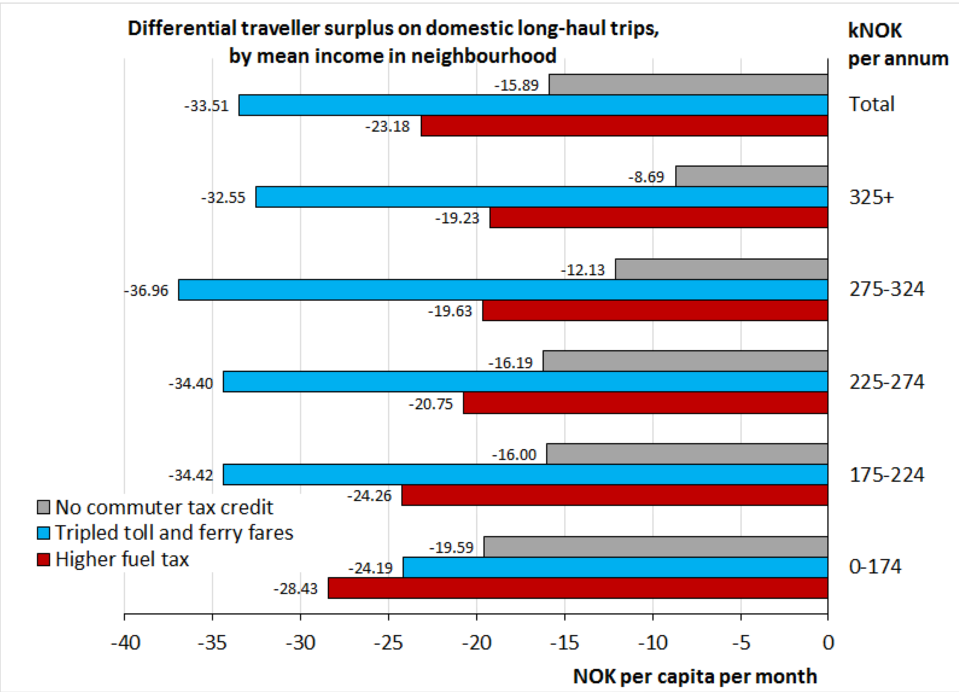

Fig. 5.10. Calculated per capita changes in traveller surplus on long-haul domestic trips, under three policy scenarios, by mean income in neighbourhood in 2001.

As measured *in relation to the income level*, the inequality ratios come out several times higher. Multiplying the tax incidence factors of Figs. 5.9-5.10 by the income ratios shown in Table 4.1, we obtain the following indicators for the excess burden borne by the residents of low income neighbourhoods as compared to those living in high income zones:

1. Tripled toll rates and ferry fares: 2.1 in short-haul model, 1.8 in long-haul model
2. NOK 0.20/km higher fuel tax: 6.9 in short-haul model, 3.5 in long-haul model
3. Abolished commuter tax credit: 14.7 in short-haul model, 5.3 in long-haul model.

That is, as measured by the relative traveller surplus change in relation to per capita local income, abolishing the commuter tax credit would affect the low income neighbourhoods about 15 times more strongly than the most affluent ones, according to the Oslo Intercity Regional Model. In the NTM6 long distance model, the corresponding inequity ratio is around 5.

The augmented fuel tax option results in analogous inequity indicators of 7 and 3.5 in the short- and long-haul models, respectively. The tripled toll rates and ferry fares option trips results in indicators around 2 – suggesting twice as high a relative burden on low income neighbourhoods as on high income areas.

The picture emerging is one of very strong regressivity, especially in the case of abolishing the commuter tax credit, but also in the higher fuel tax case.

Since we have not been able to relate travel behaviour response to individual or household income, but only to the mean local income as of 2001, results must be interpreted with some caution. There is, however, reason to believe that there is a strong degree of permanence in the spatial income pattern.

As shown in Fig. 4.2, income levels tend to diminish as one moves out from the capital city, or – more generally – from any large urbanization. This may be a reflection of the well-known rent gradient phenomenon. In or near the city centre, rents are generally higher than in the suburban and exurban areas. Hence these areas tend to be inhabited by the more affluent families. Since jobs tend to be concentrated in or near the city centre, workers living in more remote neighbourhoods, with lower rents and lower income level, generally sustain longer commutes.

Therefore, low income earners tend to be more strongly affected by increases in the fuel cost. They benefit from the commuter tax credit to a significantly larger extent than do urban or suburban dwellers. They will, in other words, be more severely drabbed by its revocation.

5.4.2 Effects by county of residence

The three CO_2 abatement policies will affect the population in different counties unequally. This is true in particular of the tripled toll and ferry fares scenario, since toll roads and ferry crossings are unevenly spread between the counties.

The small county of Vestfold, on the west side of the Oslo fjord, appears to be more severely hit by increased toll and ferry fares than any other county in south-eastern Norway (Figs. 5.11 and 5.12). In Vestfold, a large share of the traffic volume is subject to toll.

Residents of the three northernmost counties, on the other hand, are hardly affected at all by an increase in toll and ferry fares.

The fuel cost increase is seen to affect the highly urbanised county of Oslo least and the less densely populated counties most.

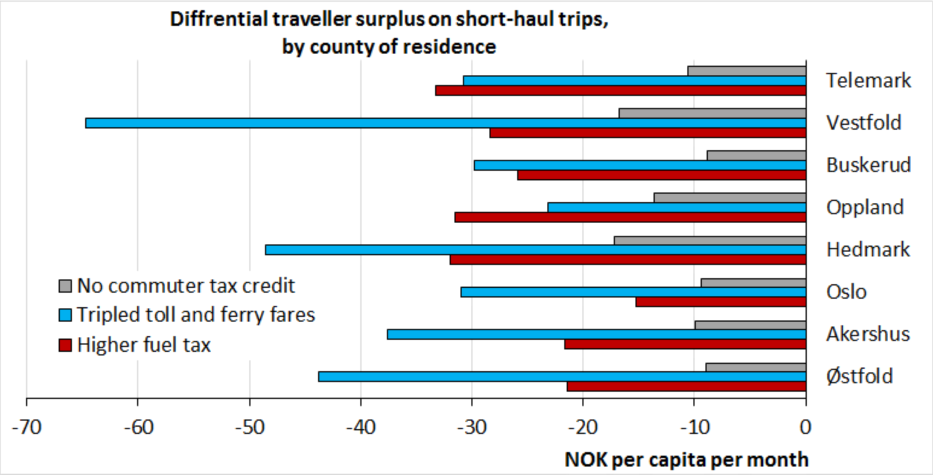

Fig. 5.11. Calculated per capita changes in traveller surplus on short-haul trips in the Oslo intercity region, under three policy scenarios, by county of residence.

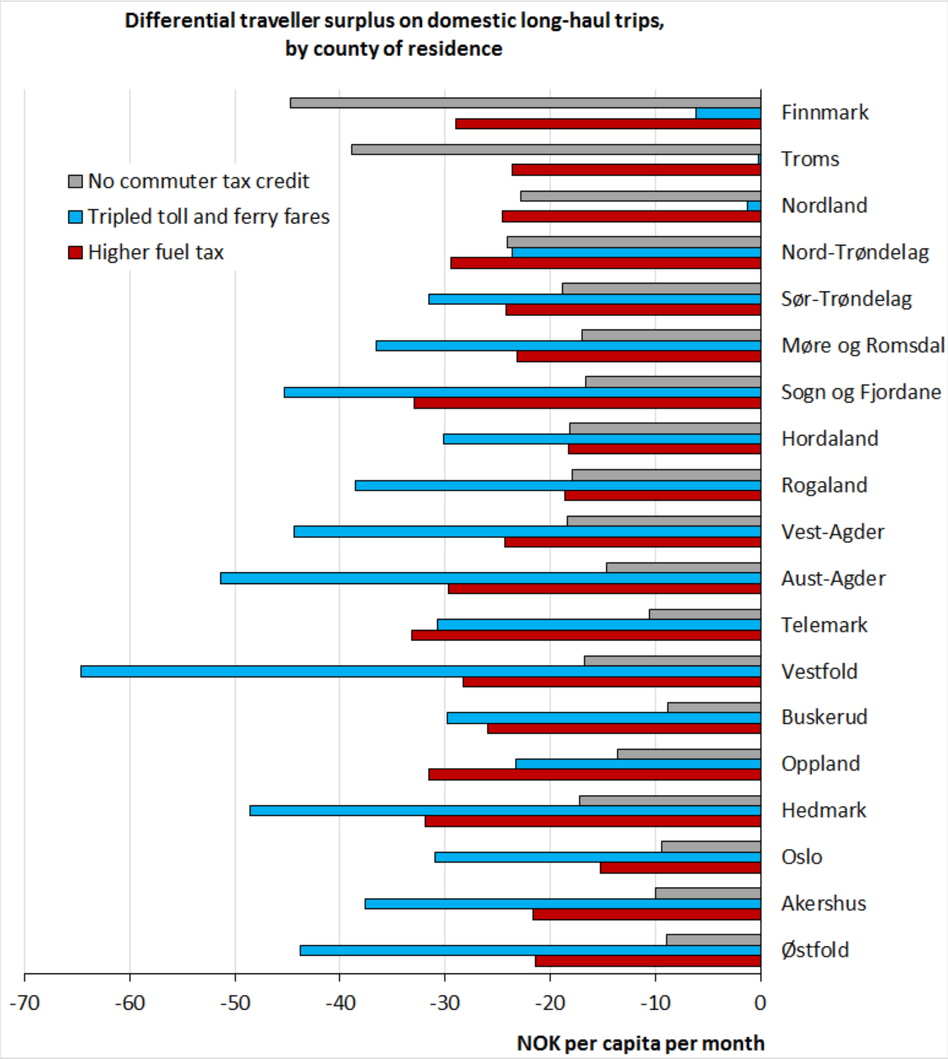

Fig. 5.12. Calculated per capita changes in traveller surplus on long-haul domestic trips, under three policy scenarios, by county of residence.

The commuter tax credit revocation also hits harder in the sparsely populated counties. In the northernmost county of Finnmark, the per capita traveller surplus loss on long-haul trips is nearly five times higher than in Oslo.

5.4.3 Effects by age and gender

Age and gender effects are shown in Figs. 5.13 and 5.14.

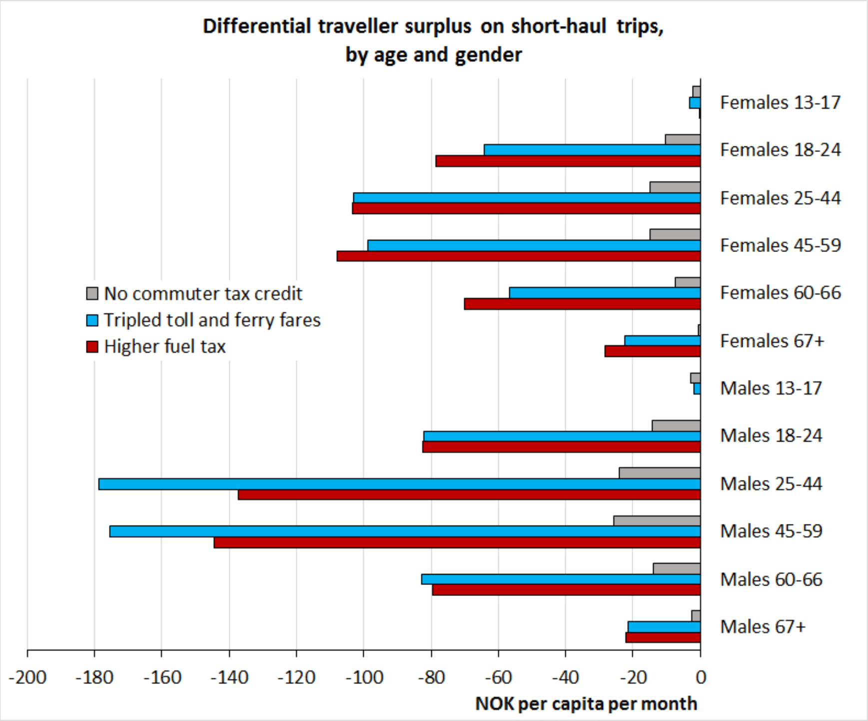

Fig. 5.13. Calculated per capita changes in traveller surplus on short-haul trips in the Oslo intercity region, under three policy scenarios, by age and gender.

There is a clear tendency for all three policy measures to affect males more strongly than females. The gender difference is particularly noticeable in the case of abolished commuter tax credit. Long-haul commutes are far more frequent among males than among females.

The gender gap is clearly visible also in the scenario based on tripled toll rates and ferry fares. This probably reflects the gender difference in modal choice and car use, shown in Figs. 4.7 and 4.8.

The age profile offers no surprise. Persons aged 25 to 66 incur higher fuel, toll and ferry costs than the younger or the older. Obviously, they are also harder hit by cutbacks in the commuter tax credit.

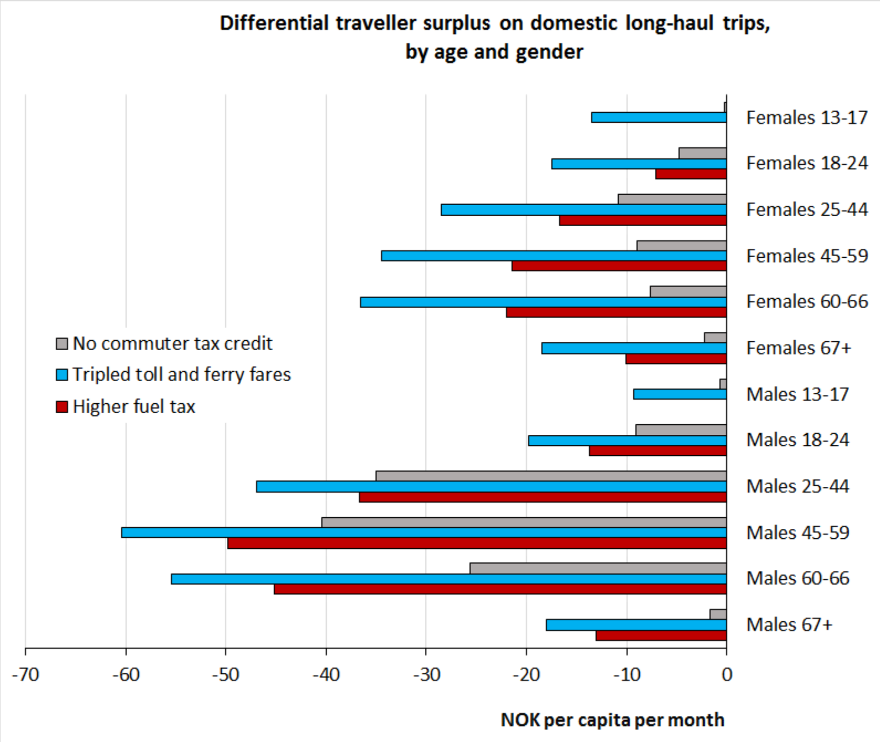

Fig. 5.14. Calculated per capita changes in traveller surplus on long-haul domestic trips, under three policy scenarios, by age and gender.

5.4.4 Effects by household structure

The policy measures considered do not, according to the models, result in grossly inequitable effects across family types. Per capita losses vary little by type of households (Figs. 5.15 and 5.16), although the fuel tax increase hits somewhat harder in families with children than for single adults. The most 'vulnerable' group, single adults with children, incur per capita losses that are just about average.

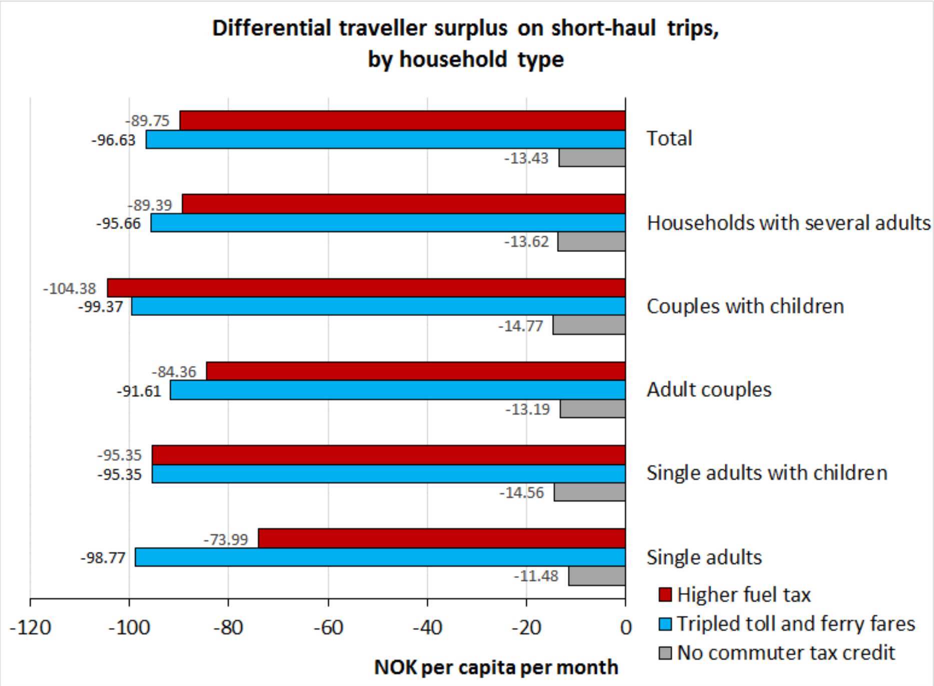

Fig. 5.15. Calculated per capita changes in traveller surplus on short-haul trips in the Oslo intercity region, under three policy scenarios, by household size and structure.

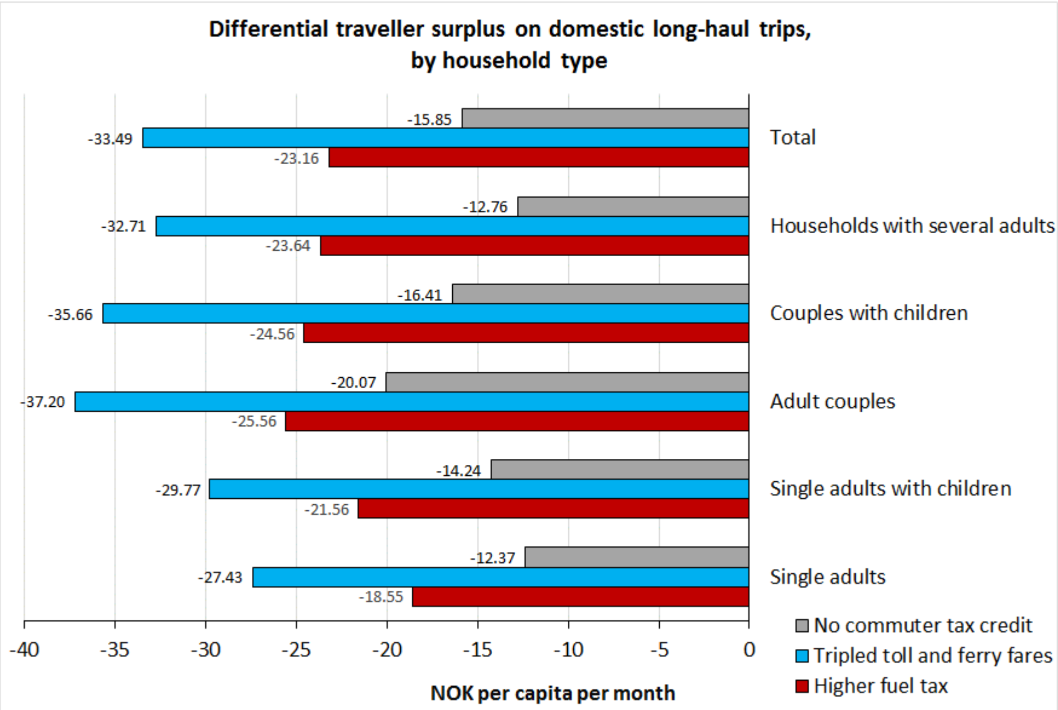

Fig. 5.16. Calculated per capita changes in traveller surplus on long-haul domestic trips, under three policy scenarios, by household size and structure.

5.4.5 Effects by degree of access to cars

Finally, we consider utility losses across households with differing degrees of access to cars (Figs. 5.17 and 5.18). Here, car 'ownership' or 'access' includes the cases where a vehicle is leased or owned by a company but put at the household's disposal.

Obviously, any fiscal measure targeting car use affects car owners much more than others. This is true of the fuel tax increase as well as the rise in toll and ferry fares.

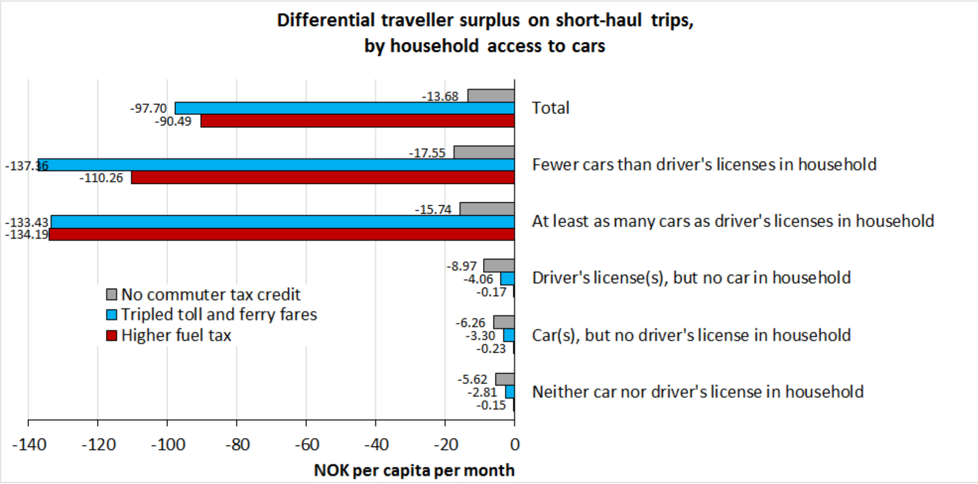

Fig. 5.17. Calculated per capita changes in traveller surplus on short-haul trips in the Oslo intercity region, under three policy scenarios, by household car ownership and driver's license holding.

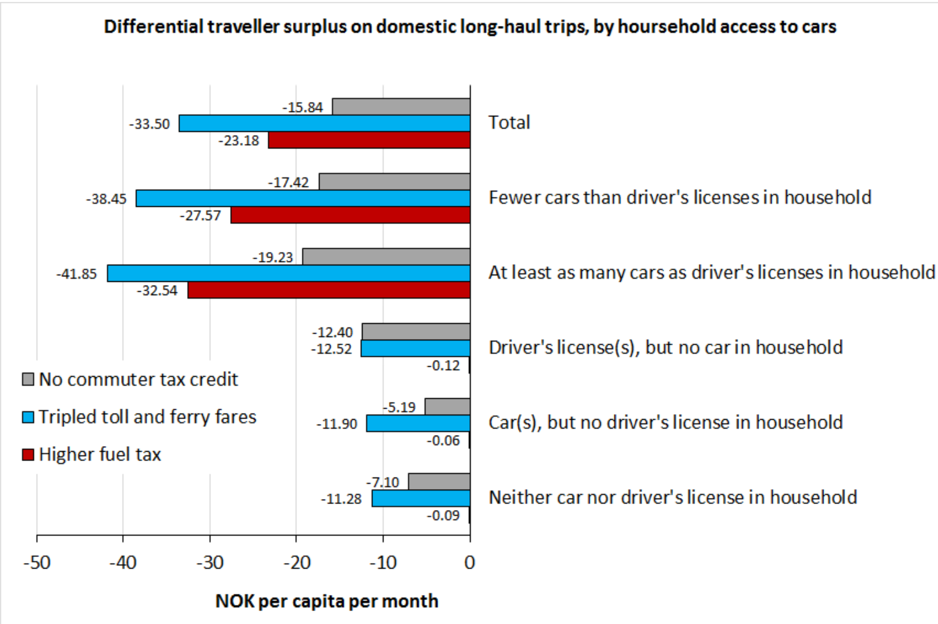

Fig. 5.18. Calculated per capita changes in traveller surplus on long-haul domestic trips, under three policy scenarios, by household car ownership and driver's license holding.

Revoking the commuter tax credit has a more evenly distributed effect across car ownership groups, since it affects public transport commuters as well as motorists. But even this measure is felt more strongly by families possessing a car and a license to drive it.

6 Car purchase modelling results

By means of the BIG discrete choice model of passenger car acquisition we have simulated six different policy options bearing on the automobile purchase tax. These are (confer section 2.4)

1. A 10 per cent increase in all purchase tax components.
2. A 10 per cent increase in the CO_2 component
3. A 10 per cent increase in the curb weight component
4. A 10 per cent increase in the engine power component
5. A revocation of the purchase tax exemption for BEVs
6. A revocation of the VAT and purchase tax exemptions for BEVs

Simulations are made on the basis of a benchmark calculated for 2014, as shown in Figs. 3.10 to 3.13. The model was calibrated so as to yield correct aggregate market shares for battery electric, hybrid electric, petrol and diesel driven cars, as well as for the Tesla make of BEVs. Since the Teslas stand out as rather more expensive than other BEVs, it was considered necessary, in a study focusing on the distributional effects of Norway's steep and convex vehicle purchase tax (Fig. 2.2), to account for these most expensive BEVs as accurately as possible.

6.1 Retail prices by segment

As shown by the left-most cluster of bars in Fig. 6.1, a 10 per cent increase in every purchase tax component would, if passed on entirely to the buyers, translate into an about 5 per cent higher retail price for the heaviest diesel vehicle model, and an about 4 per cent rise for large petrol driven cars. The model predicts that in this scenario, the average price of BEVs will go down, as BEV sales shift towards somewhat cheaper models[11]. Apparently, the cross-price elasticity of demand for BEVs is higher with respect to the cheaper petrol and diesel vehicle models than in the upper price brackets.

Obviously, when only one tax component changes, the resulting impact is smaller.

The introduction of purchase tax on BEVs will have only very moderate effects, since in most cases the CO_2 component will more than outweigh the weight component, while the power and NOx components will be zero. In fact, the average price of BEVs can be expected to fall, since demand is shifted away from the few models that are heavy enough to be affected more by the positive weight component than by the negative CO_2 component.

But if both exemptions – from VAT and purchase tax – were to revoked, the price increase for BEVs would be large – a full 22.8 per cent (note that in Figs. 6.1 and 6.3, the vertical scale has been cut at 6 or 8 per cent).

[11] Recall that the discrete choice model predicts market shares for individual vehicle models (Section 3.4). The effects shown in Figs. 6.1-6.10 pertain to aggregates of individual models.

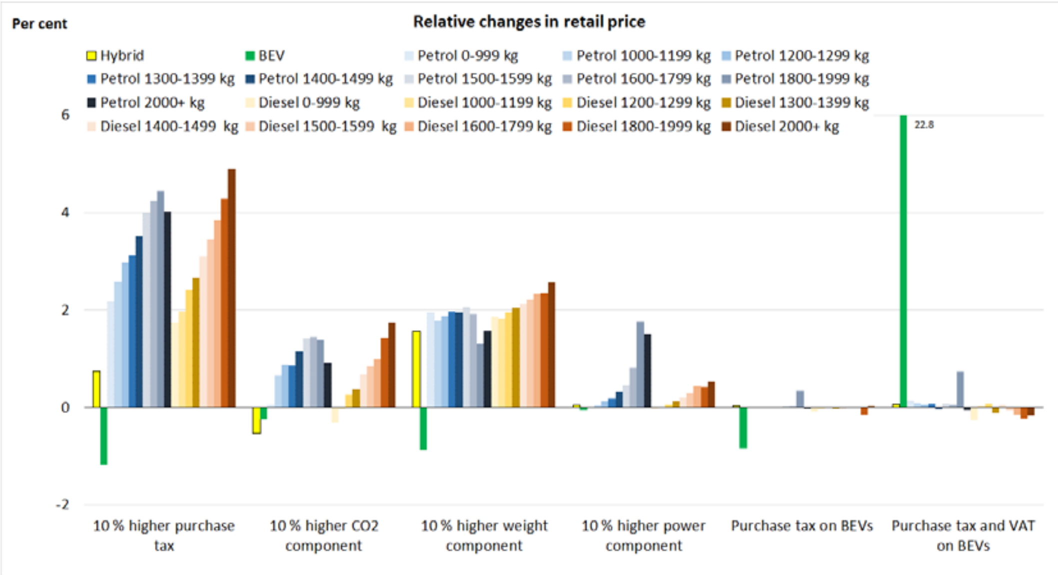

Fig. 6.1. Relative changes in fuel and weight segments' average retail prices under six fiscal policy scenarios, assuming that tax increases are passed on 100 per cent to buyers.

The market shares change, roughly speaking, in the opposite direction of prices (compare Fig. 6.2 to 6.1).

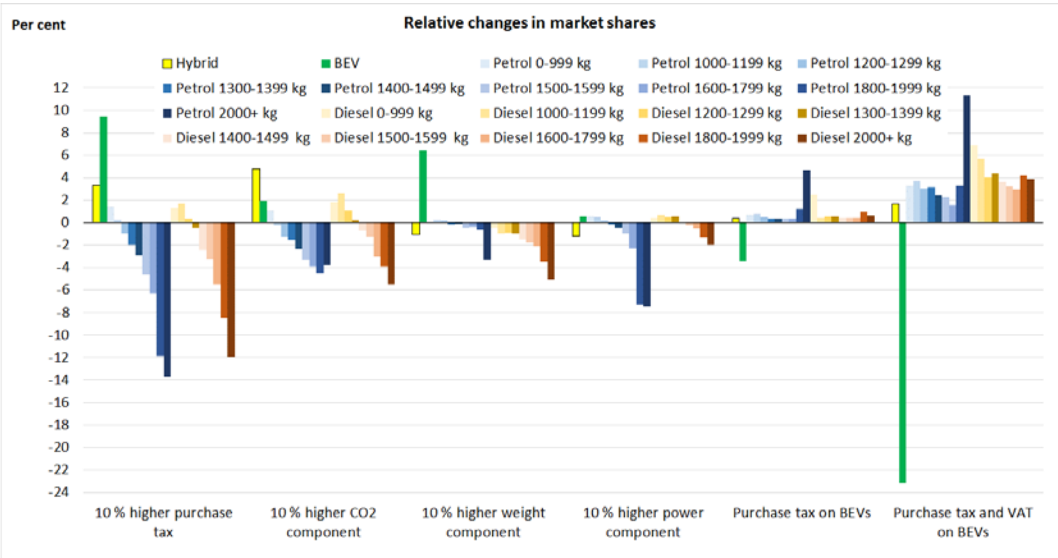

Fig. 6.2. Relative changes in fuel and weight segments' market shares under six fiscal policy scenarios, assuming that tax increases are passed on 100 per cent to buyers.

In Fig. 6.3, we report price changes by CO_2 emission bracket. The uniform 10 per cent increase in purchase tax components makes the least fuel efficient cars 6 per cent more expensive and the zero emission cars about one per cent cheaper. If only the CO_2 component is increased, low emission cars (emitting 1-99 gCO_2/km) will become cheaper, too – on average. An increased weight component will lead to 1.5-2 per cent higher average prices for of all cars accept the zero emission models.

Increasing the power component will have small price effects, except for 'fuel guzzlers'.

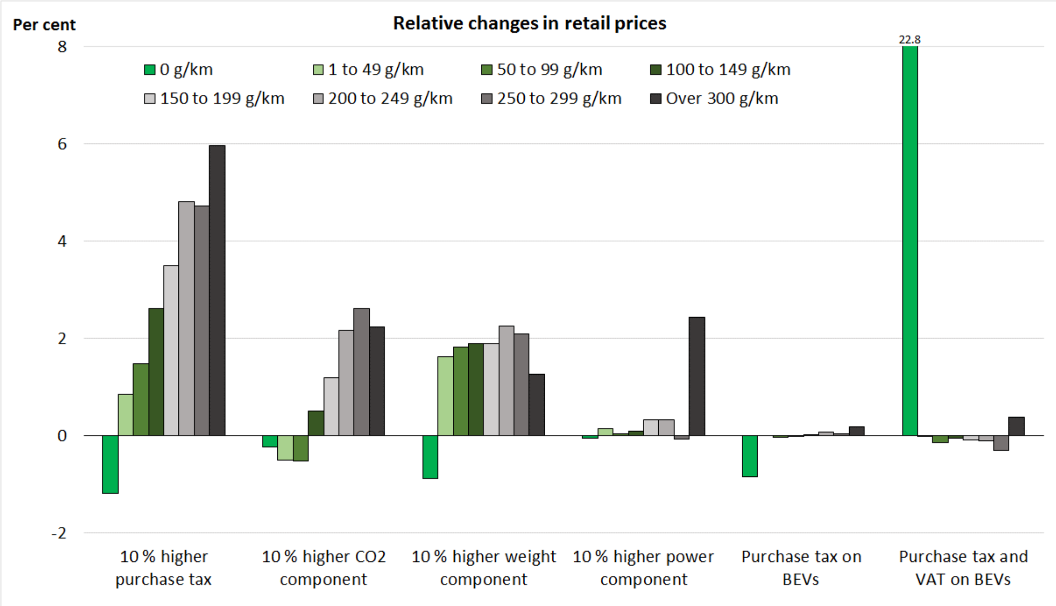

Fig. 6.3. Relative changes in average retail prices under six fiscal policy scenarios, by CO_2 emission interval, assuming that tax increases are passed on 100 per cent to buyers.

6.2 Type approval CO_2 emission rates

The associated changes in market shares by CO_2 emission bracket are shown in Fig. 6.4.

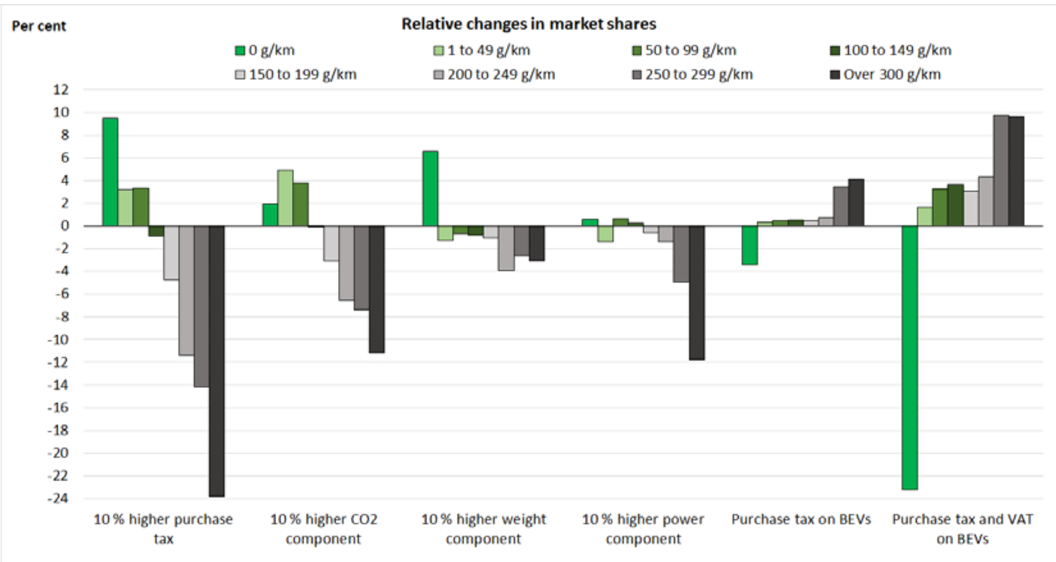

Fig. 6.4. Relative changes in market shares under six fiscal policy scenarios, by CO_2 emission interval, assuming that tax increases are passed on 100 per cent to buyers.

If all purchase tax components increase by 10 per cent, zero and low emission cars up to 99 gCO_2/km will enjoy higher market shares, while the fuel guzzlers will lose an estimated 24 per cent of their market. A similar, but more moderate pattern of change applies to the case where only the CO_2 component is increased. Even the weight and power components are seen to have some effect on the market shares of low vs. high emission vehicles.

The overall changes in average type approval CO_2 emissions from new passenger cars, under the six different policy scenarios, are shown in Fig. 6.5.

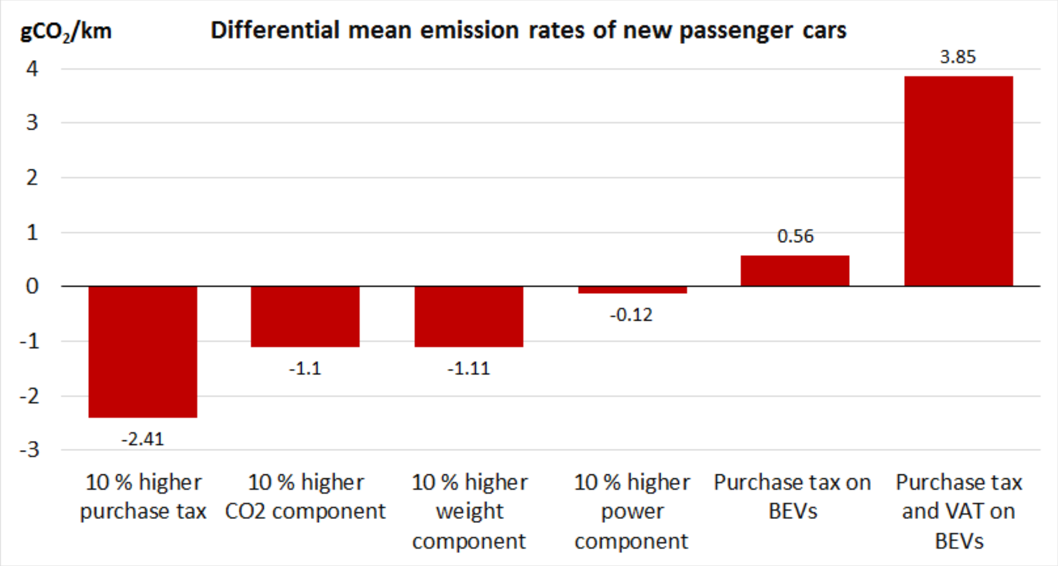

Fig. 6.5. Absolute changes in mean type approval CO_2 emission rates of new passenger cars, compared to reference case, under six fiscal policy scenarios.

A uniformly 10 per cent higher purchase tax will reduce the mean emission level by 2.4 gCO_2/km, or about 2.2 per cent compared to the reference level of 113.33 gCO_2/km. Increasing the CO_2 or weight component leads to a 1.1 gCO_2/km decrease in average emissions, while an increase in the power component will have very little effect on the CO_2 level.

Introducing a purchase tax for BEVs, identical to the one in effect for PHEVs, will lead to a moderate, 0.56 gCO_2/km increase in the average emission level of new cars.

If, however, both the VAT and the purchase tax exemptions are lifted, the result will be an estimated 3.85 gCO_2/km higher level of emissions. The VAT effect alone can be calculated as 3.85 – 0.56 = 3.3 gCO_2/km.

6.3 Distribution by price segment

Lacking household income data on the automobile buyers, the best we can do in terms of distributional analysis is to study changes by vehicle price bracket. High income earners would supposedly tend to buy more expensive cars than do the less affluent.

In Fig. 6.6 we show relative changes in automobile retail prices, broken down by price bracket, under the six policy scenarios.

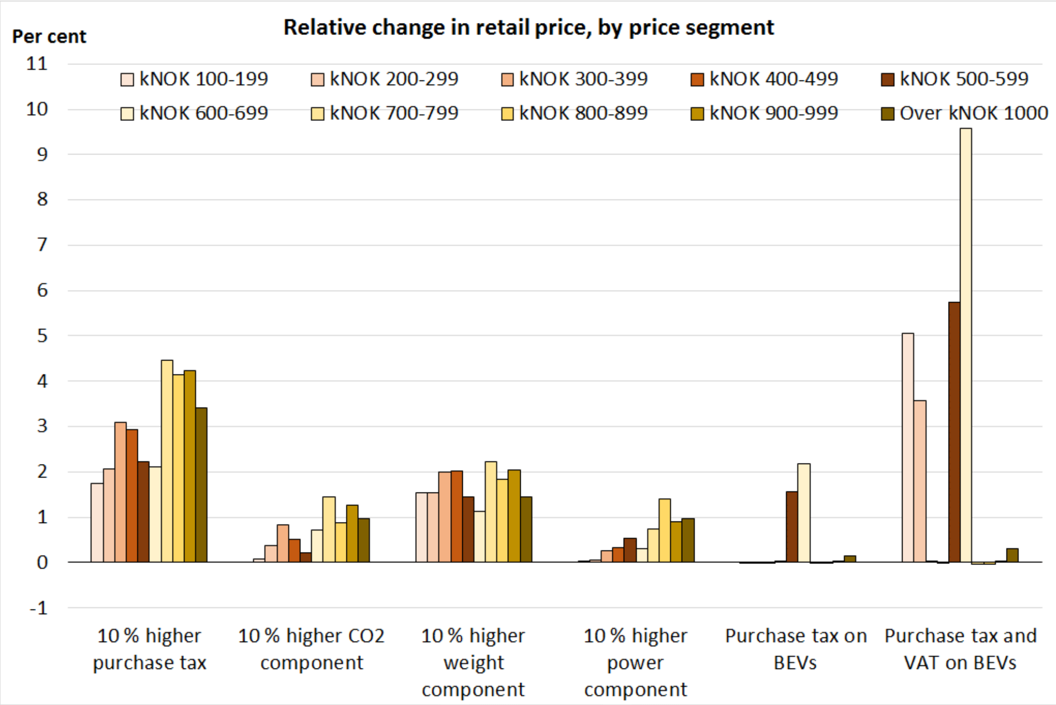

Table 6.6. Relative changes in automobile prices under six fiscal policy scenarios, by vehicle price bracket (kNOK 2010).

The uniformly 10 per cent higher purchase tax will translate, roughly speaking, into price increases of 2 to 4 per cent, assuming a 100 per cent pass-on to the buyers. There is tendency for the price of the most expensive cars to increase the most, but this relationship is not monotonous.

Similar, but less pronounced patterns are seen when only one component – CO_2, weight or power – is increased.

Introducing purchase tax on BEVs will primarily affect cars in the NOK 500-699 000[12] price segment, where the Teslas are.

Introducing VAT and purchase tax on BEVs will result in 4-5 per cent higher average prices the NOK 100-299 000 price segment, where the Nissan LEAF and the VW eGolf are, and a 6-10 per cent increase in the NOK 500-699 000 segment.

These price changes will, of course, affect the market shares, as shown in Fig. 6.7.

Generally speaking, increases in the vehicle purchase tax rates will boost the sale of cheaper vehicle models and reduce the sale of expensive ones.

Revoking the tax exemptions for BEVs will lead to higher sales in most price segments, but not in NOK 100-299 000 and NOK 500-699 000 brackets, where the BEV market shares are considerable.

[12] Reckoned in NOK 2010, this price bracket corresponds to NOK 550-770 000 when adjusted for inflation until November 2015.

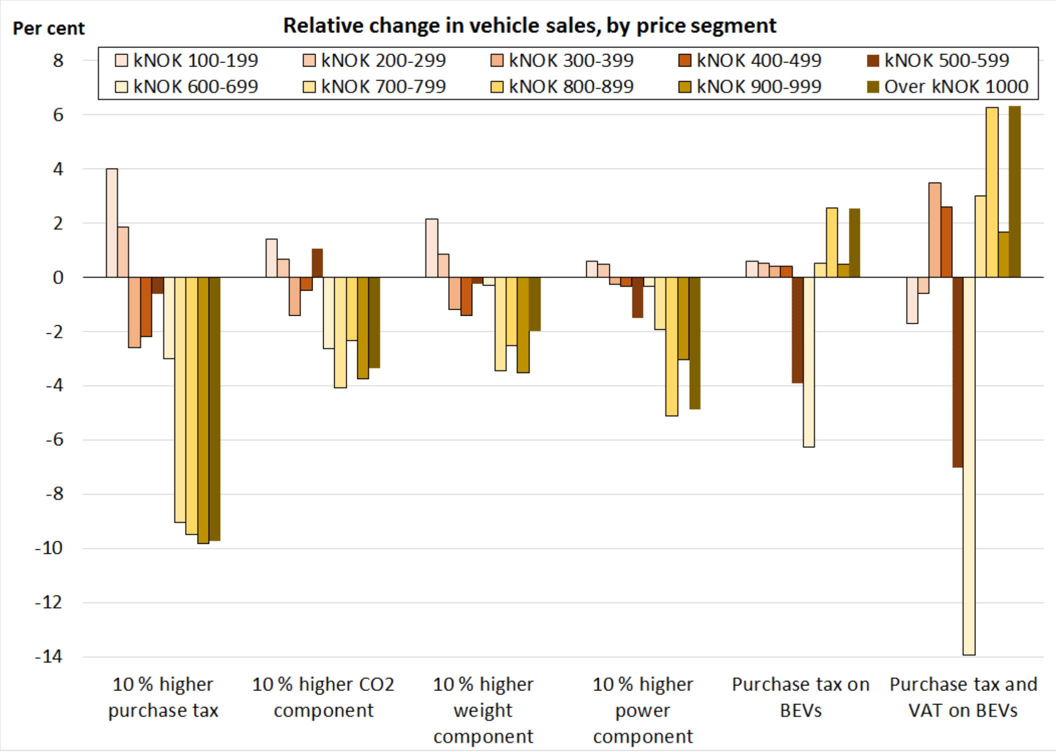

Fig. 6.7. Relative changes in automobile sales under six fiscal policy scenarios, by vehicle price bracket (kNOK 2010).

Although the predicted *relative* changes in sales are considerable, they are moderate as reckoned in *absolute* terms (Fig. 6.8, confer Fig. 3.11).

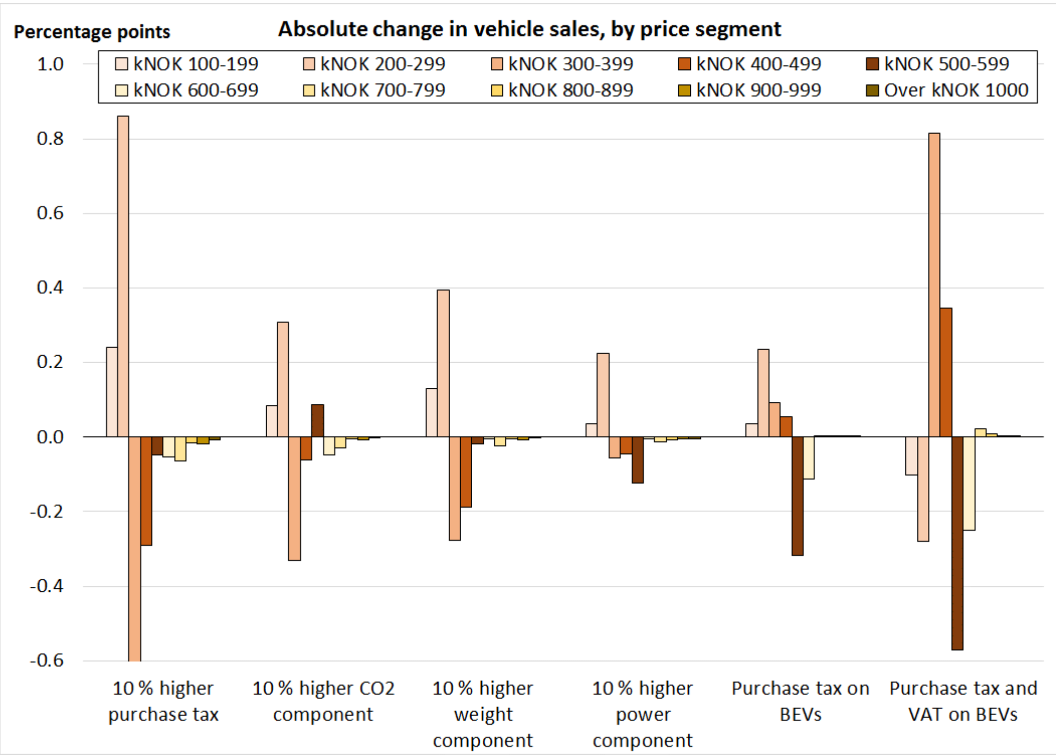

Fig. 6.8. Absolute changes in automobile sales under six fiscal policy scenarios, by vehicle price bracket (kNOK 2010).

How can these results be interpreted in terms of fairness or equity? Should we emphasize changes in price or in market shares?

We propose the following: Summarize consumer utility losses among buyers within each vehicle price bracket, by applying the rule-of-the-half just like in standard cost-benefit analysis. The change in price and the change in sales is all we need to use the rule. We shall refer to this measure as the '*pseudo* consumer surplus change', since we disregard the fact that the buyers within each price segment are not the same in the reference scenario as in any one of the policy scenarios.

The aggregate pseudo consumer surplus changes are shown in Fig. 6.9. In Fig. 6.10 we have divided the aggregate surplus change by the number of vehicles sold, so as to obtain values per buyer or transaction.

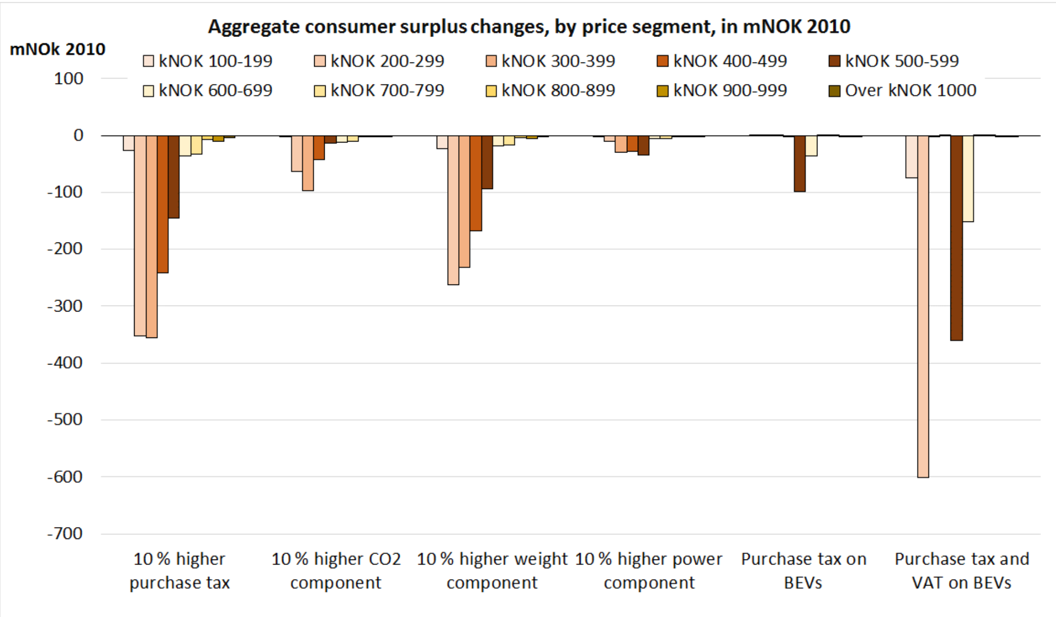

Table 6.9. Pseudo consumer surplus changes under six fiscal policy scenarios, by vehicle price bracket (kNOK 2010).

Apparently, a uniform 10 per cent increase in purchase tax is a progressive tax reform, in that the buyers of the most expensive models incur the highest extra cost per vehicle (Fig. 6.10). The same applies, although at a smaller scale, to increases in the CO_2, weight or power component of the purchase tax.

Introducing purchase tax on BEVs will primarily affect buyers in the NOK 500-699 000 price segment.

The last scenario, where VAT on BEVs is introduced in addition to purchase tax, will produce losses among buyers in the low price segments (NOK 100-299 000) as well as in the upper-mid-price segments (NOK 500-699 000), where the Tesla models belong. Tesla buyers incur the largest loss per transaction (Fig. 6.10). But larger aggregate losses are incurred by buyers in the lower price segments (Fig. 6.9). Most BEVs sold belong here. Thus the equity effect is somewhat ambiguous.

Had it not been for the Tesla models, a revocation of the VAT and purchase tax exemption would seem to be clearly regressive. The purchase tax itself and its BEV exemptions would, in other words, appear as progressive tax instruments, favouring buyers in the lower price segments.

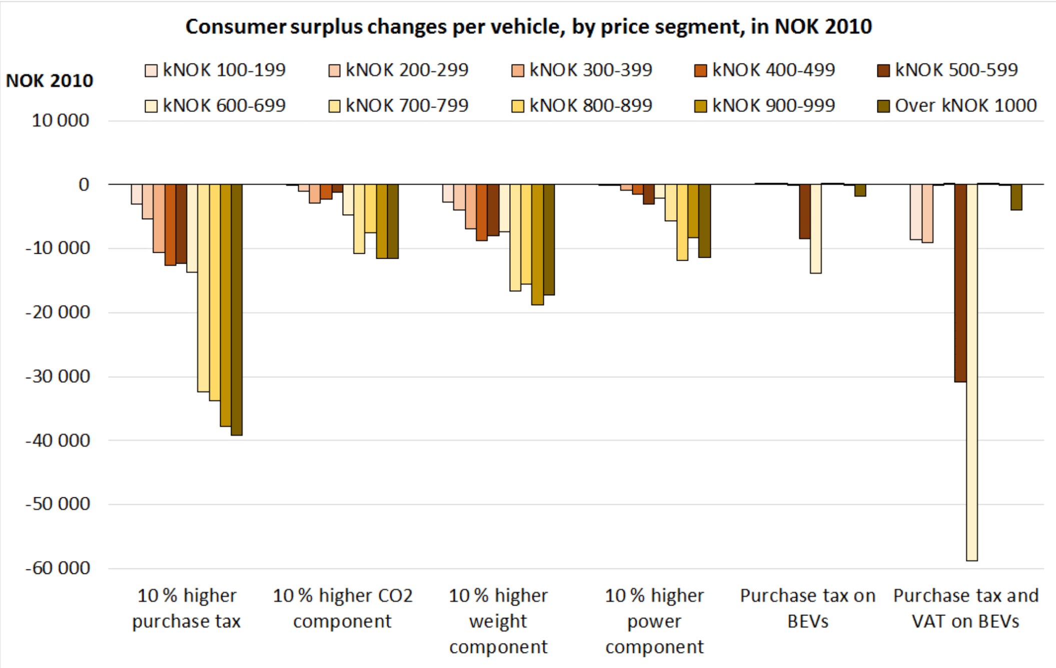

Table 6.10. Average per vehicle pseudo consumer surplus changes under six fiscal policy scenarios, by vehicle price bracket (kNOK 2010).

6.4 Public revenue effects

Since 2007, the vehicle purchase tax has been used as a climate policy instrument. In the first place, however, the purchase tax is a fiscal tool, whose main purpose is to collect funds for the central government.

In discussing changes to the vehicle purchase tax, one cannot therefore disregard the public revenue impact. In Fig 6.11, we show estimated changes in VAT and purchase tax revenue under our six fiscal policy scenarios, all of them in comparison to our reference scenario (benchmark).

Increasing all purchase tax components by 10 percent generates an extra NOK 742 million per annum for the public treasury, according to the model. Note, however, that the possible rebound effect in the form of lower aggregate car sales is not taken into account here, nor in any of the other scenarios studied.

Increasing the CO_2 component by 10 per cent will have comparatively small effects on the purchase tax revenue. The same is true of the engine power component. The weight component, however, is a potent one. Most of the revenue increase obtained by a uniform 10 per cent increase in all tax components is due to the weight factor.

Interestingly, the purchase tax exemption for BEVs reduces public revenue by only NOK 200 million – a small amount compared to the large numbers featured in multiple media announcements on the 'cost' of the electric vehicle incentives. Note, however, that our point of reference is a tax regime in which low and zero emission vehicles in general enjoy very much lower tax rates – especially if they are equipped with an electric motor – than do fuel guzzlers.

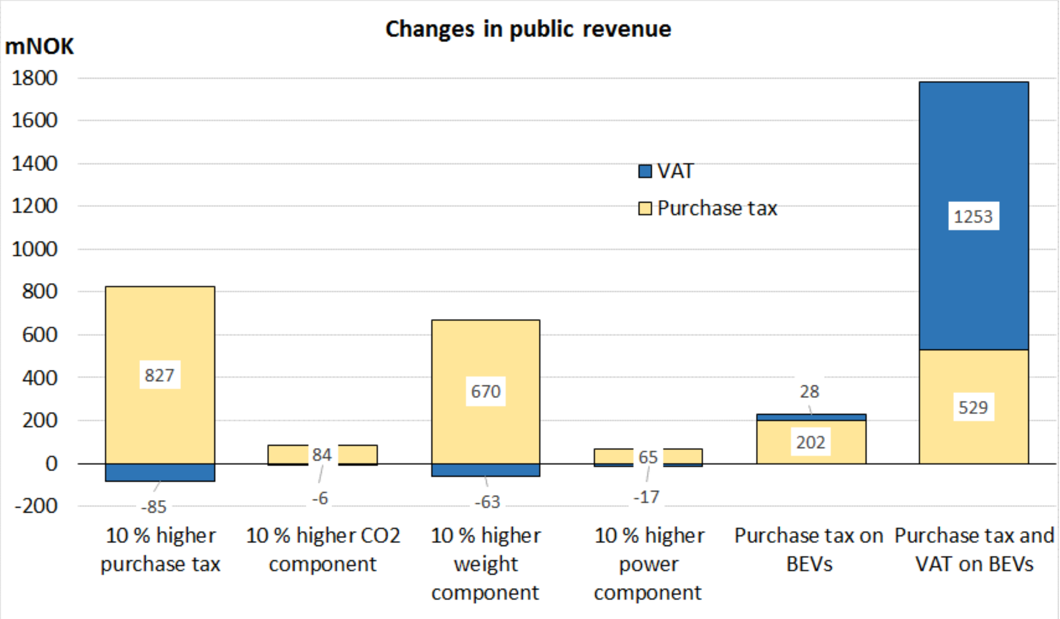

Fig. 6.11. Differential annual VAT and purchase tax revenue under six fiscal policy scenarios.

A much larger increase in public revenue would take place if the VAT exemption were lifted as well. In such a case, some car buyers would shift from BEVs to ICE vehicles (Fig. 6.2), whereby the purchase tax revenue would increase, not by NOK 200 million, but by more than NOK 500 million. A more than twice as large revenue increase would come from the VAT system[13].

The total revenue increase, of an estimated NOK 1 782 million, is still smaller than expected in view of certain press reports on the amount of 'subsidies' for BEVs.

It is interesting to consider Fig. 6.11 along with Fig. 6.5. The left-most scenario generates NOK 1.04 billion less revenue for the public and a 6.3 gCO_2/km lower type approval rate of emissions from new cars than does the introduction of VAT and purchase tax on BEVs.

In the long run, reduced emissions from cars will result in an almost proportional decrease in fossil fuel consumption and hence in fuel tax revenue. This effect is not included in our revenue calculations. A 6.3 gCO_2/km difference in emissions corresponds to roughly 2.5-3 ml/km lesser fuel consumption. For a car running 200 000 km before scrapping, the corresponding fuel savings are 5-600 litres over the vehicle's lifetime, with a NOK 2500-3000 reduced fuel tax bill. As applied to the 2014 cohort of new cars (144 202 vehicles), the lifetime fuel tax revenue difference between our two most extreme scenarios is around NOK 360-430 million. Since real-

[13] In Norway 2014, 47.4 per cent of new cars were registered to commercial businesses (source: www.ofv.no). Most of these firms are VAT registered. With the exception of taxi companies, however, corporate buyers are not allowed to deduct input VAT on automobiles in their VAT account. We have therefore included the full amount of VAT on automobiles in our revenue calculations.

world, on-the-road emissions for the 2014 cohort of cars are about 40 per cent higher than at the type approval test (Tietge et al. 2015), the real fuel tax revenue difference is probably as high as NOK 5-600 million over the vehicles' lifetime.

Under the same assumptions, the CO_2 emissions savings between the two fiscal policy alternatives, as reckoned for the whole 2014 cohort of vehicles over their entire lifetime, is 254 000 tonnes.

Obviously, an even larger reduction in CO_2 emissions could be obtained from an even more drastic increase in the purchase tax – say, a 20 per cent rather than a 10 per cent increase in the tax rate. Such a strategy would also generate public revenues comparable to those resulting from the reintroduction of VAT and purchase tax on BEVs.

7 Policy comparison and discussion

7.1 Shifts in travel behaviour

Network models of travel demand have been adapted and used to assess the equity implications of selected, potential GHG abatement measures as implemented in Norwegian transport. The three measures studied include (i) a NOK 0.20 km charge on private cars, or an equivalent increase in the fuel tax, (ii) a uniform 200 per cent increase in toll rates and ferry fares, and (iii) a revocation of the commuter tax credit for persons travelling more than 10 000 km per annum to and from their job.

All three measures result in comparable reductions in GHG emissions, between 80 and 120 000 tCO_2/annum on short distance trips in the Oslo intercity region, and between 12 and 17 000 tCO_2/annum in on long distance trips nationwide.

The cost efficiency and equity of these three measures differ, however, widely.

Apparently, the most cost efficient measure is the *revocation of the commuter tax credit*. When account is taken of reduced external costs and increased public revenue, the latter valued at a 20 per cent premium, the policy comes out with negative net economic costs, i. e. as socially profitable even before CO_2 abatement benefits.

An almost equally profitable measure is the NOK 0.20 increase in car km cost, be it on account of a new km charge or a *higher fuel tax*.

By far the least efficient GHG abatement measure considered is to *triple the toll and ferry fares*.

In terms of equity effects, however, the ranking between three measures becomes exactly opposite.

Revoking the commuter tax credit is a clearly regressive measure, in the sense that noticeably higher traveller surplus losses are incurred by people living in low income neighbourhoods. This is true for short (< 100 km) as well as for long (> 70 km) distance trips. A breakdown of traveller surplus effects by county confirms that taxpayers in the most remote regions will lose more from a tax credit revocation than people in the central urban areas.

The commuter tax credit is, in other words, in itself progressive.

A *fuel tax increase* will have similar distributional effects as a revocation of the commuter tax credit, although somewhat less pronounced. The highest costs are incurred by people living in neighbourhood with the lowest per capita income. Even this is true for short as well as for long-haul trips.

Families with children are somewhat harder hit by a fuel tax increase than are households without children. Males are harder hit than females, and persons aged 25-59 are harder it than the younger or older.

Increased road toll and ferry fares would affect the various parts of the population in more haphazard ways, depending on how many toll roads and ferry crossings are in operation in each region. In eastern Norway, the county of Vestfold appears to be the most strongly affected. The three northernmost counties are generally less affected by toll and ferry fares than the rest of the country.

Males are more affected by toll and ferry fares than are women. There are only small differences across household size and types.

Not surprisingly, all three policy measures affect car-owning households much more strongly than households without cars.

7.2 Shifts in car purchase behaviour

Previous studies based on Norwegian models and data (Fridstrøm & Alfsen 2014, Fridstrøm et al. 2015, Madslien & Kwong 2015) suggest that the elasticity of demand for fossil fuel is too small for politically feasible levels of fuel taxation to bring about sizeable GHG emission cuts. The large, upfront expenditure involved in buying a (more expensive) car is more likely to affect consumer behaviour than the relatively marginal extra cost caused by a fuel tax. Thus, Brand et al. (2013) find, in a comprehensive analysis of British incentives, that '… car purchase feebate policies are shown to be the most effective in accelerating low carbon technology uptake, reducing life cycle gas emissions …'

Their conclusion is corroborated by recent findings for Norway (Fridstrøm & Østli 2015). The high initial levels of VAT and vehicle purchase tax make it possible to create strong incentives without introducing direct subsidies. A continued application of these fiscal instruments may halve the CO_2 emissions from the automobile fleet within two or three decades.

Model simulations carried out in the present project shed light on the equity implications of such a policy. While our model cannot directly relate vehicle purchases to household or individual income, calculations differentiated by price segment show larger behavioural responses among buyers of the more expensive vehicle models. This suggests that the vehicle purchase tax is clearly progressive, as could be predicted from the fact that three out of four purchase tax component schedules are markedly convex.

The VAT and purchase tax exemptions for battery electric vehicles have made these vehicles affordable to a large part of the buyers. The great bulk of BEVs come out no more expensive than the smaller petrol and diesel driven vehicles offered. Hence, a revocation of the VAT and purchase tax exemptions would limit the choices available to the less affluent car buyers. Such a fiscal reform could therefore be perceived as regressive.

The VAT and purchase tax exemptions have, however, also given rise to large price benefits on some fairly expensive cars, such as the Tesla models S 60 and S 85. The buyers of these vehicles belong most probably at the high end of the income scale.

If and when the VAT and/or purchase tax exemptions are lifted, the overall equity effect will be dual. Consumer surplus losses will be shared between the buyers of relatively inexpensive models and those able to afford vehicles in the NOK 550-800 000 price range.

7.3 Caveats and qualifications

On account of imperfections in the modelling apparatus used in this study, results must be interpreted with some caution.

7.3.1 Income proxies

While our *travel demand* models fail to contain income data at the individual or household level, the best proxy available is the mean taxable income recorded in 2001 among residents within each 'neighbourhood' or basic statistical unit (BSU).

The validity of this proxy depends (i) on the relative income homogeneity of residents of a given BSU and (ii) on the temporal stability of regional and local income differentials. While both of these assumptions can be questioned, there is no doubt that there are large and permanent income differences between BSUs, since high income earners tend to cluster in certain zones, as do also low income earners. This phenomenon is closely linked to the so-called rent gradient, i. e. to the fact that housing rents are generally higher near the city centre, tapering off as we move out into the suburban and exurban areas.

In essence, our income proxy is a projection of the two-dimensional geographic map onto a per capita local income scale. It is thus a mixture between disaggregate income measurements and aggregate spatial variation.

For the *car purchase choice* model no income data are available. Instead we study effects by vehicle price segment. The validity of this proxy hinges on the assumption that household willingness to pay for vehicle quality is positively correlated with income.

7.3.2 External effects

Although we are primarily interested in private economic costs and their distribution, certain external costs have been taken account of in our calculations, so as to assess the net economic cost or benefit to society of the various policy measures considered.

Road use externalities

Thune-Larsen et al. (2014, revised 2016) have shown how private car use generates multiple externalities and estimated the average marginal external costs of petrol and diesel driven cars, respectively. While the fuel tax comes fairly close to internalising the external cost of petrol cars, the same is not true of diesel driven vehicles. Hence, policy measures that limit road use demand also serve to reduce negative externalities. When we take this into account, the net social costs of certain policies are turned into net benefits. This applies in three out of six cases studied. The end result is, in other words, sensitive to changes in the external cost assessment.

Cost of public funds

According to Pigou (1948), since nearly all forms of taxation distort the price signals in the economy, leading to reduced economic efficiency, public funds should be valued at a premium compared to private money. According to the Norwegian Ministry of Finance (2014), the premium should be set uniformly at NOK 0.20 per NOK 1 expenditure or revenue. However, Sandmo (1998) notes that unless the taxation system is already optimally designed as seen from a welfare economics point of view, the marginal cost of public funds depends on the tax instrument. Bjertnæs (2015) concludes, in a recent general equilibrium analysis of the Norwegian economy, that the rate is only 0.05 for general income taxation and VAT, but possibly as high as 0.20 for taxes on capital dividends and corporate profits.

Whether or not one takes account of the cost of public funds, and at what rate, can reverse the sign of the overall economic benefit. For the NOK 0.20 per km increased fuel tax option, the break-even premium on public funds is found to be NOK 0.118 per NOK tax revenue in the short-haul market and NOK 0.173 in the long-haul market. In other words, a rate as low as 0.05 would make this policy socially unprofitable before CO_2 abatement benefits.

For the abolishment of the commuter tax credit, the corresponding break-even points are negative in the short-haul market and 0.0165, i. e. is less than two per cent, in the long-haul market. Tripling the toll rates and ferry fares would remain unprofitable no matter what value is assigned to increased public revenue.

Wider economic effects

Our analysis is a partial one, that does not take into account possible repercussions outside the travel market or the automobile market. For instance, value added in the tourist industry may be negatively affected by higher fuel prices, toll rates or ferry fares, as visitors and vacationers choose other destinations than Norway. To assess such economy-wide effects, general equilibrium modelling would be needed.

Results under the 'abolished commuter tax credit' scenario are particularly susceptible to this kind of error. When the model predicts CO_2 emissions to go down in this scenario, it is primarily due to shorter commuting distances, in other words that people move, change jobs or cease to be employed. In all of these cases, a welfare loss can be expected over and above the traveller surplus change calculated. According to Venables (2007), job-seekers living outside the city trade off wage differentials against commuting costs. They may obtain a better paid job if willing to commute out of the local community. Increasing the cost of commuting means restraining the labour market, with negative effects on overall productivity. These effects have not been encompassed in our calculations. Thus, the economic cost of the 'abolished commuter tax credit' policy could be grossly underestimated.

When the 'tripled toll rates and ferry fares' scenario comes out as economically highly inefficient, this reflects a massive increase in the deadweight loss sustained at tolling stations and ferry crossings. In a few instances, higher toll rates may serve to internalise the costs of congestion, road wear, accidents, noise or local pollutants, but in the large majority of cases, Norwegian toll rates are already too high compared to the marginal external costs of using that particular road. Benefits are lost when a road is underused, especially if traffic is diverted into local road networks, where the nuisance caused by noise, accidents or emissions may be worse than on the toll road. Moreover, certain economy-wide general equilibrium effects may arise even in this scenario. Taken together, this suggests that the economic cost of tripling the toll rates and ferry fares may be even higher than suggested by the travel demand model.

Note, however, that the deadweight loss created by toll is roughly proportional to the square of the toll rate. The loss induced by a tripled the toll rate is thus out of proportion to the effect of more moderate increases, say a 50 per cent adjustment, which would generate just about one quarter of the gross benefits, but a roughly sixteen times smaller deadweight loss. Smaller changes in the toll rates and ferry fares would therefore not be as unprofitable, per unit of CO_2, as tripling the rate.

7.3.3 Rebound effects

When relative prices change, so does demand. Improved fuel mileage for private cars will, e. g., result in higher car travel demand. Part of the reduction in per km fuel use will be counteracted by more vehicle miles travelled. This is the so-called rebound effect (Schipper and Grugg 2000, Small and van Dender 2005).

In the output from the network travel demand models, rebound effects have, in principle, been integrated. In the car purchase choice model, they have not.

When certain car models become more expensive, as in the scenarios shown in Figs. 6.1-6.10, the aggregate demand for new cars goes down. The welfare and environmental effects of this are disregarded in our analysis, since our scenarios presuppose an exogenously given, constant aggregate demand for new cars. Only market shares are predicted in our car purchase choice model.

In an analysis of the French feebate system for new cars, D'Haultfoeuille et al. (2014) revealed a quite important rebound effect – so large, in fact, that the whole feebate scheme was found to be counterproductive.

While it is highly unlikely that the same would apply to any of our policy scenarios, one cannot exclude the possibility of certain rebound effects, leading to a somewhat smaller national automobile fleet when the purchase tax is increased. This would translate into a slightly lower amount of vehicle miles travelled and correspondingly lower fuel consumption and CO_2 emissions than what follows under constant aggregate car ownership. To unravel these relationships, a model for aggregate car ownership or aggregate new car sales would have to be developed.

7.3.4 Who bears the tax?

Another caveat concerns the assumed 100 per cent pass-on of purchase tax changes to customers in the form of proportional price variations. The degree to which retailers are able to pass on taxes will depend on the degree of competition in the relevant market, as expressed, e. g., by direct and cross-demand price elasticities. When the demand curve is more elastic (i. e., less steep) than the supply curve, the price paid by buyers will change less, in response to a tax wedge, than the price received by sellers. The sellers bear the tax more than the buyers.

Relying on the very same car purchase choice model which is used in the present report, Østli et al. (2015) derive example price demand elasticities for individual vehicle models or makes. Obviously, the elasticities depend strongly on the level of aggregation: The demand for a single vehicle model is more price elastic than the overall demand for a given make, which in turn would be more price elastic than broader categories of vehicles or, for that matter, aggregate automobile demand.

In Fig. 7.1 we show arc elasticities derived under two different assumptions: (a) that the price varies for only one Volvo model at a time, or (b) that all Volvo models have their prices increased by 10 per cent simultaneously.

Single Volvo models have estimated price elasticities in the range –4 to –1. But if we imagine that all Volvo models increase in price simultaneously, elasticities range from –3 to +0.3. That is, when all Volvo models become 10 per cent more expensive, some models will sell more, since more buyers than before will come to decide on the cheaper alternatives. Under this same assumption, the overall price elasticity of Volvo cars is estimated at –0.48 (Østli et al. 2015), assuming that no other makes have their prices changed.

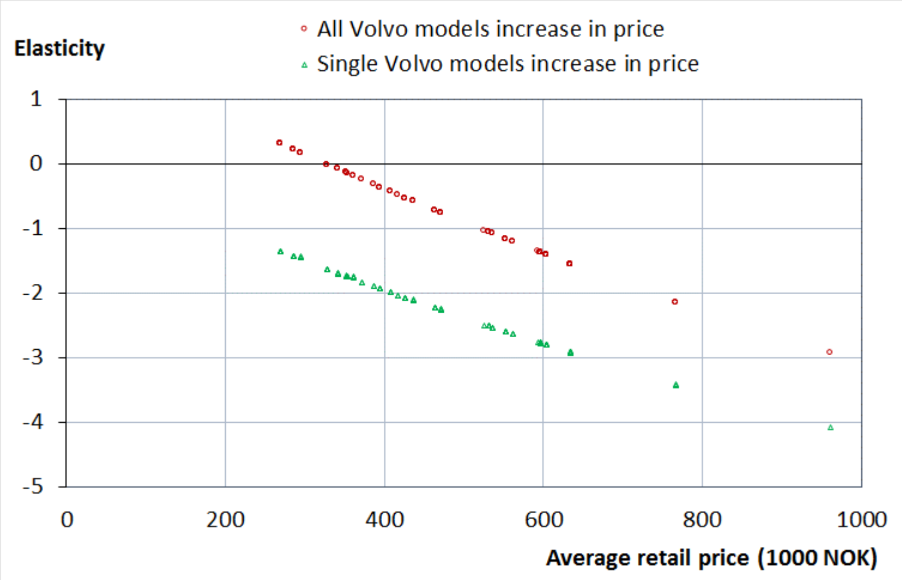

Fig. 7.1. Estimated price elasticities of demand for Volvo models as of 2010, plotted against the models' respective retail prices. 10 per cent arc elasticities. Source: Østli et al. (2015).

In the context of increasing vehicle purchase tax rates, simultaneous price changes will occur to all vehicle makes and models, and in similar ways for vehicles of comparable size, engine power, energy carrier and fuel mileage. Figs. 6.2, 6.4 and 6.7 actually predict the relative changes in sales occurring to broad categories of vehicles under the assumptions of constant aggregate sales and a 100 per cent pass-on of purchase tax changes.

To relax the assumption of a 100 per cent pass-on, a natural second step in this analysis could have been to iterate on the vehicle prices, starting from the 'first-round' market responses derived. Such an exercise has, however, been beyond the scope of the present report. To assess the changes in equilibrium prices and market shares, one would have to make assumptions about the vehicle supply elasticities. Since Norway represents only a small share of the global market for cars, almost negligible except perhaps for BEVs, it might not be unreasonable to assume that supply is highly elastic, in which case a purchase tax (increase) will be passed on almost entirely to the buyers.

Moreover, since all retailers and manufacturers sell several different vehicle models, and many dealers market more than one make, there is reason to expect a considerable amount of tactical and strategic pricing on the part of wholesalers and retailers. Prices may respond to taxation in ways that differ from textbook predictions.

Finally, to assess the final burden of taxation, a general equilibrium model is – again – called for. Changes in the car market may have spillover effects in, e. g., the markets for fuel, electricity, vehicle maintenance or labour. Quantifying these effects, and their possible distributional implications, has been outside the scope of our study.

8 Conclusions

8.1 Effects in the travel market

We have examined three different policy instruments aimed at reducing the CO_2 emissions from domestic travel in general and from private car use in particular. The instruments have been evaluated (i) by their CO_2 abatement effect, (ii) by their economic cost, and (iii) by their effect on equity, as measured in terms of income, gender, age, geographic region, household car ownership, and household size and structure.

Our findings are summarised in Table 8.1.

Table 8.1. Summary of results from travel demand modelling

	NOK 0.20 per km higher fuel cost	Tripled toll rates and ferry fares	Abolished commuter tax credit
Emissions reduction (tCO_2/annum)			
on short trips in and around Oslo	121	80	105
on long trips in Norway	15	17	12
Economic benefit on short / long trips (mNOK/annum):	149 / 27	-1624 / -1376	125 / 146
traveller surplus change	-2238 / -1249	-2387 / -1805	-293 / -838
operator and public revenue	1815 / 1014	519 / 305	192 / 794
road use externalities	209 / 59	140 / 63	188 / 31
economic value of public funds	363 / 203	104 / 61	38 / 159
Equity			
by per capita local income	clearly regressive	mildly regressive	strongly regressive
by county	less hard on Oslo, Rogaland, Hordaland	harder on Vestfold, less hard in north	much harder on remote regions
by gender	harder on males	harder on males	harder on males
by age	harder on aged 25-59/66	harder on aged 25-59/66	harder on aged 25-59
by household type	slightly harder on families with children	only small differences	only small differences
by access to cars	no impact on households without car	small impact on households without car	small impact on households without car

Out of the three policy options studied by means of travel demand models, the apparently most efficient one is the revocation of the commuter tax credit. When account is taken of known external effects, including the prescribed extra value assigned to public funds, this policy results in a net social *gain* before GHG abatement benefits of € 100-120 per tonne CO_2 in the short-haul market around Oslo and € 1 200-1 500 in the long-haul domestic market. The abatement cost is, in other words, negative.

Note, however, that our cost-benefit analysis is a partial one, disregarding effects outside the travel market. Higher commuting costs may result in a de facto contraction of the labour market, leading to loss of productivity. If present, such effects may well reverse the sign of the result, turning a net benefit into a net loss.

The NOK 0.20 per km increased fuel tax option results in very similar benefits in the short-haul market, but smaller benefits in the long distance market: € 180-220 per tonne CO_2. Even here, certain wider economic costs may be suspected, reducing the net economic benefit.

The by far least efficient option is to raise the toll rates and ferry fares. Here, CO_2 abatement comes at a *cost* a € 1 700-2 000 and € 8 000-10 000 on short, resp. long distance trips.

In terms of equity, however, the ranking the three options is completely reversed. Abolishing the commuter tax credit would be a strongly regressive fiscal policy measure, hitting low income and remote areas much harder than high income, urban neighbourhoods. The tax credit rule in itself is, in other words, distinctly progressive.

The fuel tax increase also appears to be regressive, although the pattern is less pronounced than for the commuter tax credit. Inhabitants of low income neighbourhoods travel longer distances, also by car, than those living in more well-to-do and central communities. They are therefore harder hit by a fuel tax increase.

The welfare impact of toll rates and ferry fares vary strongly by geography, but shows no characteristic pattern in terms of local income level.

Males appear generally harder hit than females by the policy options considered. There is no evidence of toll rates being particularly hard on families with children.

8.2 Effects in the automobile market

Turning to the fourth fiscal policy instrument considered, a 10 per cent increase in all four components of the vehicle purchase tax would reduce the average type approval emissions from new cars by an estimated 2.4 gCO_2/km as of 2014, equivalent to 2.2 per cent. BEV sales would grow by 9.5 per cent, while diesel vehicle sales would fall by 2.2 per cent (Table 8.2). Given the size of one cohort of Norwegian registered new cars, a 1 gCO_2/km reduced average type approval rate of emissions translates into 40 000 tonnes of avoided GHG emissions over the vehicles' lifetime.

Lifting the VAT and purchase tax exemptions for BEVs will, on the other hand, lead to a 3.85 gCO_2/km increase in mean emission rates. BEV sales will shrink by an estimated 23 per cent, while diesel vehicle sales go up by nearly 4 per cent. Cars emitting more than 250 gCO_2/km would sell about 10 per cent more.

The purchase tax exemption alone has a limited effect on sales, as compared to a tax regime where BEVs would be taxed according to the rules currently in effect for

PHEVs. Only the very largest BEVs, for which the weight component would more than offset the CO_2 deduction, would become subject to a positive purchase tax. The VAT exemption means a lot more for BEV competitiveness than the purchase tax exemption.

Table 8.2. Summary of results from car purchase choice modelling.

	10 per cent higher purchase tax	10 per cent higher CO_2 component	Purchase tax on BEVs	VAT and purchase tax on BEVs
New cars' type approval emissions (gCO_2/km)	-2.41	-1.10	+0.56	+3.85
Relative changes in sales				
BEV	+ 9.5 %	+ 1.9 %	- 3.4 %	- 23.2 %
Hybrid	+ 3.3 %	+ 4.8 %	+ 0.4 %	+ 1.7 %
Petrol	- 1.2 %	- 1.1 %	+ 0.5 %	+ 3.1 %
Diesel	- 2.2 %	- 0.6 %	+ 0.5 %	+ 3.8 %
1-49 gCO_2/km	+ 3.2 %	+ 4.9 %	+ 0.3 %	+ 1.6 %
50-99 gCO_2/km	+ 3.3 %	+ 3.8 %	+ 0.5 %	+ 3.3 %
100-149 gCO_2/km	- 0.8 %	- 0.1 %	+ 0.5 %	+ 3.6 %
150-199 gCO_2/km	- 4.7 %	- 3.1 %	+ 0.5 %	+ 3.0 %
200-249 gCO_2/km	- 11.4 %	- 6.5 %	+ 0.7 %	+ 4.3 %
250-299 gCO_2/km	- 14.2 %	- 7.4 %	+ 3.5 %	+ 9.8 %
over 300 gCO_2/km	- 23.8 %	- 11.2 %	+ 4.1 %	+ 9.7 %

It is often maintained that the generous fiscal incentives directed at BEVs have unwanted distributional effects, in that it allows certain wealthy buyers of high-end electric vehicles to get away with not paying any purchase tax.

The picture emerging from our analysis is more balanced. Around 78 per cent of the BEVs sold in Norway in 2014 were relatively inexpensive models, priced at less than NOK 300 000 (in NOK 2010). In 2015, the share of 'cheaper' BEVs was 84 per cent (www.ofv.no). Thus, the most dominant effect of the BEV tax exemptions is that consumers are offered a large new assortment of relatively affordable vehicles – cars that are also quite economical in use, since BEVs are three to four times more energy efficient than ICE vehicles, and since the retail price of electricity in Norway is lower than for fossil fuel, as reckoned per energy unit.

8.3 Equity and efficiency

The contradiction between equity and efficiency is a long-standing topic in politics and economics. Is it truth or myth?

Our study provides a few clues. The travel demand analyses rank the three climate policy instruments considered in the following order in terms of net economic benefit:

1. Abolished commuter tax credit
2. Higher fuel tax
3. Tripled toll rates and ferry fares

The difference between the two first options is comparatively small. Only the third option stands out as radically less profitable than the other two.

The equity analyses result in quite different rankings. In terms of inequalities in the traveller surplus loss in per cent of local per capita income, the ranking comes about in the exact opposite order:

1. Tripled toll rates and ferry fares
2. Higher fuel tax
3. Abolished commuter tax credit

As measured in relation to the local income level, abolishing the commuter tax credit represents a five to fifteen times higher burden on the low income neighbourhoods than on the most affluent.

Increasing the fuel tax by NOK 0.20 per km is also a quite regressive measure, with inequity ratios between three and seven, although less extreme than revoking the commuter tax credit.

Even the toll and ferry fares increase comes out as clearly regressive when evaluated in this way, but since the trend is not monotonous between the lowermost and uppermost income bracket, this result must be interpreted with more caution. Apparently, the inequity caused by increased toll and ferry fares is more a question of geography per se than of local income levels.

In summary, when policy makers are to choose among the above three options, the contradiction between equity and efficiency is as present as ever. In principle, however, the final equity effect will depend crucially on how the public revenue from tax, toll or ferry fares is being used. For some policy options, it might be possible to redistribute the increased public revenue in such a way that the final distributional effect would become progressive. At least this would be true of policies affecting travellers more or less in general, such as a fuel tax increase. A reduced VAT on food might, for instance, do the trick. It might be harder to design redistribution schemes to compensate the relatively few affected by an abolished commuter tax credit, or the relatively haphazard set of travellers hit by higher toll rates or ferry fares.

Some policy strategies may affect certain markets in addition to the travel market. These repercussions have not been taken into account in our appraisal. The abolishment of the commuter tax credit may, for instance, have the effect of restraining the labour market, resulting in reduced productivity. Rural dwellers may no longer want to commute for a well-paid job in the city, but prefer a lower paid job in the local community. It is conceivable that such effects could turn the net economic benefit into a net loss, in which case efficiency as well as equity would speak against the policy measure.

The vehicle purchase tax appears to be clearly progressive, as could be expected by the distinctly upward-bending form of its three large components. Since car buyers are, in principle, free to choose among all vehicle models offered in the market, one might characterise the vehicle purchase tax as a voluntarily progressive tax.

Here, the contradiction between equity and (climate policy) effectiveness seems much less pronounced, in that the option of even steeper and more progressive tax curves will also lead to markedly lower emissions from new cars.

If and when the VAT and purchase tax exemptions for BEVs are abrogated, the probably most important distributional effect will be that a number of comparatively cheap cars become generally less affordable. Although we cannot tell for sure who gain or lose by this, chances are that the less affluent car buyers will lose more, relatively to their income, than the wealthy. The BEV tax exemptions are, in other words, more appropriately seen as progressive than regressive, and their revocation would be a regressive fiscal measure. Again, there is no obvious contradiction between equity and GHG abatement results, since the BEVs exemptions are quite effective in bringing down the mean CO_2 emission rate of new cars.

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Visiting and postal address:
Institute of Transport Economics
Gaustadalléen 21
NO-0349 Oslo

+ 47 22 57 38 00
toi@toi.no
www.toi.no