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Towards Green Driving? Income Tax Incentives for Company Cars*

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Abstract

We examine the real effects and cost-efficiency of a targeted policy designed to promote low-emission corporate mobility. Specifically, we study a German reform that introduced a preferential income tax treatment for plug-in hybrid and electric company cars. Using a difference-in-differences design, we identify its causal impact on the sustainability of corporate fleets and compare car models eligible for the preferential tax treatment in Germany with the same models in the neighboring country Austria. Our findings indicate that the tax benefit increases the number of newly registered eligible cars by 95%. This finding is robust to several robustness checks, including a triple difference-in-differences specification. A cost-benefit analysis reveals that the reform is cost-inefficient from a government perspective, with estimated costs of 1,266 € per saved ton of carbon dioxide (CO_2), substantially exceeding those of comparable transport-sector measures. We also assess the reform's implications for firms and estimate substantial abatement costs of 1,302 € per saved ton of corporate emissions. We show that the costs for both the government and firms would substantially decrease if the electric driving share of plug-in hybrids would be increased or only purely electric cars were eligible for the preferential tax treatment.

Keywords: green taxes, electric mobility, tax incentives, ESG reporting

JEL Classification: H24, Q53, R41

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1 Introduction

Environmental protection and reducing carbon dioxide (CO_2) emissions are among the most pressing topics in public debate across generations and nations (see, e.g., Lewis et al., 2019). To achieve the climate goals codified in the Paris Agreement, governments have used various tax and non-tax measures to incentivize environmentally friendly behavior and reduce emissions. A major source of emissions is the transportation sector; it accounts for 27% of total emissions in the United States and 20% in Europe (United States Environmental Protection Agency, 2022; European Environment Agency, 2017). Within this sector, company cars play a particularly important role in shaping current and future emissions trajectories, as they account for over 60% (45%) of new car registrations in many European countries (the US) (see Sopp and Gast, 2020; Global Fleet, 2024). To understand the real effects of targeted environmental tax policies, we examine a German tax reform aimed at encouraging green driving by granting an income tax incentive for employees driving electric and plug-in hybrid company cars. We assess the reform's effectiveness in increasing the environmental sustainability of corporate fleets, its cost-efficiency from a government perspective, and its implications for firms by estimating the reduction in corporate CO_2 emissions and the associated costs.

Electric and plug-in hybrid cars potentially have a much smaller climate footprint than traditional combustion engine vehicles, especially when their batteries are recharged with renewable energy (see, e.g., Orsi et al., 2016). However, several factors have hampered the mobility transformation, including the higher upfront cost of these eco-friendly cars, individual preferences, and infrastructure issues (see, e.g., Liao et al., 2017). To overcome these barriers, governments implement various policies to promote hybrid and electric cars.[1] Most

[1] Although fundamental reforms may appear to be the most promising approach to addressing the climate crisis, they often face significant implementation challenges. For instance, in June 2022, the US Supreme Court restricted the Environmental Protection Agency's authority to implement comprehensive regulations, such as a carbon tax, to regulate carbon emissions (New York Times, 2022). Such decisions prompt the question of whether less ambitious and more targeted regulations might offer a more promising avenue to reduce CO_2 emissions and address the climate crisis.

countries focus on the end of the value chain and incentivize the purchase of eco-friendly vehicles by offering diverse incentives to consumers, ranging from direct subsidies to preferential parking to tax incentives (van der Steen et al., 2015).[2] Understanding the effectiveness and cost-efficiency of specific interventions, along with their effects on firm behavior, provides policymakers with crucial guidance for policy design. These insights enable the development of measures that achieve substantial emission reductions while minimizing public spending.

We focus on a specific tax stimulus introduced in 2019 designed to encourage the adoption of eco-friendly cars in Germany. While most tax and non-tax instruments promoting green driving apply to both private and company cars, this policy reform exclusively targets company cars. It provides employees with a financial incentive through an income tax benefit when selecting an eligible plug-in hybrid or electric vehicle as a company car. Specifically, the reform reduces the taxable value of the private use of company cars by 50 percent, lowering employees annual income tax payments by on average 875 €. The reform thus reduces the operating costs of company cars for employees. While the reform formally targets employees, it also has significant implications for firms. First, companies determine the set of available vehicles by assembling a car catalogue from which employees may choose – often constrained by job level or function – thereby guiding the ultimate selection. Second, firms are directly affected by the composition of their vehicle fleets and the resulting CO_2 emissions. As corporate sustainability reporting gains importance – particularly through frameworks like Environmental, Social, and Governance (ESG) disclosures – many firms are required to disclose their emissions publicly. By transitioning to eligible vehicles, firms can lower their reported emissions. Given the dominance of company cars in new car registrations and their dual impact on societal and corporate emissions, evaluating reforms that target company cars specifically can enhance the overall effectiveness of emission reduction policies.

We conduct our analysis in two parts. First, we assess the effectiveness in fostering

[2] As the focus of our paper is on a tax policy, we will abstract from non-tax policy interventions in the following.

employees to choose more eco-friendly company cars. We use a difference-in-differences design and compare new company car registrations of eligible plug-in hybrid and electric cars in Germany with the same car models in neighboring Austria (so-called pseudo-eligible car models). Germany and Austria are comparable German-speaking countries with similar legal and tax systems. Additionally, the car markets of both countries are very similar in terms of brand shares and the share of company cars in new car registrations.[3] However, unlike Germany, Austria did not change the tax treatment of hybrid and electric company cars or subsidize them during our observation period, making it a suitable control country.

We build our analysis on administrative data from the German Federal Motor Transport Authority and the Austrian Federal Office of Statistics, which contain monthly new company car registrations for all vehicle models on the German and Austrian car market from January 2017 until December 2019. We combine these data with hand-collected information on several car model-specific properties.

We find that introducing the preferential tax treatment for plug-in hybrid and electric company cars effectively increased eco-friendly car registrations in Germany. Specifically, the results from our difference-in-differences approach show that the reform leads to a statistically and economically significant increase in new registrations of eligible company cars in Germany of 95% compared to pseudo-eligible company cars in Austria. In aggregate, this equals to 120,000 additional eligible car registrations per year across the country. Differentiating between plug-in hybrid and electric cars reveals that, even though both car types benefit, the effect for plug-in hybrids exceeds that for electric cars by 25%. The findings are confirmed by a triple difference-in-differences design, where we compare the difference between eligible and non-eligible cars in Germany and Austria. In contrast to our baseline specification, this setting allows us to include all car models (eligible and non-eligible) and

[3]For the comparability of brand shares between Germany and Austria, see Figure A1 in the appendix. Comparing the share of company cars, our data reveals that in Germany, 67% of new car registrations were company cars, while the share in Austria was 65%. Both numbers refer to the year 2018, which is the year prior to the implementation of the reform.

thus increase power. In heterogeneity analyses, we find that the increase in new car registrations is particularly pronounced for (a) cars produced by German manufacturers and (b) more expensive plug-in hybrids, which tend to emit more than less expensive plug-in hybrids. These results suggest that the reform (a) is also a subsidy to German manufacturers, and (b) results in only minimal emission reductions, as the incentivized plug-in hybrids are predominantly used with the internal combustion engine.

Subsequently, we assess the cost-efficiency of the reform from a government perspective by comparing the fiscal costs – measured as lost income tax revenue – to the environmental benefits in terms of saved CO_2 emissions. In the baseline scenario, we estimate reform-induced costs per newly registered company car of 3,623 €, and CO_2 savings of 2.9 tons. This implies reform-induced costs per saved ton of CO_2 of 1,266 €. This estimate exceeds the costs of interventions that reduce the upfront costs of cars, e.g., by Chandra et al. (2010), by a factor of three or more and ranges at the upper end of cost estimates in the few studies examining policies that also reduce vehicles operating expenses, e.g., by Metcalf (2008). It also surpasses the price of CO_2 allowances traded on the European Climate Exchange over our observation period by a factor of 60, and exceeds estimated social costs of CO_2 by a factor of six (Rennert et al., 2022). Overall, we conclude that this reform is a rather cost-inefficient policy. However, our scenario analyses suggest that the reforms cost-efficiency could be substantially improved if (a) employees made greater use of the electric-drive mode of eligible plug-in hybrids, (b) the tax benefit were restricted to fully electric vehicles only, or (c) both vehicle types were primarily charged using renewable energy. We therefore propose design adjustments that could enhance both the environmental effectiveness and cost-efficiency of this tax policy.

Beyond the government perspective, we also assess the reform's impact on firms by estimating reform-induced changes in corporate emissions and associated costs at the firm level. When employees select more eco-friendly vehicles, coporate emissions decline. However, realizing these environmental benefits often involves financial trade-offs, as eligible vehicle models tend to entail higher acquisition or leasing costs. Based on the price differential between eligible and non-eligible cars and the associated CO_2 savings, we estimate that firms face average abatement costs of 1,302 € per ton of CO_2. Consistent with our findings from the government perspective, we find that firm-level abatement costs decline significantly under alternative assumptions – falling to 331 € when plug-in hybrids are more frequently driven in electric mode, and turning negative (57 €) when only electric vehicles are incentivized or adopted, implying cost savings alongside reduced (reported) emissions. These findings underscore that both policy design and behavioral responses critically shape the cost-efficiency of climate-related tax incentives at the firm level.

Our study contributes to three strands of literature. First, we contribute to the literature on environmental taxation, specifically on tax policy instruments incentivizing electric mobility. This body of work typically addresses the upfront costs of eco-friendly cars, such as direct subsidies or reduced sales taxes (see, e.g., Sallee, 2011; Narassimhan and Johnson, 2018; Chandra et al., 2010; d'Haultfoeuille et al., 2014), the operating costs of eco-friendly cars, such as income tax incentives or higher fuel taxes (see, e.g., Giménez-Nadal and Molina, 2019; Cerruti et al., 2019), or a combination of the two (see, e.g., Klier and Linn, 2015; Bigler and Radulescu, 2022; Grigolon et al., 2018; Diamond, 2009; Beresteanu and Li, 2011; Gallagher and Muehlegger, 2011; Kok, 2015). While we focus on the reduction of operating costs in this study, we also contribute to the broader literature on taxation and e-mobility. In contrast to our work, previous studies have (mostly) focused on the effectiveness of such reforms but have not estimated their cost-efficiency. Thus, we also follow the call by Lester and Olbert (2024) for more research on the effectiveness and cost-efficiency of climate-related policies. Furthermore, we use car registration data instead of purchase data, ensuring a more accurate depiction of real car market dynamics.[4]

[4]Exceptions are d'Haultfoeuille et al. (2014), who investigate upfront costs; Klier and Linn (2015), who investigate a penalty on environmentally harmful cars instead of an incentive for eco-friendly ones; Diamond (2009), who finds reducing operating costs to be more important than reducing upfront costs in a US setting, and Cerruti et al. (2019), who examine the effects of changes in an annual vehicle registration tax in the United Kingdom. These papers also rely on car registration data in their studies.

We further contribute by examining the largely overlooked market for company cars. Previous studies have primarily examined policies targeting private vehicles or both private and company cars, without explicitly distinguishing between the two. Kok (2015) is the only exception, analyzing a series of CO_2-based tax reforms in the Netherlands between 2008 and 2013 that applied to vehicle purchases, annual road use, and the private use of company cars. However, unlike our study, Kok (2015) relies on purchase data rather than registration data and uses counterfactual scenarios instead of a comparative market analysis to evaluate the reform effects. This gap is surprising given that company cars represent a substantial share of new vehicle registrations and thus play a pivotal role in shaping both current and future transportation-sector emissions. Yet in many countries, including the United States and most European countries, existing tax policies tend to disincentivize the adoption of eco-friendly vehicles (Berggren and Kågeson, 2017; Mandell, 2009; PricewaterhouseCoopers, 2007; Wesseling et al., 2015). By evaluating a targeted tax incentive aimed specifically at plug-in hybrid and electric company cars, this study offers new evidence on how such policies can influence fleet composition and contribute to reducing CO_2 emissions. Given the institutional and market similarities between Germany and other developed economies, our findings have broad relevance for international policy design.

Second, this study contributes to the broader literature on the real effects of taxation. In line with research that shows the role of taxation in shaping consumer and organizational behavior (e.g., Stinson et al., 2018; Desai and Goolsbee, 2004), we analyze the impact of preferential tax treatment on adopting eco-friendly company cars. By highlighting the interaction between tax policies and firm-level decision-making, our findings shed light on how tax incentives can affect environmental outcomes, emphasizing the potential of fiscal policy as a tool for promoting sustainable business practices and fostering greener economies. An additional contribution of our paper is to increase awareness of the importance of evaluating both the effectiveness and the cost-efficiency of policy evaluation (Leuz, 2018, 2022). While our findings show that the reform was very effective, it was rather cost-inefficient, largely due to plug-in hybrids receiving preferential tax treatment without requiring emissions-reducing driving behavior, leading to free-riding problems.

Third, our study contributes to the literature on corporate strategies to reduce (reported) CO_2 emissions. Corporate vehicle fleets represent a significant source of these emissions. Evidence from European Corporate Social Responsibility reports suggests that, on average, 30% of a companys direct emissions are attributed to its fleet. As various stakeholders value both ESG disclosures and strong environmental performance, particularly in the form of low emissions (see Griffin et al., 2017; Guiral et al., 2020; for a literature review on this relationship, see Christensen et al., 2021), firms have a financial incentive to decarbonize their operations, including by adopting a greener fleet (see, e.g., Matsumura et al., 2014; Tomar, 2023; Lin et al., 2024; Abraham et al., 2024). While prior studies have documented firm efforts to lower reported emissions (see, e.g. Ioannou et al., 2016; Downar et al., 2021), we contribute to this literature by isolating the causal impact of a targeted tax incentive for company cars on firm-level (reported) CO_2 emissions and the associated financial trade-offs.

The following section discusses the institutional setting and derives our hypothesis. Section 3 introduces our empirical strategy. Section 4 outlines our data and discusses descriptive statistics. Section 5 provides our main results for the effectiveness and cost-efficiency as well as several robustness checks. Section 6 concludes.

2 Institutional Setting and Hypotheses Development

While other sectors have succeeded in reducing CO_2 emissions in recent years, the (German) transportation sector has repeatedly missed its emission targets and has even recorded increasing emissions for several years, e.g., in 2017 (Harendt et al., 2018). Since the transportation sector accounts for around 20% of CO_2 emissions in the European Union (European Environment Agency, 2017) and 27% in the United States (United States Environmental

Protection Agency, 2022), fostering electric mobility is crucial to achieve climate targets. Within this sector, company cars play a particularly important role: they account for over 60% of new car registrations in many European countries. These vehicles are provided by employers to their employees for business and private purposes. In practice, employees typically select a company car from a tiered catalogue provided by the employer, with their selection constrained by a position-related budget.[5]

Due to the substantial share of company cars in new car registrations, they exert substantial influence on both current and future emissions trajectories (Sopp and Gast, 2020; Global Fleet, 2024). Apart from other policies that promote electric mobility[6], the German government, therefore, additionally implemented a reform that exclusively targets company cars. More specifically, Germany has changed the income tax treatment of privately used company cars.

For tax purposes, the private use of a company car generally qualifies as a non-cash benefit for the employee and is subject to income tax. In Germany, the taxable noncash benefit equals 1% of the company car's domestic gross list price per month. The reform we are investigating implemented a preferential tax treatment for electric cars and plug-in hybrids, i.e., vehicles whose batteries can be recharged by an external electric power source and its onboard combustion engine. It was announced on August 1, 2018 and took effect on January 1, 2019. Both, plug-in hybrid and electric cars were eligible if they were provided by the employer to the employee after December 31, 2018. While the preferential tax treatment applies to all electric car models, plug-in hybrids need to fulfill an additional requirement

[5]Anecdotal evidence suggests that some companies also increase the budget if an employee chooses a hybrid or electric car. Some even subsidize the installation of charging infrastructure at home.

[6]In Germany, the government introduced a law in 2011 that exempts purely electric vehicles from the annual motor vehicle tax for the first 10 years after newly registering a car. In 2015, Germany implemented an e-mobility law that provides several benefits for electric vehicles, e.g., preferential parking. In 2016, Germany additionally introduced an environmental bonus that grants a direct subsidy for purchasing new electric or hybrid cars both for private and business use (see Federal Ministry for Economic Affairs and Energy, 2016). The environmental bonus amounted to 4,000 € for purely electric cars and 3,000 € for hybrid cars. Car manufacturers and the federal government equally share the financial burden of the environmental bonus.

to be eligible: the hybrid has to either (a) emit a maximum of 50 grams CO_2 for each driven kilometer or (b) have a range of 40 kilometers or more with the exclusive use of the electric engine. If an employee drives a company car that is eligible, he or she has to pay income tax only on 0.5% of the car's gross list price per month.[7] Therefore, the tax base for eligible company cars is halved compared to non-eligible cars. Apart from implementing this preferential tax treatment for hybrid and electric company cars, there was no further tax reform that affected company cars during our observation period.

The main driver of the employee's tax liability on the private use of a company car is the car's gross list price. Since eligible cars are, on average, more expensive than non-eligible cars, it is questionable whether the reform provides a real fiscal incentive for choosing an eligible company car. Table 1 compares the average eligible car with the average non-eligible car in our sample and shows a net tax advantage of 875 € per year for the employee from choosing an eligible instead of a non-eligible company car.[8]

[Insert Table 1 about here.]

While there is, on average, a financial incentive to choose an eligible company car from an employee's perspective, there are also potential barriers to taking advantage of the tax benefit. Choosing an electric or plug-in hybrid may involve an infrastructure investment to charge the electric engine at home, which reduces the financial incentive.[9] Besides, employees could refuse to switch from an internal combustion to an electric or plug-in hybrid company car, due to personal preferences or due to an underdeveloped public charging infrastructure.

[7]From January 2020 onward (after our sample period), the incentive for electric vehicles was increased. The tax base of purely electric cars with a gross list price below 40,000 € was reduced to 0.25%.

[8]We use a marginal personal income tax rate of 42% to calculate the tax liabilities. Company cars are most likely provided to employees with an above-average taxable income. Since the average income in Germany for 2018 (2019) is 55,980 € (57,810 €), these employees at least pay a marginal tax rate of 42%. Some may even experience the top income tax rate of 45%, resulting in even higher net tax savings of 812 €. In Table A2 in the appendix, we calculate the tax advantage for a typical company car, the Mercedes S-Class. The annual tax advantage for an employee driving this model as a company car amounts to 1,930 €.

[9]Whether the employee receives a subsidy on fuel costs for private use depends on the employer.

The higher acquisition price for eligible cars could also exclude employees from being able to choose these as company cars, due to employer budget restrictions. Finally, the design of the reform as an indirect benefit through the income tax code could be too complex, resulting in employees being unaware of the benefit.

The success of the preferential tax treatment for fostering green driving also depends on whether employers offer plug-in hybrid and electric vehicles as company cars. Employers acquire or lease company cars before providing them to their employees. Therefore, employers must bear the higher acquisition costs for eligible in contrast to non-eligible cars, which may prevent them from offering these cars as company cars.[10] However, employers have an incentive to make their fleets greener, as they constitute for a significant share of corporate emissions. While fuel combustion, i.e., from combustion engines or the non-electric use of plug-in hybrids, generates Scope 1 emissions, the electricity used to recharge plug-in or electric vehicles is accounted for as Scope 2 emissions. Evidence from European Corporate Social Responsibility reports suggests that vehicle fleets contribute, on average, to 30 % of corporate Scope 1 emissions. Ever more companies have to publicly report their emissions to stakeholders (Johnson et al., 2020). In the European Union, CO_2 reporting is mandatory for public firms (see, e.g., Fiechter et al., 2022), and similar regulations have recently been proposed in the US (Greenstone et al., 2023). Prior literature has shown that various stakeholders value good ESG performance and hence low emissions (see, e.g., Downar et al., 2021; Tomar, 2023; Lin et al., 2024), resulting in an incentive for firms to offer eco-friendly company cars. As fleet composition depends on employer procurement (catalogue offerings) and employee selection, both parties jointly determine the fleets emissions profile.

In summary, there are arguments for and against the effectiveness of the reform. The outcome of the policy is thus an open question for empirical analysis. Despite the raised objections, we expect the number of eligible car registrations in Germany to increase after

[10]The annual vehicle registration tax, which is also paid by the employer and decreases with the car's CO_2 emissions, partly offsets the higher purchase price.

the reform, due to the significant tax savings for employees and incentives for employers to offer eco-friendly company cars. Specifically, we test the following hypothesis.

> H1: *The tax reform increased the number of newly registered eligible plug-in hybrid and electric cars.*

If we find the policy to be effective, this does not necessarily imply that the reform is also cost-efficient. The reason for a potential mismatch between effectiveness and cost-efficiency is that the actual benefits of the reform, i.e., reduced CO_2 emissions, depend on several factors, e.g., on the electric driving share of plug-in hybrids and the energy sources used to charge the batteries of both plug-in and electric cars. As a result, it is an open question whether the benefits of the reform outweigh the costs. Therefore, we also conduct a cost-benefit analysis both from a government and from a corporate perspective to investigate whether the tax reform efficiently reduced CO_2 emissions.

3 Empirical Strategy

3.1 Baseline Specification: German versus Austrian eligible company cars

To investigate whether the preferential tax treatment increased new registrations of eligible company cars in Germany (H1), we apply a difference-in-differences research design and compare new registrations of eligible plug-in hybrid and electric company cars in Germany with new registrations of the same car models in Austria (so-called pseudo-eligible company cars) before and after the German reform. Formally, we estimate the following regression model.

$$\text{EligibleCompanyCarRegistrations}_{i,t} = \beta_0 + \beta_1 \text{German}_i + \beta_2 \text{Post}_t + \beta_3 (\text{German}_i * \text{Post}_t) + \gamma X_{i,j,t} + \zeta_{\text{t}} + \eta_{\text{i}} + \epsilon_{i,t}. \tag{1}$$

The dependent variable, $EligibleCompanyCarRegistrations_{i,t}$, depicts the number of new company car registrations of a specific (pseudo) eligible car model i in month t. $German_i$ is an indicator variable equal to one for all German, i.e., treated, observations and zero for all Austrian, i.e., control, observations. $Post_t$ equals one for observations from August 2018, when the regulation was announced. We include the transition period between announcement and enactment in our post-period since the preferential tax treatment also applies if an employer buys and registers a car before January 2019 but provides it to the employee for the first time after December 31, 2018. Therefore, the number of new registrations could have increased in the transition period before January 1, 2019.[11] The explanatory variable of interest is the interaction term $German_i * Post_t$. If the tax reform increased the number of newly registered eligible company cars, we expect a positive β_3.

$X_{i,j,t}$ comprises car model-specific control variables, i.e., the entry-level price[12] and the mileage, as specified by the car manufacturer. ζ_t represents time fixed effects, η_i are car model fixed effects, and $\epsilon_{i,t}$ is the error term. In several robustness checks (see Section 5.1.5), we address that our dependent variable, the number of newly registered cars per car model, is a count variable and estimate a Poisson pseudo-maximum likelihood model (PPML) and a zero-inflated Poisson model (ZIP) and use the scaled number of registrations as the dependent variable. Since treatment is assigned based on the individual technical characteristics of each car model, we use heteroskedasticity-robust standard errors clustered at the car model level

[11] In a robustness test, we exclude the transition period and find similar results (see Section 5.1.5).

[12] The entry-level price is model (i), country (j), and time (t) specific. Mileage is model (i) and time (t) specific.

in all regressions (see Abadie et al., 2023).[13]

We chose Austria as the control group since the German and Austrian car markets are highly comparable (see Section 4 for details).[14] Austria did not, however, incentivize electric or plug-in hybrid company cars during our observation period.[15]

3.2 Validation Specifications: German car market and triple difference-in-differences approach

Comparing Germany to Austria in our baseline analysis allows us to focus on the car models that receive preferential tax treatment and thus control for a general increase in new registrations of eco-friendly cars during our observation period. However, this approach also restricts us to using only a fraction of available models on the car market, which limits power. To validate our findings and include all available (eligible and non-eligible) car models, we use two additional research designs to complement our first approach. First, we build on a within Germany setting and compare registrations of eligible company cars to non-eligible company cars. Formally, we estimate the following regression model.

[13]Following Cunningham (2021) and Bertrand et al. (2004), we use clustered standard errors at the car model level to obtain correct confidence intervals in our difference-in-differences design. We cluster at the brand level in untabulated results and find similar standard errors.

[14]One advantage of using Austria is the similarity in brand preferences, due to the proximity of the two countries. However, this proximity may also threaten our identification. If the German reform leads to an increase in the demand for eligible car models in Germany, car manufacturers may meet this increase in demand and sell a larger proportion of eligible car models in Germany. Assuming a delay in providing sufficient supply to meet the overall demand, manufacturers may temporarily decide to sell fewer eligible car models in Austria. This could reduce car sales in Austria, causing upward bias to our estimates. We address this concern by comparing the share of eligible car sales as well as total car sales for Austria before and after the reform for the largest German car manufacturers (untabulated). We find no change in the share of eligible car sales over our sample period, showing no clear sign of a supply-driven effect. We also find no evidence of differences in the level entry price between Germany and Austria for eligible car models, either before or after the reform.

[15]In Austria purely electric vehicles have been exempt from a one-time tax for newly registered cars since 2016. Additionally, purely electric business vehicles have been eligible for input tax deductions since 2016. Since March 2017, Austria has applied an environmental bonus for new private and business electric cars. In a business context, a car does not have to fulfill specific technical criteria to be eligible for this bonus.

$$
\begin{aligned}
\text{CompanyCarRegistrations}_{i,t} = {} & \beta_0 + \beta_1 \text{Eligible}_i + \beta_2 \text{Post}_t + \beta_3 (\text{Eligible}_i * \text{Post}_t) \\
& + \gamma X_{i,t} + \zeta_{\text{t}} + \eta_{\text{i}} + \epsilon_{i,t}.
\end{aligned} \tag{2}
$$

The dependent variable in this first validation specification is *CompanyCarRegistrations*$_{i,t}$, which depicts the number of newly registered company cars of a car model i in month t in Germany. In contrast to our baseline specification, we do not include only eligible car models but all available car models (i.e., electric cars, eligible and non-eligible plug-in hybrids, and combustors). *Eligible*$_i$ is an indicator variable equal to one if a car model is eligible for the preferential tax treatment and zero otherwise. All other variables correspond to Equation (1). If the tax reform increased the number of newly registered eligible company cars in Germany, we expect a positive and statistically significant estimate for β_3.[16]

Second, we combine our baseline approach and the within-Germany validation approach and conduct a triple difference-in-differences analysis to compare the German and Austrian car markets as a whole. Specifically, we investigate the difference between eligible and non-eligible company cars in Germany and the difference between pseudo-eligible and pseudo-non-eligible company cars in Austria. Formally, we estimate

$$
\begin{aligned}
\text{CompanyCarRegistrations}_{i,j,t} = {} & \beta_0 + \beta_1 \text{German}_j + \beta_2 \text{Post}_t + \beta_3 \text{Eligible}_i \\
& + \beta_4 (\text{German}_j * \text{Post}_t) + \beta_5 (\text{German}_j * \text{Eligible}_i) \\
& + \beta_6 (\text{Post}_t * \text{Eligible}_i) + \beta_7 (\text{German}_j * \text{Post}_t * \text{Eligible}_i) \\
& + \gamma X_{i,j,t} + \zeta_{\text{t}} + \eta_{\text{i}} + \epsilon_{i,j,t}.
\end{aligned} \tag{3}
$$

[16]These estimates might be biased due to employees switching from a non-eligible to an eligible car (substitution effect), making the true effect size unclear.

The dependent variable in this specification is $CompanyCarRegistrations_{i,j,t}$, which depicts the number of newly registered company cars of a car model i in country j in month t. The main explanatory variable in this setting is the triple interaction term between $German_j$, $Post_t$, and $Eligible_i$. The coefficient estimate of this triple interaction term, β_7, equals the difference between eligible versus non-eligible company cars in Germany relative to the difference between pseudo-eligible versus pseudo-non-eligible company cars in Austria. The remaining variables correspond to Equation (1). If the German tax reform increased the number of newly registered eligible company cars in this bilateral comparison, we expect a positive and statistically significant estimate for the triple interaction-term coefficient β_7.

4 Data and Descriptive Analysis

Our empirical analysis builds on administrative data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt) and the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich), which contain monthly new registrations for all vehicle models on the German and Austrian car markets from January 2017 until December 2019.[17] The data differentiates combustion engine, electric, and hybrid car models. For Austria, we can further distinguish between private and company car registrations at the level of car model and engine type. Therefore, we know the exact and absolute number of new company car registrations for the different engine types of the same car model, e.g., hybrid and combustion engine version of a car model.[18] As the preferential tax treatment only applies to company cars, we use this data on new registrations of company cars for Austria. For Germany, we

[17]We end our sample period in 2019, due to the introduction of an additional incentive for electric cars with a gross list price of less than 40,000 € in January 2020. The tax base of these cars was reduced to 0.25% of the gross list price each month. Although this increases the variation in treatment that we could explore, we refrain from doing so due to the COVID-19 crisis starting in March 2020. The widespread use of home office and the economic downturn could affect car registrations. This leaves us only with a short period of three months to explore the impact of the new preferential tax treatment.

[18]We provide a comprehensive description on obtaining and processing the data in the appendix in Section ??.

only have information on private and company car registrations at the car model level but not at the engine type level. For example, we know the share of company car registrations for each car model, but we do not know whether this share differs between, e.g., the internal combustion engine and the hybrid version of the car model. Therefore, we approximate company car registrations for Germany and assume that the company car share for a specific car model applies equally to all engine types of that model.[19] The following graphs provide an overview of our administrative data and confirm the close similarity between the German and Austrian car markets.

[Insert Figure 1 about here.]

Figure 1 depicts the number of available car models by engine type for Austria and Germany over time. The first vertical line indicates the announcement of the preferential tax treatment in Germany (August 2018), while the second vertical line indicates when the reform came into force (January 2019). Both for Germany and Austria, the number of different car models with a combustion engine slightly decreased from 277 in January 2017 to 274 in December 2019 in Germany and from 223 to 207 in Austria. In Germany, the number of different hybrid car models more than doubled over our sample period, from 38 in January 2017 to 79 in December 2019. Similarly for Austria, the hybrid models increased from 28 to 51. When the preferential tax treatment became effective in January 2019 in Germany, 32 hybrid models were eligible. This number increased to 42 eligible hybrids in December 2019. The number of electric models increased by 53 (38)% from 15 (13) to 23 (18) in Germany (Austria). Figure 1 shows that the availability of car models by engine type is highly comparable between Germany and Austria.

[Insert Figure 2 about here.]

[19]Given the high fiscal incentive to choose an eligible model in the post-period, this procedure might bias against finding an effect. Obtained positive estimates can be hence seen as lower bounds.

Figure 2 descriptively shows the number of new company car registrations by engine type across our observation period in Germany (Figure 2a) and Austria (Figure 2b). Comparing the two figures shows that the German car market is much larger than the Austrian car market (the scale of the two graphs differs by a factor of ten). The composition in new company car registrations is, however, very comparable. While the number of new combustors fluctuates for both countries over time,[20] the number of new eligible hybrids and electric cars tends to increase in both countries. Overall the number of newly registered combustors significantly exceeds that of newly registered hybrid and electric cars throughout the observation period.

[Insert Figure 3 about here.]

Figure A1 in the appendix compares the brand shares in the German and Austrian car markets. Overall the shares are comparable across the two markets. To further ensure comparability, especially prior to the German reform, Figure 3 depicts newly registered eligible hybrid company cars (Panel A) and electric company cars (Panel B) as a share of newly registered company cars for Germany and Austria. We observe a highly comparable share and trend for both eligible hybrid and electric company cars prior to the reform. For eligible plug-in hybrids, the share of new registrations in Germany almost always exceeds the share in Austria, and the difference increases over time. In contrast, the share of newly registered electric company cars is almost always higher in Austria than in Germany. In both countries, the share of electric cars is more volatile than the share of eligible plug-in hybrids.

In addition to the administrative data on new car registrations, we hand-collected technical information for each vehicle model from the German Automobile Club (Allgemeiner Deutscher Automobil-Club - ADAC) (see Allgemeiner Deutscher Automobil-Club, 2022).

[20] We can observe a striking decrease in new registrations in September 2018 in both countries. The reason for this decrease is that, since September 2018, newly registered cars have had to meet the requirements of a new, stricter emission test. As a result, some car models were no longer allowed to be registered, which may result in a decrease in observed new registrations (see Kraftfahrt-Bundesamt, 2018). The new requirements are EU-based and apply to both countries.

Specifically, we collected data on the CO_2 emissions in grams for each driven kilometer and on the range with the exclusive use of the electric engine to identify the eligible plug-in hybrid models. We further collected mileage and the entry-level price for the basic configuration of each vehicle model over time.[21] Table 2 shows the descriptive statistics for our German and Austrian data.

Overall the baseline sample consists of 2,290 model-month observations for the German and Austrian car markets. These observations are almost equally split between pre- and post-period. The average number of newly registered eligible company cars per month per model in Germany in the pre-period (post-period) is 103 (211). Since the Austrian car market is significantly smaller than the German one, the respective average for the Austrian sample is lower (14 in the pre-period and 19 in the post-period). This also holds true for the overall car market. In Germany 643 (648) new cars are registered per car model per month in the pre-period (post-period). In Austria, there are 59 (52) registrations per car model per month.

[Insert Table 2 about here.]

5 Empirical Results

5.1 Effectiveness of the Policy Reform

We start by investigating the effectiveness of the preferential tax treatment (H1). In our baseline setting, we focus on the eco-friendly car models that receive preferential tax treatment in Germany. We compare new company car registrations of eligible cars in Germany to new registrations of the same models in Austria. To validate our results and increase power, we also analyze the complete German car market and compare company car registrations of eligible to non-eligible car models within Germany. Finally, we extend this analysis to the Austrian car market and combine both entire car markets in a triple difference-in-differences

[21] We always use the mileage for the model with a gasoline engine.

analysis, which allows us to investigate the change in the difference between eligible and non-eligible company cars in the two countries.

5.1.1 Parallel Trends Assumption

Applying a difference-in-differences research design relies on the assumption that parallel trends in the treatment and control group would have continued absent the reform. Since we cannot test this directly, we focus on investigating whether our treatment and control groups trended similarly prior to the implementation of the preferential tax treatment.

For our baseline setting (Equation (1)), we assume parallel trends in the number of new company car registrations of eligible models in Germany and the same models (i.e., pseudo-eligibles) in Austria. For our validations (Equations (2) and (3)), we assume parallel trends in newly registered eligible and non-eligible cars in Germany.[22]

[Insert Figure 4 about here.]

Figure 4 shows three different parallel trends graphs. Since the German and Austrian car markets substantially differ in size, we normalize all values to one in July 2018, i.e., the month prior to the reform announcement. The first vertical line in each graph depicts the announcement of the policy reform (August 2018), and the second vertical line depicts when the reform came into force (January 2019). Panel A shows the number of newly registered company cars for the baseline treatment group (eligible plug-in hybrid and electric cars in Germany) and the baseline control group (pseudo-eligible cars in Austria). We observe parallel trends in both groups prior to the announcement of the reform with new car registrations in Austria exceeding new registrations in Germany. Panel B compares our validation control groups, non-eligible cars in Germany and pseudo-non-eligible cars in Austria. We observe

[22] Olden and Møen (2022) show that a triple difference-in-differences estimator does not require two parallel trends assumptions for a causal interpretation, as the difference between two biased difference-in-differences estimators will be unbiased as long as both estimators have the same bias. Therefore, our assumption is conservative with respect to the triple difference-in-differences setting.

parallel trends both prior to and after the German reform, which again confirms the similarity in the two markets. Both Panel A and Panel B plot the monthly data as used in our main analyses. To smooth the visual dispersion on the monthly data, Panel C combines the data from Panels A and B, but plots the data on a quarterly basis. Before the announcement of the reform, all groups show similar trends. After the implementation of the regulation, we see a sharp increase in new company car registrations of eligible cars in Germany compared to the control groups. We also observe an increase in new company car registrations for the pseudo-eligible car models in Austria, which is, however, less pronounced than in Germany. This increase suggests an overall upward trend in new registrations of eco-friendly cars. Therefore, our baseline specification compares these eco-friendly cars across the two countries, eliminating the overall general trend towards these cars.

[Insert Figure 5 about here.]

We further test our parallel trends assumption by conducting an event study for our baseline specification, where we compare German eligible models and Austrian pseudo-eligible models. We replace the post-indicator from Equation (1) with a series of month indicators. Figure 5 plots the estimated coefficients of the modified interaction term. The bars depict 90 percent confidence intervals. We can interpret the estimated coefficients as the differential changes in newly registered eligible company cars in Germany relative to new registrations of pseudo-eligible company cars in Austria.

Figure 5 shows similar trends in new registrations for the treatment and the control group before the announcement and implementation of the reform. The coefficient estimates are indistinguishable from zero for almost all months prior to the reform. The coefficient estimates start to be positive and statistically different from zero after December 2018. This increase indicates a difference in new registrations of eligible and pseudo-eligible cars after the implementation of the preferential tax treatment. For the time between the announcement and the enactment, we find a positive but not statistically significant increase in new registration, indicating only moderate anticipation effects.

5.1.2 Baseline Results: German versus Austrian eligible company cars

In the baseline specification, we compare the company car registrations of eligible plug-in and electric car models in Germany and Austria. Table 3 reports the baseline estimation results for Equation (1). Following the difference-in-differences design presented in Section 3, Column (1) regresses the number of new company car registrations on the interaction term $Eligible_i * Post_t$ and its components. Column (2) represents our full model and additionally includes model-specific technical control variables (the entry-level price and the mileage) as well as time and car model fixed effects. In Column (3), we report the coefficient estimates for eligible plug-in hybrid and electric cars separately, by replacing the treatment dummy with an indicator variable for eligible hybrid and electric cars.

The coefficient estimates of the interaction terms are positive and statistically significant in all specifications. The results of the reduced form estimation in Column (1) represent a reform-induced increase of 103 new eligible car registrations per month. The result from our main specification in Column (2) shows a very similar coefficient estimate for the interaction term of 98. Therefore, the reform resulted in an increase of approximately 98 cars per eligible car model. The average number of newly registered eligible cars per month per model in our sample in the pre-reform period is 103. Relating our coefficient estimate to this mean of eligible cars per model suggests a reform-induced increase of 95%. This effect translates into a semi-elasticity of 2.16%. On average, tax savings amount to 44%, see Table 1. The reform leads to a 95% increase in eligible car registrations, equivalent to 103 additional registrations per month. Consequently, a 1% decrease in tax payments results in a 2.16% increase in new car registrations, corresponding to 2.3 additional registrations per month. In aggregate, the reform results in 120,000[23] additional eligible car registrations per year across the country. The results of Column (3) reveal that, while both eligible plug-in hybrid and electric cars benefited from the reform, the effect on the hybrid models is 25% larger.

This effect size is larger than those reported in prior literature examining reforms that reduce the upfront costs (e.g., Sallee, 2011 and Narassimhan and Johnson, 2018 for US settings, Chandra et al., 2010 for a Canadian setting, and d'Haultfoeuille et al., 2014 for a French setting) of a car investment, but comparable to studies focusing on reforms that reduce the operating costs of cars (e.g., Cerruti et al., 2019; Giménez-Nadal and Molina, 2019).

[Insert Table 3 about here.]

5.1.3 Validation Results: German versus Austrian Car Market

A limitation of our baseline approach is that it only includes eco-friendly car models. To increase power and include all available car models in our analyses, we extend our approach to the entire car market in two validation specifications. First, we investigate the German car market more closely and compare new company car registrations of eligible car models with non-eligible ones before and after the reform. This specification therefore does not include any Austrian data. Column (1) in Table 4 reports the coefficient estimates for Equation (2). The coefficient estimate of the interaction term is positive and statistically significant. After the reform, we observe an increase of 126 company cars per eligible car model per month in Germany. Using the average number of new registrations per eligible hybrid model per month in Germany of 103, the results in Column (1) indicate a 122% increase in newly registered eligible company cars in Germany compared to non-eligibles after the reform. The effect size is slightly larger than in our baseline specification, which could be explained by a general

[23] We multiply the coefficient estimate of 98 by the number of available eligible car models in December 2019 (79 plug-in hybrid and 23 electric models). We multiply this monthly increase by twelve to get annual new registrations.

increase in the eco-friendly car market that we pick up with this specification. Investigating the effects for eligible plug-in hybrid and electric cars separately yields similar inferences as in our baseline specification: we find a more pronounced effect for plug-in hybrids than for electric cars.

Second, we evaluate all available car models in Germany and Austria and combine our first two analyses. We apply a triple difference-in-differences design and compare the difference in eligible versus non-eligible cars in Germany with the difference in pseudo-eligibles versus pseudo-non-eligibles in Austria. Column (3) in Table 4 reports the coefficient estimates for Equation (3). The coefficient estimate of the triple interaction term is positive and statistically significant. Therefore, after the reform in Germany, the difference between eligible and non-eligible car registrations in Germany was higher (by 121 cars per car model) than the difference between pseudo-eligible and pseudo-non-eligible car registrations in Austria. This is true for both eligible plug-in hybrids and electric cars (Column (4)). Our results remain robust when including month-by-country fixed effects.

Overall our results support our hypothesis that the reform effectively fostered eco-friendly driving in Germany.

[Insert Table 4 about here.]

5.1.4 Heterogeneity Analyses

We conduct two heterogeneity analyses to learn more about which car models benefited from the reform. We report the results based on our baseline specification (Equation (1)). We conducted all analyses for Equations (2) and (3) and find similar results (untabulated).

The first heterogeneity analysis is based on the gross list price of company cars, which we also interpret as a proxy for prestige. We split the sample based on the median entry-level price of all car models in July 2018, the month before the reform was announced.

Table 5 shows the results for this sample split. We find a 2.5 times[24] larger effect for cars with an above-median entry-level price.[25] Moreover, we find that this effect is concentrated among eligible plug-in hybrids, whereas low-priced electric cars benefit from the reform. Since plug-in hybrids with an above-median entry-level price emit more CO_2 than hybrids with a below-median price (the mileage of the "high priced" cars is 25% higher than the mileage of the "low priced" cars), this raises questions about the environmental effect of the incentive.

One concern regarding the tax law change was that the government designed it to disproportionally benefit German car manufacturers (see, e.g., Heinrich Böll Stiftung, 2018). If true, this would suggest that the incentive functioned not only as an environmental policy but also as a subsidy to German manufacturers. In a second heterogeneity analysis, we therefore split the sample into car models produced by German and non-German manufacturers.[26] Table 6 presents the results. We obtain a positive and statistically significant coefficient estimate for the interaction term for models produced by German manufacturers. In contrast, the estimate for non-German models is marginally not statistically significant, indicating a potential but less pronounced effect. In addition, the effect size is noticeably larger for German manufacturers, suggesting that they benefited more strongly from the reform. An F-test confirms the statistically significant difference between the coefficient estimates for German and non-German car manufacturers. This pattern also holds when distinguishing between plug-in hybrids and electric cars in Columns (2) and (4). Our findings indicate that German manufacturers benefited more from the reform than non-German manufacturers.

[Insert Table 5 about here.]

[Insert Table 6 about here.]

[24] The pre-reform average of new car registrations for low-priced (high-priced) cars is 140 (67).

[25] Conducting an F-Test confirms a statistically significant difference between the coefficient estimates for low- and high-priced models.

[26] The German car manufacturers in our sample are Audi, BMW, Mercedes, Mini, Opel, Porsche, Smart, and Volkswagen.

5.1.5 Robustness

Our findings are robust to a set of additional tests. We report all robustness checks for the baseline analysis comparing eligible cars in Germany to pseudo-eligibles in Austria (Equation (1)). In addition, we conducted all robustness checks for Equations (2) and (3) and find similar results (untabulated).

Dealing with count data Since our dependent variable (the number of new company car registrations for each model per month) is a count variable, consists of many zero values, and is skewed[27], we perform a Poisson Pseudo Maximum Likelihood (PPML) estimation, a zero-inflated Poisson model (ZIP), and use a ratio by scaling the dependent variable by the overall number of registrations. Table 7, Columns (1) and (2) show the results for the PPML model. Columns (3) and (4) presents the results for the ZIP, and Columns (5) and (6) display the results for the ratio transformation. In all specifications, the coefficient estimates of the interaction terms are positive and statistically significant, confirming our baseline results. They translate into effect sizes of about 80%.[28] The effect sizes are therefore slightly smaller than in our baseline specification.

[Insert Table 7 about here.]

Constant models over our observation periods During our observation period, the number of available eligible car models increased. To ensure that an increased model supply does not drive our results in the post-period, we restrict our sample to car models that were already available by the time of the policy announcement (prior to August 2018). This restriction reduces our sample size to 1,450 observations. The results reported in Table 8

[27]Using both the Shapiro-Wilk and the Shapiro-Francia test, we find evidence that our dependent variable is skewed.

[28]Implementing a difference-in-differences research design requires strong functional form assumptions since the common trend assumption is not equivariant to nonlinear transformations (Melly and Santangelo, 2015). We still report Poisson regression results to account for our dependent variable being a count variable. However, these results should be interpreted with caution.

Column (1) support our main finding. The coefficient estimate of the interaction term is positive and statistically significant. When we compare the magnitude of this coefficient estimate with our baseline result, the result translates into a slightly lower increase of 78%.

Cutout In the baseline regression, we include the months between the announcement of the reform in August 2018 and the entry into force in January 2019 into our post-period. Since the preferential tax treatment applies for new cars that are provided by the employer to the employee for the first time after December 2018, we expect anticipation effects in company car registrations within these six months. In this robustness check, we exclude the anticipation period from our sample. Column (2) in Table 8 reports the results. The coefficient estimate for the interaction term is positive and statistically significant and translates into an increase of 121%, which is slightly higher than our baseline result. Therefore, there seem to be no anticipation effects in the period between the announcement and the reform implementation.

Collapsed periods The literature has raised the issue of serial correlation in difference-in-differences designs with several pre- and post-periods (Bertrand et al., 2004). To circumvent this issue, we follow the suggestion of Bertrand et al. (2004) and collapse all pre-reform months into one pre-period and all post-reform months into one post-period (Column (4)). Estimating this reduced model yields a statistically significant coefficient estimate for the interaction term, even without adjusting the t-statistics for the small number of observations. However, the coefficient estimate is smaller in magnitude (64.98) resulting in an increase of only 68%, which is smaller than our baseline estimate, but still economically significant.

German hybrid market Lastly, we exploit the heterogeneous treatment of hybrid cars in Germany. As outlined in Section 2, hybrid cars are only eligible for the preferential tax treatment if they fulfil one of the following two criteria: emit a maximum of 50 grams CO_2 for each driven kilometer or have a range of 40 kilometers or more with the exclusive use of the electric engine. We build on the different tax treatment of these hybrid car models and estimate (1) within the German hybrid car market and compare eligible versus non-eligible hybrid company car registrations. The coefficient estimate for the interaction term is positive and statistically significant and translates into an increase of 88%.

[Insert Table 8 about here.]

5.2 Cost-Efficiency & Firm-Level Implications

While our results so far indicate that the reform has effectively increased the environmental sustainability of corporate fleets in Germany, we now assess its overall effectiveness by conducting a cost-benefit analysis from a government and from a corporate perspective.

We first assess the costs and benefits from the perspective of the policymaker. The reform costs from the government perspective are equal to the lost income tax revenue.[29] The German Treasury receives income tax on only 0.5% instead of 1% of the gross list price of a company car per month. This tax base reduction, creates a measurable loss in income tax revenues. The corresponding benefits of the reform are twofold. First, it increases the number of eco-friendly cars in the German car market boosting the mobility turnaround. In the previous section, we showed evidence for this benefit. Second, the reform reduces CO_2 emissions in the transportation sector, which is a direct consequence of the first benefit.

In addition to the cost-benefit analysis for the government, we also consider the impact of the reform on firms. When firms permit employees to select plug-in hybrid or electric cars as company cars, the adoption of these cars typically entails higher upfront acquisition or leasing costs compared to combusters. However, switching to hybrid and electric company cars also reduces direct CO_2 emissions from company fleets.[30] These emission reductions contribute to overall social emission targets as well as to corporate climate goals

[29] The aim of this section is a rough estimation of costs and benefits. We therefore abstract from a potential increase in value added tax revenues and a potential decrease in fuel duty.

[30] Fuel consumption of company cars is attributed to Scope 1 emissions whereas the recharging of these cars is allocated to Scope 2.

and sustainability strategies. In addition, for companies subject to mandatory reporting or voluntarily disclosing under ESG frameworks, lower fleet emissions can enhance reported environmental performance. Such improvements not only support compliance with emerging regulatory standards but also strengthen firms reputational standing with investors, customers, and other stakeholders. The reform thus facilitates both physical emissions reductions and broader strategic benefits in the form of regulatory alignment and reputational gains.

In the following, we estimate both the costs of the reform and the resulting savings of CO_2 emissions using a back-of-the-envelope calculation. We use a baseline scenario and four alternative scenarios, in which we vary several key drivers of costs and benefits.[31]

5.2.1 Baseline Scenario

In the baseline scenario, we aim at providing the most realistic estimates of the costs and benefits of the preferential tax treatment for the government and for firms.

Costs

As stated above, the costs of the tax reform for the government are the loss in income tax revenues, due to the preferential tax treatment. Instead of receiving income tax on 1% of the gross list price of a company car per month, the German Treasury only obtains income tax on 0.5% of the gross list price. Three additional assumptions drive the resulting reform costs. First, the forgone income tax revenue depends on whether an employee switched from a non-eligible car to an eligible hybrid or to an eligible electric car. As eligible hybrid cars are, on average, more expensive (63,028 €[32]) than electric cars (40,989 €), the foregone income

[31] For detailed calculations, see Appendix 1.B.

[32] We use the unweighted average post-reform values over all car models. We use post-reform values to estimate the real costs and benefits of the reform, which depend on car prices and emissions of cars that were registered after the reform. We devote a paragraph in the appendix (Section B) to discussing the choice of baseline values and how using different values would change our results.

tax revenue is higher if an employee switches to an electric car due to the lower tax base.

Second, the forgone income tax revenue depends on the number of years a car is used as a company car. Since the preferential tax treatment is only granted for company cars, the German government has a reform-induced tax revenue loss only during the use as a company car, which is, on average, 4.4 years (Statista, 2021). If a company car enters into private use afterward, the private owner does not benefit from the preferential tax treatment, and there are no additional costs for the government.[33] Third, the forgone income tax revenue depends on the individual income tax rate of the employee. We assume an individual income tax rate of 42%, which is the marginal tax rate for above-average earners in Germany.[34]

As eligible cars are on average more expensive than non-eligible cars, the main cost component, from a corporate perspective, is the higher leasing or purchase price of eligible vehicles. For our calculations, we focus on leasing rather than purchasing vehicles for two reasons. First, operational leasing is the predominant financing method for company cars in Germany, especially among larger firms, as it offers full tax deductibility of leasing payments and avoids balance sheet activation of the asset (see Gerstenberger, 2023; Dataforce, 2020). Second, leasing allows for a more realistic assessment of recurring monthly costs, which is particularly relevant when comparing vehicles of different price classes and technologies. This approach is consistent with common corporate fleet management practices, especially in the context of electric and hybrid vehicles, which often come with higher acquisition costs. Firms that offer their employees hybrid and electric cars as company cars bear this additional investment when their employees choose an eligible company car. Although some firms may apply fixed budgets for company car selection, anecdotal evidence from industry practice suggests that many companies provide increased budgets or additional incentives

[33]In contrast, the benefits (lower emissions) persist beyond the lifetime of a car as a company car.

[34]Company cars are most likely provided to employees with an above-average taxable income. Since the average income in Germany for 2018 (2019) is 55,980 (57,810), these employees at least pay a marginal tax rate of 42%. Some may even experience the top income tax rate of 45%, resulting in even higher net tax losses.

for choosing eco-friendly vehicles. The monthly leasing costs for a company car correspond to a leasing factor multiplied by the respective gross list price of the car. On average, this leasing factor is 0.67 for all private and company leases (see LeasingMarkt.de, 2020 for 2020). As corporations most likely have better leasing conditions than private individuals, we use a discounted leasing factor of 2/3 of the value to reflect the more favorable terms.[35] Compared to private individuals, firms benefit from lower leasing factors due to volume discounts, stronger negotiating power, lower credit risk, long-term relationships with leasing providers, and reduced transaction costs (see, e.g., Schallheim et al., 1987; Grenadier, 1996).

Tables B2 and B3 in the appendix summarize the estimations of the costs from the government perspective (Table B2) and the corporate perspective (Table B3). We distinguish between two cases. In Case 1, an employee switched from a non-eligible car to an eligible plug-in hybrid. In Case 2, an employee switched from a non-eligible car to an electric car.[36]

Benefits

The central benefit of the tax reform is lower CO_2 emissions. From a government perspective, this helps to meet emissions targets in the transport sector. From a corporate perspective, it helps to meet corporate sustainability goals and reduce reported emissions. There are two key factors that drive the actual reduction in emissions.

The first key factor is the electric driving share of plug-in hybrids. As stated above, plug-in hybrids can be driven either by using the internal combustion engine or the charged battery of the car. The extent to which a plug-in hybrid is driven with the battery drives the

[35]If we apply the overall leasing factor to our analyses, our baseline cost estimate per saved ton of CO_2 is 1,860 €.

[36]In general, an employee could also switch from having no company car prior to the reform to having an eligible company car after the reform. Our data does not allow us to study this case. However, as we observe a general decrease in new car registrations over time in Germany (see Figure 2), we assume that this case occurs rather rarely. We acknowledge that switching from no company car to an eligible company car would increase income tax revenue. Therefore, we would overestimate the costs if employees choose a company car after the reform for the first time.

emissions that arise from using a plug-in hybrid.[37] While manufacturer information on the mileage assumes an electric driving share of 75%, the actual electric driving share is much lower. Combining data on real-world plug-in hybrid usage from online databases, companies, and surveys, the Fraunhofer Institute in cooperation with the International Council on Clean Transportation (Plötz et al., 2020) determines the realistic electric driving share for company car plug-in hybrids in Germany to be 12%.[38] For selected car models, the study by the Fraunhofer Institute in cooperation with the International Council on Clean Transportation also provides real-world fuel consumption data for selected car models. We use this real word data whenever it is available for a car model. For all car models without real-world fuel consumption data, we use manufacturer information adjusted for the realistic electric driving share of 12%.

The second key factor that determines the emission reductions is the energy mix that is used for recharging the batteries of the plug-in hybrid and the electric cars. If the energy used for recharging stems from conventional or fossil energy sources, such as coal, natural gas, or oil, the CO_2 emissions per kilowatt hour of electricity are much higher than for renewable energy.[39] In our baseline scenario, we apply CO_2 emissions of 411 gram per kilowatt hour of electricity which refers to the average energy mix in Germany in the post-reform year 2019, where about 54% of electricity was generated by conventional or fossil energy sources and 46% was generated by renewable energy (Fraunhofer Institute for Solar Energy Systems ISE, 2020).

While the costs of the reform from a government perspective only occur during the use of a car as a company car, the benefits of reduced emissions persist over the lifetime of a

[37]When running our difference-in-differences with fuel demand being the dependent variable, Germany being the treated and Austria being the control group, we find only a marginal decrease in fuel consumption after the reform in Germany, which is, however, not statistically distinguishable from zero (untabulated).

[38]We provide additional estimates using the manufacturers' assumed driving shares in an alternative scenario (Scenario 2).

[39]We provide additional estimates assuming the use of renewable energy only in an alternative scenario (Scenario 5).

car, which is, on average, 129,000 km.[40] From a corporate perspective, firms focus only on emissions generated during the period a car is used as a company car. As cars are on average used as company cars for 4.4 years (see above), emission savings for firms are calculated over 59,840 km.

Table B4 in the appendix summarizes the estimations of reform-induced emission reductions over the lifetime of a car (government perspective) and for the lifetime of a car as a company car (corporate perspective). We differentiate between the case that an employee switched from a non-eligible car to an eligible plug-in hybrid (Case 1) and the case that an employee switched from a non-eligible car to an electric car (Case 2).

Results

Table 9 summarizes the results of our baseline cost-benefit analysis from the government perspective (Panel A) and from the corporate perspective (Panel B). From a policymaker's perspective (Panel A), we estimate the lost income tax revenue for the German Treasury (costs) and the CO_2 emission reductions over the lifetime of a car (benefits) for two cases. In Case 1, an employee switched from a non-eligible car, i.e., from a combustor or a non-eligible (plug-in) hybrid, to an eligible hybrid. The foregone income tax revenue per car is relatively modest since the average eligible hybrid is about 50% more expensive than the average non-eligible car. We estimate the average reform-induced costs per car in Case 1 to be 2,488 €. In terms of emissions, an eligible plug-in hybrid emits on average more CO_2 than a non-eligible car. The high emissions for eligible plug-in hybrids arise from the low electric driving share of only 12%. As a result, in Case 1, the emissions per car after the switching are even higher than before (4.6 tons more CO_2).

In Case 2, an employee switched from a non-eligible car to a purely electric car. The

[40] On average, a car is used for 9.5 years and driven 13,600 kilometers yearly (Kraftfahrt-Bundesamt, 2022a,b). We use the value for 2019 since this is the first year of the preferential tax treatment. Over the working life of a car, this results in 129,200 kilometers.

foregone income tax revenue is higher in this case since the average electric car is less expensive than the average non-eligible car, but only 0.5% (instead of 1%) of the price is taxed. We estimate the average reform-induced costs in Case 2 to be 4,932 € per car and therefore twice the average costs for switching to an eligible hybrid. When we investigate arising CO_2 emission reductions, the average electric car emits much less CO_2 than the average non-eligible car, resulting in emission reductions of 11.4 tons CO_2 per car.

To derive which proportion of employees switched from a non-eligible to an eligible hybrid company car (Case 1) and which proportion switched from a non-eligible car to an electric company car (Case 2), we refer to our regression analysis focusing on the German car market in Table 4 and infer the switching shares from the regression coefficients in Column (2), resulting in the following shares: 53.58% switch from a non-eligible car to an eligible plug-in hybrid (Case 1) and 46.42% switch from a non-eligible car to a purely electric car (Case 2). We apply these shares to estimate average reform-induced costs per car amounting to 3,623 € and average reform-induced CO_2 savings per car of 2.9 tons. This results in overall reform-induced cost for each ton of saved CO_2 of 1,266 €.[41]

For firms (Panel B), the relevant cost in Case 1 is the higher leasing price of plug-in hybrid vehicles compared to combustion engine cars. The average incremental cost for firms when an employee switches from a combustor to a plug-in hybrid is 3,518 € per company car. Since the CO_2 emissions of plug-in hybrids in the baseline scenario are higher than those of the average combustor - due to the low electric driving share - this switch results in an increase of emissions by 2.1 tons of CO_2 per car. Accordingly, firms' (reported) emissions increase rather than decrease.

Case 2, the switch from a non-eligible combustion engine car to a purely electric vehicle,

[41] In an untabulated robustness check, we exclude the 10% least expensive car models and the 10% most expensive car models from our cost-benefit analysis. The 10% least expensive car models are almost exclusively combustors with missing hybrid or electric pendant in a comparable price range. The 10% most expensive cars are cars that are registered rarely, e.g., the Porsche Cayenne. The reform-induced costs for each ton of saved CO_2 in this robustness check is 1,307 €. Our baseline results, therefore, are not driven by particularly expensive or cheap cars.

results in a financial advantage for the firm. Electric cars are, on average, 303 € less expensive than the combustion engine models they replace. Combined with a reduction of 5.4 tons of CO_2 emissions over the vehicles lifetime as a company car, this leads to negative abatement costs. When we weight the costs and benefits for each case with the derived switching shares, we get average reform-induced costs for each ton of saved CO_2 of 1,302 €.

[Insert Table 9 about here.]

5.2.2 Alternative Scenarios

The aim of the baseline scenario was to estimate the most realistic reform-induced price for each ton of saved CO_2. In the following, we derive a cost range by varying key assumptions and factors that drive the estimates for costs and benefits. Table 10 gives an overview of the scenarios and underlying assumptions. We vary one assumption at a time, keeping the others constant.

The first Column (Scenario 1) displays the assumptions for our baseline scenario. In Scenario 2, we assume a more optimistic electric driving behavior for the eligible plug-in hybrids. In line with the mileage indications by the car manufacturers, we assume an electric driving share of 75%. From a government perspective, we estimate reform-induced costs for each ton of saved CO_2 emissions of 321 € for Scenario 2, which is less than 75% of the costs for our baseline Scenario 1. From a corporate perspective, the costs per saved ton of CO_2 reduce to 331 €. While we observed an *increase* in CO_2 emissions for the case where an employee switched to an eligible plug-in hybrid in our baseline scenario, the higher electric driving share results in a reduction in CO_2 emissions for switching to plug-in hybrids in this scenario.[42] These benefits result in much lower costs for each ton of saved CO_2 emissions. From a government perspective, this result implies that tying the tax benefit for plug-in

[42]While this scenario leads to lower overall emissions, for firms reporting emissions, the higher electric driving share for hybrid company cars would result in lower reported Scope 1 and higher reported Scope 2 emissions.

hybrids to a high electric driving share would substantially reduce the costs of the reform. As firms have to report their emissions based on real use values, employers could achieve these lower costs for reduced emissions by incentivizing their employees to primarily drive plug-in hybrid company cars with the electric battery, e.g., by providing charging opportunities at the firm site.

While we abstracted from emissions that occur from producing and recycling a car in our baseline scenario, we include these emissions in Scenario 3 to incorporate emissions along the full life cycle of a car. The resulting costs per saved ton CO_2 from a government perspective amount to 5,673 € and are thus almost five times higher than in our baseline scenario. The life-cycle emissions for plug-in hybrids and purely electric cars are substantially higher than those of non-eligible cars. While emissions for production and recycling amount to 5.41 tons of CO_2 for the average non-eligible car, emissions amount to 6.70 tons for the average plug-in hybrid and 8.70 tons for the average electric car (European Federation for Transport and Environment, 2022). The higher life-cycle emissions for eligible cars in comparison to non-eligible ones reduce the benefits of the reform and therefore result in substantially higher reform costs.

From a corporate perspective, this scenario includes upstream and downstream life-cycle emissions, which extend beyond operational use. Firms should, in general, include the emissions from vehicle and battery production (upstream emissions) and recycling-related emissions (downstream emissions) under Scope 3 (World Resources Institute and World Business Council for Sustainable Development, 2013). When we include life-cycle emissions in the cost-benefit calculations, firms emit on average more when their employees switch to an eligible car. As a results, the firm bears higher costs for causing and potentially reporting higher emissions. Therefore, we cannot report a price for this scenario from a corporate perspective.

Our baseline scenario revealed that only the switch to purely electric cars actually results in reduced CO_2 emissions. In Scenario 4, we estimate the costs and benefits for the hypothetical case that the preferential tax treatment would only apply to purely electric cars. Restricting the tax benefit to electric cars would reduce the costs per saved ton CO_2 from a government perspective to 431 €. This is less than half the price compared to the baseline estimate. Therefore, granting the tax benefit only for electric cars would substantially reduce the reform costs for the government. However, requiring a high electric driving share for plug-in hybrids (Scenario 2) results in still slightly lower costs due to substantially higher reform costs for switching to an electric car.

For firms, restricting employees choice to electric vehicles only also substantially reduces incurred costs for reducing emissions. Since electric cars are, on average, less expensive than combustors and offer meaningful emission savings, firms achieve a cost advantage of 57 € per ton of CO_2 abated. More specifically, firms could reduce their (reported) emissions while also reducing their investment costs for company cars.

In Scenario 5, we estimate the currently hypothetical scenario that all energy used for recharging batteries in plug-in hybrid and electric cars would stem from renewable sources. Using renewable energy for recharging significantly lowers emissions for both plug-in hybrid and electric cars, thereby substantially decreasing reform-induced costs both from a government perspective (to 446 €) and from a corporate perspective (to 554 €).

In summary, our estimated costs per saved ton of CO_2 from a government perspective range from 321 € under an optimistic electric driving share of plug-in hybrids (Scenario 2) to 5,673 € when considering full life-cycle emissions (Scenario 3). For firms, the range includes cases where they can reduce emissions while realizing cost savings, such as when only electric vehicles are eligible (Scenario 4), as well as scenarios in which firms incur higher costs while emitting even more, as in the full life-cycle case (Scenario 3). These scenario analyses highlight that the reform's cost-efficiency is highly sensitive to the actual electric driving share of plug-in hybrids and the carbon intensity of the electricity used for charging.

[Insert Table 10 about here.]

5.2.3 Policy Evaluation

Government Perspective

To evaluate the cost-efficiency of the policy from a government perspective, we compare the costs per saved ton of CO_2 to different environmental policies. An obvious comparison is the CO_2 credits trading price on the European Climate Exchange, derived from CO_2 emission futures. The average price for such future contracts over the whole sample period (the treatment period) is 12.87 € (21.51 €). Our estimates therefore exceed the costs of CO_2 credits by a factor of 97 (58).

Several studies have evaluated the efficiency of policy interventions reducing the upfront costs of ecologically friendly cars. All of these studies report lower costs per saved ton of CO_2 than we estimate. For a US setting, Beresteanu and Li (2011) estimate the cost of federal tax credit for acquiring hybrid cars of up to $177 (approximately 158 €[43]) per saved ton of CO_2. Chandra et al. (2010) evaluate the use of a sales tax reduction on hybrid cars and estimate costs of $195 (174 €) per saved ton of CO_2. Several studies investigate the "Cash-for-Clunkers" program in the United States, which was designed to encourage owners of older cars to purchase more fuel-efficient ones. Li et al. (2013) estimate the costs of this extensive program with up to $288 (257 €) per reduced ton of CO_2, while Knittel (2009) estimates potential costs of $200 up to $450 (179 to 402 €).

Few studies investigate the cost-efficiency of reducing the operating costs of environmentally friendly cars. Metcalf (2008) investigates an ethanol tax credit to improve the use of ethanol in passenger vehicle gasoline. The lower bound of his estimated cost per saved ton of CO_2 for this policy is $450, while his baseline results amount to $1,700. In a Swiss setting, Alberini and Bareit (2019) evaluate the link between annual circulation taxes and CO_2 emissions. While they also find a demand effect on the car market, they estimate costs

[43]We apply the average euro to US dollar exchange rate in 2019 of 1.12 (Statista, 2022).

for each reform-induced ton of saved CO_2 of about \$837 (832 CHF[44]).

Our baseline cost estimate from a government perspective exceeds previous studies evaluating reforms targeting the upfront costs of cars by a factor of three or more and ranges at the upper end of costs from the few previous studies that have focused on reforms targeting operating costs.

As a result, our cost-benefit analysis suggests that, compared to other potential emission-reducing policies in the transportation sector, the investigated preferential income tax treatment for plug-in hybrid and electric cars in Germany is rather expensive. Several aspects accentuate this result. Our heterogeneity analysis in Section 5.1.4 shows that the reform particularly increases the number of newly registered large and expensive hybrid company cars. This result contradicts a claim proposed by Damert and Rudolph (2018) that tax policy should aim at reducing the vehicle size for company cars. Besides, hybrid cars can be used both with the electric battery and the combustion engine. Used with the combustion engine only, the hybrids in our sample emit, on average, more CO_2 than non-eligible cars. The German government does not monitor the driving behavior of employees to grant the preferential tax treatment. Therefore, the reform may cause free rider behavior. One positive aspect of the reform is that it promotes environmentally friendly company cars, whereas tax policy in most OECD countries favors traditional combustors (see Berggren and Kågeson, 2017; Mandell, 2009; PricewaterhouseCoopers, 2007; Wesseling et al., 2015).

While the pure focus on CO_2 prices may be too narrow to evaluate the policy, we also follow Dechezleprêtre et al. (2022). They argue that the support and success of climate policies depend on three key perceptions: (1) the effectiveness of the policy in reducing CO_2 emissions, (2) distributional impacts on lower-income households, and (3) the impact on the beneficiarys household. Applied to the German policy reform for plug-in hybrid and electric company cars, we find only limited reductions in CO_2 emissions. Regarding inequality

[44] We apply the average CHF to US dollar exchange rate in 2019 of 1.0065.

aspects, the German reform also tends to perform rather poorly: the government favors employees who drive a company car, who are generally wealthier. Evaluating the impact on the employee's household, we see a clear financial benefit in taking advantage of the reform and choosing an eligible company car. Finally, we compare the costs of the reform in Germany to the social costs of CO_2, as derived by Rennert et al. (2022). Their preferred estimate for the social costs of one ton of CO_2 is 185$. Our baseline estimate exceeds these costs by a factor of more than six.

Corporate Perspective

To contextualize our estimates from the corporate perspective, we compare them to typical abatement costs in other sectors. Across a wide array of industrial decarbonization technologies, the cost of avoiding a ton of CO_2 spans a broad range, from $ 20 per ton (Baylin-Stern and Berghout, 2021) to $ 1,000 (Herzog, 2022). At the lower end of the spectrum, relatively efficient technologies such as calcium looping in ammonia production report abatement costs starting at around $ 20 (18 €) per ton (Zhang et al., 2024). Carbon capture and storage technologies used in hard-to-abate sectors like steel and cement typically fall within a mid-range of $ 40 (36 €) to 135 (121 €) per ton (Zhang et al., 2024), depending on the specific process and implementation context. At the upper end, direct air capture – a more technologically demanding and general-purpose approach – can exceed $ 300 (268 €) per ton (Baylin-Stern and Berghout, 2021), with some estimates reaching as high as $ 1,000 (893 €) (Herzog, 2022).

Assessing the firm-level costs of the reform compared to alternative abatement strategies reveals a nuanced picture. While the baseline scenario entails relatively high costs per ton of saved CO_2, cost-efficiency improves substantially when the scope of the reform is narrowed – either by increasing the electric driving share of plug-in hybrids or by focusing exclusively on electric vehicles. In the latter case, firms even face negative abatement costs, achieving emission reductions while lowering vehicle acquisition expenses. This divergence underscores a structural asymmetry: although the financial burden of the reform is primarily borne by the public sector, it can induce highly cost-effective decarbonization on the part of private actors. A meaningful evaluation of such policies must therefore account for both public and private cost structures, as well as the behavioral and regulatory dynamics that mediate their interaction.

6 Conclusion

This paper analyzes the effectiveness and cost-efficiency of a German tax reform that introduced a preferential income tax treatment for plug-in hybrid and electric company cars. Based on administrative data on new car registrations, we conduct a difference-in-differences analysis and find that the reform increased new car registrations of eligible cars by 95% compared to pseudo-eligible cars in the neighboring country Austria. To validate our findings, we extend our sample to the entire German and Austrian car markets in a triple difference-in-differences design and find similar inferences. Our findings are robust to an extensive number of robustness checks. Overall, we find the reform to be effective in fostering green driving. We also find larger effect sizes than most previous studies, which have analyzed other reforms aimed at reducing emissions in the transportation sector.

While the reform was effective in stimulating the adoption of lower-emission vehicles, our cost-benefit analysis shows that it was not cost-efficient from a governmental perspective. We estimate a baseline price of 1,266 € per saved ton of CO_2, substantially exceeding those of comparable transport-sector interventions and far above prevailing CO_2 prices or estimated social costs. This inefficiency is primarily driven by the inclusion of plug-in hybrid vehicles, which are often used with their combustion engines and offer limited actual emission reductions under current usage patterns. We also derive reform options that could substantially reduce the reform-induced costs: requiring a high electric driving share for plug-in hybrids or granting the tax benefit only to electric cars would substantially reduce the costs per saved ton CO_2. Adopting such design changes could make the reform more environmentally effective and significantly more cost-efficient.

We also examine the implications of the reform for firms. Although the policy was not designed with firms as the primary target, it affects corporate fleets and (reported) emissions. In the baseline scenario, firms face abatement costs similar to those incurred by the government. However, when electric vehicles are adopted more widely or plug-in hybrids are driven more frequently using the electric engine, firm-level abatement costs decline significantly and may even become negative. These outcomes suggest that, under certain conditions, the reform can offer firms a low-cost pathway to reduce emissions, with potential benefits for ESG reporting and stakeholder perception.

Overall, our findings highlight a critical trade-off in the design of green tax policies: while broad eligibility criteria may enhance short-term adoption rates, they risk undermining cost-efficiency and environmental integrity. A more targeted policy – limiting preferential treatment to vehicles that deliver verifiable emission reductions – could improve the balance between effectiveness and fiscal responsibility. As governments seek to accelerate decarbonization in the transportation sector, especially through corporate channels, designing smarter, behaviorally responsive tax incentives will be key to maximizing both environmental and economic returns.

Appendix

A Tables and Figures

Table A1: Variable Definitions

Variable	Description	Source
$CompanyCarRegistrations_{i,t}$	Number of new company car registrations of a specific car model i in month t in country j	Kraftfahrt-Bundesamt & Bundesanstalt Statistik Österreich
$HybridCarRegistrations_{i,t}$	Number of new registrations of a specific eligible hybrid car model i in month t	Kraftfahrt-Bundesamt & Bundesanstalt Statistik Österreich
$Eligible_i$	Indicator variable equal to one if the respective car model i is an eligible plug-in hybrid, zero otherwise	ADAC
$Post_t$	Indicator variable equal to one for observations after December 2018 (implementation of tax reform), zero otherwise	Kraftfahrt-Bundesamt & Bundesanstalt Statistik Österreich
$German_j$	Indicator variable equal to one for German observations, zero otherwise	Kraftfahrt-Bundesamt & Bundesanstalt Statistik Österreich
$Hybrid_i$	Indicator variable equal to one if the car model is an eligible plug-in hybrid, zero otherwise	Kraftfahrt-Bundesamt & Bundesanstalt Statistik Österreich
$Electro_i$	Indicator variable equal to two if the car model is an electric car, zero otherwise	Kraftfahrt-Bundesamt & Bundesanstalt Statistik Österreich
$EntryLevelPrice_{i,t}$	Entry-level price for the basic configuration of a specific car model i in month t in country j	ADAC
$Mileage_{i,t}$	Mileage of a specific car model i in month t	ADAC

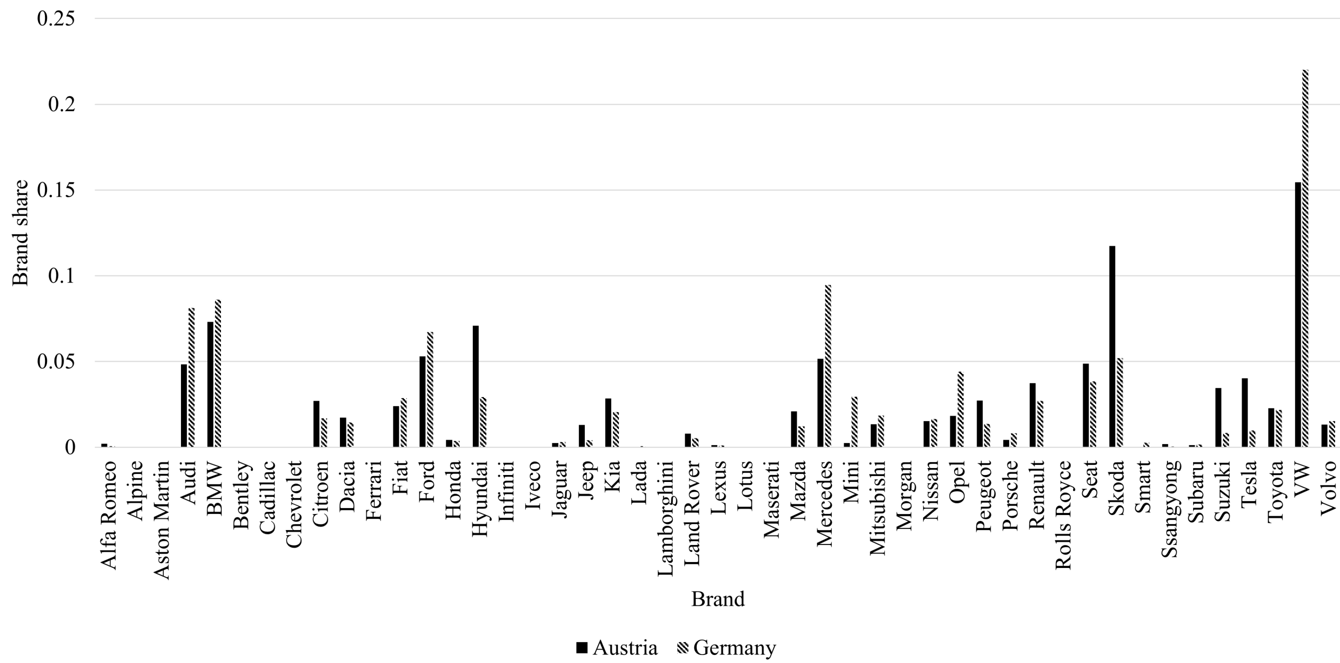
Notes: Overview of variables and data sources we use in this paper.

Table A2: Tax Advantage after Policy Change for a Mercedes S-Class

	Hybrid	Combustor Plug-in Hybrid	Tax Advantage
Mean gross list price	110,254 €	93,385 €	
Old law			
** 1%*			
= monthly tax base	1,103 €	934 €	
** 12 months*			
= annual tax base	13,236 €	11,208 €	
** 42% income tax rate*			
= annual tax liability	5,559 €	4,707 €	
New law			
** 1% / **0.5%***			
= monthly tax base	551 €	934 €	
** 12 months*			
= annual tax base	6,612 €	11,208 €	
** 42% income tax rate*			
= annual tax liability	2,777 €	4,707 €	**+1,930 €**

Notes: Own calculations on the tax liability for an eligible hybrid Mercedes S-Class and a non-eligible combustor Mercedes S-Class. Data from the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC).

Figure A1: Brand Shares in Germany and Austria.



Notes: Graph shows the brand shares in Germany and Austria in our sample. Data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt) and the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich).

B Details on Calculating Costs and Benefits of the Reform

Baseline Values

To derive the costs and benefits of the reform from a government and a corporate perspective, we rely on data on car level entry prices and mileage which is available at the car model level over time. Calculating a price for each ton of saved CO_2 using this information involves two design choices. One design choice is whether to use values based on the pre- or the post-period of the reform. Taking the pre-reform information to estimate the costs and benefits of the reform corresponds to taking an ex-ante, anticipatory approach. From a government perspective, this approach is equivalent to evaluating the cost-efficiency of the reform before it was introduced.[45] Taking the post-reform values corresponds to taking an ex-post, real world approach. As we want to evaluate the actual (vs. expected) cost-efficiency of the reform, we rely on post-reform values.

A second design choice relates to whether to use weighted or unweighted values for the level entry price and mileage. For example, the average level entry price for a non-eligible car could be calculated as either an unweighted mean of all car model prices, or as a weighted average where the number of car registrations per model is used as the weighting factor. This takes the prevalence of a model on the market into account. The advantage of the weighted approach is that the resulting values depict the composition of the German car market, allocating more weight to car models that are used more frequently. The main limitation of

[45] Applying this approach allows us to compare our cost estimate to the costs predicted by the German government. Combining the number of newly registered eligible hybrids and electric company cars between January 2019 and March 2020 (234,304) and the average estimated costs per registered eligible car (3,623 €), we derive total costs of 849 million €. This amount is about twice as high as the estimated costs by the German government, amounting to 420 million €. Comparing the estimated costs by the German government with the number of newly registered cars which we observe, the average costs per car should amount to 1,793 €, which is relatively close to the costs for switching from a non-eligible car to an eligbile plug-in hybrid (-2,488 €). Therefore, our cost estimates would be comparable with the estimate by the German government if we assumed that all employees switched from a non-eligible car to an eligible plug-in hybrid.

this approach, however, is that it disproportionately emphasizes models without an eligible counterpart within the same vehicle class. For instance, combustion engine models like the VW Polo or the Opel Corsa are commonly used as company cars. However, employees driving these cars may have no realistic option to switch to an eligible plug-in hybrid or electric alternative, as few such models exist within the same vehicle class. In other words, switching to an eligible plug-in hybrid or electric car model would require an upgrade to a higher vehicle class. Under the weighted approach, however, these frequently used models - despite lacking comparable eligible counterparts - are assigned greater weights, potentially biasing the analysis. Therefore, we use unweighted values in our cost-benefit analysis.

Table B1 summarizes the different design choices (sample period and weighting) and displays the reform-induced price of reducing one ton of CO_2 from a government perspective for all possible combinations.

TABLE B1: Baseline Values and Efficiency Results

		Timing	
		Pre-Reform Values	Post-Reform Values
Weighting	Weighted	2,774 €	1,184 €
	Unweighted	948 €	**1,266 €**

Notes: Overview of base value options.

Costs

From a government perspective, the costs of the reform amount to the foregone income tax revenue for the German Treasury. When an employee chooses a non-eligible car (i.e., a combustor, a full hybrid, or a non-eligible plug-in hybrid) as a company car, the tax base for the non-cash benefit amounts to 1% of the entry-level price of the respective company car per month. In contrast, when an employee chooses an eligible car (i.e., an eligible plug-in hybrid or an electric car) as a company car, the tax base for the non-cash benefit amounts only to 0.5% of the car's gross list price each month.

Table B2 calculates the average costs of the reform per eligible car for two different cases. In Case 1, an employee switches from the average non-eligible car to the average eligible hybrid. In Case 2, an employee switches from the average non-eligible car to the average electric car.[46]

We start our calculation with the average gross list prices for the different car types.[47] For the non-eligible cars, the annual tax base equals to twelve times 1% of the average gross list price (12%). For the eligible cars, the annual tax base equals to twelve times 0.5% of the average gross list price (6%). We assume an individual income tax rate of 42% to derive annual tax payments. We calculate the annual income tax revenue loss per car by comparing the annual tax payments for the average non-eligible car to the annual tax payments for the average eligible plug-in hybrid (Case 1) or the average electric car (Case 2). For switching to an eligible plug-in hybrid (electric car), we estimate average costs of 566 € (1,121 €) per year and car. The foregone income tax revenue for the German government for switching to an electric car is almost twice as high as for switching to an eligible plug-in hybrid. While the average eligible plug-in hybrid is more expensive than the average non-eligible car, the average electric car's gross list price is lower than for the average non-eligible car. As a result, halving the tax base has stronger implications for switching to an electric car. As the

[46] In general, an employee could also switch from having no company car prior to the reform to having an eligible company car after the reform. Our data does not allow us to study this case. However, as we observe a general decrease in new car registrations over time in Germany (see Figure 2), we assume that this case occurs rather rarely. We acknowledge that switching from no company car to an eligible company car would increase income tax revenue. Therefore, we would overestimate our costs if employees choose a company car after the reform for the first time.

[47] We average prices as well as mileage over the post-reform period from August 2018 to December 2019.

German government grants this tax benefit only for company cars, the income tax revenue occurs as long as a car is used as such, which is, on average, 4.4 years (see Section 5.2).

Table B2: Baseline Costs - Government

	Case 1		Case 2	
	Non-eligible car	Eligible hybrid	Non-eligible car	Electric car
Gross list price	42,734 €	63,028 €	42,734 €	40,989 €
Annual tax base	5,128 €	3,782 €	5,128 €	2,459 €
Annual tax payment (42%)	2,154 €	1,588 €	2,154 €	1,033 €
Annual tax revenue loss	**566 €**		**1,121 €**	
Tax revenue loss per car (*4.4)	**2,488 €**		**4,932 €**	

Notes: Own calculations on the reform-induced average costs per car. Data based on post-reform months from the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC).

From a corporate perspective, the costs of the reform stem from the higher acquisition or leasing costs associated with eligible cars. For our calculations, we focus on leasing rather than purchasing vehicles for two reasons. First, operational leasing is the predominant financing method for company cars in Germany, especially among larger firms, as it offers full tax deductibility of leasing payments and avoids balance sheet activation of the asset (see Gerstenberger, 2023; Dataforce, 2020). Second, leasing allows for a more realistic assessment of recurring monthly costs, which is particularly relevant when comparing vehicles of different price classes and technologies. This approach is consistent with common corporate fleet management practices, especially in the context of electric and hybrid vehicles, which often come with higher acquisition costs.

Table B3 reports the average costs of the reform per eligible car for Case 1 (switch to eligible plug-in hybrid) and Case 2 (switch to electric car). As with the government perspective, the calculation begins with the average gross list prices of the respective vehicle types. The monthly gross leasing rate is determined by multiplying the leasing factor with the gross list price of the company car and dividing it by 100. In 2020, the overall average leasing factor was 0.67 (LeasingMarkt.de, 2020). As corporations most likely have better leasing conditions than private individuals, we use a discounted leasing factor of 2/3 of the value to reflect the more favorable terms resulting in an adjusted leasing factor of 0.47. Leasing costs are tax deductible for corporate income tax purposes. As the combined tax rate on corporate profits (from the corporate income tax and the trade tax) is approximately 30%, we derive the monthly net leasing factor (0.33) by multiplying with 0.7. We derive annual net leasing costs by extrapolating the monthly net leasing costs to the full year.

We proceed by comparing the annual leasing costs from the firm perspective between the average non-eligible car and the average eligible hybrid in Case 1, and the average electric car in Case 2. For Case 1, a firm faces annual additional leasing costs of 799 €, as eligible plug-in hybrids are on average more expensive than non-eligible cars. For Case 2, a firm faces annual *savings* in leasing costs of 69 €, as the average electric car is cheaper than the average non-eligible car. Firms face these additional costs (savings) as long as the eligible car is used as a company car, which is on average 4.4 years (see Section 5.2). Therefore, the total additional leasing costs per eligible hybrid (Case 1) amount to 3,518 €, while the total savings per eligible electric car (Case 2) amount to 303 €.

Table B3: Baseline Costs - Firms

	Case 1		**Case 2**	
	Non-eligible car	Eligible hybrid	Non-eligible car	Electric car
Gross list price	42,734 €	63,028 €	42,734 €	40,989 €
Monthly gross leasing rate (*0.47)	200 €	296 €	200 €	192 €
Monthly net leasing rate (*0.7)	140 €	207 €	140 €	135 €
Annual net leasing	1,684 €	2,483 €	1,684 €	1,615 €
Annual additional leasing costs	**799 €**		**-69 €**	
Additional costs per car (*4.4)	**3,518 €**		**-303 €**	

Notes: Own calculations on the reform-induced average costs per car. Data based on post-reform months from the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC).

Benefits

The benefit of the reform is a potential reduction in CO_2 emissions in the German transportation sector from a government perspective and a reduction in corporate emissions from a corporate perspective. Table B4 calculates the average CO_2 reduction per car for switching from a non-eligible car to an eligible hybrid (Case 1) and from a non-eligible car to an electric car (Case 2). We start with average CO_2 emissions per driven kilometer. For combustors and full hybrids, we can directly infer the CO_2 emissions per kilometer from the mileage.[48] For plug-in hybrids, the emissions per kilometer consist of two components. The first component are the emissions resulting from using the plug-in hybrid with the internal combustion engine. In line with the procedure for combustors, the emissions can simply be derived from the mileage. However, we need to adjust the mileage reported by car manufacturers as the mileage of plug-in hybrids reported by car manufacturers assumes an electric driving share

[48] One liter corresponds to 2.370 grams of CO_2 (Handelsblatt, 2022).

of 75%. Plötz et al. (2020) show, that this share is much lower for company cars in Germany and amounts to only 12%. Based on this lower electric driving share, we recalculate the mileage for plug-in hybrids and infer higher CO_2 emissions per kilometer.[49] Where available, we use the real-word fuel consumption data from the study conducted by the Fraunhofer Institute in cooperation with the International Council on Clean Transportation. The second component is the emissions resulting from the use of the electric battery, i.e., the emissions resulting from generating the energy to charge the battery. As stated in Section 5.2, we apply the energy mix in Germany in 2019 in our baseline specification. We use information on the energy consumption of the car manufacturer and infer CO_2 emissions per driven kilometer.[50] For fully electric cars, we can simply derive CO_2 emissions per kilometer from their energy consumption.

These procedures result in different CO_2 emissions per driven kilometer for the different car types, being the lowest for the average electric car (73g per kilometer) and highest for the average eligible plug-in hybrid (196g per kilometer). To derive reform-induced CO_2 emission reductions, we compare the emissions per kilometer across car types. Switching from the average non-eligible car to the average eligible plug-in hybrid (Case 1) does not result in reduced, but in increased CO_2 emissions of 36 gram per kilometer. In contrast, switching from the average non-eligible car to the average electric car reduces CO_2 emissions by 88 gram per kilometer.

From a government perspective, the reform costs only arise as long as a car is used as a company car while the benefits in form of reduced emissions arise over the whole lifetime of a car. Therefore, we multiply the average CO_2 emission reductions per kilometer by the average working life of a car (129,200 km) and get a reduction of CO_2 emissions per car. In Case 1, when an employee switches from a non-eligible car to an eligible plug-in hybrid, we

[49]We derive the mileage for hybrid cars with the exclusive combustion engine use with the following formula: $((Electricrange + 25) * Mileage)/25$ (The International Council of Clean Transportation, 2017).

[50]Emissions in gram per kilometer can be derived by dividing the energy consumption (in kilowatt hours) by 100 and multiplying it by the emissions from the energy mix.

estimate an increase in CO_2 emissions of 4.6 tons per car. For the switch to an electric car (Case 2), we estimate CO_2 emission reductions of 11.4 tons per car.

From a corporate perspective, emission reductions are relevant only for the period during which a vehicle is used as a company car. Therefore, we extrapolate the emission reductions per kilometer on the lifetime of a company car to derive average emission reductions per company car from a corporate perspective. Given that company cars are typically in use for 4.4 years (60,480 km), emissions are estimated to increase by 2.1 tons per company car in Case 1 and to decrease by 5.4 tons in Case 2.

Table B4: Baseline Benefits - Emission Reductions

	Case 1		**Case 2**	
	Non-eligible car	Eligible hybrid	Non-eligible car	Electric car
∅ Emissions per km	161 g	196 g	161 g	73 g
∅ Reduction per km	**-36 g**		**88 g**	
Lifetime car	129,200 km		129,200 km	
∅ Reduction per car	**-4.6 tons**		**11.4 tons**	
Lifetime company car	60,477 km		60,477 km	
∅ Reduction per company car	**-2.1 tons**		**5.4 tons**	

Notes: Own calculations on the reform-induced average benefits per car. Data based on post-reform months from the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC). Negative values refer to additional emissions, positive values refer to emission reductions.

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Tables

Table 1: Tax Advantage after Policy Change

	Non-eligible Car	Eligible Car	Tax Advantage
Mean gross list price	39,811 €	44,890 €	
Old law			
** 1%*			
= monthly tax base	398 €	449 €	
** 12 months*			
= annual tax base	4,777 €	5,388 €	
** 42% income tax rate*			
= annual tax liability	2,006 €	2,263 €	-257 €
New law			
** 1% / **0.5%***			
= monthly tax base	398 €	224 €	
** 12 months*			
= annual tax base	4,777 €	2,693 €	
** 42% income tax rate*			
= annual tax liability	2,006 €	1,131 €	**+875 €**

Notes: Own calculations of the tax liability for an average non-eligible car and an average eligible car before the tax reform (old law) and afterward (new law). Data from the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC).

Table 2: Descriptive Statistics

Germany

	Eligible Cars				Non-eligible Cars				Car Market			
Pre	N	Mean	Median	SD	N	Mean	Median	SD	N	Mean	Median	SD
CompanyCarRegistrations	557	103.42	68.30	108.99	4,260	713.44	288.03	1,195.51	4,817	642.90	236.00	1,141.66
EntryLevelPrice (€)	557	51,889.61	39,990.00	28,800.28	4,260	32,441.36	24,740.00	29,682.78	4,817	34,690.20	25,900.00	30,226.03
Mileage (l/km)	557	2.06	2.00	0.67	4,260	6.19	5.80	1.76	4,817	5.71	5.60	2.13
Post	N	Mean	Median	SD	N	Mean	Median	SD	N	Mean	Median	SD
CompanyCarRegistrations	545	211.33	111.59	255.93	3,794	710.95	304.70	1,159.14	4,339	648.19	259.00	1,100.20
EntryLevelPrice (€)	545	54,122.48	43,730.00	29,824.18	3,794	34,573.66	26,690.00	32,076.37	4,339	37,029.09	28,450.00	32,452.35
Mileage (l/km)	545	2.23	2.00	0.91	3,794	6.67	6.40	1.95	4,339	6.11	6.20	2.37

Austria

	Pseudo-eligible Cars				Pseudo-ineligible Cars				Car Market			
Pre	N	Mean	Median	SD	N	Mean	Median	SD	N	Mean	Median	SD
CompanyCarRegistrations	622	14.33	4.00	24.10	4,660	64.56	20.00	110.83	5,282	58.64	16.00	105.67
EntryLevelPrice (€)	622	54,374.12	43,090.00	30,525.85	4,660	44,520.32	27,450.00	56,230.03	5,282	45,680.69	29,650.00	53,935.88
Mileage (l/km)	622	2.15	2.00	0.70	4,660	6.41	6.00	2.12	5,282	5.91	5.70	2.43
Post	N	Mean	Median	SD	N	Mean	Median	SD	N	Mean	Median	SD
CompanyCarRegistrations	566	19.19	5.00	37.60	4,313	56.42	15.00	98.41	4,879	52.10	13.00	94.16
EntryLevelPrice (€)	566	54,518.99	41,270.00	31,807.41	4,313	51,032.75	31,869.00	66,343.13	4,879	51,437.18	33,490.00	63,317.76
Mileage (l/km)	566	2.23	2.00	0.93	4,313	7.08	6.60	2.32	4,879	6.51	6.30	2.70

Notes: The observational units are vehicle models. Monthly data from January 2017 to December 2019. Table A1 in the appendix defines variables. Data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt), the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich), and the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC).

Table 3: German versus Austrian eligible company cars

EligibleCompanyCarRegistrations	(1)	(2)	(3)
German*Post	103.05***	97.80***	
	(3.70)	(3.50)	
GermanHybrid*Post			106.90***
			(2.77)
GermanElectric*Post			85.63**
			(2.08)
German	89.09***		
	(5.94)		
Post	4.85*		
	(1.69)		
EntryLevelPrice		-0.01**	-0.00**
		(-2.43)	(-2.44)
Mileage		1.02	0.90
		(0.06)	(0.05)
Constant	14.33***	328.96***	324.39***
	(3.92)	(2.75)	(2.78)
Car model FE	No	Yes	Yes
Time FE	No	Yes	Yes
Observations	2,290	2,290	2,290
Adjusted R^2	0.25	0.63	0.63

Notes: The observational units are vehicle models. The dependent variable *EligibleCompanyCarRegistrations* is the number of new company car registrations per car model per month. *Eligible* is an indicator variable equal to one for all eligible car models and zero otherwise. *GermanHybrid* (*GermanElectric*) is an indicator variable equal to one (two) for eligible hybrid (electric) models and zero otherwise. *Post* is an indicator variable equal to one for all observation periods after July 2018, representing the time after the announcement of the preferential tax treatment. The sample only consists of eligible models in Germany and their counterparts in Austria. Detailed variable definitions are provided in Table A1 in the appendix. The baseline specification in Columns (2) and (3) include time and car model fixed effects. Monthly data from January 2017 to December 2019. t-statistics are given in the parentheses, and standard errors are heteroskedasticity-robust and clustered at the car model level. ***, ** and * label statistical significance at 1%, 5%, and 10% levels, respectively. Data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt), the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich), and the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC).

Table 4: German car market and triple difference-in-differences approach

Robustness	German car market	German car market	Triple DiD	Triple DiD
	(1)	(2)	(3)	(4)
Eligible*Post	125.52***		9.82**	
	(3.81)		(2.08)	
Hybrid*Post		131.14***		
		(3.10)		
Electric*Post		117.84***		
		(2.67)		
German*Eligible*Post			120.80***	
			(3.42)	
German*Post			-22.69	
			(-1.16)	
German*Hybrid*Post				98.27***
				(2.96)
German*Electric*Post				111.50**
				(2.37)
Hybrid*Post				11.02**
				(2.45)
Electric*Post				8.64
				(1.61)
Controls	Yes	Yes	Yes	Yes
Car model FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Observations	9,156	9,156	19,317	19,317
Adjusted R^2	0.90	0.90	0.91	0.91

Notes: The observational units are vehicle models. The dependent variable is the number of new company car registrations per car model in Germany (and Austria) per month. *Eligible* is an indicator variable equal to one for all eligible car models and zero otherwise. *Hybrid* (*Electric*) is an indicator variable equal to one (two) for eligible hybrid (electric) models and zero otherwise. *German* is an indicator variable equal to one for all German observations and zero otherwise. *Post* is an indicator variable equal to one for all observation periods after July 2018, representing the time after the announcement of the preferential tax treatment. Detailed variable definitions are provided in Table A1 in the appendix. The sample consists of all available car models in Germany and their counterparts in Austria. All specifications include time and car model fixed effects. Monthly data from January 2017 to December 2019. t-statistics are given in the parentheses, and standard errors are heteroskedasticity-robust and clustered at the car model level. ***, ** and * label statistical significance at 1%, 5% and 10% levels, respectively. A constant is included but not reported. Data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt), the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich), and the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC).

Table 5: Heterogeneity - Price

EligibleCompanyCarRegistrations	**Low Price**		**High Price**	
	(1)	(2)	(3)	(4)
German*Post	84.62**		101.72**	
	(2.13)		(2.48)	
GermanHybrid*Post		41.51		123.86**
		(0.79)		(2.61)
GermanElectric*Post		104.94**		5.37
		(2.07)		(0.32)
Controls	Yes	Yes	Yes	Yes
Time & Car Model FE	Yes	Yes	Yes	Yes
Observations	1,084	1,084	1,032	1,032
Adjusted R^2	0.68	0.69	0.58	0.58

Notes: The observational units are vehicle models. This table presents a sample split at the median of the entry-level price of cars in our sample based on prices in July 2018, the month before the reform was announced. The dependent variable *EligibleCompanyCarRegistrations* is the number of new company car registrations per car model per month. The sample only consists of eligible car models in Germany and the same models in Austria (pseudo-eligible). *German* is an indicator variable equal to one for all German observations and zero otherwise. *Post* is an indicator variable equal to one for all observation periods after July 2018, representing the time after the announcement of the preferential tax treatment. The following control variables are included: *EntryLevelPrice* and *Mileage*. Detailed variable definitions are provided in Table A1 in the appendix. All specifications include time and car model fixed effects. Monthly data from January 2017 to December 2019. t-statistics are given in the parentheses, and standard errors are heteroskedasticity-robust and clustered at the car model level. ***, ** and * label statistical significance at 1%, 5%, and 10% levels, respectively. A constant is included but not reported. Data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt), the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich), and the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC).

Table 6: Heterogeneity - German Car Manufacturer

EligibleCompanyCarRegistrations	**German Producer**		**Non-German Producer**	
	(1)	(2)	(3)	(4)
German*Post	136.90***		50.65	
	(3.29)		(1.64)	
GermanHybrid*Post		128.32**		50.56
		(2.39)		(1.34)
GermanElectric*Post		158.22***		50.73
		(2.90)		(1.05)
Controls	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Car model FE	Yes	Yes	Yes	Yes
Observations	1,078	1,078	1,212	1,212
Adjusted R^2	0.67	0.67	0.62	0.62

Notes: The observational units are vehicle models. This table presents a sample split into models by German and non-German car manufacturers. The dependent variable *EligibleCompanyCarRegistrations* is the number of new company car registrations per car model per month. The sample only consists of eligible car models in Germany and the same models in Austria (pseudo-eligible). *German* is an indicator variable equal to one for all German observations and zero otherwise. *Post* is an indicator variable equal to one for all observation periods after July 2018, representing the announcement date of the preferential tax treatment. The following control variables are included: *EntryLevelPrice* and *Mileage*. Detailed variable definitions are provided in Table A1 in the appendix. All specifications include time and car model fixed effects. Monthly data from January 2017 to December 2019. t-statistics are given in the parentheses, and standard errors are heteroskedasticity-robust and clustered at the car model level. ***, ** and * label statistical significance at 1%, 5%, and 10% levels, respectively. A constant is included but not reported. Data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt), the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich), and the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC).

Table 7: Count Data

CompanyCarRegistrations	PPML	PPML	ZIP	ZIP	Ratio	Ratio
	(1)	(2)	(3)	(4)	(5)	(6)
German*Post	0.5933***		0.5897***		0.0004**	
	(8.02)		(7.92)		(2.26)	
GermanHybrid*Post		0.7607***		0.7559***		0.0004**
		(8.53)		(8.44)		(2.00)
GermanElectric*Post		0.4345***		0.4321***		0.0003
		(5.25)		(5.20)		(1.30)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Car model FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,164	2,164	2,291	2,291	2,290	2,290
Adjusted R^2					0.61	0.61
Pseudo R^2	0.82	0.82				

Notes: The observational units are vehicle models. The dependent variable *CompanyCarRegistrations* is the number of new company car registrations per car model per month. *German* is an indicator variable equal to one for all German observations and zero otherwise. *Post* is an indicator variable equal to one for all observation periods after July 2018, representing the announcement date of the preferential tax treatment. The following control variables are included: *EntryLevelPrice* and *Mileage*. Detailed variable definitions are provided in Table A1 in the appendix. All specifications include time and car model fixed effects. Columns (1) and (2) show a Poisson-Pseudo Maximum Likelihood (PPML), Columns (3) and (4) show a zero-inflated Poisson model (ZIP), Columns (5) and (6) use a ratio by scaling the dependent variable by the overall number of registrations. All specifications include time and car model fixed effects. Monthly data are from January 2017 to December 2019. t-statistics are given in the parentheses, and standard errors are heteroskedasticity-robust and clustered at the car model level. ***, ** and * label statistical significance at 1%, 5%, and 10% levels, respectively. A constant is included but not reported. Data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt), the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich), and the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC).

Table 8: Robustness Analyses

Sample	Constant Models	Cutout	Collapsed	German hybrid market
	(1)	(2)	(3)	(4)
German*Post	85.27**	125.17***	64.98**	78.16*
	(2.65)	(3.71)	(2.59)	(1.79)
Controls	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Car model FE	Yes	Yes	Yes	Yes
Observations	1,450	1,949	152	1,165
Adjusted R^2	0.59	0.63	0.58	0.61

Notes: The observational units are vehicle models. The dependent variable *CompanyCarRegistrations* is the number of new company car registrations per car model per month. *German* is an indicator variable equal to one for all German observations and zero otherwise. *Post* is an indicator variable equal to one for all observation periods after July 2018, representing the announcement date of the preferential tax treatment. The following control variables are included: *EntryLevelPrice* and *Mileage*. Detailed variable definitions are provided in Table A1 in the appendix. Column (1) only investigates models that were available on the market before the announcement of the tax policy reform. Column (2) excludes observation periods between announcement and implementation. Column (3) collapses all pre-announcement months into one pre preiod and all post-announcement months into one post period. In Column (4), we investigate the German hybrid car market separately. All specifications include time and car model fixed effects. t-statistics are given in the parentheses, and standard errors are heteroskedasticity-robust and clustered at the car model level. ***, ** and * label statistical significance at 1%, 5%, and 10% levels, respectively. A constant is included but not reported. Data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt), the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich), and the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC).

Table 9: Cost-benefit Analysis

Panel A: Government Perspective		
	Switching from a non-eligible car to an ...	
	Eligible hybrid **Case 1**	Electric car **Case 2**
Average costs per car	2,488 €	4,932 €
Average CO_2 reduction per car	-4.6 tons	11.4 tons
Estimated switching share	53.58%	46.42%
Weighted average costs per car	3,623 €	
Weighted average CO_2 reduction per car	2.9 tons	
Costs per saved ton of CO_2	**1,266 €**	

Panel B: Corporate Perspective		
	Switching from a non-eligible car to an ...	
	Eligible hybrid **Case 1**	Electric car **Case 2**
Average costs per company car	-3,518 €	303 €
Average CO_2 reduction per company car	-2.1 tons	5.4 tons
Estimated switching share	53.58%	46.42%
Weighted average costs per company car	-1,477 €	
Weighted average CO_2 reduction per company car	1.3 tons	
Costs per saved ton of CO_2	**1,302 €**	

Notes: Own calculations on the reform-induced average costs per saved ton of CO_2. Data from the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC).

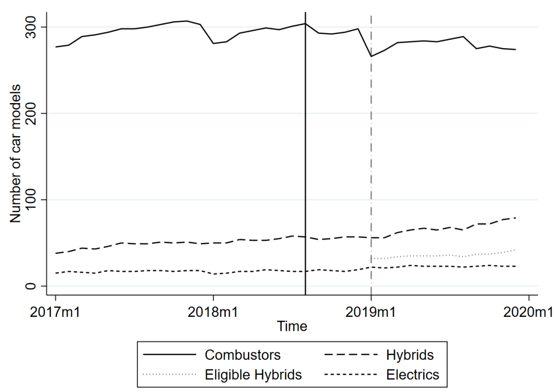
Table 10: Cost-benefit Analysis: Scenarios & Assumptions

	Scenario 1 Baseline	**Scenario 2** Optimistic use	**Scenario 3** Full life-cylce	**Scenario 4** Electrics only	**Scenario 5** Renewables only
Electric driving share of plug-in hybrids	12%	**75**%	12%	-	12%
Life-cycle emissions	no	no	**yes**	no	no
Eligible cars	hybrid & electric	hybrid & electric	hybrid & electric	**only electric**	hybrid & electric
Energy mix	mixed	mixed	mixed	mixed	**only renewables**
Government Perspective: Costs per saved ton of CO_2	1,266 €	321 €	5,673 €	431 €	446 €
Corporate Perspective: Costs per saved ton of CO_2	1,203 €	331 €	-	-57 €	554 €

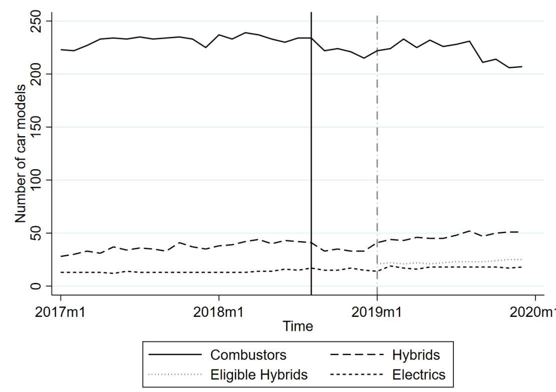
Notes: Overview of assumptions underlying the cost-benefit analysis for our five different scenarios.

Figures

Figure 1: Car Models by Engine Type.



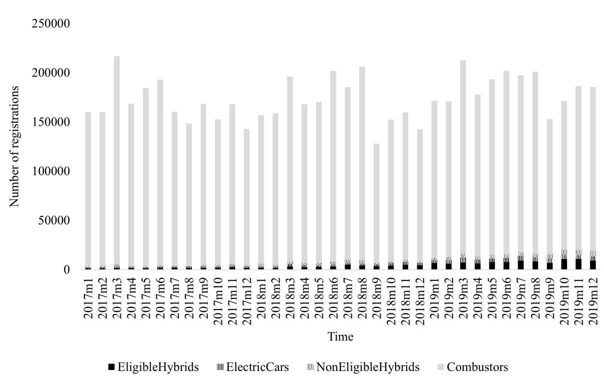
(A) Germany



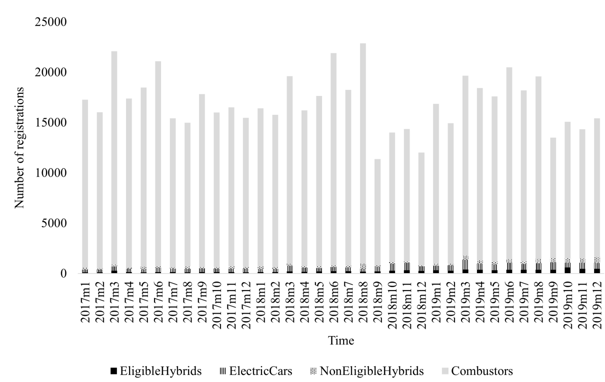
(B) Austria

Notes: Graphs show the number of available car models on the German (Panel A) and the Austrian (Panel B) car markets by engine type over time. Data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt) and the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich).

Figure 2: New Company Car Registrations by Engine Type.



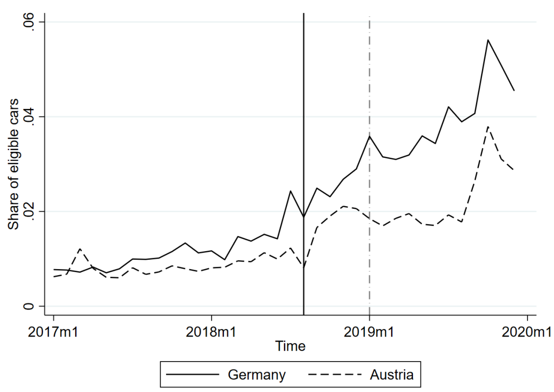
(A) Germany



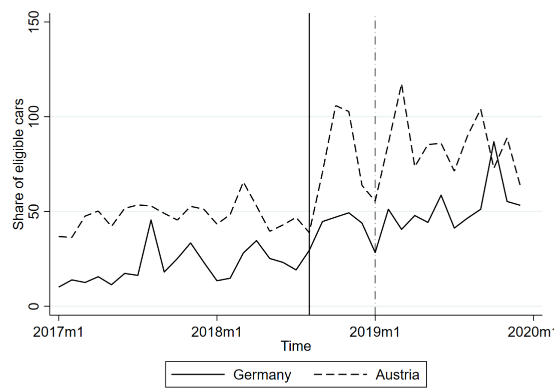
(B) Austria

Notes: Graphs show the number of newly registered cars on the German (Panel A) and the Austrian (Panel B) car markets by engine type over time. Data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt) and the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich).

Figure 3: Shares of Eligible Cars - German and Austrian Car Market.



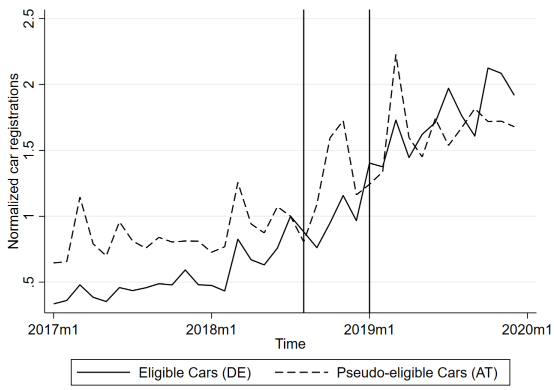
(A) Eligible Plug-in Hybrids



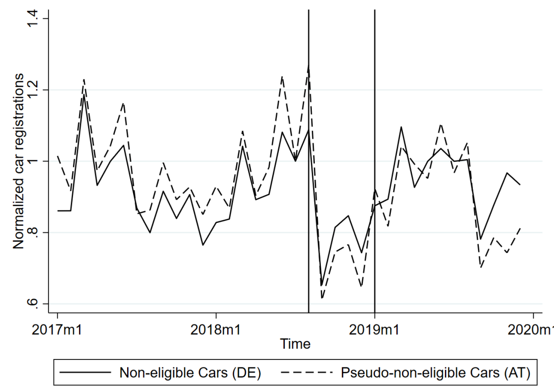
(B) Electric Cars

Notes: Graphs show the number of eligible hybrid (Panel A) and electric car (Panel B) registrations as a share of total car registrations for Germany and Austria over time. Data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt) and the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich).

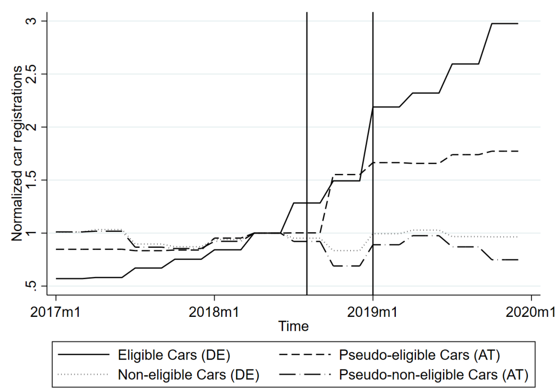
Figure 4: Parallel Trends.



(A) Eligibe Car Models - Monthly Data



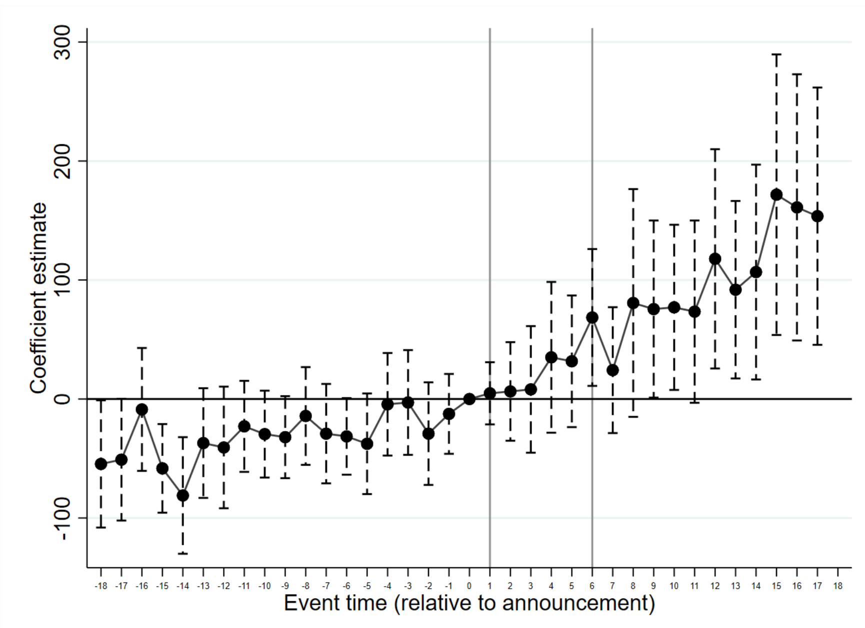
(B) Non-eligible Car Models - Monthly Data



(C) All Car Models - Quarterly Data

Notes: Panel A shows the number of eligible company car registrations per month in Germany and pseudo-eligible company car registrations in Austria. Panel B shows the number of non-eligible company car registrations per month in Germany and pseudo-non-eligible company car registrations in Austria. Panel C combines the data from Panels A and B using quarterly data. We normalize all values to one in July 2018. The first vertical line indicates the announcement of the preferential tax treatment in Germany (August 2018), while the second vertical line indicates that the reform came into force (January 2019). Data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt) and the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich).

Figure 5: Event Study.



Notes: Graph shows coefficient estimates of the event study for our baseline specification comparing eligible car models in Germany and pseudo-eligible car models in Austria. The first vertical line indicates the announcement of the preferential tax treatment in Germany (August 2018), while the second vertical line indicates that the reform came into force (January 2019). Data from the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt), the Austrian Federal Office of Statistics (Bundesanstalt Statistik Österreich), and the German Automobile Club (Allgemeiner Deutscher Automobil-Club – ADAC).

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