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Would my driving pattern change if my neighbor were to buy an emission-free car?*

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Abstract

Aiming to reduce the number of brown (polluting) cars on the road, several countries currently promote the purchase and use of green (emission-free) cars through financial and non-financial incentives. We study how such incentives affect consumers who continue to drive brown cars. Using a simple model, we analyze the effects of policy instruments such as subsidizing green cars, taxing brown cars, and allowing green cars to drive in bus lanes. Car owners are influenced by price incentives as well as by external effects from traffic (such as congestion) both in regular lanes and in bus lanes. An extension of the model also considers how changes in local driving habits affect brown-car driving. We find that subsidizing green cars and allowing them to drive in bus lanes might increase brown-car driving. We also report the results of a recent survey containing questions specifically designed to tap the significance of the model's core mechanisms. The results are partially consistent with propositions derived from the model. While most brown-car respondents report their driving was unchanged after the implementation of the policies to promote green cars, some – particularly in major cities – report that these policies caused them to reduce or increase their driving. We conclude that some mechanisms in our model are more important than others and that certain mechanisms appear to influence different brown-car drivers in different ways. Overall, it seems that Norwegian policies to promote the transition from brown to green cars have somewhat reduced brown-car driving.

Keywords: Electric vehicles, environmental policies, external effects, habit formation, social norms

JEL classifications: D62, H23, Q54, R42, R48.

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1. Introduction

Aimed at influencing behavior, laws and policies are sometimes directed toward a specific group of agents. For example, lower-income families might be subsidized if their children attend a specific activity or educational program. Similarly, ethnic minority groups or a particular gender might be given priority for certain positions. In some cases, people are able to choose whether to be affected by a policy or which policy instrument to face, by selecting which group to join. Consider economic policy instruments designed to induce consumers to choose a green (environmentally clean) good over a brown (polluting) good. For instance, consumers picking the green good might receive a subsidy, while consumers opting for the brown good might face a tax. While the response of consumers opting for green goods is well researched, we know far less about how consumers of brown goods are influenced by polices aimed at stimulating consumption of green goods. This paper aims to help fill this gap.

Policies to mitigate greenhouse gas (GHG) emissions might influence agents not targeted by the policies, through externalities and changes in prices. For example, because technology spillovers might change a company's production possibilities and therefore its production decisions, policies aimed at promoting technology innovation might affect other companies than those targeted by the policy (e.g., competing companies in other countries).

Another way in which a policy or a law might influence non-targeted agents' behavior is by changing social norms, habits, or agents' sense of justice. If agents targeted by a policy change their behavior, non-targeted agents might also change their habits or alter their views concerning what is the dominant social norm, particularly if the targeted group has high social status. Moreover, if a policy is considered unfair, it might affect the behavior of the non-targeted group. For example, the non-targeted group might vote for a different political party in the next election or express dismay by behaving in a seemingly non-rational way.

In this paper, we study some effects of policies designed to promote the shift to a green economy. These effects might be intended or unintended. They are unintended if they affect the behavior in a non-desired direction; for instance, if the non-targeted group decides to behave less green. In particular, we focus on economic instruments and other regulations aimed at stimulating the transition to an emission-free transport sector. Such instruments and regulations typically offer benefits to consumers who buy and drive a green (emission-free) car, punish consumers who do not convert to a brown (petroleum-based) car, or both.

A policy instrument might affect the non-targeted group through externalities such as traffic congestion. However, consumers with social preferences will likely be affected differently by other agents' behavior than consumers acting in accordance with the standard *homo oeconomicus* model will be. In particular, they might be influenced by people who drive a different car type (e.g., status effects) or by the average driving habits in their neighborhood. An interesting and important question is, therefore, if the effectiveness of transport policies might suffer if they unintentionally also influence non-targeted consumers. The transport sector is responsible for a substantial share of global emissions;[1] hence, it is vital that policies aimed at reducing emissions from this sector be effective. Globally, almost all energy used in the transport sector comes from petroleum-based fuels; however, this sector – particularly road transport – has started a transition to non-fossil energy (electricity, hydrogen, biofuels).

We present a simple model that includes two types of representative consumers, one driving a green car and the other driving a brown car. The consumers are identical apart from their preferences concerning the choice of car. Policy instruments such as subsidies, taxes, and permission to drive in bus lanes also affect this choice. Consumers gain utility from driving and disutility from traffic congestion, which is a flow externality. We find that subsidizing green cars increases green-car driving. It therefore also increases congestion, which reduces brown-car driving. Taxing brown cars reduces brown-car driving, and makes green cars more attractive, which has an indeterminate effect on congestion. Permitting green cars to drive in bus lanes increases the share of green cars. However, it also reduces congestion in regular lanes, thereby making brown-car driving more attractive. This effect is reinforced by more bus lane traffic, which slows down buses and reduces demand for public transport. These results are illustrated by numerical simulations. Finally, if brown consumers are motivated by other consumers' behavior (e.g., through the average level of driving in the neighborhood), more mileage driven by green consumers might incentivize brown consumers to drive more, thereby dampening the effect of congestion.

[1] In 2010, the transport sector was responsible for 14% of global GHG emissions (IPCC 2014), while in 2016 it contributed 27% of the total EU-28 GHG emissions; see EEA (2018). For Norway, the share is even higher: in 2017 about 29% of GHG emissions came from inland transport; see https://www.ssb.no/klimagassn/.

We also report some empirical evidence on the effects of Norwegian policies aimed at stimulating consumers to purchase and drive electric vehicles (EVs). Norway is a leading country in the transition from petroleum-based cars to electric cars. A comprehensive subsidization program (including tax exemptions and local benefits) reduces the cost of purchasing an EV and makes green-car driving inexpensive. At the same time, brown cars are being heavily taxed. By the end of 2017, the aggregate share of EVs in the fleet remained as low as 5%;[2] however, it has grown rapidly in the last few years, and in 2017, EVs constituted about 20% of new car sales (Autosys 2018). EVs are so far most common in and around cities, because the benefits have been considerably more significant there than in rural areas. Norway's ambitious policies to increase the share of EVs make it a good case for studying the induced effect of EV-enhancing policies on the behavior of brown-car drivers.

We present new survey data on the impacts of Norwegian EV policies on brown-car driving. While broad in scope, this survey contained some questions specifically designed to tap EV policies' influence on brown-car drivers' driving habits. Whereas some brown-car drivers report to have reduced their driving because of the EV policies, a few report to have increased their driving. The results are largely consistent with two of the four core mechanisms of the model. A third mechanism does not generate a clear prediction, while the prediction generated by the fourth mechanism receives at best moderate support. Another finding is that different mechanisms appear to work differently for different consumers.

Building on the literature on externalities (see, e.g., Cornes and Sandler, 1996), our work contributes to the literature on traffic congestion. Scholars in this field study the causes and effects of congestion as well as the influence of various measures to reduce it. For example, using a dynamic model, Bando et al. (1995) identify conditions under which "spontaneous" congestion might arise. Moreover, Arnott and Small (1994) show how strategic traffic behavior might entail paradoxical effects concerning congestion (for example, enlarged road capacity might *increase* travel time). Thus, they argue that common-sense solutions to congestion might well fail to solve the problem. Finally, using Southern California as an example, Barth and Boriboonsomsin (2008) study the relationship between congestion and CO_2 emissions from road traffic. They find that emissions might be reduced by 20% through

[2] Norway has the highest market share of EVs in the world, while China has the largest market (IEA 2017).

(1) curbing the most severe congestion, (2) reducing excessive free-flow speeds to more moderate levels, and (3) reducing stop-and-go traffic.

Our paper also contributes to the literature on unintended effects of policy instruments. As documented by behavioral economics, a tax (or a fee) might not produce the intended effect if it also affects non-monetary motivations. In particular, a monetary incentive might crowd in or crowd out the motivation to carry out this task (see, e.g., Frey and Oberholzer-Gee (1997) and Gneezy and Rustichini (2000)). Some unintended effects might also be explained in a standard homo oeconomicus setup. When it comes to transportation policies, Davis (2008) found that policies aimed at enhancing Mexico City's air quality in 1989 had two unintended effects. Banning drivers from using their cars one day per week (based on the last digit on their cars' license plates) caused not only the size of the car fleet to increase but also a shift toward high-emission cars because many drivers bought an additional – often older, cheaper, more polluting – vehicle to be able to continue driving every day. Another example stems from France, where a combination of subsidies for low-emission cars and a purchase tax on high-emission cars was introduced in 2008 to reduce emissions. D'Haultfœuille et al. (2014) found that these policies led to a shift toward low-emission cars, but the total number of cars also increased, leading to higher emissions. Similarly, Zhao (2018) finds that at the partial equilibrium level, policies to promote high-occupancy vehicle lanes reduce congestion and emissions. However, at the general equilibrium level, such policies have little effect, because they reduce transportation costs, thereby causing urban sprawl and hence more driving.

Thirdly, our work is related to the literature on habit formation, social norms, and identity. While the absolute level of goods constitutes the main carrier of utility in neoclassical economics, behavioral economists have introduced external and internal reference levels in utility functions (e.g., Frank 1989; Rabin 1998). An example of external reference levels is status seeking, whereby individuals compare themselves with others. In contrast, examples of internal reference levels include habits, addiction, and adaptation, whereby the utility of current consumption depends on past consumption levels (Becker 1992) or the utility of current health depends on past health levels (Gjerde et al. 2005). Similarly, a social norm could be seen as a reference point, a rule, or a standard that governs behavior (Bierstedt 1963) and might be represented as a distribution of earlier behavior (Acemoglu and Jackson 2015). Acemoglu and Jackson (2017) represent an external norm as the expected behavior in the population, where this expected behavior has important payoff consequences for the individual. In contrast, internal norms are based on moral reasons and might be related to the identity or self-image of the individual (Akerlof and Kranton 2000; Brekke et al. 2003).

Lastly, our work contributes to the literature on peer effects and bandwagon effects. Individual outcomes correlate strongly with group average outcomes. For example, there might be a social spillover often interpreted as a peer effect (see, e.g., Angrist 2014). Moreover, a bandwagon effect might exist if a consumer demands more (or less) of a good – at a given price – when other consumers demand more (or less) of this good (Leibenstein 1950: 190). A neighbor effect demonstrated by Kuhn et al. (2011) concerns the Dutch Postcode Lottery, where winners are selected based on their postcode, and cash and a new BMW are distributed to winners. While winners often covert their new BMW into cash, their expenditures on cars and other durables tend to increase. Interestingly, this increase also caused the winners' neighbors to increase their car consumption.

The rest of this paper is organized as follows. In section 2, we review existing literature on what factors motivate the decision to purchase an EV, as well as how the purchase of an EV influences the buyer's driving pattern. In section 3, we present a simple model and derive a set of propositions concerning how public-policy-induced changes in green-car owners' driving patterns might change the driving patterns of brown-car users. In section 4, we provide some empirical evidence. Finally, in section 5 we conclude.

2. Literature review

In this section, we review the existing literature on two related research questions concerning electric (and hybrid) vehicles. The first is what factors motivate the decision to purchase an EV. The second is how the purchase of an EV influences the buyer's driving patterns.

2.1. Factors influencing the purchase decision

Numerous scholars have found that a multitude of factors might influence the decision to buy an EV. These factors include purchase price and operating costs (including subsidies), fossil fuel taxes, non-tax incentives (such as free parking and permission to drive in bus lanes), mandatory compatibility in charging standards, density of charging stations, social norms, consumers' environmental values, and consumers' interest in new technology (see, e.g., Mille et al. 2014; Kahn 2007; Ozaki and Sevastyanova 2009; Tran et al. 2012; Li 2016; Greaker and Kristoffersen 2017; Springel 2017).

For example, Tran et al. (2012) find that the purchase decision is influenced by the consumer's interest in new technology as well as by financial benefits, environmental values, and policy-related benefits. Ozaki and Sevastyanova (2009) report that financial benefits constitute an important motivating factor for the purchase of a (hybrid) EV, while emphasizing that the nature of social norms and the consumer's willingness to comply with such norms are also influential. Li (2016) shows that mandating compatibility in charging standards is likely to expand the size of the market for EVs (see also Greaker and Kristoffersen 2017). Finally, Kahn (2007) finds that in California, environmentalists are more prone to purchase an EV than non-environmentalists are.

Based on an extensive literature review, Rezvani et al. (2015) organize the factors influencing the purchase of an EV in five categories:

(1) "attitudinal" factors (e.g., advantageous ownership and operation costs);
(2) "environmental" factors (e.g., a desire to contribute to protecting the environment);
(3) factors related to "innovation adaption" (e.g., seeing EVs as the cars of the future);
(4) "symbolic" factors (e.g., buying an EV to express one's identity);
(5) "emotional" factors (e.g., positive feelings associated with driving an EV).

While these and other studies have identified a large number of relevant explanatory factors, yet others have attempted to determine the relative importance of different factors. A particularly interesting finding for policy makers is that the type of incentive seems as important as the incentive size. For example, Gallagher and Muehlegger (2011) study the relative effectiveness at the US state level of political measures such as sales tax waivers, income tax credits, and non-tax incentives. They find that, conditional on value, sales tax waivers tend to produce an increase in sales of (hybrid) EVs that is ten times greater than the sales increase produced by income tax credits. Springel (2017) reports an additional result that supports the same general point: NOK100 million spent on subsidies for charging stations produces an increase in EV sales that is twice the increase produced by NOK100 million in price subsidies. A similar result is reported by Wang et al. (2017), who find that in China, "convenience policy measures" (such as sufficient charging infrastructure) are more important than financial incentives and relevant information (e.g., concerning vehicle reliability) for motivating consumers to buy an EV.

Egbue and Long (2012) find, based on a survey, that concerns for sustainability and the environment influence the purchase decision; however, such concerns rank below concerns about financial costs and vehicle performance. Noppers et al. (2014) use both a "direct" method (asking the respondents) and an "indirect" (regression-based) method to study the relative importance of symbolic, instrumental, and environmental factors on the purchase decision. The direct method suggests that symbolic factors (e.g., a desire to signal that one is a green person) are less important than are instrumental factors (e.g., the price or the number of seats) and environmental factors (e.g., EVs' effects on the environment, compared to other cars). Interestingly, the indirect method indicates that instrumental factors are less important than symbolic and environmental factors are. Thus, the results are not particularly robust.

Finally, a selection effect based on driving habits might entail that the choice of car does not depend only on the factors mentioned above. In a Dutch study, Hoen and Koetse (2014) find that consumers' preferences for alternative-fuel vehicles, including EVs, decrease substantially with increasing annual mileage, which is unsurprising because most EVs still have a rather limited range. A limited range is less of a problem for consumers with low annual mileage; hence, such consumers might be overrepresented among early adopters of EVs. Nevertheless, survey results for Norway suggest that EV owners on average have a longer commute than those driving a diesel or gasoline car have (Figenbaum and Kolbenstvedt, 2016). This apparent contradiction with Hoen & Koetse's (2014) results may be explained by the fact that many Norwegian EV owners also own a petroleum-based car for use on weekends and holidays. Such a two-car solution was not an option in Hoen and Koetse's (2014) study.

2.2. How purchasing an EV influences driving

The second research question – how the purchase of an EV influences the buyer's driving pattern – has so far received less attention than the first has. Moreover, scholars focusing on this second question have almost exclusively focused on Norway, presumably because of Norway's role as a front-runner in stimulating the purchase and use of EVs.

In an early study based on a survey of 600 EV owners and 600 randomly sampled license holders in the three biggest Norwegian cities, Rødseth (2009) finds that the purchase of an EV caused the buyers to increase their car use. A related result is reported by Figenbaum et al. (2014), who find that EV owners in Norway on average drive longer per day than owners of internal combustion engine vehicles (ICEVs) do. In their survey, the number of respondents who increased their driving distance after purchasing an EV outweighed by a factor of about three the number who reduced their driving distance.[3] Finally, again using a survey, Figenbaum and Kolbenstvedt (2016: 44) find that the average daily distance driven by owners of battery EVs (BEVs) was roughly 30% longer than the corresponding distance driven by owners of plug-in hybrid EVs (PHEVs) and by owners of ICEVs.[4]

Why do EV owners drive more?[5] First, the operating costs of driving an EV are only a small fraction of the costs of driving a fossil-fuel-driven car (e.g., Millo et al. 2014). Second, many respondents report a switch from public transportation to their new car after purchasing an EV (Rødseth 2009). For example, in Norway BEVs constitute an attractive option for commuters, because they are eligible for free parking in many public parking spots, exempt from paying tolls, and permitted to drive in bus lanes. Finally, purchasing an EV seems to reduce the buyer's sense of moral obligation to limit car driving (Klöckner et al. 2013).

In summary, much scholarly work has considered consumers' motives for purchasing an EV. Moreover, some research has considered how the purchase of an EV influences car use. In contrast, few (if any) studies have thus far considered how the increased use of EVs might influence the use of fossil-fuel-driven vehicles. We aim to contribute to closing this gap.

3. The model

Assume that two types of cars are available – *green* (g) and *brown* (b). The green type is largely emissions free, while the brown type creates air pollution through combustion of fossil fuel. This pollution entails local environmental effects (e.g., particulates, sulfur, NOx) as well

[3] However, a majority of respondents reported that their average driving distance remained unchanged after switching from an ICEV to an EV.

[4] Note that the relative difference in average yearly driving is smaller (within 5%) than the difference in daily driving, because many EV owners do not use their EV for vacations and holidays.

[5] Although most scholars seem to take the direction of causality for granted, it is important to remember that purchase is endogenous. Thus, it is not obvious if the purchase of an EV causes more driving or if drivers who are planning to increase their driving tend to purchase an EV, see section 2.1 above.

as global environmental effects (CO_2). Assume that the government wants to reduce emissions from transport by increasing the share of green cars.[6]

We first present and analyze a model based on standard *homo oeconomicus* assumptions. We then consider an extension that includes social preferences.

3.1 A homo oeconomicus model

The number of consumers (car owners) is fixed and normalized to one for simplicity. Each consumer must choose between a green car and a brown car (we disregard the possibility of having more than one car). The choice depends on the consumer's preferences, for instance concerning environmental protection and new technology. Consumers also care about financial benefits and other benefits that facilitate the use of a green car (see section 2.1). We assume that, for each consumer, a tipping point exists where the consumer will switch from a brown to a green car. This tipping point depends on the preferences for driving a green car and can be reached by providing sufficient incentives for green-car driving. Moreover, consumers are heterogeneous in the sense that the location of their tipping point varies. This variation can be thought of as a fixed addition to the utility function that does not influence the driving or consumption decisions. This fixed addition is omitted in the utility function below, because it has no bearing on the driving decision, which is the focus in our analysis.[7]

Given the choice of car, the utility function of a consumer driving car *i* (*i* = *g*,*b*) is

[6] In reality, green cars such as EVs also create local pollution (e.g., particulates), but to a lesser extent than brown cars (diesel and gasoline cars) do.

[7] One possible formalization of this is the following. Assume that the utility function for a consumer *j* driving a green car equals $U_j = V\left(x_j, c_j, y_j, G\right) + K_j$, where K_j is the additional utility of driving a green car (the notation is explained below). For consumers driving a brown car, we then have $U_j = V\left(x_j, c_j, y_j, G\right)$. K_j can be positive or negative, and differs across consumers because it depends on individual preferences on, for instance, environment and technology (see section 2.1 above). Given the utility function, the consumer face a two-stage decision. In the first stage, the consumer has to decide which car to drive, and in the second stage, the consumer has to choose how much to drive. The choice of car is a choice between two budget constraints, one for green cars and one for brown cars (see below). Thus, which budget constraint (car) the consumer chooses depends on both the financial incentives and the value of K_j. In the text, we solve the model backwards focusing on the second stage, the driving decision. $V\left(x_j, c_j, y_j, G\right)$ is specified in equation (1), where we omit the constant term, K_j, in the utility function, as mentioned in the text.

(1) $u\left(x_i, G\right) + v(y_i) + w(c_i), \quad i = g, b$

$$u'_{x_i} > 0,\ u''_{x_i,x_i} < 0, v'_{y_i} > 0, v''_{y_i,y_i} < 0,\ w'_{c_i} > 0,\ w''_{c_i,c_i} = 0,$$

$$u'_G < 0, u''_{G,G} < 0, u''_{x,G} < 0,$$

where *x* is kilometers driven by car, *y* is kilometers traveled with public transport, *c* is consumption of other goods, and *G* is a local public bad creating a negative flow externality.[8] As mentioned, all consumers are assumed identical, except regarding their preferences concerning car type.

We further assume that the total demand for transport is completely inelastic, so that the demand for public transportation is determined by the demand for driving a car. For simplicity, the total demand for transport is set equal to one, that is, $0 \le x_i \le 1, i = g, b$:

(2) $y_i = 1 - x_i, \quad i = g, b$

The public bad can be traffic congestion or accidents that follow from the number of cars on the road. The higher the public bad, the lower is the marginal utility of driving. The *G* function can therefore be specified as

(3) $G = n\left(s,t\right)x_g + (1 - n\left(s,t\right))x_b$,

where $0 < n < 1$ is the share of consumers driving a green car. In line with the literature review in section 2.1, we assume that this share is increasing in the policy instruments; a subsidy for green cars (*s*) and a tax on brown cars (*t*).

[8] Note that when $w''_{c_i,c_i} = 0$, the utility function is a variant of the quasi-linear utility function, which is a standard utility function in transport economics; see, for example, Börjesson et al. (2017) and Wangsness et al. (2018). The advantage is that the income effect of price changes can be ignored, and therefore, we do not include recycling of tax revenues in the budget constraints below. This specification can be justified because transport accounts for a small share of total consumer expenditures (typically 10–20%). In Norway, it has been between 15% and 20% over the last 15 years (see https://www.ssb.no/inntekt-og-forbruk/artikler-og-publikasjoner/lite-endring-i-forbruksmonsteret).

Without public policies, the total cost per mile of driving a green car equals *r*, and the corresponding cost of driving a fossil-fuel-based car equals *p*. Thus, the unit cost of driving a green car after public policies are implemented equals $r(1-s)$, where *s* is the subsidy rate,[9] while the corresponding unit cost of driving a brown car equals $p(1+t)$, where *t* is the tax rate ($0 \le s < 1$ and $0 \le t < 1$). We further let *f* denote the unit price of public transport, while *q* denotes the unit price of other consumption. Then, the budget constraints for consumers using green and brown cars, respectively, where *B* is the total budget, become:[10]

(4) $$r(1-s)x_g + fy_g + qc_g \le B$$

(5) $$p(1+t)x_b + fy_b + qc_b \le B$$

Inserting from (2) gives:

(6) $$ax_g + f + qc_g \le B$$

(7) $$dx_b + f + qc_b \le B,$$

where $a = r(1-s) - f$ and $d = p(1+t) - f$. If it is more expensive to drive a car than to take public transport, then $a > 0$ ($d > 0$). In contrast, if public transport is the cheaper alternative, then $a < 0$ ($d < 0$).

Both green- and brown-car owners maximize their utility function (1), given their budget constraint ((6) or (7)), taking the behavior of other car owners and the flow externality in (3) as given. Thus, we can calculate the Nash equilibria for the different policy instruments.

3.1.1 The effect of policy instruments

We first study the effects of increasing the subsidy *s*. We find:[11]

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[9] Because the unit cost *r* includes all the costs of green-car driving (including capital depreciation), *s* covers a wide set of policy instruments, such as tax exemptions on purchase, free parking, free use of toll roads, etc.

[10] This paper focuses on the driving decision. Therefore, the cost of buying a car enters the budget constraint only through the unit cost of driving. This unit cost is endogenous, because it depends on the consumer's mileage. However, we disregard such endogeneity by considering this cost as given. This assumption will play only a minor role as long as the policy instruments do not change driving too much.

[11] See Appendix A for details. We do not present the results in reduced form, because we find it harder to interpret them in that case. However, results in reduced form are available from the authors upon request.

(8) $$\frac{\partial x_g}{\partial s} = \frac{-rw'_{c_g} - qu''_{x_g,G}\frac{\partial G}{\partial s}}{q\left(u''_{x_g,x_g} + v''_{y_g,y_g}\right)}$$

(9) $$\frac{\partial x_b}{\partial s} = \frac{-u''_{x_b,G}\frac{\partial G}{\partial s}}{u''_{x_b,x_b} + v''_{y_b,y_b}}.$$

The impact on *green-car* driving depends on the price effects of the subsidy, but also on the effect on the externality, *G*. We see that green-car driving will increase because of the change in price, thereby reducing consumption of other goods as a result of changes in relative prices (see the first part of equation (8)), but this increase is modified as a result of congestion (see the second part of equation (8)).

In contrast, the effect on *brown-car driving* depends only on the subsidy's effect on *G*. Thus, we need to study the effect on total traffic of an increase in the subsidy rate:

(10) $$\frac{\partial G}{\partial s} = n'_s\left(x_g - x_b\right) + n\frac{\partial x_g}{\partial s} + (1-n)\frac{\partial x_b}{\partial s}$$

The change in total traffic depends on three factors. The first term on the right-hand side is the effect of more consumers switching to a green car (the extensive margin). If the unit cost of driving a green car is lower than that of driving a brown car, that is, $r(1-s) < p(1+t)$, then $x_g > x_b$,[12] and this term is positive (which is in line with the empirical literature reviewed in section 2.2). The next effects are the effects on the intensive margin. The second term reflects the effect on green-car driving. This effect is positive but moderated by the change in *G* (see

[12] This follows from the optimization problems above, because the only difference between the optimization problems for green- and brown-car drivers is the price of driving.

(8)). Finally, we see from (9) that the effect on x_b goes in the opposite direction of the effect on G. Thus, we find that $\frac{\partial G}{\partial s} > 0$, while $\frac{\partial x_b}{\partial s} < 0$.[13,14]

The intuition is as follows. By making green cars more attractive, a subsidy on green cars increases the share of green cars on the road. In addition, green-car owners drive more because of the reduced unit cost of driving. Green-car owners' use of public transport declines, meaning more vehicles on the road, which causes brown-car owners to reduce their driving and to increase their use of public transport. This yields Proposition 1:

Proposition 1: *An increase in the subsidy rate for green cars reduces brown-car driving.*

To get an estimate of the size of the effects, we have calibrated equations (8)–(10) based on data for the Oslo metropolitan area, see Appendix B for specified functions and information on the data. The simultaneous equation system (8)-(10) is solved in Excel. We find:

$$\frac{\partial x_g}{\partial s} = 0.79, \quad \frac{\partial x_b}{\partial s} = -0.04, \quad \frac{\partial G}{\partial s} = 0.07$$

These estimates display the same signs as the effects identified in the analysis above, that is, a higher subsidy will increase green-car driving, thereby increasing congestion, which reduces brown-car driving. Taking elasticities, we find:

$$\frac{\partial x_g}{\partial s}\frac{s}{x_g} = 0.17, \quad \frac{\partial x_b}{\partial s}\frac{s}{x_b} = -0.01, \quad \frac{\partial G}{\partial s}\frac{s}{G} = 0.02$$

The elasticities show that a 10% subsidy increase will increase green-car driving by about 1.7% and reduce brown-car driving by about 0.1%. Thus, the reduction in brown-car driving

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[13] $\frac{\partial G}{\partial s} < 0$ would entail a contradiction, because the alleged reduction in G would cause both x_g and x_b to increase (thereby leading to an increase in G).

[14] The effect of less traffic on CO_2 emissions is not clear, because it depends on how fast the traffic flows without congestion. Emissions are lowest for a speed of about 60–70 kilometers an hour (km/h) and significantly higher above 100 km/h. Moreover, a queue that involves multiple starts and stops generates more emissions. See the discussion in section 1 above and Fontaras et al. (2014).

is relatively small. The main reason is that the share of green cars on the road is still small; in the Oslo metropolitan area, it was about 12% in 2018 (Statistics Norway, 2019). Thus, even if green cars drive more than brown cars, and the share increases slightly with the higher subsidy, the effect on congestion is still relatively small.

The sensitivity analysis shows that the green-car subsidy's effect on brown-car driving increases with the share of green cars. If this share were to equal 50% (n = 0.5), a 10% subsidy increase would increase green-car driving by 1.4%, while reducing brown-car driving by 0.4% due to more congestion (parameters are recalibrated in line with a higher n; see Appendix B). Thus, more congestion limits the increase in green-car driving and spurs the reduction in brown-car driving. The effect also increases with a higher initial subsidy for green cars (s). For example, with an initial subsidy rate of 40% (s = 0.4), a 10% increase in the subsidy rate would increase green-car driving by about 3.5% and reduce brown-car driving by about 0.2%.

Next, we study the effect of a higher tax rate, t, on green-car driving and brown-car driving:

$$(11) \qquad \frac{\partial x_g}{\partial t} = \frac{-u''_{x_g,G}\dfrac{\partial G}{\partial t}}{u''_{x_g,x_g} + v''_{y_g,y_g}}$$

$$(12) \qquad \frac{\partial x_b}{\partial t} = \frac{p w'_{c_b} - q u''_{x_b,G}\dfrac{\partial G}{\partial t}}{q\left(u''_{x_b,x_b} + v''_{y_b,y_b}\right)}$$

The impact on *green-car* driving is exclusively caused by the change in traffic on the road; see equation (11). *Brown-car driving* is reduced, because driving becomes more expensive relative to other consumption (the first part of equation (12)); however, this reduction is moderated by the change in traffic (second part of equation (12)).

Taxation's effect on traffic can be derived from (3):

$$(13) \qquad \frac{\partial G}{\partial t} = n'_t\left(x_g - x_b\right) + n\frac{\partial x_g}{\partial t} + (1-n)\frac{\partial x_b}{\partial t}$$

The first term on the right-hand side is the effect of a larger share of green cars on the road. Again, this effect is positive provided the unit cost of brown-car driving exceeds that of green-car driving. The third term is negative, because the tax causes brown-car driving to decline ($\frac{\partial x_b}{\partial t} < 0$). Finally, the effect on green-car driving (the second term) goes in the opposite direction of the change in *G*; see (11). However, the change in *G* is indeterminate, because the other two effects in (13) pull in opposite directions. Thus, while increased taxation of brown cars reduces brown-car driving and increases the demand for public transport, the effect on green-car driving is indeterminate because the change in total traffic is also indeterminate. Thus, the effect on total traffic is not necessarily symmetric for an increase in brown-car taxation and an increase in green-car subsidization.[15] This gives Proposition 2:

Proposition 2: *An increase in the tax on brown cars reduces brown-car driving. The effects on total traffic and green-car driving are indeterminate.*

Again, we have conducted some numerical simulations to study the size of the effects. From the data presented in Appendix B, we find:

$$\frac{\partial x_g}{\partial t} = 0.17, \quad \frac{\partial x_b}{\partial t} = -0.36, \quad \frac{\partial G}{\partial t} = -0.27$$

These findings confirm the sign of the effect on brown-car driving. While the change in *G* was indeterminate in theory, we find that *G* decreases with our data. Thus, the impacts of more green-car driving and more green cars on the road are lower than that of reduced brown-car driving. Further, we find:

$$\frac{\partial x_g}{\partial t}\frac{t}{x_g} = 0.07, \quad \frac{\partial x_b}{\partial t}\frac{t}{x_b} = -0.21, \quad \frac{\partial G}{\partial t}\frac{t}{G} = -0.15$$

Thus, a 10% increase in the tax would reduce brown-car driving by about 2% and increase green-car driving by 0.7%. While an increase in the subsidy on green cars causes additional

[15] Even if brown-car driving decreases, the effect on CO_2 emissions is indeterminate because emissions are also influenced by traffic congestion, as mentioned in the previous footnote.

congestion (see above), an increase in the tax on brown cars *reduces* congestion. It also has a bigger negative impact on brown-car driving than a corresponding increase in the subsidy on green cars has.

The sensitivity analysis shows that increasing the share of green cars on the road would strengthen the decline in brown-car driving. In contrast, green-car driving would still increase, albeit only slightly. The explanation is a bigger congestion effect. For example, with $n = 0.5$, we find that a 10% tax increase would reduce brown-car driving by 2.6%, while increasing green-car driving by only 0.3%. Further, if the initial tax were 60%, the effects of a tax increase would be bigger; for instance, a further 10% increase (to 66%) would then reduce brown-car driving by 3.7%.

We now introduce a new policy instrument that might reduce the externality from traffic on the road and increase the share of green cars: allowing green-car driving in bus lanes.[16]

Let $0 < \alpha < 1$ denote the share of roads with open bus lanes, that is, bus lanes that allow for green-car driving. Allowing green cars to drive in bus lanes means less exposure to traffic for such cars. It therefore constitutes a non-financial benefit enhancing the attractiveness of green-car driving (see section 2.1).[17] Thus, green-car drivers will, by assumption, always prefer to drive in the bus lane when possible. If driving is spread equally across all roads, α captures the share of green cars driving in bus lanes. We assume that this benefit adds to the other benefits of green-car driving, meaning that it might spur the transition to green cars.[18] However, it also increases traffic in bus lanes; hence, it entails a negative externality on public transport.

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[16] This policy instrument was introduced in Norway in 2003, where it still applies. However, in some areas, a restriction was later imposed, specifying that to use bus lanes, cars had to have a certain number of passengers.

[17] Figenbaum and Kolbenstvedt (2016: page 53) calculate the average value of local incentives to drive an EV, and find that bus lane time saving is an important part of the local incentives. They account for 32% of the average yearly savings for an EV owner, or about NOK 4500 per year.

[18] While $n_s^{'} > 0$ and $n_t^{'} > 0$ follow from the fact that an increase in the subsidy for green cars or in the tax on brown cars make green cars relatively cheaper to drive than brown cars, that is, the policy instruments affect the budget conditions, allowing green cars to drive in bus lanes affects only the utility functions as specified below. Thus, the choice of car no longer only means choosing a particular budget constraint, but also means choosing a particular utility function. As seen from the utility functions (14) and (15), allowing green cars to drive in bus lanes gives green-car owners a benefit if $M < G$. We assume this condition to hold, and therefore $n_\alpha^{'} > 0$.

The utility function for a *brown-car owner* can now be written as:[19]

(14) $u\left(x_b, G\right)+v(y_b, F)+w(c_b)$,

where F is the queue in the bus lane. In addition to the properties given in equation (1), we also assume that $v_F^{'} < 0$ and $v_{y_i,F}^{"} < 0$, $i = g,b$.

For a *green-car owner*, the utility function now becomes:

(15) $u\left(x_g, M\right)+v(y_g, F)+w(c_g)$,

where $M = \left(1-\alpha\right)G+\alpha F$, because the share of green cars driving in the regular lanes equals (1–α) and the share of green cars driving in the bus lanes equals α. By previously made assumptions, we have $u_M < 0$ and $u_{x_g,\mathrm{M}}^{"} < 0$

From the optimization problem of the brown-car drivers (see Appendix A), we find that the effect of an increase in the share of roads with open bus lanes, α, is:[20]

(16) $$\frac{\partial x_b}{\partial \alpha} = \frac{-u_{x_b,G}^{"}\frac{\partial G}{\partial \alpha}+v_{y_b,F}^{"}\frac{\partial F}{\partial \alpha}}{u_{x_b,x_b}^{"}+v_{y_b,y_b}^{"}} .$$

Because an increase in α does not influence prices, the effects on green- and brown-car driving depend only on the congestion in the two types of lanes. Note that while an increase in G reduces brown-car driving, an increase in F increases brown-car driving through lower demand for public transport.

From the optimization problem of the green-car driver, we get:

[19] Note that G is defined differently than in equation (3); see equation (19) below.
[20] This can be thought of as allowing driving in bus lanes, or reducing the number of passengers required for green cars to be allowed in bus lanes.

(17) $$\frac{\partial x_g}{\partial \alpha} = \frac{-u^{"}_{x_g,\mathrm{M}}\left(F-G\right) - u^{"}_{x_g,\mathrm{M}}\left(1-\alpha\right)\frac{\partial G}{\partial \alpha} + \left(v^{"}_{y_g,F} - \alpha \cdot u^{"}_{x_g,\mathrm{M}}\right)\frac{\partial F}{\partial \alpha}}{u^{"}_{x_g,x_g} + v^{"}_{y_g,y_g}}.$$

Similar to their effects on brown-car driving, an increase in *G* and a reduction in *F* (through easier transit for buses) reduce green-car driving. However, we here get two additional effects. First, given that $F < G$, the average traffic externality goes down, thereby increasing green-car driving (first part of eq. (17)). Second, while a reduction in *F* increases demand for public transport, it also makes green-car driving more attractive (last part of eq. (17)). Thus, the effect on green-car driving of more congestion in the bus lanes is indeterminate.

Setting $F = A + n\left(s,t,\alpha\right)\alpha x_g$, we find:[21]

(18) $$\frac{\partial F}{\partial \alpha} = n^{'}_{\alpha}\alpha x_g + n x_g + n\alpha\frac{\partial x_g}{\partial \alpha}.$$

The first term on the right-hand side is the increase in the number of cars driving in bus lanes because of a higher number of green cars on the road. The second term is the corresponding increase due to a higher share of (green) cars driving in bus lanes. Finally, the last term is the change in bus-lane driving caused by a change in the average driving of green cars. We can rule out the possibility that the last effect is negative and large enough to outweigh the effect of an increase in the number of cars in the bus lanes.[22] Thus, we find that $\frac{\partial F}{\partial \alpha} > 0$.

Furthermore, total traffic in the regular lanes now equals:

(19) $$G = n\left(s,t,\alpha\right)x_g(1-\alpha) + (1-n\left(s,t,\alpha\right))x_b.$$

[21] Here, public transport is unaffected by a change in driving patterns, as it enters as a constant, *A*. In other words, a change in driving affects the number of passengers taking the bus, but not the frequency of buses.

[22] In other words, we rule out the possibility that the sum of the second and third terms is negative. This would require that a possible decline in driving exceeds the existing driving level, that is, $x_g < \alpha\left|\frac{\partial x_g}{\partial \alpha}\right| \ for \ \frac{\partial x_g}{\partial \alpha} < 0$.

Thus, the effect on G of an increase in α is:

(20) $$\frac{\partial G}{\partial \alpha} = n_{\alpha}^{'}\left(x_g(1-\alpha) - x_b\right) + n(1-\alpha)\frac{\partial x_g}{\partial \alpha} - nx_g + (1-n)\frac{\partial x_b}{\partial \alpha}.$$

This effect depends on several factors. First, because permission to drive in the bus lanes is a benefit for green-car owners, some consumers will switch to green cars ($n_{\alpha}^{'} > 0$). If α is substantial, so that $x_g(1-\alpha) - x_b < 0$, this switch will contribute to reducing traffic (G). Second, this policy instrument influences green-car driving. If this influence is positive ($\frac{\partial x_g}{\partial \alpha} > 0$), it pulls in the direction of more traffic. Third, moving green cars from regular lanes to bus lanes reduces traffic in the regular lanes. Finally, the effect on G also depends on the effect on brown-car driving, $\frac{\partial x_b}{\partial \alpha}$. If the latter effect is positive, it pulls in the direction of more traffic. Thus, the overall effect on regular traffic is indeterminate.

Because the impact on G is indeterminate, we cannot determine the overall effect on brown-car driving. Two possibilities exist: $\frac{\partial F}{\partial \alpha} > 0$ and $\frac{\partial G}{\partial \alpha} < 0$; and $\frac{\partial F}{\partial \alpha} > 0$ and $\frac{\partial G}{\partial \alpha} > 0$. In the first case, the effect on brown-car driving is positive, while in the second case, brown-car driving can increase or decrease. However, if α is sufficiently large, so that the effect on G of an increase in green-car driving and more green cars on the road is small (see (20)), brown-car driving increases. A large α might be likely near urban areas where people are commuting.

Finally, the impact on green-car driving is more complex than that on brown-car driving, because the effect of an increase in F might work in both directions. The impact on CO_2 emissions of allowing green cars in the bus lanes is also indeterminate. A higher share of green cars pulls in the direction of lower emissions, but could still result in higher emissions if the remaining brown cars drive (substantially) more.

We can now summarize the effect on brown-car driving:

Proposition 3: *While allowing green cars to drive in bus lanes accelerates the transition from brown to green cars, the effect on brown-car driving is indeterminate. However, if a* *sufficiently large share of the bus lanes is open to green cars, the effect on brown-car driving will be positive.*

Our simulations suggest the following effects of opening more bus lanes for green cars in the Oslo metropolitan area:

$$\frac{\partial x_g}{\partial \alpha} = 0.32, \quad \frac{\partial x_b}{\partial \alpha} = 0.04, \quad \frac{\partial G}{\partial \alpha} = 0.06, \quad \frac{\partial F}{\partial \alpha} = 0.13 .$$

The direction of the effect is as expected for bus-lane congestion. In addition, the results show that brown-car driving increases only slightly, as does congestion in regular lanes, while green-car driving increases. Thus, based on the data for the Oslo metropolitan area, the factors pulling in the direction of more traffic in regular lanes dominate. As described analytically above, the effects on brown-car and green-car driving of more congestion both in bus lanes and in regular lanes are indeterminate. When it comes to brown-car driving, the effect of bus-lane congestion dominates in our simulations, thereby producing a net increase in driving. For green-car driving, the effects of a lower average congestion externality and the negative externality on public transport dominate and increase the driving distance.

To study the size of the effects, we find the following elasticities:

$$\frac{\partial x_g}{\partial \alpha}\frac{\alpha}{x_g} = 0.11, \quad \frac{\partial x_b}{\partial \alpha}\frac{\alpha}{x_b} = 0.02, \quad \frac{\partial G}{\partial \alpha}\frac{\alpha}{G} = 0.03, \quad \frac{\partial F}{\partial \alpha}\frac{\alpha}{F} = 0.17 .$$

The effects on the traffic in regular lanes and on brown-car driving are relatively small. However, the effects increase with the share of roads having open bus lanes (α) and with the share of green cars on the road (n). For instance, for $\alpha = 0.5$, we get $\frac{\partial x_b}{\partial \alpha}\frac{\alpha}{x_b} = 0.03$, and for $n = 0.5$, we find $\frac{\partial x_b}{\partial \alpha}\frac{\alpha}{x_b} = 0.08$ (with recalibrated parameters, see Appendix B). In the first case, more green cars will use bus lanes, thereby reducing congestion in regular lanes and increasing brown-car owners' demand for driving. This supports the result from the analytical analysis above. In the second case, bus-lane congestion increases, thereby reducing demand for public transport among brown-car owners.

3.2 A model with social preferences

Consumers might be influenced by the behavior of other consumers. In section 2.2, we provided evidence that the purchase of an EV tends to cause the buyer to drive more. This evidence is consistent with the model above if the unit price of driving a brown car exceeds the unit price of driving a green car. Moreover, increased green-car driving might influence brown-car driving through its influence on congestion. However, it might also influence the behavior of brown-car owners in other ways than studied above. In particular, it might change general driving habits or social norms concerning acceptable driving.

Increased green-car driving might tempt brown-car owners to copy the driving habits of green-car owners, meaning that brown-car owners will drive more as well (a bandwagon effect).[23] In addition, increased green-car driving might reduce brown-car owners' motivation for behaving environmentally friendly. An ongoing debate in Norwegian media concerns EVs' effects on GHG emissions and other pollutants. Such debate might cause people to doubt that driving an EV is more environmentally friendly than driving a petroleum-based car is. Thus, brown-car owners' motivation to use public transport or other alternatives for shorter journeys might decline when they observe that EV owners drive more.[24]

We know from the literature on peer effects that individual outcomes correlate strongly with group average outcomes (see section 1). Thus, if policy measures cause increased green-car driving in a neighborhood, brown-car driving might also increase in that neighborhood. We therefore now assume that average driving in the local community influences both green- and brown-car driving. This influence might include bandwagon effects, modifications in social norms, or changes in motivation.

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[23] An everyday observation made by one of the authors of this paper might serve as an example. His son and all the other boys in his class went to a summer course close to the city center, where it was hard to find available parking spots. Although good public-transport options existed, EV owners began organizing driving groups where parents took turns in driving the boys to and from the course site. Many other parents (brown-car owners) then followed by joining the driving groups as well.

[24] Households' motivation to drive less could also increase for several reasons. For example, the use of policy instruments to enhance the transition to green cars might send a signal to car owners that it is important to reduce brown-car driving. This can be seen as an information spillover effect. Having more green cars on the road might work similarly and might therefore also increase the motivation to reduce brown-car driving. It seems less likely that an increase in green-car driving would have a similar motivating effect; however, we cannot rule out that car owners gain utility from driving less than the average, thereby feeling more environmentally friendly the lower their driving distance is compared to the average driving distance in the local community.

Recall that the number of consumers in the model is normalized to one. Thus, when access to bus lanes is not permitted, average driving equals *G*, as defined in equation (3). We can therefore specify the car owners' utility function as

$$(21)\qquad u\left(x_i, G\right) + v(y_i) + w(c_i) - \frac{\beta_i}{2}\left(x_i - G\right)^2, \quad i = g, b.$$

β_i reflects how much weight the consumer attaches to the behavior of other consumers. If green-car owners drive more than brown-car owners do, $\left(x_g - G\right) > 0$ and $\left(x_b - G\right) < 0$. In this case, the interpretation of β_i differs across the two types of car owners. The bandwagon effect, the peer effect, and the reduced motivation of brown-car owners to behave environmentally friendly are represented by $\beta_b > 0$. Now, increasing the driving distance, so that it gets closer to the average, increases utility. However, $\beta_g > 0$ means that green-car owners want to reduce their driving. This may again be due to bandwagon and peer effects.[25]

The changes in green- and brown-car driving caused by an increase in the policy instruments *s* and *t*, respectively, now equal:[26]

$$(22)\qquad \frac{\partial x_g}{\partial s} = \frac{-\frac{r}{q} w'_{c_g} - \left(u''_{x_g,G} + \beta_g\right)\frac{\partial G}{\partial s}}{\left(u''_{x_g,x_g} + v''_{y_g,y_g}\right) - \beta_g}$$

[25] $\beta_i = 0$ means that the consumers have no social preferences, and $\beta_i < 0$ means that car owners gain utility by driving less (brown-car owners) or more (green-car owners) than the average. However, in the text, we focus on the case where $\beta_i > 0$.

[26] The optimization problems are solved in Appendix A. To ensure local utility maxima, we may need to put some restrictions on β_i. For instance, the first order condition for a brown car driver is specified in equation (60) in the appendix, and gives $u'_{x_b} - v'_{y_b} - \beta_b(x_b - G) > 0$ for $d > 0$ and $u'_{x_b} - v'_{y_b} - \beta_b(x_b - G) < 0$ for $d < 0$. For $\beta_b > 0$ and $d < 0$, β_b must not be "too large" as $(x_b - G) < 0$ unless $\lim_{y \to 0} v_y' = +\infty$. However, the second order condition requires $u''_{xx} + v''_{yy} - \beta_b < 0$ which is satisfied for all $\beta_b > 0$. Similar conditions are found for a green car driver. To see if the local utility maxima also are global maxima, we have solved the optimization problem graphically in Excel (available from the authors on request), using the specified utility function in Appendix B. The indifference curves are convex, which only gives one maximum. Thus, the local maxima are indeed global maxima.

(23) $$\frac{\partial x_b}{\partial s} = \frac{-\left(u''_{x_b,G} + \beta_b\right)\frac{\partial G}{\partial s}}{\left(u''_{x_b,x_b} + v''_{y_b,y_b}\right) - \beta_b}$$

and

(24) $$\frac{\partial x_g}{\partial t} = \frac{-\left(u''_{x_g,G} + \beta_g\right)\frac{\partial G}{\partial t}}{\left(u''_{x_g,x_g} + v''_{y_g,y_g}\right) - \beta_g}$$

(25) $$\frac{\partial x_b}{\partial t} = \frac{\frac{p}{q} w'_{c_b} - \left(u''_{x_b,G} + \beta_b\right)\frac{\partial G}{\partial t}}{\left(u''_{x_b,x_b} + v''_{y_b,y_b}\right) - \beta_b}.$$

While the main mechanisms are similar to those described in section 3.1.1, the effect of each policy instrument now depends on how much weight the representative consumer attaches to the change in the average driving habits. As seen from equations (22)-(25), for $\beta_i > 0$ the direct effect is that the habits factor reduces the effects of the policy instruments. The analysis in section 3.1.1 shows that the policy instruments may have opposite effects on driving for green-car and brown-car drivers, thereby increasing the difference in average driving distance. The direct effect of the habits factor is a reduction in this increase, as a higher difference enters negatively in the utility functions. However, the habits factor also entails indirect effects, through changes in $\partial G / \partial s$ and $\partial G / \partial t$. In the case of a subsidy increase, the direct effect reduces the increase in green-car driving and reduces the fall in brown-car driving. Thus, the effect on the change in total traffic, $\partial G / \partial s$, is indeterminate. The same holds in the case of a change in the tax. However, these indirect effects would unlikely be bigger than the direct effects.

For $u''_{x_i,G} + \beta_i < 0$, the direction of the effects likely remains unchanged. However, for $u''_{x_b,G} + \beta_b \geq 0$, a subsidy increase may now fail to reduce brown-car driving; in fact, it could even cause it to increase. Concerning increased taxation, the likely effect is still a reduction in brown-car driving; indeed, for $\beta_b > 0$, such driving could increase only for high values of β_b.

We can also derive the effects of allowing green cars to drive in bus lanes. With social preferences, the utility function of a brown-car driver will be (see Appendix A for the case for green-car drivers):

$$(26) \quad u\left(x_b, G\right) + v(y_b, F) + w(c_b) - \frac{\beta_b}{2}\left(x_b - H\right)^2.$$

In this case, average driving will differ from *G*, because *G* follows from (19). Thus, average driving now equals:

$$(27) \quad H = n\left(s,t,\alpha\right)x_g + (1 - n\left(s,t,\alpha\right))x_b.$$

The effect of an increase in *α* on brown-car driving will therefore be:

$$(28) \quad \frac{\partial x_b}{\partial \alpha} = \frac{-u''_{x_b,G}\dfrac{\partial G}{\partial \alpha} + v''_{y_b,F}\dfrac{\partial F}{\partial \alpha} - \beta_b\dfrac{\partial H}{\partial \alpha}}{\left(u''_{x_b,x_b} + v''_{y_b,y_b}\right) - \beta_b}.$$

As before, including social preferences in the utility function of brown-car owners generates the opposite effect of the other externalities when $\beta_b > 0$, and might change the result of an increase in α from less to more brown-car driving.

These results are summarized in Proposition 4:

Proposition 4: *If consumers are influenced positively by the average driving habits in the local community ($\beta_i > 0$, $i = g,b$), the policy instruments' effects are likely to be reduced and could even go in the opposite direction, compared to the homo oeconomicus case. In particular, an increased tax or subsidy might now cause brown-car driving to increase.*

So far, our discussion of social preferences has focused on the intensive margin, that is, on changes in driving distance. However, there might also be effects on the extensive margin, because the car choice of neighbors, friends, and family might matter. An EV might be seen as trendy or modern, and switching to an EV might increase the owner's social status. Alternatively, continuing to drive a brown car might reduce the owner's social status.

Moreover, learning effects (e.g., concerning range or maintenance costs) might make green cars more attractive. These positive adoption spillovers might increase the number of green cars on the road. And even if the policy instruments, with social preferences, might cause an increase in brown-car driving (as stated in Proposition 4), such preferences might also reduce the number of brown cars on the road.

4. Empirical evidence

The model studied in this paper generates predictions concerning how the various policy instruments influence the use of polluting cars through changes in prices, externalities, and habits. To get an even better understanding of what mechanism(s) are most important, we use survey data for Norway to illustrate the impacts on the use of polluting cars.

Before turning to the survey, we briefly describe Norwegian policies to promote EVs.

4.1 Norwegian policies to promote EVs

The development of the Norwegian BEV policy, spanning almost three decades, has been the result of opportunities generated from niche market activities (e.g., cars for city use) and actors (e.g., Think), a weak national automotive regime as Norway has no car manufacturers, a powerful governance level where heavy taxes are levied on polluting vehicles and BEVs are exempted, and international developments of BEV technologies and policies (Figenbaum 2017).

Since the 1960s, Norway has had a high tax on the first-time registration of vehicles. This tax has been transformed twice over the years: from constituting a percentage of the vehicle's sales value to constituting a tax on vehicle weight, engine volume (later replaced by CO_2 emissions), and engine power, and then was transformed again to the 2018 tax consisting of three sub elements: (1) a tax on vehicle weight, (2) a tax on CO_2 emissions, and (3) a tax on NOX emissions.[27] To account for the added weight of the battery and other systems, PHEVs are granted a 23% deduction of the vehicle weight before calculating the vehicle weight tax.[28]

[27] The total tax is the sum of the three elements. For vehicles emitting less than 75 g CO_2/km, the CO_2 tax is negative. The overall tax is, however, not allowed to become negative.

[28] However, from 1 July 2018, they must have an electric mode range of at least 50 km to qualify for the full deduction. Vehicles with a shorter electric mode range will qualify for a proportional reduction of the full deduction percentage (23%).

For BEVs, no tax has been imposed on first-time registration; however, from 2018, BEVs above two tons are being taxed. In addition, taxes on the use of ICEVs have traditionally been high, but relatively constant. In contrast, the number of toll roads and the corresponding fees have increased in recent years, especially in and around the major cities, increasing the costs of driving an ICEV.

The Norwegian policy framework for BEVs dates to 1990, when the first BEV imported to Norway was granted exemption from the import tax (Figenbaum 2017). This exemption remains in force, and in the 1990s it enabled initial experimentation with EVs in cities and also an attempt to industrialize BEVs (i.e., to manufacture them in Norway). However, this exemption proved inadequate to stimulate sales and industrialization efforts. New incentives were therefore introduced, including free driving on toll roads (1997), free parking (1998), and value added tax (VAT) exemption (2001) (Figenbaum 2017).[29] The Norwegian Public Roads Administration allowed BEVs to drive in the bus lanes in Oslo from 2003 and elsewhere from 2005. The other incentives were kept in place.

A focus on BEV adoption to meet climate policy targets led to a renewal of BEV policies with the 2009 introduction of reduced rates for BEVs on ferries. The effects of the 2008/2009 global financial crisis were in Norway counteracted by a government supported program to install public charging stations.

With new BEV models introduced (in particular Nissan Leaf), all the nationwide incentives still in place and with several thousand experienced BEV owners, attractive local incentives, and nationwide EV dealers, instant success was achieved (Figenbaum 2017). The market expanded further with new models from Tesla, VW, and BMW in 2013–14, and from Kia and Hyundai in 2015–16. Moreover, substantial price reductions and the installation of fast chargers along major roads provided further incentives. By 2015, BEVs were – thanks to the tax exemptions – highly competitive in all market segments. Local incentives such as exemption from toll road fees, reduced ferry rates, free parking, and access to the bus lanes, worth around 1500 euros/BEV/year (Figenbaum and Kolbenstvedt 2016) boosted the market

[29] The VAT exemption was linked to Ford Motor Company’s takeover of Norwegian BEV producer Think in 1999, thereby creating the prospect of a national BEV industry. Ford’s main motivation was to produce BEVs for the Californian Zero Emission Vehicle (ZEV) mandate. Following the 2002 changes to the ZEV mandate, Ford decided that Think BEVs were no longer needed. Think was therefore sold and later went bankrupt. BEV industrialization hibernated internationally after 2003, and BEVs were no longer produced in Norway.

further. Other conditions favoring BEV adoption include the availability of cheap and clean electricity and access to home parking for the majority of households (Figenbaum and Kolbenstvedt 2015). By 2017, the promotion of BEVs had become an integral part of the Norwegian climate policy (Figenbaum 2017).

4.2 Survey on transportation habits

4.2.1 About the survey

In May and June 2018, the Norwegian Institute of Transport Economics conducted a survey of BEV and ICEV owners. The survey was emailed to members of the Norwegian EV Association (NEVA) and the Norwegian Automobile Federation (NAF). The EV owners were recruited from a random sample drawn from the members of the EV association. When purchasing a new BEV from any of the brand dealerships, the buyer gets a free one-year membership in the EV association. This subsample is thus representative of EV owners, and further investigation proved it to be representative also concerning geography and BEV type. The ICEV sample was a nation-wide representative sample of members of the Norwegian Automobile Federation, the largest Norwegian vehicle owner association.

While the survey was broad in scope, some questions were particularly designed to tap how BEV policies influence owners of green and brown cars. Below we focus on brown-car driving. Brown-car owners were recruited from the members of the NAF. A nationwide representative sample of 15,000 vehicle owners was drawn from the NAF membership database. Due to data-technical issues, the initial survey received only 1400 valid responses. Therefore, an additional sample of 9000 members was invited to participate in the survey. This additional sample brought the total number of responses up to 2264, of which 1989 came from brown-car owners.[30] For more information on the survey questions, see Appendix C.

Of course, cross-sectional comparisons such as the ones reported here cannot properly address causality. The following sections should be read with this caveat in mind.

[30] Of the rest, 89 owned a PHEV, 172 owned a BEV, and 14 respondents did not own a car. About 97% of the brown-car owners reported that they own only brown cars.

4.2.2 Results from the survey

Table 1 shows how brown-car users report to have adjusted their driving patterns because of benefits granted to EV users. The vast majority of respondents (86.1%) report to drive as before; however, 10.8% say they drive less, while 3.1% say they drive more.

As shown in Table 1,[31] the policies designed to promote the purchase and use of green cars have had a bigger influence on brown-car driving in major cities than in other types of municipalities. This correlation, which is statistically significant ($\chi^2 = 10.11$; df = 2; $p < 0.01$), is consistent with propositions 1 and 2. First, Proposition 1 states that subsidizing green cars will slow down traffic through more congestion, thereby reducing brown-car driving. This effect is more likely to occur in major cities.

Second, according to Proposition 2, increased brown-car taxation will reduce brown-car driving.[32] In recent years, such increased taxation has been particularly strong in and around the major cities, mostly in the form of road tolls and parking fees. Thus, the tax effect pulls in the same direction as the congestion effect. Unfortunately, our data do not permit us to determine which of these effects is more important for explaining why the proportion of respondents reporting to have reduced their driving is larger in major cities.

Question: *To reach environmental and climate goals, the authorities have granted electric vehicles particular benefits, such as tax exemption, free parking, battery charging, and (in some places) permission to drive in bus lanes. To what extent have these policies influenced your household's car use?*

	Major city*	**Other**	**Total**
Drives less	15.1% (59)	9.3% (103)	10.8% (162)
No change	81.6% (320)	87.6% (970)	86.1% (1290)
Drives more	3.3% (13)	3.1% (34)	3.1% (47)
Total	100.0% (392)	100.0% (1107)	100.0% (1499)**

Table 1. Change in brown-car driving by type of home municipality. % (absolute numbers).

*) Oslo, Bergen, Trondheim, Stavanger, Drammen, Kristiansand, Tromsø.

**) Of the 1989 respondents, 490 answered "Don't know" on this question.

[31] Appendix D provides a more detailed version of Table 1.

[32] The question does not specifically mention brown-car taxation. However, it is not unreasonable to assume that respondents, when answering this question, have borne in mind the entire package of measures imposed to promote a transition from brown to green cars, including brown-car taxation.

Our results provide only weak support for propositions 3 and 4, which provide open-ended hypotheses concerning the effects on brown-car driving of permitting EVs to drive in bus lanes and a large number of green cars in the neighborhood. Bus lanes exist only in major cities, and the density of green cars is significantly higher in and around major cities than in other parts of Norway, so a positive effect (if any) should be most likely in and around major cities. However, in our survey the proportion reporting increased driving is only marginally higher in major cities, and this marginal difference does not even come close to being statistically significant.

Thus, our data suggest that the (negative) effects of EV policies on brown-car driving suggested by Propositions 1 and 2 dominate the (possibly positive) effects suggested by Propositions 3 and 4. Overall, therefore, the results suggest that Norwegian policies to promote the purchase and use of green cars have (if anything) reduced brown-car driving.

This finding is supported by field data from the toll road ring around Oslo (Fjellinjen, 2019; Statistics Norway, 2019). These data show that a disproportionately large share of BEVs are used for commuting, compared to BEVs' share of the fleet. In December 2018, the BEV share of light vehicles in the toll ring equaled 20%, almost twice the BEV share of the passenger car fleet in Oslo and the surrounding county Akershus (11.7%). A likely explanation is that many households now own both a BEV and an ICEV, use their BEV for local transport and commuting, and thereby reduce brown-car (ICEV) driving in and around the city.[33]

To dig a bit deeper into the mechanisms behind the responses, we also asked questions about the reasons for driving more or less. Those who reported driving *less* were asked to what extent they agreed with the statements below:

[33] The potential congestion effects of Norwegian EV policies have spurred considerable media attention. A search in the "Retriever" Norwegian news search service revealed a total of more than 500 news articles (paper and web) for the search words "EV", "bus lane" and "queue", of which 368 in the period 2013-2016. These articles contain criticism, support, broader presentations of BEV policy, and details about practical solutions (e.g., BEVs must now carry at least one passenger to have access to bus lanes during the rush hours).

a.	There are more cars on the road and more queues.
b.	Driving has become more expensive.
c.	The household's motivation to limit driving has been strengthened.
d.	My/our habits have changed.

Similarly, those who reported driving *more* were asked to what extent they agreed with the following statements:

a.	The performance of buses has decreased and their travel time has increased.
b.	There are fewer queues on the roads than before.
c.	The household's motivation to limit driving has been weakened.
d.	My/our habits have changed.

Of those reporting to drive less, a large majority (63%) agreed (somewhat or strongly) that traffic is more congested than before. This result is consistent with Proposition 1, because having more green cars on the road due to subsidized green-car driving, creates more traffic that affects all cars adversely. Furthermore, about 78% agree that driving has become more expensive. This finding is in line with Proposition 2, which points to higher taxes as a reason to drive less. Also, 69% agree that their motivation to drive less has been strengthened, and a majority (68%) of respondents reporting to drive less state that their habits have changed.

Scrutinizing respondents who say they drive more, reveals that 70% agree that the performance of buses has been reduced. This finding might seem compatible with Proposition 3, which states that allowing green cars in bus lanes could increase brown-car driving. However, this does not necessary lead to less congestion (as our simulation results show), and 64% of those who report driving more disagree that there are fewer queues on the roads. Thus, those who report driving more seem to agree with those who report driving less that EV policies have caused more congestion on the roads. Furthermore, about 38% of the respondents reporting to drive more say their household's motivation to limit driving has been weakened. In contrast, only 7–8% of those reporting to drive less disagree that their household's motivation to limit their driving has been *strengthened*. A possible interpretation is that the policies favoring EVs have influenced brown-car users in different ways, motivating some of them to drive less, while causing others to drive more. While a majority (68%) of respondents reporting to drive less state that their habits have changed, only a minority (36%) of those reporting to drive more do the same. This finding might be read as consistent with Proposition 4, which states that consumers who are influenced positively by average driving in their local community might increase their driving.

5. Conclusions

To reduce emissions from transport, governments in several countries including Norway, South Korea, USA, UK, Spain, France, Germany, and Sweden have begun promoting the purchase and use of emission-free cars such as EVs, using financial as well as non-financial incentives. In this paper, we study how such incentives affect non-targeted consumers, that is, consumers who continue to drive a brown (polluting) car. These incentives make green (non-polluting) cars more attractive, make brown cars less attractive, and influence both green- and brown-car driving. We present a simple model of how different policy instruments, such as subsidizing green cars, taxing brown cars, and allowing green cars to drive in bus lanes, affect driving with both types of cars. Car owners are influenced by price incentives, but also by external effects, such as accidents and congestion outside and inside bus lanes.

All the policy instruments considered here might – based on the literature review in section 2 – enhance a transition from brown to green cars. Unsurprisingly, a subsidy on green cars increases driving with such cars, because the unit cost of green-car driving declines. In contrast, such a subsidy reduces brown-car driving, because of the negative externality of having more cars on the road. Likewise, taxing brown cars also reduces brown-car driving. The tax makes green cars relatively more attractive and increases the number of green cars on the road. However, the effect of such a tax on green-car driving depends on the change in traffic, and is indeterminate if green-car owners drive more than brown-car owners do (e.g., because of lower unit costs of driving). In this case, additional green-car driving increases traffic, while reduced brown-car driving pulls in the opposite direction.

We have also studied the implications of permitting green cars in bus lanes. While such permission spurs the transition to green cars, the effects on green- and brown-car driving depend on the impact on traffic in regular lanes as well as in bus lanes. The effect on traffic in regular lanes is indeterminate, because it depends mainly on the share of green cars that drive in bus lanes. If this share is large, traffic in regular lanes will likely decline, giving an incentive to increase brown-car driving. In addition, having more traffic in bus lanes slows down buses, thereby causing some travelers to switch from public transport to cars. Thus, driving might well increase for both types of cars.

Finally, we studied how a change in average driving habits in the local community might influence brown-car driving. Having more green-car driving might change the social norms of what is considered acceptable driving. However, it could also reduce the motivation of brown-car drivers to behave environmentally friendly if they are annoyed by the exclusive benefits offered to green-car drivers. We model these conjectures by assuming that average driving in the local community influences both green- and brown-car driving. Changes in average driving depend on the increase in the share of green cars (because green-car drivers on average drive more because of lower costs) and on how much green- and brown-car driving change because of the use of the policy instruments. We show that if average driving in some reference group influences driving, the effects of policy instruments become weaker than otherwise. Indeed, the result could – at least in principle – even be increased brown-car driving.

To illustrate the model, we conducted numerical simulations and presented results from a new survey. The numerical simulations confirm the analytical results, and show that the effects on brown cars will be larger with a larger share of green cars on the road. In the survey, a sample of brown-car drivers were asked how policies to promote the use of EVs have affected their driving. While most respondents' driving remains unaffected, 10.8% say they drive less, while 3.1% say they drive more. As expected, the proportion of respondents saying their driving has been influenced is significantly higher in and around major cities.

Those who report to have changed their driving were also asked if they agreed to a set of statements illustrating the mechanisms from the model. The results are largely consistent with two of the mechanisms. The third and fourth mechanisms – which derive from social preferences – do not provide clear predictions, but suggest that the policy instruments *might* cause an increase in brown-car driving. This conjecture receives little support in our data. More generally, it appears that the homo oeconomicus mechanisms are more important than the social preferences mechanisms. Finally, our survey indicates that some mechanisms work differently for different brown-car drivers and that Norwegian policies to promote EVs may have (moderately) reduced brown-car driving.

We have not provided an analysis of optimal policy design, which will depend on the aims of policy makers. One such aim might be to reach a certain share of green cars in the car fleet by a particular year. Another possible aim could be to reach an emission target for the transport sector by some deadline. Concerning the former aim, policy makers need not care about the results from this study. What matters is the effect on the extensive margin, that is, how policy instruments affect the choice of car. The model studied in this paper includes this effect in the policy instruments' effect on the share of consumers driving a green car; however, we have not studied whether, and if so how, different policy instruments affect this share differently.

Our results are more relevant for the latter aim. Based on our analysis, taxes and subsidies seem better able to prevent emission leakage from more brown-car driving than allowing green-car driving in the bus lanes does. In addition, taxes seem more promising than subsidies do, because taxes reduce congestion more effectively. However, to draw firm conclusions, a more thorough study is needed, because the effects on emissions will also depend on the results on the extensive margin, that is, on how much the brown-car fleet is reduced. Thus, although permitting green-car driving in bus lanes would result in more brown-car mileage, this increase would not matter much if such permission significantly increases the number of green cars and reduces the number of brown cars. Whether this is the case is an empirical question, and answering it would require more extensive data than our survey could offer.

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Appendix A: Solving the model

1. <u>The optimization problem for a *green*-car driver</u>

The Lagrangian for a consumer driving a *green* car is:

(29) $$L_g = u\left(x_g, G\right) + v(1-x_g) + w(c_g) + \lambda_g\left(B - \left[r(1-s) - f\right]x_g - f - qc_g\right) ,$$

where λ_g is the Lagrange multiplier and $y_g = 1 - x_g$.

This gives the following first-order conditions, where the behavior of other drivers as well as G are taken as given:

(30) $$u'_{x_g} - v'_{y_g} = \lambda_g\left[r(1-s) - f\right]$$

(31) $$w'_{c_g} = \lambda_g q$$

This gives

(32) $$\frac{u'_{x_g} - v'_{y_g}}{w'_{c_g}} = \frac{a}{q} ,$$

where

(33) $$a = r(1-s) - f .$$

Equation (32) and the budget constraint (6) determine x_g and c_g.

To find the effect of *an increase in s*, we get from (32) and (6):

(34) $$\frac{\partial x_g}{\partial s}\left(u''_{x_g,x_g} + v''_{y_g,y_g}\right)q = -w'_{c_g}r - u''_{x_g,G}q\frac{\partial G}{\partial s}$$

(35) $$\frac{\partial c_g}{\partial s} = \frac{r}{q}x_g - \frac{a}{q}\frac{\partial x_g}{\partial s}$$

From (34) we find:

$$(36) \qquad \frac{\partial x_g}{\partial s} = \frac{-rw'_{c_g} - qu''_{x_g,G}\frac{\partial G}{\partial s}}{q\left(u''_{x_g,x_g} + v''_{y_g,y_g}\right)} \ .$$

To see the effect of *an increase in t*, we find from (32) and (6):

$$(37) \qquad \frac{\partial x_g}{\partial t}\left(u''_{x_g,x_g} + v''_{y_g,y_g}\right) = -u''_{x_g,G}\frac{\partial G}{\partial t}$$

$$(38) \qquad \frac{\partial c_g}{\partial t} = -\frac{a}{q}\frac{\partial x_g}{\partial t}$$

Equation (37) gives:

$$(39) \qquad \frac{\partial x_g}{\partial t} = \frac{-u''_{x_g,G}\frac{\partial G}{\partial t}}{u''_{x_g,x_g} + v''_{y_g,y_g}}$$

2. The optimization problem for a *brown-car* driver

The Lagrangian for a consumer driving a *brown* car is:

$$(40) \qquad L_b = u\left(x_b, G\right) + v(1-x_b) + w(c_b) + \lambda_b\left(B - \left[p(1+t) - f\right]x_b - f - qc_b\right)$$

where λ_b is the Lagrange multiplier and $y_b = 1 - x_b$.

The behavior of other drivers as well as *G* are taken as given. This gives the following first-order conditions:

$$(41) \qquad u'_{x_b} - v'_{y_b} = \lambda_b\left[p(1+t) - f\right]$$

$$(42) \qquad w'_{c_b} = \lambda_b q$$

This gives

$$(43)\qquad \frac{u'_{x_b} - v'_{y_b}}{w'_{c_b}} = \frac{d}{q}\ ,$$

where

$$(44)\qquad d = p(1+t) - f\ .$$

Equation (43) and the budget constraint (7) determine x_b and c_b.

To find the effect of *an increase in s*, we get from (43) and (7):

$$(45)\qquad \frac{\partial x_b}{\partial s}\left(u''_{x_b,x_b} + v''_{y_b,y_b}\right) = -u''_{x_b,G}\frac{\partial G}{\partial s}$$

$$(46)\qquad \frac{\partial c_b}{\partial s} = -\frac{d}{q}\frac{\partial x_b}{\partial s}$$

Equation (45) gives:

$$(47)\qquad \frac{\partial x_b}{\partial s} = \frac{-u''_{x_b,G}\dfrac{\partial G}{\partial s}}{u''_{x_b,x_b} + v''_{y_b,y_b}}$$

To see the effect of *an increase in t*, we find from (43) and (7):

$$(48)\qquad \frac{\partial x_b}{\partial t}\left(u''_{x_b,x_b} + v''_{y_b,y_b}\right)q = w'_{c_b}p - u''_{x_b,G}q\frac{\partial G}{\partial t}$$

$$(49)\qquad \frac{\partial c_b}{\partial t} = -\frac{p}{q}x_b - \frac{d}{q}\frac{\partial x_b}{\partial t}$$

Using (48) gives:

(50) $$\frac{\partial x_b}{\partial t} = \frac{pw'_{c_b} - qu''_{x_b,G}\frac{\partial G}{\partial t}}{q\left(u''_{x_b,x_b} + v''_{y_b,y_b}\right)} \quad .$$

3. <u>Introducing driving in bus lanes</u>

The Lagrangian for a consumer driving a *brown* car is now:

(51) $$L_b = u\left(x_b, G\right) + v(y_b, F) + w(c_b) + \lambda_b\left(B - \left[p(1+t) - f\right]x_b - f - qc_b\right),$$

where λ_b is the Lagrange multiplier, $y_b = 1 - x_b$, $d = p(1+t) - f$, $F = A + n\alpha x_g$ and $G = n\left(s,t,\alpha\right)x_g(1-\alpha) + (1 - n\left(s,t,\alpha\right))x_b$.

As long as the behavior of other car drivers and the externalities, *G* and *F*, are taken as given, the first-order conditions are the same as given by (43). Differentiating (43) and taking into account the effects on *G* and *F* give:

(52) $$\frac{\partial x_b}{\partial \alpha}\left(u''_{x_b,x_b} + v''_{y_b,y_b}\right) = -u''_{x_b,G}\frac{\partial G}{\partial \alpha} + v''_{y_b,F}\frac{\partial F}{\partial \alpha}$$

From (52) we find:

(53) $$\frac{\partial x_b}{\partial \alpha} = \frac{-u''_{x_b,G}\frac{\partial G}{\partial \alpha} + v''_{y_b,F}\frac{\partial F}{\partial \alpha}}{u''_{x_b,x_b} + v''_{y_b,y_b}} \quad .$$

In a similar way, we find the effects on *green*-car driving:

(54) $$L_g = u\left(x_g, M\right) + v(\mathrm{y}_g, F) + w(c_g) + \lambda_g\left(B - \left[r(1-s) - f\right]x_g - f - qc_g\right) \ ,$$

where λ_g is the Lagrange multiplier, $y_g = 1 - x_g$, $a = r(1-s) - f$, $M = \left(1-\alpha\right)G + \alpha F$, $F = A + n\alpha x_g$, and $G = n\left(s,t,\alpha\right)x_g(1-\alpha) + (1 - n\left(s,t,\alpha\right))x_b$.

The first-order conditions become as in (32). Differentiating (32) and taking into account the effects on *M* and *F* give:

(55) $$\frac{\partial x_g}{\partial \alpha} = \frac{-u^{''}_{x_g,\mathrm{M}}\left(F-G\right) - u^{''}_{x_g,\mathrm{M}}\left(1-\alpha\right)\frac{\partial G}{\partial \alpha} + \left(v^{''}_{y_g,F} - \alpha \cdot u^{''}_{x_g,\mathrm{M}}\right)\frac{\partial F}{\partial \alpha}}{u^{''}_{x_g,x_g} + v^{''}_{y_g,y_g}} \ ,$$

where we have used:

(56) $$\frac{\partial M}{\partial \alpha} = \left(F-G\right) + \left(1-\alpha\right)\frac{\partial G}{\partial \alpha} + \alpha \frac{\partial F}{\partial \alpha} \ .$$

We also get:

(57) $$\frac{\partial F}{\partial \alpha} = n^{'}\alpha x_g + n x_g + n\alpha \frac{\partial x_g}{\partial \alpha}$$

(58) $$\frac{\partial G}{\partial \alpha} = n^{'}_{\alpha}\left(x_g(1-\alpha) - x_b\right) + n(1-\alpha)\frac{\partial x_g}{\partial \alpha} - n x_g + (1-n)\frac{\partial x_b}{\partial \alpha}$$

4. <u>Introducing social preferences</u>

If driving in bus lanes is not allowed, the Lagrangian for a consumer with social preferences driving a *brown* car now becomes:

(59) $$L_b = u\left(x_b, G\right) + v(y_b) + w(c_b) - \frac{\beta_b}{2}\left(x_b - G\right)^2 + \lambda_b\left(B - \left[p(1+t) - f\right]x_b - f - qc_b\right) \ ,$$

where *G* follows from (3).

Setting $d = p(1+t) - f$ and $y_b = 1 - x_b$, the first-order condition for a consumer who takes *G* as given is:

(60) $$\frac{u'_{x_b} - v'_{y_b} - \beta_b(x_b - G)}{w'_{c_b}} = \frac{d}{q} \ .$$

Differentiating with respect to *s* gives:

(61) $$\frac{\partial x_b}{\partial s}\left(u''_{x_b,x_b} + v''_{y_b,y_b} - \beta_b\right) = -\left(u''_{x_b,G} + \beta_b\right)\frac{\partial G}{\partial s}$$

From the budget constraint, we have:

(62) $$\frac{\partial c_b}{\partial s} = -\frac{d}{q}\frac{\partial x_b}{\partial s}$$

From (61) we find:

(63) $$\frac{\partial x_b}{\partial s} = \frac{-\left(u''_{x_b,G} + \beta_b\right)\dfrac{\partial G}{\partial s}}{\left(u''_{x_b,x_b} + v''_{y_b,y_b}\right) - \beta_b}$$

Differentiating (60) with respect to *t* gives:

(64) $$\frac{\partial x_b}{\partial t}\left(u''_{x_b,x_b} + v''_{y_b,y_b} - \beta_b\right)q = w'_{c_b}\,p - q\left(u''_{x_b,G} + \beta_b\right)\frac{\partial G}{\partial t}$$

From the budget constraint, we have:

(65) $$\frac{\partial c_b}{\partial t} = -\frac{p}{q}x_b - \frac{d}{q}\frac{\partial x_b}{\partial t}$$

Equation (64) gives:

(66) $$\frac{\partial x_b}{\partial t} = \frac{\dfrac{p}{q}w'_{c_b} - \left(u''_{x_b,G} + \beta_b\right)\dfrac{\partial G}{\partial t}}{\left(u''_{x_b,x_b} + v''_{y_b,y_b}\right) - \beta_b}$$

When introducing driving in bus lanes for green cars, the Lagrangian for a consumer driving a *brown* car will be:

(67) $$L_b = u\left(x_b, G\right) + v(y_b, F) + w(c_b) - \frac{\beta_b}{2}\left(x_b - H\right)^2 + \lambda_b\left(B - \left[p(1+t) - f\right]x_b - f - qc_b\right),$$

where G follows from (19), H from (27), and F is defined as

(68) $$F = A + n(\mathrm{s}, \mathrm{t}, \alpha)\alpha x_g .$$

The first-order condition for a consumer who takes G, F, and H as given is:

(69) $$\frac{u'_{x_b} - v'_{y_b} - \beta_b(x_b - H)}{w'_{c_b}} = \frac{d}{q}$$

Differentiating (69) with respect to α gives:

(70) $$\frac{\partial x_b}{\partial \alpha}\left(u''_{x_b,x_b} + v''_{y_b,y_b} - \beta_b\right)q = -qu''_{x_b,G}\frac{\partial G}{\partial \alpha} + qv''_{y_b,F}\frac{\partial F}{\partial \alpha} - q\beta_b\frac{\partial H}{\partial \alpha}$$

From the budget constraint, we have:

(71) $$\frac{\partial c_b}{\partial \alpha} = -\frac{d}{q}\frac{\partial x_b}{\partial \alpha}$$

Using (70) gives:

(72) $$\frac{\partial x_b}{\partial \alpha} = \frac{-u''_{x_b,G}\frac{\partial G}{\partial \alpha} + v''_{y_b,F}\frac{\partial F}{\partial \alpha} - \beta_b\frac{\partial H}{\partial \alpha}}{\left(u''_{x_b,x_b} + v''_{y_b,y_b}\right) - \beta_b}$$

We now turn to the *green-car owner*. If driving in bus lanes is not allowed, the Lagrangian for a consumer driving a green car is:

(73) $$L_g = u\left(x_g, \mathrm{G}\right) + v(y_g) + w(c_g) - \frac{\beta_g}{2}\left(x_g - G\right)^2 + \lambda_g\left(B - \left[\mathrm{r}(1-s) - f\right]x_g - f - qc_g\right).$$

Setting $a = r(1-s) - f$ and $y_g = 1 - x_g$, the first-order condition for a consumer who takes G as given is:

(74) $$\frac{u'_{x_g} - v'_{y_g} - \beta_g(x_g - G)}{w'_{c_g}} = \frac{a}{q}$$

In a similar way as for the brown-car owner, we find the effects on green-car driving of increasing *s* and *t*:

(75) $$\frac{\partial x_g}{\partial s} = \frac{-\frac{r}{q}w'_{c_g} - \left(u''_{x_g,G} + \beta_g\right)\frac{\partial G}{\partial s}}{\left(u''_{x_g,x_g} + v''_{y_g,y_g}\right) - \beta_g}$$

(76) $$\frac{\partial x_g}{\partial t} = \frac{-\left(u''_{x_g,G} + \beta_g\right)\frac{\partial G}{\partial t}}{\left(u''_{x_g,x_g} + v''_{y_g,y_g}\right) - \beta_g}$$

When introducing green-car driving in bus lanes, the Lagrangian for a consumer driving a *green* car will be:

(77) $$L_g = u\left(x_g, M\right) + v(\mathrm{y}_g, F) + w(c_g) - \frac{\beta_g}{2}\left(x_g - H\right)^2 + \lambda_g\left(B - \left[r(1-s) - f\right]x_g - f - qc_g\right),$$

where $M = (1-\alpha)G + \alpha F$, $H = n(s,t,\alpha)x_g + (1 - n(s,t,\alpha))x_b$ and $F = A + n(s,t,\alpha)\alpha x_g$.

In a similar way as for brown-car drivers, we can derive the effect of increasing α:

$$(78) \qquad \frac{\partial x_g}{\partial \alpha} = \frac{-u^{"}_{x_g,\mathrm{M}}\left(F-G\right) - u^{"}_{x_g,\mathrm{M}}\left(1-\alpha\right)\frac{\partial G}{\partial \alpha} + \left(v^{"}_{y_g,F} - \alpha \cdot u^{"}_{x_g,\mathrm{M}}\right)\frac{\partial F}{\partial \alpha} - \beta_g \frac{\partial H}{\partial \alpha}}{\left(u^{"}_{x_g,x_g} + v^{"}_{y_g,y_g}\right) - \beta_g}.$$

Appendix B: The numerical model

The first model we simulate concerns the effect of *increasing subsidies*. This model consists of the simultaneous equation system (8)-(10) from the main text:

$$\frac{\partial x_g}{\partial s} = \frac{-rw'_{c_g} - qu''_{x_g,G}\frac{\partial G}{\partial s}}{q\left(u''_{x_g,x_g} + v''_{y_g,y_g}\right)}$$

$$\frac{\partial x_b}{\partial s} = \frac{-u''_{x_b,G}\frac{\partial G}{\partial s}}{u''_{x_b,x_b} + v''_{y_b,y_b}}$$

$$\frac{\partial G}{\partial s} = n'_s\left(x_g - x_b\right) + n\frac{\partial x_g}{\partial s} + (1-n)\frac{\partial x_b}{\partial s}.$$

We calibrate the model based on data for the Oslo metropolitan area of Norway. To do this, we need to specify the utility function. Following Börjesson et al. (2017) and Wangsness et al. (2018), we use:

(79) $$u\left(x_i, G\right) + v(y_i) + w(c_i) = \left[\phi_{x_i} x_i - 0.5\varphi_{x_i} x_i^2 - \gamma_{x_i} x_i G\right] + \left[\phi_{y_i} y_i - 0.5\varphi_{y_i} y_i^2\right] + \mathrm{c}_i, \quad \mathrm{i} = g, \mathrm{b}$$

Using this utility function, inserting for (2) and optimizing with respect to (4) and (5) gives:

(80) $$x_g = \frac{\phi_{x_g} - \gamma_{x_g} G - \frac{1}{q}\left[r(1-s) - f\right]}{\varphi_{x_g} + \varphi_{y_g}}$$

(81) $$x_b = \frac{\phi_{x_b} - \gamma_{x_b} G - \frac{1}{q}\left[p(1+t) - f\right]}{\varphi_{x_b} + \varphi_{y_b}}$$

Setting q =1 and inserting for G from equation (3), we find:

(82) $$x_g = \frac{\varphi_{x_g} - (1-n)\gamma_{x_g}\left(\frac{\varphi_{x_b} - (p(1+t) - f)}{\varphi_{x_b} + \varphi_{y_b} + (1-n)\gamma_{x_b}}\right) - (r(1-s) - f)}{\varphi_{x_g} + \varphi_{y_g} + n\gamma_{x_g} - \left(\frac{n(1-n)\gamma_{x_g}\gamma_{x_b}}{\varphi_{x_b} + \varphi_{y_b} + (1-n)\gamma_{x_b}}\right)}$$

(83) $$x_b = \frac{\varphi_{x_b} - n\gamma_{x_b}\left(\frac{\varphi_{x_g} - (r(1-s) - f)}{\varphi_{x_g} + \varphi_{y_g} + n\gamma_{x_g}}\right) - (p(1+t) - f)}{\varphi_{x_b} + \varphi_{y_b} + (1-n)\gamma_{x_b} - \left(\frac{n(1-n)\gamma_{x_g}\gamma_{x_b}}{\varphi_{x_g} + \varphi_{y_g} + n\gamma_{x_g}}\right)}$$

Based on (82) and (83), we find:

(84) $$\frac{\partial x_g}{\partial r(1-s)} = -\frac{1}{\varphi_{x_g} + \varphi_{y_g} + n\gamma_{x_g} - \left(\frac{n(1-n)\gamma_{x_g}\gamma_{x_b}}{\varphi_{x_b} + \varphi_{y_b} + (1-n)\gamma_{x_b}}\right)}$$

(85) $$\frac{\partial x_b}{\partial p(1+t)} = -\frac{1}{\varphi_{x_b} + \varphi_{y_b} + (1-n)\gamma_{x_b} - \left(\frac{n(1-n)\gamma_{x_g}\gamma_{x_b}}{\varphi_{x_g} + \varphi_{y_g} + n\gamma_{x_g}}\right)}$$

and

(86) $$\frac{\partial x_g}{\partial r(1-s)}\frac{r(1-s)}{x_g} = -\frac{1}{\varphi_{x_g} + \varphi_{y_g} + n\gamma_{x_g} - \left(\frac{n(1-n)\gamma_{x_g}\gamma_{x_b}}{\varphi_{x_b} + \varphi_{y_b} + (1-n)\gamma_{x_b}}\right)} \cdot \frac{r(1-s)}{x_g}$$

(87) $$\frac{\partial x_b}{\partial p(1+t)}\frac{p(1+t)}{x_b} = -\frac{1}{\varphi_{x_b} + \varphi_{y_b} + (1-n)\gamma_{x_b} - \left(\frac{n(1-n)\gamma_{x_g}\gamma_{x_b}}{\varphi_{x_g} + \varphi_{y_g} + n\gamma_{x_g}}\right)} \cdot \frac{p(1+t)}{x_b}$$

To find $(\varphi_{x_i} + \varphi_{y_i})$, we use estimates of money price elasticities from Börjesson et al. (2017), set to -0.7.[34] However, to do this, we first have to calibrate the other variables and parameters in equations (86) and (87).

We set the average cost of driving a kilometer for a brown car, *p(1+t),* and a green car, *r(1-s*) respectively to NOK 6.80 and NOK 5.40 per kilometer based on estimates from Smarte Penger (2019a), the cost of a ticket of public transport to NOK 36 (based on the price in Oslo), and the average distance per trip with public transport to 17 kilometers (Hjorthol et al. 2014).[35] The shares of driving compared to total transport by car and public transport are set to 0.7 (x_b) and 0.91 (x_g) in the baseline, where x_b is based on Hjorthol et al. (2014), and green driving is set to be 30% higher for local driving, based on Figenbaum and Kolbenstvedt (2016: 44). The cost of congestion for both brown and green cars ($\gamma_{x_i} G$) is set to NOK 3,70 (Thune-Larsen et al. 2014). Further, we set *s* = 0.2 and *t* = 0.4 based on own calculations using numbers from Smarte Penger (2019b), Figenbaum and Kolbeinstvedt (2016), and Faktisk.no (2018). Note that most of the financial benefits to EV owners are tax exemptions. We do not consider VAT (25%) a car tax as it is a general tax on goods, but exemption for VAT is considered a subsidy in our calculations. Finally, EVs' share of the total stock of cars in the Oslo metropolitan area (*n*) was about 12% in 2018, according to data from Statistics Norway (2019). Based on all these estimates and equations (86) and (87), we calibrate $(\varphi_{x_g} + \varphi_{y_g})$ to be 0.81 and $(\varphi_{x_b} + \varphi_{y_b})$ to be 0.98.

Finally, we have calculated the elasticity of the number of green cars with respect to the subsidy ($\frac{\partial n}{\partial s}\frac{s}{n}$) to be able to find $\frac{\partial n}{\partial s}$. Based on price elasticities from Fridstrøm and Østli (2018), a share of 40% EVs in new car sale in Oslo in 2018 (Elbilforeningen, 2019), and the number and types of cars in Oslo from Oslo municipality (2019), we calculate this elasticity to be 0.1.

[34] These estimates are from Stockholm, Sweden, but are unlikely to differ substantially from the price elasticities for Oslo. The elasticity for cars equals the average of peak time and off-peak time elasticities.
[35] However, in the calibration, all prices in NOK are scaled down to 10% of their real value, to get them in the same range as the other values. This downscaling does not matter for the optimal solution as long as the relative prices remain unchanged. Note that in this model where the total demand for transport is inelastic, all that matters for driving and congestion are the relative prices of the different transportation options.

The table below summarizes the calibration:

s	0.2
t	0.4
p	0.49
r	0.68
f	0.21
q	1
x_b	0.7
x_g	0.91
$\varphi_{x_b} + \varphi_{y_b}$	0.98
$\varphi_{x_g} + \varphi_{y_g}$	0.81
γ_{x_b}	0.51
γ_{x_g}	0.51
w'_{c_g}	1
n	0.12
n'_s	0.06

Table B1: Calibrated parameters in the model with increased subsidies

In the sensitivity analysis, we assume that preferences are stable, so we do not change the parameters in the utility functions.

Changing the share of green cars to 0.5 (n = 0.5) will influence $\frac{\partial n}{\partial s}$. By keeping $\frac{\partial n}{\partial s}\frac{s}{n}$ equal to 0.1, we get the following new parameters:

n	0.5
n'_s	0.25

Table B2: Calibrated parameters in the model with increased subsidies – *n* = 0.5

When subsidies are set at 40% (s = 0.4), we recalculate $\frac{\partial n}{\partial s}\frac{s}{n}$ = 0.2. For a doubling of both the elasticity and *s*, $\frac{\partial n}{\partial s}$ remains at 0.06. The initial driving with green cars will probably change, as driving a green car will be relatively cheaper than driving a brown car with the new subsidy rate. However, as the initial green-car driving is already high, we keep the initial share of driving with a green car ($x_g = 0.91$).

s	0.4

Table B3: Calibrated parameters in the model with increased subsidies – *s* = 0.5

The next model addresses the effects of *higher taxes*. This model consists of the simultaneous equation system (11)-(13) from the main text:

$$\frac{\partial x_g}{\partial t} = \frac{-u^{"}_{x_g,G}\frac{\partial G}{\partial t}}{u^{"}_{x_g,x_g} + v^{"}_{y_g,y_g}}$$

$$\frac{\partial x_b}{\partial t} = \frac{pw^{'}_{c_b} - qu^{"}_{x_b,G}\frac{\partial G}{\partial t}}{q\left(u^{"}_{x_b,x_b} + v^{"}_{y_b,y_b}\right)}$$

$$\frac{\partial G}{\partial t} = n^{'}_t\left(x_g - x_b\right) + n\frac{\partial x_g}{\partial t} + (1-n)\frac{\partial x_b}{\partial t}$$

The parameters are as in Table B1, but in addition we need the elasticity of the number of green cars with respect to the tax ($\frac{\partial n}{\partial t}\frac{t}{n}$) to calculate $\frac{\partial n}{\partial t}$. This elasticity is set equal to 0.4 based on calculations drawing on Fridstrøm and Østli (2018), Smarte Penger (2019b,c), and statistics for Oslo (Elbilforeningen, 2019; Oslo municipality, 2019). We then get:

$n^{'}_t$	0.15

Table B4: Additional calibrated parameter in the model with increased tax rate

In the sensitivity analysis, we first increase the share of green cars on the road to 50%. For $\frac{\partial n}{\partial t}\frac{t}{n}$ still equal to 0.4, we calculate $\frac{\partial n}{\partial t}$ to be 0.5; see the table below.

n	0.5
$n_t^{'}$	0.5

Table B5: Calibrated parameters in the model with increased tax rate – *n* = 0.5

Second, we increase the taxes to 60% (t = 0.6). In this case, we recalculate $\frac{\partial n}{\partial t}\frac{t}{n}$ = 0.6, and $\frac{\partial n}{\partial t}$ remains at 0.15. However, a higher tax on brown cars will also reduce the initial driving with brown cars. With price elasticities of -0.7 (Börjesson et al., 2017, see above), and a price increase of about 20%, we calculate $x_b = 0.6$. The new parameters are shown in table B6:

t	0.6
x_b	0.6

Table B6: Calibrated parameters in the model with increased tax rate – t = 0.6

The final model estimates the effects of *allowing green-car driving in bus lanes*. This model consists of the simultaneous equation system (16)–(18) and (20) from the main text:

$$\frac{\partial x_b}{\partial \alpha} = \frac{-u^{"}_{x_b,G}\frac{\partial G}{\partial \alpha} + v^{"}_{y_b,F}\frac{\partial F}{\partial \alpha}}{u^{"}_{x_b,x_b} + v^{"}_{y_b,y_b}}$$

$$\frac{\partial x_g}{\partial \alpha} = \frac{-u^{"}_{x_g,\mathrm{M}}\left(F-G\right) - u^{"}_{x_g,\mathrm{M}}\left(1-\alpha\right)\frac{\partial G}{\partial \alpha} + \left(v^{"}_{y_g,F} - \alpha \cdot u^{"}_{x_g,\mathrm{M}}\right)\frac{\partial F}{\partial \alpha}}{u^{"}_{x_g,x_g} + v^{"}_{y_g,y_g}}$$

$$\frac{\partial F}{\partial \alpha} = n^{'}_{\alpha}\alpha x_g + n x_g + n\alpha\frac{\partial x_g}{\partial \alpha}$$

$$\frac{\partial G}{\partial \alpha} = n^{'}_{\alpha}\left(x_g(1-\alpha) - x_b\right) + n(1-\alpha)\frac{\partial x_g}{\partial \alpha} - n x_g + (1-n)\frac{\partial x_b}{\partial \alpha}$$

Because we allow for congestion in the bus lane, the new utility function for brown-car drivers is:

(88) $$u\left(x_b, G\right) + v(y_b, \mathrm{F}) + w(c_b) = \left[\phi_{x_b} x_b - 0.5\varphi_{x_b} x_b^2 - \gamma_{x_b} x_b G\right] + \left[\phi_{y_b} y_b - 0.5\varphi_{y_b} y_b^2 - \gamma_{x_b} y_b F\right] + c_b$$

Similarly, the new utility function for green-car drivers is:

(89) $$u\left(x_g, \mathrm{M}\right) + v(y_g, \mathrm{F}) + w(c_g) = \left[\phi_{x_g} x_g - 0.5\varphi_{x_g} x_g^2 - \gamma_{x_g} x_g M\right] + \left[\phi_{y_g} y_g - 0.5\varphi_{y_g} y_g^2 - \gamma_{x_g} y_g F\right] + c_g$$

To remain consistent with the other simulations, we keep the parameters $(\varphi_{x_i} + \varphi_{y_i})$ as before. We set the cost of congestion in bus lanes to one third of the corresponding cost in regular lanes. To calibrate *A* (where $F = A + n\alpha x_g$), we also set the initial congestion in bus lanes to one third of the congestion in regular lanes ($F / G = 1/3$). In addition, we set the share of roads with open bus lanes, *α*, to 0.3. EVs in the Oslo metropolitan area are to a large extent used for commuting to work, and the estimate is for times when roads are maximally loaded and public lane driving is a real benefit (rush time). To find $\frac{\partial n}{\partial \alpha}$, we set the elasticity of the number of green cars with respect to the open bus lanes ($\frac{\partial n}{\partial \alpha}\frac{\alpha}{n}$) to 0.1. This parameter value is based on calculations of the benefits of bus-lane driving from Figenbaum and Kolbeinstvedt (2016), as well as the calculations on subsidies above. This gives the values in Table B7:

α	0.3
A	0.20
γ_{x_b}	0.5
γ_{x_g}	0.5
$n_\alpha^{'}$	0.05

Table B7: New calibrated parameters in the model with driving in bus lanes

In the sensitivity analysis, we first set *α* = 0.5. This requires a recalibration of $\frac{\partial n}{\partial \alpha}$. The following new parameters are given in table B8:

α	0.5
$n_{\alpha}^{'}$	0.03

Table B8: New calibrated parameters in the model with driving in bus lanes – *α* = 0.5

For *n* = 0.5, we also need a recalibration of $\frac{\partial n}{\partial \alpha}$, as shown in the table below:

n	0.5
$n_{\alpha}^{'}$	0.17

Table B9: Calibrated parameters in the model with driving in the bus lanes – *n* = 0.5

Appendix C: Survey questions

The following question were included in the survey and contains the framing of the issue:

1. "To reach environmental and climate goals, the authorities have granted electric vehicles particular benefits, such as tax exemption, free parking and battery charging, and (in some places) permission to drive in the bus lane. To what extent have these policies influenced your household's car use?"

The response categories were:

a. Drives considerably less than before
b. Drives somewhat less than before
c. Drives as before
d. Drives somewhat more than before
e. Drives considerably more than before
f. Don't know

The following question was asked to those who reported to drive more than before:

2. "You have answered that you drive more or considerably more than before. To what extent do you agree with the following statements?":
   a. The performance of buses has decreased and their travel time has increased.
   b. There are fewer queues on the roads than before.
   c. The household's motivation to limit driving has been weakened.
   d. My/our habits have changed.

The respondents could choose from a 5-point Likert scale ranging from (1) Highly agree, (2) Somewhat agree, (3) Neither agree nor disagree, (4) Somewhat disagree, (5) Highly disagree. It was possible to type in a free text under a fan "Other."

The following question was asked to those who answered that they drive less than before:

3. “You have answered that you drive less or considerably less than before. To what extent do you agree with the following statements?”:

a. There are more cars on the road and more queues.

b. Driving has become more expensive.

c. The household’s motivation to limit driving has been strengthened.

d. My/our habits have changed.

Again, a 5-point Likert scale ranging as the one above was used.

Appendix D: Detailed survey results

Question: *To reach environmental and climate goals, the authorities have granted electric vehicles particular benefits, such as tax exemption, free parking and battery charging, and (in some places) permission to drive in the bus lane. To what extent have these policies influenced your household's car use?*

	Frequency	Valid Percent ('don't know' included)	Valid Percent ('don't know' excluded)
Drives considerably less than before	43	2.2	2.9
Drives somewhat less than before	119	6.0	7.9
Drives as before	1290	64.9	86.0
Drives somewhat more than before	31	1.6	2.1
Drives considerably more than before	16	0.8	1.1
Don't know	490	24.6	-
Total	1989	100	100

Table D1: Changes in brown-car driving due to benefits granted to EV users