

Norway: Selected Issues



NORWAY

SELECTED ISSUES

June 2021

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ELECTRIC VEHICLES, TAX INCENTIVES AND EMISSIONS: EVIDENCE FROM NORWAY

The share of electric vehicles (EVs) is much higher in Norway than in other countries, thanks to generous tax and other incentives. Norway has therefore become a global focal point on how a country can green its car fleet. Estimates show that the annual savings in emissions for the average household from the purchase of an EV are limited on average. However, recalibrating the tax incentives in a way that would incentivize the replacement of the most polluting conventional cars by EVs to a greater extent in a revenue-neutral way could significantly improve their environmental benefits and cost effectiveness. This would also serve to complement Norway's laudable target that all new cars are electric by 2025.

A. Introduction

1. The share of battery powered electric vehicles (EVs) is much higher in Norway than in other countries. Around half of the cars sold annually in Norway are EVs, thanks to generous tax and other incentives. EVs are not subject to VAT, and the one-off motor vehicle registration taxes have a strong green component and are designed to incentivize the purchase of EVs. In combination, both incentives can amount to more than 40 percent of the pre-tax price depending on assumptions.² Owners of EVs also benefit from other advantages, including lower annual vehicle license fees, reductions of certain tolls and parking fees and the possibility to use special road lanes; see Bjerkan et al. (2016) and Figenbaum et al. (2015) for a detailed summary of incentives in Norway. Fridstrøm (2021) calculate the price of carbon implicit in the fiscal incentives bearing on vehicles, fuel or road use. Norway has also one of the largest number of public charging stations per capita (Hall and Lutsey, 2020).

2. Given the scale of Norwegian tax incentives and the market share of EVs, the Norwegian example can potentially provide important lessons for other countries. Beyond Norway, tax incentives, subsidies and 'feebates' for electric vehicles feature prominently in other countries' recovery programs from the Covid crisis (IEA, 2021) and electric vehicles are often seen as an important element of climate change mitigation strategies (Hausfather, 2019). Norway is demonstrating that bold economic policies can dramatically speed up the electrification of a country's passenger car fleet—Norway itself is targeting 100 percent EVs for all new vehicle sales by 2025—and any lessons could be useful for other countries, especially for those that primarily rely on green electricity sources.

3. The objective of this paper is to analyze the effectiveness from an environmental perspective of one important component of government EV policies, the tax incentives for the purchase of EVs. Research in Norway and elsewhere mostly suggests that up-front price reduction

² The VAT exemption for electric cars was introduced in the early 2000s, and the zero one-off motor vehicle registration tax has been implemented in the early 1990s, but it has been changed [recently](#) to further strengthen the preferential treatment of electric cars.

is the most important incentive in promoting EV adoption (Bjerkan et al., 2016), although there is some disagreement on the relative importance of policy instruments (Mersky et al., 2016). The paper empirically analyzes the contribution of EVs to emission reductions and the implied costs of the tax incentives per tCO₂ saved; it also suggests some routes for Norway to enhance their environmental benefits.

4. Focusing on Norway as a case study for the emission reductions from EV usage and effectiveness of tax incentives for EVs has clear advantages. First, Statistics Norway collects unique data on the universe of passenger cars and households that own them which is unparalleled in terms of granularity, quality, and richness, covering the 2010–2019 period (with some gaps). Second, electricity in Norway comes almost entirely from renewable sources which makes the environmental impact of EVs easier to analyze. In other countries, the share of non-renewable electricity sources is typically much higher.³

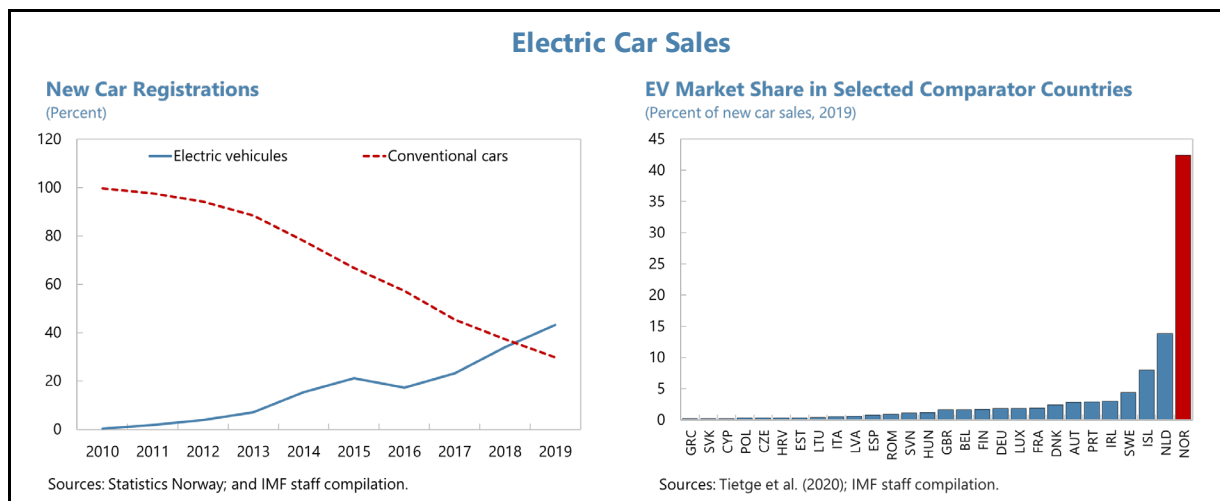
5. We build upon previous literature that examines fiscal incentives for EVs. There is broad consensus that Norway's subsidies have been an important factor in driving the increase in the sale of EVs (Aasness et al., 2015; Figenbaum, 2017; Holtsmark and Skonhoft, 2014). Holtsmark and Skonhoft (2014) use a simple but compelling example to argue that subsidies for EVs in Norway deliver low emission savings at relatively high costs. Ciccone (2018) finds that a past vehicle registration tax reform in Norway led to a decline in emissions, driven by a drop in the share of high CO₂-intensive vehicles and an increase in the market share of diesel cars. Camara et al. (2021) summarizes the international literature. Compared to previous papers, our data allows estimating empirically the emission savings that result from EVs, and we explore their heterogeneity across households to inform policy in a more granular way.

B. Stylized Facts

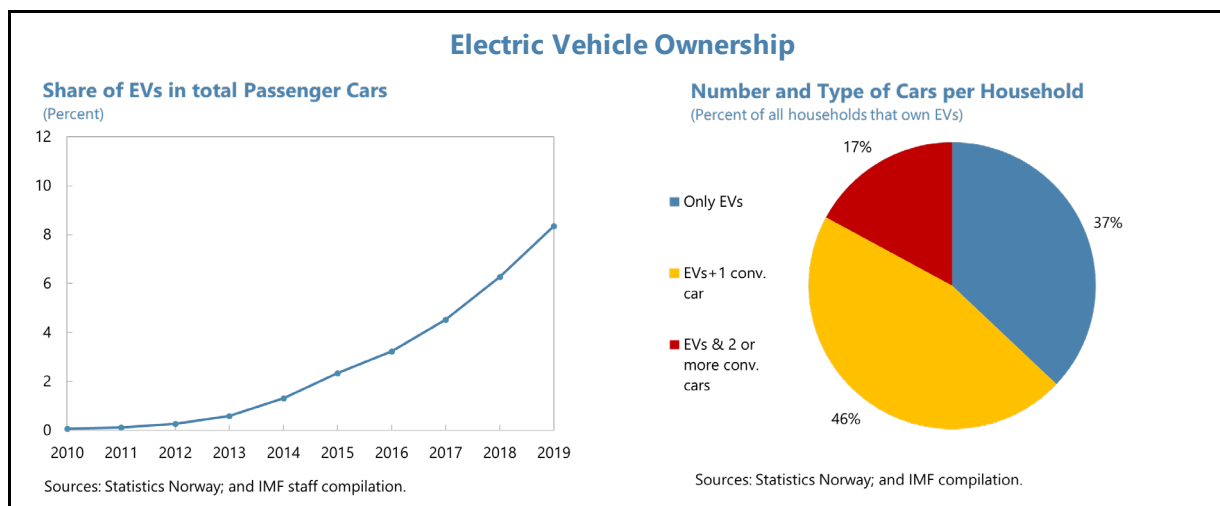
Ownership of Electric Vehicles

6. Norway's tax incentives have undoubtedly helped to make Norway a global leader in terms of ownership of electric vehicles. The share of EVs in total sales of new cars has reached around 50 percent and is significantly higher than in comparator countries. The steady increase in the sales of EVs started in 2013 after technological improvements made EVs more attractive and a major manufacturer of EVs entered the Norwegian market.

³ For the purpose of this paper and to estimate the CO₂ emission impact of EVs, we ignore other types of exhaust emissions (mainly NO_x and PM), emissions during the production of EVs (which are sometimes found to be higher than those of ICEVs) and relatively high non-exhaust particle emissions during operation, including from wearing down of tires over time (Timmers and Achten, 2016). We also ignore the possibility that higher electricity demand through increased EV usage will reduce the share of electricity from renewable sources.

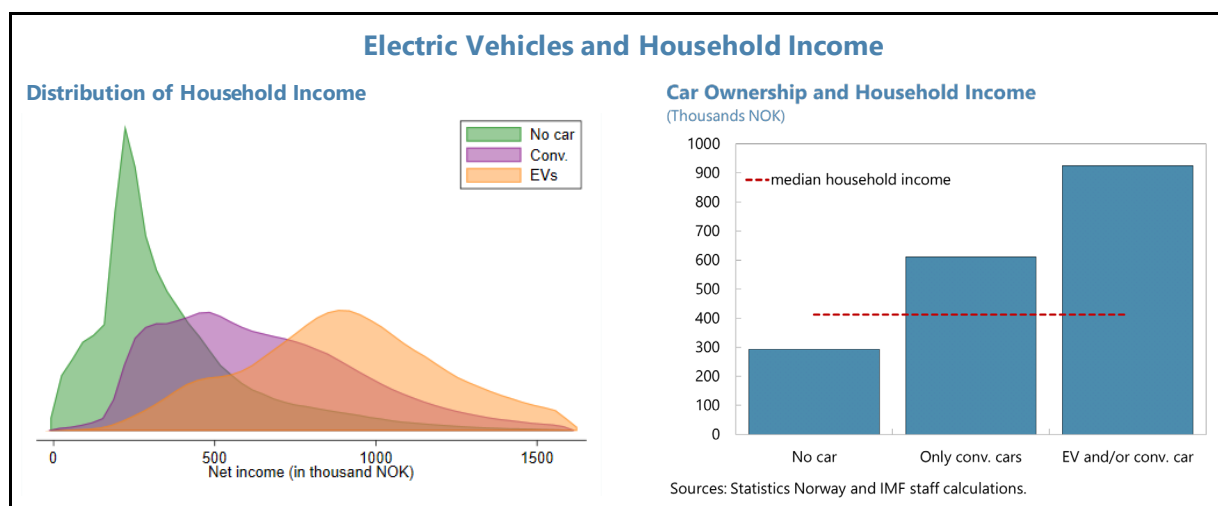


7. However, the full greening of Norway’s car fleet will take many years at the current pace. The substitution of conventional cars by EVs is limited so far, given that the increase in the number of EVs by far outpaced the decrease in conventional cars, reflected by an increase of the overall stock of cars between 2010 and 2019. Out of all households that owned EVs in 2018, just over one-third (37 percent) owned only EVs, whereas 46 and 17 percent of households had also one or more conventional cars in addition to EV(s). As a result, EV ownership as a stock of total cars remains low, with EVs representing only a relatively small share of all cars (around 9 percent) as of 2019. At current trends, the transition to full electrification of Norway’s car fleet would take several decades. However, the transition could be substantially faster, given that the share of EVs in the sale of new cars has been growing quickly and given Norway’s goal that all new vehicles sold are tailpipe emission-free by 2025.⁴



⁴ The latest data suggest that the share of EVs in new car registrations and in total cars now exceeds 50 and 10 percent, respectively.

8. Poorer households are less likely to own electric vehicles, in line with findings of Fevang et al. (2020). The median income of households that own at least one EVs was above 900,000 NOK), around 50 percent higher than that of households that own only conventional cars and twice the median household income in Norway over the 2010–18 period (413,000 NOK). In 2019, the average price of EVs and internal combustion engine vehicles (ICEVs) was around 525,000 NOK and 485,000, respectively.



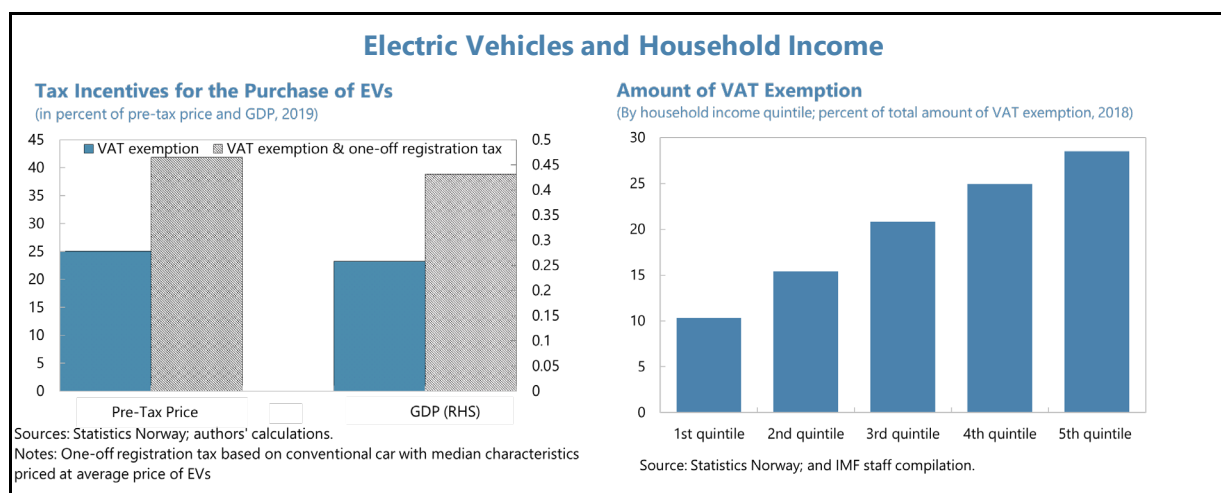
Tax Incentives

9. The purchase of EVs is incentivized through VAT exemptions and the design of one-off registration taxes. EVs are exempt from VAT, whereas conventional cars are taxed at the standard rate of 25 percent. The implicit total cost of the VAT exemptions in 2019, calculated as the product of the number of new EVs, the average price of new EVs and 25 percent, totaled 0.26 percent of mainland GDP. Conventional cars are also subject to one-off registration taxes that have a green objective – this tax is a function of the cars’ CO₂ and NO_x emissions and their weight. EVs, by virtue of zero tailpipe emissions, are not subject to such registration taxes. To give a sense of the incentives provided by one-off registration taxes, we calculate them for a hypothetical conventional car with median weight and emissions and priced at the average price of EVs. In this case, the VAT exemption and the saved one-off registration taxes combined amount to almost 42 percent of the pre-tax price of the averaged priced EV and a combined 0.43 percent of mainland GDP. However, in the remainder of the paper, we ignore the one-off registration taxes because they do not count as tax expenditures in a strict sense (they are ‘green’ by design) and the calculation of the magnitude of the incentives is sensitive to assumptions.

10. The annual cost, in particular of the VAT exemptions, in terms of GDP seems limited. However, over time, and with the increase in the market share of electric vehicles, the annual revenue implications (especially when including the registration tax) increase, and the cumulative multi-year cost is obviously much higher. Reflecting this, the Norwegian authorities recently

indicated that they are in the process of considering what changes in the incentive structure might be warranted in the future, not least to contain the fiscal costs.⁵

11. The distribution of the VAT exemptions across households is regressive. We calculate the implicit cost of the VAT exemptions by household income quintile in percent of the total cost of the VAT exemptions for EVs purchased by households. The results show that the top 20 percent of households by income secured almost 30 percent of the implicit cost of the VAT exemptions for EVs, almost three times as much as the households in the poorest quintile. This reflects the uneven distribution of EV ownership and that the VAT exemptions apply to the full value of the EV, including features which have no environmental benefits which higher income households are presumably more likely to afford.

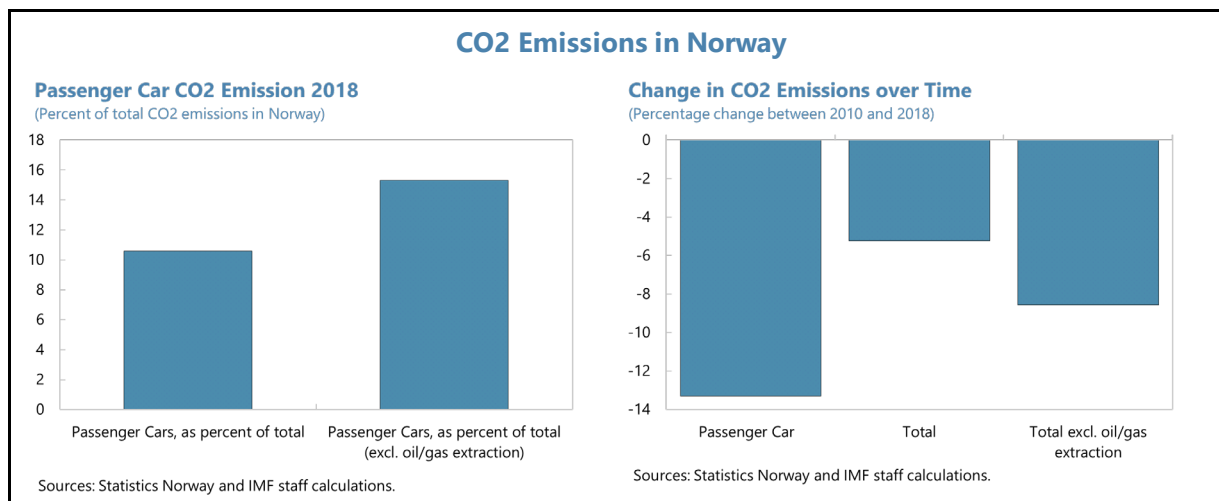


CO2 Emissions in Norway

12. The scope for CO2 emission reductions through the increased use of EVs is significant, though still modest compared to other sources of emissions in Norway. Emissions from passenger cars amount to 10 percent of Norway's total domestic CO2 emissions and around 15 percent of total emissions excluding emissions from oil and gas extraction. Since 2010, passenger car emissions fell by more than 10 percent, a faster rate of decline than overall emissions in Norway, potentially due to the combined effects of increased use of EVs and greater fuel efficiency of conventional and hybrid cars.⁶

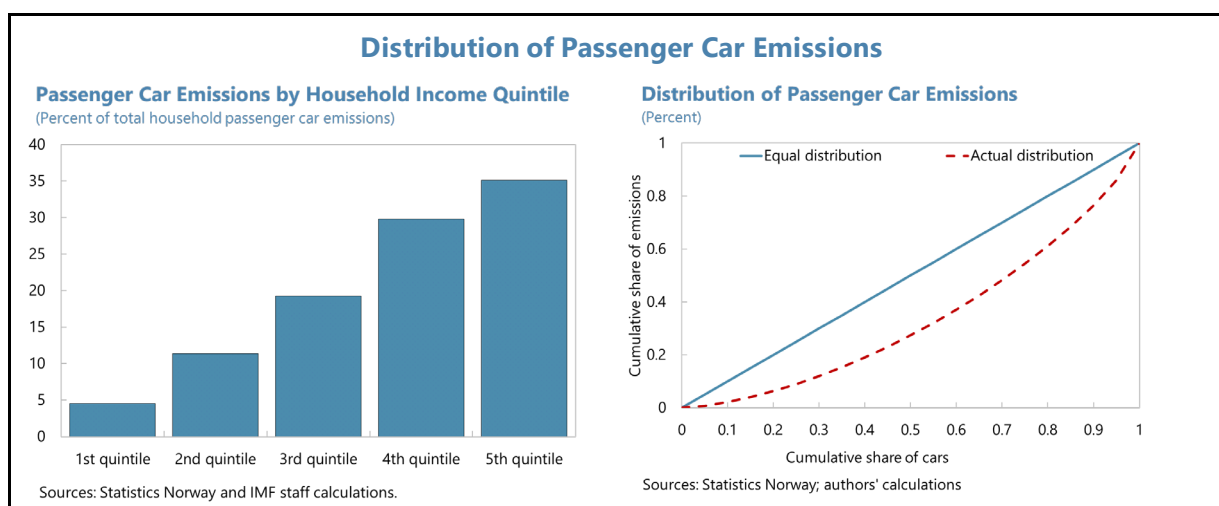
⁵ Motor vehicles tax revenue declined from around 1.9 to 0.9 percent of mainland GDP between 2010 and 2020, while VAT revenue increased slightly.

⁶ Details on total emissions in Norway are available here: <https://www.ssb.no/en/nrmiljo>.



13. CO2 emissions from conventional cars are unevenly distributed across households and cars. The combined CO2 emissions from passenger cars used by households in the highest income quintile are more than seven times higher than those of households in the lowest income decile. In addition, 5 percent of passenger cars account for 15 percent of all emissions from all passenger cars, which reflects a combination of poor fuel efficiency and the level of the annual mileage driven.

14. In this regard, there is a trade-off between climate and equity objectives. High income households are by far the largest emitters, which implies that emission reductions from the purchase of EVs are largest among this group. On the other hand, the concentration of the benefits of the VAT exemption in the upper quintiles of households is regressive. This dichotomy deserves attention but should be taken in a broader context of social policies in Norway, which have resulted in one of the most equal societies in the world, relatively speaking. This could also be partially offset by high taxes on conventional cars (especially higher polluting vehicles) which are likely to be borne by higher income households to a significant extent.



C. Econometric Results

15. We econometrically estimate the fall in emissions associated with EVs in Norway at the household level. We focus on emissions from household-owned passenger cars which depend on household preferences and behavior; intuitively, the change in emissions depends on the degree of substitution of conventional cars by EVs which is driven by household behavior and preference; for instance, this could widely differ between a household that only owns EVs to one that also owns conventional cars. In the latter case, the effects on emissions depend on the usage of each car.

16. We estimate the effects of EV ownership on emissions at the household level using the following specification:

$$Emission_{hmt} = \beta_0 + \beta_1 NumberEV_{hmt} + X_{hmt} \theta + \gamma_h + \gamma_{mt} + \varepsilon_{hmt}$$

$Emission_{hmt}$ denote total CO₂ emission of household h located in municipality m in year t , calculated as the product of annual mileage and CO₂ emissions per km, summed over all cars owned by household h . $NumberEV_{hmt}$ denote the number of EVs owned by household h located in municipality m in year t . We also include a number of socio-demographic control variables at the household level including household income and net wealth. To address any potential omitted variable bias, we also control for unobserved effects at the household and at the municipality-year level (where the municipality refers to the place of residence of the household). Our sample includes all households that own EVs, ICEVs or or hybrid vehicles.⁷

17. The results from the regression models show that EV ownership is correlated with significantly lower emissions at the household level. Table 1 shows that purchasing an additional EV lowers household-level emissions by 1.17 tCO₂ annually (specification 1, Table 1). The results are statistically and economically significant: Household-level emission savings of one additional EV amount to around half of the level of emissions from passenger cars of the average car-owning household (2.3 tCO₂ annually).

⁷ We omit from the analysis those cars that are plug-in hybrid cars and some other car types (i.e., cars that are not EVs, internal combustion engine cars and non-plug-in hybrid cars) as the emissions of some of these cars are difficult to calculate. These cars represent only a small fraction of all vehicles owned in Norway as of 2019.

Table 1. Econometric Results

VARIABLES	(1) emissions	(2) emissions	(3) emissions	(4) emissions
no_ev	-1,171.96*** (3.78)			
ev_1st_hh		-1,187.88*** (4.03)		
ev_2nd_hh		-1,082.85*** (15.41)		
ev_3rd_more_hh		-287.63*** (88.16)		
pre2016#no_ev			-996.74*** (6.29)	
post2015#no_ev			-1,209.00*** (3.89)	
only_ev#no_ev				-2,176.03*** (5.17)
icev&ev#no_ev				-630.94*** (4.33)
head_age	-15.82*** (0.22)	-15.82*** (0.22)	-15.82*** (0.22)	-15.72*** (0.22)
head_female	-84.00*** (2.38)	-83.96*** (2.38)	-83.73*** (2.38)	-84.12*** (2.36)
no_adult	535.78*** (2.01)	535.77*** (2.01)	535.93*** (2.01)	525.87*** (1.99)
no_child	122.50*** (1.65)	122.62*** (1.65)	122.38*** (1.65)	123.08*** (1.64)
netinc	0.01* (0.00)	0.01* (0.00)	0.01* (0.00)	0.01* (0.00)
netwealth	-0.09 (0.12)	-0.09 (0.12)	-0.08 (0.12)	-0.10 (0.12)
Constant	2,549.95*** (12.94)	2,550.16*** (12.94)	2,548.65*** (12.94)	2,563.51*** (12.89)
Observations	9,358,297	9,358,297	9,358,297	9,358,297
R-squared	0.65	0.65	0.65	0.65
Mun.-Year FE	YES	YES	YES	YES
HH FE	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1

18. However, depending on circumstances and characteristics of the household, the emission savings can be much smaller or larger than the average effects. In specification 2, we show that the effects decrease in the number of EVs that a household owns, with the first one having the largest effects. In specification 3, we show that the effects increased in recent years, and that before 2016, the emission savings were much smaller, perhaps due to technological improvements of EVs which made them more versatile (or factors such as household behavioral changes over time). In specification 4, we show that the emission savings are much larger in households that own only EVs relative to those who own conventional cars and EVs.

D. Cost Effectiveness and Aggregate Emission Savings

19. We use a simple back-of-the envelope calculation to infer the cost effectiveness of the VAT tax incentives. Relating the carbon emissions saved to the amount of fiscal incentives per EV yields a measure of cost effectiveness:

$$effectiveness = subsidies / (emissions_saved \times lifetime)$$

where *emissions_saved* denote the regression-based estimates of annual emission savings from buying one additional EV (i.e., the coefficient on the number of EVs which is expressed in kgCO₂), *lifetime* denotes the assumed lifespan of the average EV (which we assume to be 15 years, though foreseeable technological progress may make older EVs obsolete sooner and newer EVs even better substitutes for ICE vehicles, e.g., longer range), and *subsidies* denotes the implicit cost of the VAT exemption (we use the average price of newly purchased EVs in 2019 by households which is around NOK 525,000; the implicit cost of the VAT exemption is then around NOK 131,000 or USD 12,500). This type of back-on-the-envelope calculation is for illustrative purposes and comes with several caveats. We ignore the one-off registration taxes because they have a strong green component and aim at promoting EV usage as discussed above. We also ignore the possibility that in the absence of the VAT exemption, households may opt for a cheaper conventional car, costs due distortions from car taxation in Norway, and any indirect costs or benefits.

20. The amount of emissions saved from purchasing EVs are small relative to the costs of the tax incentives compared to estimated abatement costs in the literature. The baseline estimate in Table 1, specification 1, suggests that the annual savings amount to 1.17 tCO₂ which can be used to calculate the lifetime emission savings from the purchase of one additional EV: $15 \times 1.17tCo2 = 17.55tCo2$. This implies a cost (from the VAT exemption for EVs) per tCO₂ of around USD 710.⁸ Gillingham and Stock (2018) present a survey of estimated abatement costs of different interventions mostly in the U.S., i.e., estimates of the cost to reduce one ton of CO₂. Our

⁸ The implicit cost of all tax benefits for the purchase and operation of EVs including the VAT exemption have been estimated at around USD 1,400 per tCO₂ saved by [Norway's Ministry of Finance](#) in the 2021 budget, which is broadly consistent with our estimates.

estimates are in the upper range of those estimates and are notably much larger than those of a cash-for-clunker program, changes in land use, or increases in energy efficiency for example.⁹

21. However, the cost effectiveness of Norway’s EV tax subsidies can be significantly higher under some circumstances. First, in line with specification 4, Table 1, the emission savings double for households that buy one additional EV and that do not own conventional cars. Similarly, as shown by Camara et al. (2021), the emission savings can more than triple if households buy a new EV and replace a car whose annual emissions are in the top quintile of all conventional cars.¹⁰

22. Our back-of-the envelope calculations is subject to some caveats that could result in over- or underestimating the implicit cost to reduce one ton of CO₂. On the one hand, the fiscal incentives help lower EV production costs through reaping economies of scale and promoting learning by doing and help overcome adverse network externalities, all of which we do not account for. Our estimates also ignore any positive spillovers, which could arise if Norway’s tax incentives for EVs set a positive example (‘demonstration effect’) that other countries may wish to imitate. On the other hand, our estimates do not account for general equilibrium effects which could increase the costs, if for example any conventional vehicles that are replaced by an individual household are not scrapped but sold for use elsewhere. However, whether replaced conventional cars are sold or scrapped is a function of policies as we discuss below.

23. It is also possible to evaluate the effects of EV usage on aggregate annual emissions in Norway. Multiplying the emission savings per EV obtained from our regressions with the number of EVs owned by households in 2018 yields the total annual carbon emission savings. For illustration purposes, we compare aggregate emissions when 10 percent of all household-owned cars are EVs, slightly more than the actual share in 2019, to a scenario when there are no EVs. The difference in aggregate emissions amounts to only 8 percent, i.e., without EVs, aggregate emissions would exceed current passenger car emissions by 8 percent. Of course, aggregate emission savings would be larger if dirty conventional cars are replaced.

E. Policy Implications

24. Norway demonstrates that bold policy action can dramatically speed up the adoption of EVs at limited fiscal costs in terms of GDP. The foregone revenue from the VAT exemptions and potential foregone one-off registration taxes each at less than 0.25 percent seems moderate and reasonable in pursuit of green objectives, although that amount is set to increase and accumulates over time. If the share of EVs in the sale of new cars increases, the aggregate cost of the VAT exemptions would also grow (eventually roughly doubling under current policies, when all new vehicle purchases are EVs) in the absence of any policy reform.

⁹ The authors present a detailed table of various interventions obtained from the literature, available here: <https://www.aeaweb.org/content/file?id=8325>.

¹⁰ Of course, in this case, household-level emissions savings only translate in aggregate savings if any conventional car that is replaced is also scrapped and not used elsewhere.

25. However, the costs of Norway's tax incentives are high relative to the direct environmental benefits, at least when compared to some other climate mitigation programs.

Specifically, the implied fiscal costs of the VAT exemptions per ton of CO₂ emission cuts are in the range of USD 710 in 2019, which is high relative to the estimated costs of cutting CO₂ emissions in the literature. The annual mileage of EVs can be shown to be lower than that of conventional cars, even after controlling for potentially confounding factors, and a majority of EV-owning households also own conventional cars, reflecting that EVs are used in addition to conventional cars. Of course, the emission savings of individual EVs could grow in the future, for instance if their maximum range further increases so that they are used more.

26. The authorities could consider recalibrating the tax incentives for the purchase of new EVs in a revenue neutral way to magnify their environmental benefits and complement Norway's target that all new cars are electric by 2025.

The emission saving of EVs can increase significantly if a newly purchased EV fully replaces some of the least fuel efficient and most polluting existing cars, respectively. This could be encouraged through a combination of targeted subsidies to scrap dirty cars when they are replaced by EVs, and tax or regulatory measures, while revenue neutrality could be achieved by increasing the tax burden on high-end EVs (e.g., by capping the amount of the VAT exemption and/or levying annual road tax on some of the most luxurious EVs). Further research based on data used in this paper could determine the exact parameters of such a recalibration.

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