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Charging forward or falling behind? Effects of electric vehicle subsidy removal

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ABSTRACT

To reach climate goals in the transport sector the pace of electrification needs to speed up. Sweden has one of the highest shares of electric vehicles (EV) in the world, and 45% of the EV fleet operates under leasing agreements. In 2018, the Swedish government introduced a bonus for low emission cars and a taxation on fossil-fuelled vehicles. The bonus was however eliminated in November 2022, effective immediately. We show that this led to a significant decline in private leasing of EVs while other market segments remained stable. Private leasing played a key role in expanding the stock of lightweight EVs and dominated new EV registrations among low-income households, which declined following the bonus withdrawal. We also show that the subsidy removal led to a significant increase in EV-leasing prices, making EVs the most expensive option across price segments.

1. Introduction

Electrification of the road transport sector has been identified as a key technology shift to curb greenhouse gas (GHG) emissions (European Commission, 2019). However, despite the rapid growth of Electric Vehicles (EVs[1]) sales, they only accounted for 1.5 % of the passenger vehicle fleet in the EU in 2021, up from 1.1 % in 2020 (ACEA, 2023). To reach climate goals this pace needs to increase. More specifically, for the EU to achieve the reductions needed to meet the Paris Agreement, tail-pipe emissions from new passenger cars should be zero by 2030 or 2033 at the latest (Plötz et al., 2023).

Subsidies have played an important role in the spread of EVs (Münzel et al., 2019; Schub et al., 2025) and the main focus has been to incorporate EVs into vehicle stock, driving scaling, technology learning and mainstream acceptance. Despite a global growth in EV sales, several markets in the EU have faced slowdowns in 2024 as subsidies have been reduced or removed. The market slowdown has influenced several automakers to push back or lower their EV targets, as well as prompted calls to ease near-term vehicle CO2 targets and long-term plans to phase out internal combustion engine vehicle (ICEV) sales (BloombergNEF, 2024).

One of the main barriers to EV diffusion is their high acquisition costs (Degirmenci and Breitner, 2017; Kim et al., 2020; Xia et al., 2022), where an EV may cost approximately 6000–7500 EUR more than a comparable fossil fuelled car (Paradies et al., 2023; Slowik et al., 2023; Suttakul et al., 2022). Even with subsidies, most EV models still have higher upfront costs, making them less accessible for

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[1] In this paper we use the term electric vehicle (EV) to denote both plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV).

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low-income households (Hardman et al., 2021). This has drawn criticism for EV subsidies, as they are argued to disproportionately benefit high-income households (Sheldon et al., 2023; Sheldon and Dua, 2020). In contrast, the running costs for EVs are generally lower than for ICEV, and in some cases their total cost of ownership is lower.

Private car leasing has emerged as an increasingly popular ownership model for households from socioeconomic groups that traditionally have not been attracted to EVs (Jato Dynamics, 2021; Trafikanalys, 2018). Private leasing may help overcome the price barrier of purchasing new EVs and address uncertainties in the used EV market (Bauer et al., 2021; Hoogland et al., 2023). In addition, data from the Netherlands has shown a consumer preference for leasing of battery electric vehicles (BEVs) rather than the traditional full-price purchase, unlike conventional ICEVs and plug-in hybrid electric vehicles (PHEVs), where the full-price purchase was preferred (Liao et al., 2019).

Sweden is one of the leading countries in EV adoption in the world. Between 2017 and 2021, the share of EVs among newly registered cars increased from 5 % to 43 % (IEA Global EV Data, 2022). The sales in Sweden have partly been spurred by a bonus-malus system introduced by the Swedish government in 2018. Under this system, the buyer of a BEV was initially awarded a one-time bonus of 5200 EUR (60,000 SEK), which was later increased to 6600 EUR. In contrast, owners of new petrol and diesel cars had to pay an extra “malus”-tax for the first three years, depending on the emission intensity of the vehicle.[2] As EV adoption sped up, the malus-tax was continuously too low to pay for the bonuses, and the government had to temporarily allocate additional funds to keep up with bonus payments (Johansson, 2022; Rask, 2021). During the Swedish election in 2022, high fuel prices was a debated topic, and a campaign promise from the winning conservative coalition was to lower petrol and diesel prices. As part of their first budget, they then announced that the bonus system for EVs would be discontinued, effective immediately, and no cars sold after the 8th of November would be eligible for a bonus (The Swedish Government, 2022). This sudden policy change meant that the cost of purchasing an EV in Sweden increased by up to 6600 EUR overnight.

The high cost of EV subsidies has also been a contentious issue in other countries. In Germany, similar concerns about financial sustainability led to the removal of the German EV bonus in December 2023 (BMWK, 2023). This policy trend aligns with arguments in the scientific literature suggesting that EV bonuses are becoming increasingly expensive (Sheldon et al., 2023). Previous studies have analysed the effects of subsidies on EV sales, see, for instance, Münzel et al. (2019), and Yan (2018), as well as how leasing might be an attractive alternative to purchasing EVs (Liao et al., 2019). Yet evidence on what happens when subsidies are withdrawn is sparse. For Germany, Creutzburg et al. (2025) use a revealed-preference discrete-choice model and project sharp adoption declines absent subsidies. Most empirical studies come from China (Lu et al., 2020; Yao et al., 2025; Zhang et al., 2022). Notably, Yao et al. (2025) report that the 2018 reduction did not depress sales given a transitional period. For Sweden, Sprei (2018) studied the effects of changes in subsidies for alternative fueled vehicles and found that it was a combination of effects that led to the decline of sales. This scarcity of evidence on subsidy withdrawals—particularly by vehicle class and consumer segment—leaves a clear gap.

The aim of this paper is to address these gaps. In the first section of the paper, we summarize the literature on how ownership and policy impact BEV adoption and relate it to implemented policies for BEVs in all EU countries. We then focus on the Swedish case, and on how the removal of the bonus influenced new registrations of BEVs across different market segments, including vehicles owned by organisations, privately owned vehicles, and leased vehicles, and in different weight classes and income groups. Using a unique dataset of daily listed prices from private leasing providers collected over two years, we also analyse how private car leasing prices were impacted by the removal of the bonus.

2. BEV ownership, policies and the Swedish context

2.1. *The role of ownership models for BEV adoption*

Car ownership can be classified along two axes: who holds the registration (private individuals vs. organizations) and how the car is financed (outright purchase vs. lease). Organizational registration—covering vehicles registered to businesses, NGOs, and municipalities—includes cars used directly by the organization and those offered to employees as fringe benefits. These organizationally registered vehicles account for over half of new-car sales in Europe (Transport & Environment, 2020), and more than 15 million are estimated to be provided as employee benefits (Dimitropoulos et al., 2016).

Evidence shows that organizational registration and leasing have been especially important for BEV diffusion since they lower upfront costs and resale risk (Hoogland et al., 2022; Huang et al., 2021; Liao et al., 2019). Studies across Europe, including Sweden and the Netherlands, also show that policy support for cars owned by organizations has been a key driver of BEV uptake (Dimitropoulos et al., 2016; Engström et al., 2019; Schub et al., 2025).

2.1.1. *Leasing*

Leasing is common for organization-registered vehicles and is also widely used by private households (Mannering et al., 2002). One reason is that consumers often prefer contracts with lower payment streams despite higher total costs (Dasgupta et al., 2007). They are also more likely to favour leasing if maintenance costs are high, and while this may not be true for EVs, it can likely be translated to concerns of high battery replacement costs and uncertain resale value (Bauer et al., 2021; Trocchia and Beatty, 2003). Despite the high

[2] With a new car which was registered 2018–2021 and that was target by the malus, the additional annual tax was 7.1–9.2 €/(gCO_2/km) (82–107 SEK/(gCO_2/km)) (Swedish Transport Agency, 2018). Converted to EUR using the average 2018 SEK to EUR exchange rate of 11.6 SEK/EUR (ECB, 2022).

share of BEVs that are under leasing contracts, studies on leasing of BEVs and how policies targeting BEVs impact leasing, are scarce. Van Eck et al. (2019) found that incentives for leasing fuel-efficient cars in the Netherlands resulted in lower GHG emissions but an increase in share of diesel cars. Hoogland et al. (2023) found that the federal tax credit was more important for consumers leasing an EV than for those purchasing an EV. However the opposite was found in California regarding the state rebate (Hoogland et al., 2022). Other studies investigated the role of leasing in the adoption of EVs and found that costs are the most important factor (Huang et al., 2021; Huang and Qian, 2021).

Table 1 summarises drivers for choosing leasing contracts, or fringe benefit cars for BEVs compared to full price purchase. The table outlines how full ownership and control, financial flexibility, and tax incentives are crucial in these decisions, offering a comprehensive overview of the factors driving BEV ownership choices.

2.2. Subsidies for BEVs in theory and practice

The impact of subsidies on EV sales has been extensively studied in the literature, employing diverse methodologies and covering various geographical regions. These studies generally demonstrate that subsidies significantly impact EV sales. For instance, studies in the United States and Canada have identified a positive impact of federal and state-level monetary incentives on EV sales, utilizing panel data on model-level sales and registrations (Clinton and Steinberg, 2019; Jenn et al., 2018; Narassimhan and Johnson, 2018). Similarly for Europe, Münzel et al. (2019) used aggregated EV registrations in 32 European countries and found that an increase of incentive by 1000 EUR led to a 5–7 % increase in EV registration shares. The analysis was updated by Schub et al (2025) which included specific analysis on company car incentives. In the past five years, incentive schemes for EVs have been available in all EU-countries. The two main types of incentives are tax incentives and direct purchase subsidies. The average purchase subsidies in the EU during 2020–2023 was approximately 4500 EUR, with levels varying between 3000 EUR and 20,000 EUR (See Appendix A for an overview of all countries and sales shares of BEV). Lately, studies have found that subsidies have become less impactful and costlier over time (Sheldon et al., 2023). EV subsidies have also been criticised for subsidising high price EVs, with the argument that they are bought by wealthy individuals who could afford such cars also without the subsidy. It has thus been suggested that only EVs below a certain price should be eligible for subsidies (DeShazo et al., 2017; Sheldon et al., 2023). Twelve EU countries have implemented such eligibility limits, most within the 40,000–50,000 EUR span, but the lowest was under 30,000 EUR and the highest was 80,000 EUR (see Appendix A). In some countries the subsidy level is dependent on the type of actor that purchases the EV (private individuals or organisations), or on the price of the EV that is purchased.

Some countries, such as Italy and France, differentiate the subsidy level based on household income (DeShazo et al., 2017; Sheldon et al., 2023). In Italy, the BEV subsidy in 2024 was 4500 EUR for individuals with an income below 30,000 EUR and 3000 EUR for individuals with an income above 30,000 EUR (EAFO, 2024). Meanwhile, France launched a "social leasing" program, in 2024, where low-income individuals were offered subsidised electric car rentals at 100 euros per month. Demand for the program exceeded expectations, and it was suspended for 2024, but it was then reopened in the autumn of 2025 (EAFO, 2025a).

While some EU countries have refined their EV subsidy programs, Germany and Sweden have opted to phase out these subsidies entirely. Critics argue that the high cost of maintaining such programs is no longer justifiable, especially as BEVs are becoming increasingly affordable and accessible without financial support. Since the bonus was removed in Germany 2023, EV sales have however slowed down (BloombergNEF, 2024).

2.3. The Swedish context

Sweden does not have a specific sales target for EVs, instead, the focus is on the broader transport sector (excluding aviation). The target for 2030 is to reduce emissions from the transport sector by 70 %, compared to 2010. In addition to this, there is an overall goal to achieve net-zero emissions by 2045 (Swedish Environmental Protection Agency, 2023). To achieve these emission reductions, the electrification of the road transport sector has been highlighted as crucial (IRENA, 2020; Swedish Environmental Protection Agency, 2022). To promote the electrification of the road transport sector, the first EV subsidy was introduced in 2012, (Sveriges Riksdag, 2020).

In 2018, the bonus-malus (also called feebate) system was introduced. In this system, BEVs (or rather vehicles with tail-pipe emissions below 60 g CO_{2eq}/km) were given a one-time bonus of 5800 EUR.[3] The malus part consisted of extra fees on new high-emitting petrol and diesel vehicles for three years. Notably, BEVs were eligible for the full bonus, while PHEV received a lower bonus based on their emission performance according to the WLTP test cycle.[4] Bonuses could, however, not exceed 25 % of the car's retail value. The bonus was paid to the buyer of the car (e.g., an individual or an organisation) 6 months after the purchase, but only if the buyer still owned the car. The malus, on the other hand, was designed as a tax and was thus collected from the car owner, regardless of the original purchaser. In the case of private leasing, the bonus was paid to the leasing provider, while the malus tax was paid by the individual leasing the car. While this system was intended to be cost-revenue-neutral, high demand for BEVs and PHEVs led to repeated adjustments of the malus to cover the bonus (The Swedish Government, 2020).

Since the introduction of the bonus-malus system, there have been several revisions, (details of these changes are outlined in Appendix B). In July 2022, several significant changes were made. A price cap was set, limiting bonus eligibility to vehicles priced

[3] Converted to EUR using the 2018 average exchange rate of 10.3 SEK/EUR (ECB, 2022).

[4] See more at https://www.wltpfacts.eu.

Table 1
Drivers Influencing the choice of mode of ownership for BEVs.

Ownership structure	Drive for choosing a specific ownership model for BEVs
Traditional full price purchase	• Full ownership and control • No contractual limits (for example: no mileage limitations and resale flexibility) • Upfront payment eliminates monthly instalments • Possible government incentives
Leasing contracts	• Lower initial financial commitment (Huang et al., 2021; Huang and Qian, 2021) • Flexibility to upgrade and avoid uncertainties in resale values (Bauer et al., 2021) • Easier maintenance (Trocchia and Beatty, 2003) • Possible government incentives (Hoogland et al., 2022)
Fringe benefit cars	• Reduces financial risks for individuals as they avoid high upfront costs and resale uncertainties (Dimitropoulos et al., 2016) • Tax incentives and other policies specifically targeting the sector (Schub et al., 2025)

below 66,000 EUR, resulting in the exclusion of several EV models from the bonus scheme. Additionally, policy adjustments affected PHEVs, reducing the bonus levels, and lowering the threshold for the emission performance. Another change was the removal of the distinction in bonus allocation between companies and individuals. Prior to the change, companies received the full bonus only if the cost difference between the eligible EV and a reference fossil-fuel vehicle exceeded 19,000 EUR. Otherwise, they received 35 % of the cost difference between the EV and the fossil-fuel reference. For example, a private leasing provider would receive 4400 EUR for Skoda CITIGOe whilst an individual would receive 6600 EUR, see Appendix B.

Considering that 45 % of the Swedish EV fleet operates under leasing agreements, it is notable that the bonus was granted to the leasing company, which is the legal owner of the car, rather than to the car's user. Although leasing companies did not receive the same bonus as private owners until July 2022, car leasing firms accounted for 80 % of the total bonus distribution. By August 2021, a group of ten companies had collectively received 57 % of the total bonus allocated for that year (Moran, 2022).

On November 7th, 2022, the Swedish government made an unexpected announcement that it would be removing the bonus system for EVs, effective immediately, and no cars sold after the 8th of November would be eligible for the bonus (The Swedish Government, 2022). This sudden policy change meant that the cost of purchasing an EV in Sweden increased by up to 6600 EUR overnight. This rapid policy change opened up the possibility of studying the relationship between the bonus-malus system and its impact on new vehicles registration as well as on prices in the private leasing market.

Car users entering a leasing agreement for a fossil fuelled car are subject to the extra malus-tax during the first three years of use, however, it was up to the leasing companies to decide how to allocate the received bonus. Most leasing companies claimed that the whole bonus was used to lower the monthly rates for bonus eligible cars. However, it has been difficult to determine whether the entire bonus was used to lower the fees on these car models, or if the bonus has been used to lower fees on other car models, independent of driveline, or even to increase profits. This raises questions about the impact of the bonus-malus policy on the private leasing market and which socioeconomic groups benefit from the policy.

3. Methodology

We assess the impact of Sweden's November 2022 withdrawal of the BEV/PHEV purchase bonus on new registrations across powertrains and market segments. Using 2021–2023 registration microdata (driveline, ownership type, vehicle weight, and owners' income), we estimate level and trend shifts via an interrupted time-series design. This analysis is complemented with an analysis of collected daily leasing prices.

3.1. Vehicle registration microdata

We used a dataset purchased from Statistics Sweden, SCB, which includes all vehicles in the Swedish vehicle fleet for the years 2021, 2022, and 2023. To identify new registrations, we queried all vehicles with a registration date after January 1, 2021, excluding those with previous owners.

Worth noting is that the analysis is based on data for new registrations rather than direct sales figures, as comprehensive sales data is not publicly available for Sweden. This distinction is pertinent, given potential lags between the registration date and the actual sale date, especially for models with extended delivery times.

The data includes records on each vehicle's powertrain, model, curb weight, along with information on the registered owner – specifically, whether the registrant is a private individual or an organisation, and whether the vehicle is purchased or leased. For private individuals, the dataset also contains demographic and income data for the owner and the household to which the owner belongs.

3.1.1. Powertrains

The powertrains analysed in this study include Internal Combustion Engine Vehicles (ICEV) powered by diesel (ICEV: Diesel) and petrol (ICEV: Petrol), hybrid electric vehicles (HEV) (i.e., non-plug-in hybrid electric vehicles), Plug-in Hybrid Electric Vehicles (PHEV), and Battery Electric Vehicles (BEV). Notably, the HEVs were ineligible for the bonus throughout the entire studied period. Due to the low market share and low availability in the leasing market, ICEV utilising biogas and ethanol were excluded from the analysis.

3.1.2. Market segments

This paper categorizes new car acquisitions into four distinct market segments based on the buyer type and the nature of the transaction:

1. **Organisation Purchase:** Vehicles bought with a traditional full price purchase method by an organisation.
2. **Organisation Leasing:** Vehicles leased by an organisation.
3. **Private Purchase:** Vehicles bought with a traditional full price purchase method by private individuals.
4. **Private Leasing:** Vehicles leased by private individuals.

3.1.3. Weight classes

We categorized EVs registered between 2021 and 2023 into three weight classes based on percentiles. The "Light" group includes the 20 % of BEVs with the lowest weight, while the "Heavy" group comprises the 20 % with the highest weight. The categories are as follows:

1. **Light**: Vehicles weighing less than 1785 kg (below the 20th percentile).
2. **Medium**: Vehicles weighing between 1785 kg and 2246 kg (20th to 80th percentiles).
3. **Heavy**: Vehicles weighing more than 2246 kg (above the 80th percentile).

A percentile-based approach provides a consistent and data-driven method in the absence of a standardized weight classification for BEVs. The resulting thresholds align reasonably well with the weight ranges of BEVs in segments A to F, as defined by Euro NCAP (Ellingsen et al., 2016).

3.1.4. Income groups

All private individuals registered as owner/user of newly vehicles were classified into four different income groups. This classification was based on household disposable income per consumption unit, as defined by SCB (SCB, 2024a). Disposable income includes all types of income such as wages, capital income, taxable and tax-free transfers and deductions are made for taxes, repaid student loans, and paid child support. The disposable income is divided by the total sum of household members' weights, assigned according to a system called the consumption unit scale allowing for comparisons of the disposable income between different household types.

The income groups were determined using the 25th, 50th, and 75th percentiles of the disposable household income per consumption unit for all car owners in the dataset (not only BEV owners). The groups are:

1. **Low Income Group**: Annual disposable household income less than 28,156 EUR (below the 25th percentile).
2. **Lower-Middle Income Group**: Annual disposable household income between 28,156 and 36,566 EUR (25th to 50th percentile).
3. **Upper-Middle Income Group**: Annual disposable household income between 36,566 and 47,912 EUR (50th to 75th percentile).
4. **High Income Group**: Annual disposable household income more than 47,912 EUR (above 75th percentile).

For reference, the median per capita income in Sweden was 34,949.57 EUR in 2022 (SCB, 2024b), providing a benchmark for the middle-income classification.

3.2. Interrupted time series analysis

A time series analysis assessment was conducted to support identified changes in registrations by segment. Weekly registrations grouped by powertrain, ownership type, and, where applicable, a group categorizer (income or weight class) were analyzed with Interrupted Time Series (ITS), applying an Ordinary Least Squares (OLS) regression model to identify statistically significant changes in registration patterns before and after the removal of the bonus.

The regression model used for each segment is defined as:

$$Y_T = \beta_0 + \beta_1 {}^*PostEvent_t + \beta_2 {}^*PostEventLag_t + \beta_3 {}^*DecemberAnomaly_t + \beta_4 {}^*Y_{t-1} + {}^*\varepsilon_t$$

Where:

- $\boldsymbol{Y_T}$: Weekly vehicle registrations at time t
- $\boldsymbol{\beta_0}$: Intercept, representing the average registrations before the event
- ***PostEvent***: Binary indicator, 1 if week t is after the EV bonus removal. 0 otherwise
- ***PostEventLag***: Binary indicator, lagged by one timestep
- ***DecemberAnomaly***: Binary indicator for December 2022, excluded from post-event modelling due to anomalous behavior
- $\boldsymbol{Y_{t-1}}$: Lagged dependent variable to account for autocorrelation
- $\boldsymbol{\varepsilon_t}$: Error term

A one-month lag was added to the event to account for the named potential delay between vehicle registration and actual sale date. Registrations in December 2022 were treated as an anomaly and excluded from post-event regression modelling to minimize distortion. Additionally, a lagged variable (shifted by one time step) was included to mitigate effects from autocorrelation in the time series, after running a model diagnostics identied cases of autocorrelation.

To evaluate the impact of the bonus removal across all relevant market segments, the analysis was applied iteratively to all combinations of powertrain, ownership type, and optional grouping categorizer. For each combination, a separate OLS regression model was fitted. Model evaluations are presented in tabular form with evaluations based on

- **Statistical significance** testing via P-values of the regression coefficients.
- **Effect quantification** via magnitude (absolute and relative) and direction of the event coefficient,

i) The absolute change is defined as the sum of the post-event coefficient

ii) $AbsoluteChange = \beta_1 + \beta_2$ representing the weekly difference in registrations after the bonus removal.

iii) A relative change expresses this difference as a percentage:

iv) $RelativeChange(\%) = \left(\frac{\beta_0+\beta_1+\beta_2}{\beta_0}\right)*100$

v) to allow comparison across segments, regardless of their baseline registration.

- **Model significance** via the R-squared value, indicating how well the model explains variations in the data.

Interpretation of the results was done by evaluating the p-value, where $p < 0.05$ was treated as highly significant, $0.05 \leq p < 0.1$ as marginally significant, and any $p \geq 0.1$ as not significant. Any results where the difference was identified as highly or marginally significant, the R-squared was evaluated to ensure that the model's prediction held some explanation of the actual event.

Time series analysis was first conducted on weekly vehicle registration data, initially grouped by powertrain type and market segment. This served as the baseline for identifying broad trends. Subsequently, more detailed analyses were performed focusing on specific powertrain categories, including BEV, HEV, and PHEV, in combination with market segments and vehicle weight classes. As part of this extended analysis, the data was also examined across all powertrain types, incorporating market segments and income groups to investigate whether certain vehicle weight classes or income groups were disproportionately affected by the removal of the bonus.

3.3. *Private leasing prices*

Private leasing prices were collected daily for three online private leasing providers in Sweden (Autolease, Carplus, and Lease-online) from 2021 to 12-21——2023-05–02. The three sites were selected due to their availability of open data, and because they provide a large offering of different brands and models. Additionally, Autolease is owned by DNB Bank ASA, which, together with two additional actors, received one third of all bonus payments under 2021 (Moran, 2022). Carplus has a 7 % market share of the private leasing market in Sweden and is owned by one of the largest private car dealers in Sweden (Hedin Mobility Group, 2021; Trafikanalys, 2022).

To maintain consistency and ensure a comprehensive analysis, we chose to focus solely on the default length of the contract as advertised by each leasing provider. The default contract length, typically set at 36 months, was selected to capture the prevailing market conditions, and offer a representative overview of the private leasing prices during the study period. By excluding variations in contract length, we aim to isolate the direct impact of policy changes and avoid potential confounding factors that could arise from different contract durations.

All prices and bonus payments have been converted from SEK to EUR using the exchange rate for the corresponding day, as provided by the European Central Bank, or the average conversion rate during 2022 (10.63 SEK/EUR) for bonus payments (ECB, 2022).

3.3.1. *Classification of price segments*

For each week and powertrain, four price segments were determined using percentile rankings. Data points with a ranking below the 25th percentile were categorised as “Low price”, those within the 25th − 75th percentile were labelled as “Mid-range”, while datapoints with rankings above the 75th percentile were grouped under the label “High price”. Prices were categorised specifically for each powertrain, meaning that, for example, an ICEV: Diesel vehicle categorised as mid-range could have been categorised in the high price segment if it had an ICEV: Petrol powertrain.

3.3.2. *Specific model impacts*

To account for the variability in available vehicle models in the leasing market, we analysed price trends for some of the more popular models. The models were selected based on both the number of new registered cars per model during 2022, but also on the number of occurrences in the collected dataset – which we assume is indicative of the popularity of the model in the private leasing market. The analysed models are shown in Appendix C, together with the different powertrains available for each vehicle model.

4. Results and discussions

Fig. 1 shows monthly new registrations by powertrain and market segment before and after the bonus removal. The announcement on November 7th —that BEVs and PHEVs purchased after 8th of November would no longer qualify for the bonus—triggered a same-day rush to acquire BEVs (Andrén, 2022; Undéhn, 2022). In private leasing, this shows up as a registration peak in December 2022 (Fig. 1), likely reflecting vehicles with contracts signed on, or before, 8th of November but delivered and registered in December. After this peak, new registrations of privately leased BEVs dropped sharply and in 2023 they were nearly 45 % lower than in 2022 (see Fig. 1).

We quantify this shift with an interrupted time-series (ITS) analysis, where post-event coefficients capture the immediate level

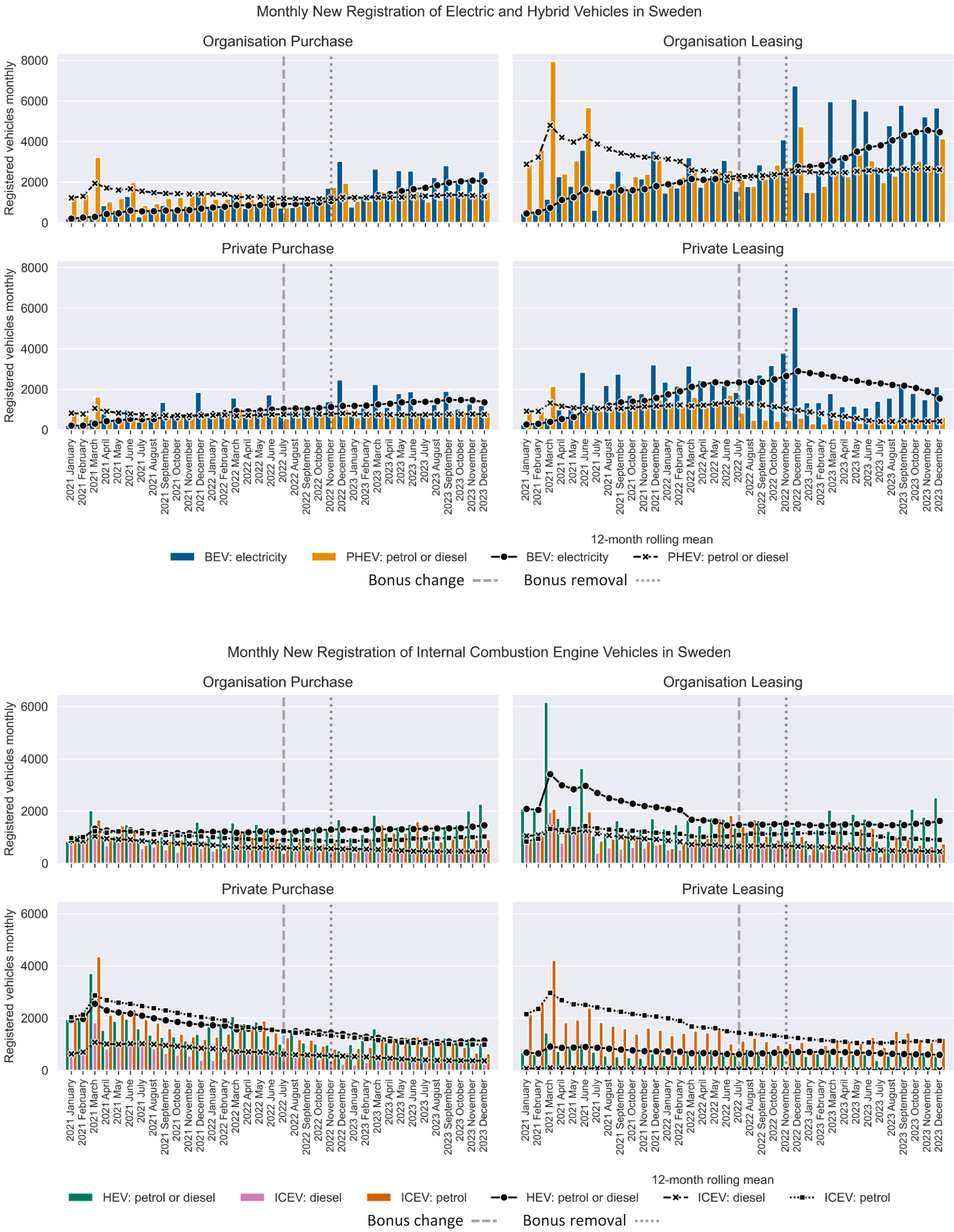

Fig. 1. Monthly new registrations in Sweden from 2021 to 2023.

change in weekly registrations relative to the pre-policy mean. The ITS estimates indicate a decline of about 225 privately leased BEVs per week after the policy change ($p = 0.001$), corresponding to an estimated 60 % drop ($R^2 = 0.501$, Table 2).

Patterns for other segments differ. PHEV leasing weakened around June 2022, when the PHEV bonus was roughly halved, but shows no clear break at the November removal (Fig. 1). Consistently, the ITS finds no statistically significant post-event change for leasing of PHEVs, even though organisation purchases of PHEVs did see a statistically significant increase (see Appendix E1).

Private leasing also decreased for petrol and diesel ICEVs, but this decline occurred gradually over the entire studied period (see Fig. 1), and the ITS detects no statistically significant post-removal shift (see Appendix E1). While broader factors (e.g., higher interest rates) may have weighed on private leasing overall, the absence of a contemporaneous break for ICEVs and PHEVs argues against a general market contraction as the primary driver of the drop in private leasing of BEVs after the bonus removal.

Meanwhile, organisational BEV registrations—both purchases and leases— increased steadily, and in 2023 their growth rate was roughly twice that of other powertrains. Yet the ITS shows no statistically significant break in organisational BEV acquisitions, suggesting decisions were less dependent on the bonus and more on other factors. One likely driver was Tesla's sharp price cuts for the Model 3 and Y in January 2023 —about €7000–€10,000—which more than offset the removed bonus (Elbilen, 2023).

These results indicate that the bonus played a substantial and statistically significant role for incentivizing private leasing of BEVs, while at the time of its removal, it had no decisive impact on organisation acquisitions, organisations leasing, or private full-price purchases of BEVs.

4.1. Substantial rise in BEV leasing prices after bonus removal

By collecting daily data from several private leasing providers over 1.5 years, we analyse how leasing prices developed around the time of the policy change. In the data, the majority of the leasing prices ranged between 490 and 760 EUR per month. Petrol and hybrid powertrains dominated the lower end of the price range, while BEV, PHEV and diesel vehicles were more prevalent in the higher price ranges (a histogram of the collected data can be found in Appendix D).

The data was divided into three segments: low, mid-range, and high price, and the average weekly leasing prices for the respective segment and powertrains are shown in Fig. 2. As can be seen in the figure, leasing prices for BEVs in the low and mid-range segments increased sharply directly after the bonus removal. In the low-price segment, the increase was 185 EUR/month (40 %) on average, and for the mid-range it was 140 EUR/month (22 %) (Fig. 2).

For BEVs in the high-price segment, most models were ineligible for the bonus after the change in July 2022, however, they still experienced a price increase of 61 EUR/month (5 %) (Fig. 2). As an example, Tesla Model Y, which was not eligible for any bonus during this period, saw a price increase of 42 EUR/month (4 %), see Fig. 3. In contrast, conventional ICE and hybrid powertrains display price fluctuations ranging from a 3 % reduction to a 2 % increase over the same time period.

For PHEVs the bonus was roughly halved in July 2022, and then it was removed in November. The average leasing prices for low and mid-price PHEVs rose after both those changes (Fig. 2), even though the increases were smaller than the one for BEVs in November.

Before the removal of the bonus, leasing a BEV was on average 150 EUR/month more expensive than leasing an ICEV-petrol, but it was still less expensive than leasing an ICEV-diesel or a PHEV. After the removal of the bonus, BEVs became the most expensive powertrain in all price segments (Fig. 2).

Since the bonus was designed as a one-time payment to the purchaser of a low-emission vehicle, it was paid to the leasing providers, and they could decide how to use it. Most leasing contracts are for 36 months, and dividing the full bonus over those months would result in a monthly deduction of 183 EUR. This sum corresponds almost exactly to the sudden price increase for leasing cars in the low-price segment after the bonus was removed. Likewise, the impact that the policy change in July 2022 had on prices of BEVs and PHEVs also indicates that the bonus was largely used by private leasing providers to lower the prices of the respective models for which it was intended (for a more detailed analysis see Appendix D Additional analysis of leasing prices). Since our analysis is limited to observed changes in leasing prices, it is possible that leasing companies used the removal of the bonus as an excuse to increase prices of BEVs without having passed on the bonuses before. However, for the customers the effect is the same: a sharp increase in cost of BEVs, especially relative to other drivelines, directly after the removal of the bonus.

A possible explanation as to why new registrations of BEVs for private leasing saw a clear drop after the removal of the bonus compared to private purchases of BEVs, is the impact that the bonus had on consumer prices. For private purchases, the customer had to pay the full price up front, and then the bonus was paid out 6 months later. So, those customers needed to be able to pay the full price or secure a corresponding loan. By contrast, because leasing companies likely netted the bonus into the monthly rate, lessees didn't need to afford the car absent the bonus.

Also, since leasing companies likely applied the entire bonus over a 36-month period, even though the customer would not fully pay

Table 2
Changes in BEV vehicle registrations after the removal of the EV bonus.

Powertrain	*Market Segment*	*Change*	*%-Change*	*Direction*	*Significance*	*p-value*	*R-squared*
BEV: electricity	Organisation (purchase)	190.7	199.7	Increase	Not significant	0.984	0.381
	Organisation (leasing)	374.6	187.3	Increase	Not significant	0.811	0.364
	Private (purchase)	46.1	125	Increase	Not significant	0.749	0.287
	Private (leasing)	−224.6	59.7	Decrease	Highly significant	0.001	0.501

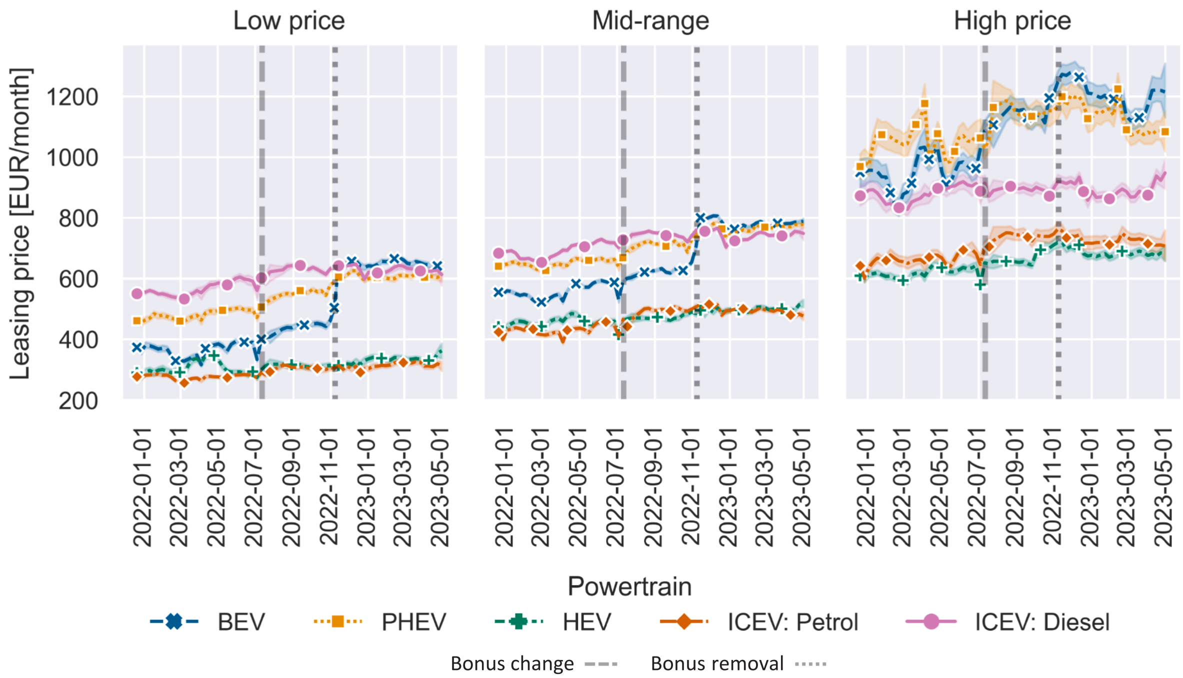

Fig. 2. Weekly leasing prices for the respective price segments and powertrains.

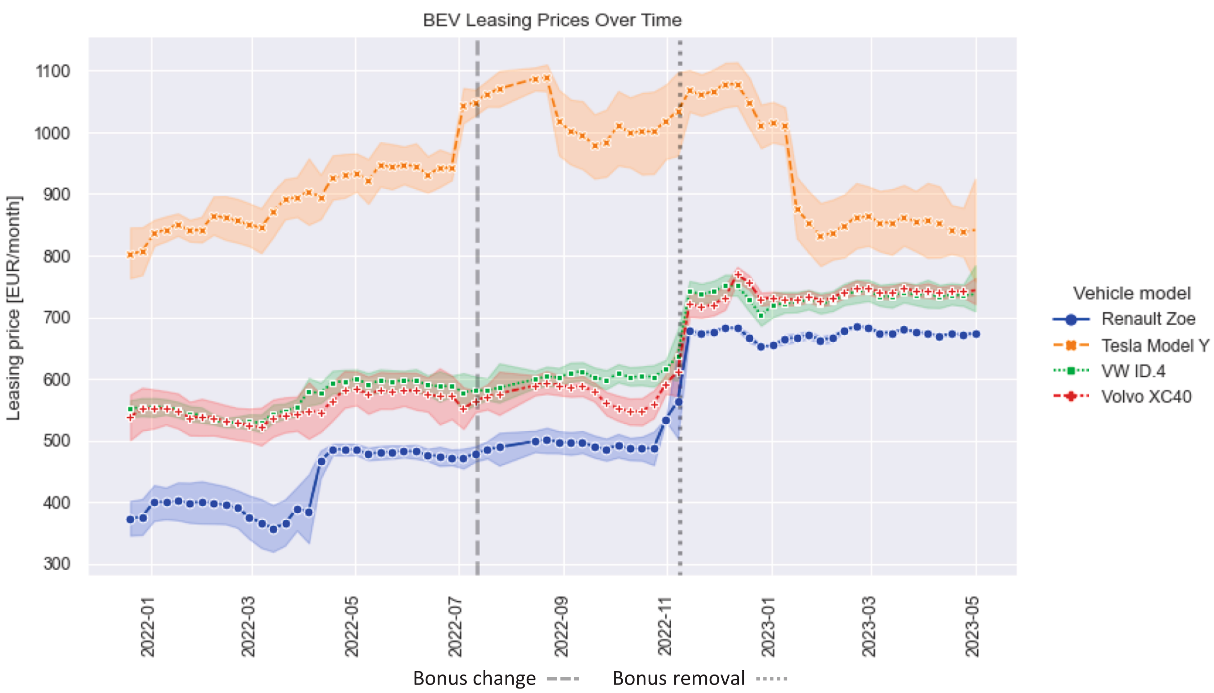

Fig. 3. Average (dotted) and span (coloured) of weekly leasing prices for BEV models.

off the car within that time frame, the percentage impact of the bonus on the consumer price was larger, compared to private full purchases. Examples of this are shown in Table 3, where we can see, for instance, that for a Renault Zoe, the bonus led to 26 % lower consumer prices for private leasing, and a 20 % lower consumer price for a full price purchase.

Since the bonus was a fixed sum of 6600 EUR, regardless of the price of the car, it caused a larger price reduction in percentage on cheaper models, which are often also smaller, lighter and more affordable to low-income households. The price increases following the removal of the bonus, together with other market developments, led to a shift in the BEV leasing market. At the beginning of the study period leasing a Tesla Model Y cost more than twice as much as a Renault Zoe and about 45 % more than a VW ID.4 or Volvo XC40. However, in January 2023 Tesla lowered their prices sharply, and this, in combination with the increased prices of other models in conjunction with the removal of the bonus, resulted in the Model Y being only about 10 % more expensive than the VW ID.4 and Volvo XC40, and 25 % more than the Renault Zoe by the end of the period (see Fig. 3).

4.2. New registrations of light weight BEVs decreased after the removal of the bonus

Private leasing played an important role in driving demand for light weight BEVs during the studied period (see Fig. 4). Following the removal of the bonus ITS results indicate a nearly 70 % drop in registrations for this segment, marginally significant and consistent with sensitivity to incentive changes (see Appendix E2 for full ITS statistics).

The mid weight category in private leasing accounted for a significant increase in the final quarter of 2022, indicating that models in this market segment were the most heavily influenced by a rush to market for the consumer to benefit from the bonus prior to its removal. After this surge, registrations fell sharply, and the ITS estimates a post-surge drop of ≈85 % ($p = 0.004$).

The figure also shows a strong increase in heavy weight vehicles among organisation purchases and leases which is likely related to the reduction in prices in this category (including Tesla). While the growth in these segments was large in relative terms, it was not statistically distinguishable from background variation, suggesting that price adjustments—rather than changes to the bonus—played a larger role.

4.3. BEV registrations among different income groups

Given the impact of the bonus removal on private leasing, especially for light weight vehicles, it is pertinent to examine how this affected different income groups. For private full-price purchases, the high-income groups accounted for more than twice as many new registrations as the low-income groups (Fig. 5). In the private leasing market, however, new registrations were more evenly distributed across the four income groups, both before and after the bonus was removed. This indicates that private leasing has facilitated BEV adoption among lower-income groups.

Across all income groups, the ITS estimates show a sharp post-removal decline in private BEV leasing. ITS estimates of the post-event level change indicate relative declines of 74.3 % ($p = 0.044$), 69.7 % ($p = 0.019$), 71.8 % ($p = 0.001$), and 73.0 % ($p = 0.024$) across the low-, below-median, above-median, and high-income groups, respectively signalling a substantial and consistent post-removal contraction across all income groups (see Appendix E3).

Considering total BEV registrations (purchases + leasing), the ITS estimates a post-event level decline of 88–94 % for the low-, below-median-, and above-median-income groups (marginally significant for low-income; highly significant for the two middle groups), whereas the high-income group shows a modest + 7 % increase (marginally significant; see Appendix E3). This pattern is consistent with a shift among high-income households from leasing to outright purchase following the bonus removal, while other income groups experienced an overall reduction in BEV uptake (see Appendix F for more information on the shift from leasing to full-price purchases).

An important question is whether the peak in private leasing registrations of BEVs contributed to the decline in BEV registrations in 2023, as households planning to lease in 2023 might have expedited their decisions to benefit from the bonus. However, total new leasing registrations across all powertrains were not higher (low-income group) or only marginally higher (other income groups) in Q4 2022 compared to previous quarters (Fig. 6). This indicates that the peak in registrations of leased BEVs in Q4 was largely caused by people choosing BEVs instead of other powertrains in that quarter.

5. Conclusions

Numerous studies have shown that subsidies increase BEV adoption (Münzel et al., 2019; Yan, 2018). However, recent studies suggest that EV subsidies have become less impactful and more costly over time, leading to suggestions that only lower-priced EVs should be eligible for subsidies (Sheldon et al., 2023). Meanwhile, some countries like Germany and Sweden have opted to phase out subsidies entirely, arguing that the high cost is no longer justifiable as BEVs become more affordable.

Our study of the sudden removal of the Swedish bonus in 2022 shows that it had minimal impact on new registrations across most BEV market segments, except for private leasing, which saw a significant decline in acquisitions. This finding suggests that organisational and private full price purchases of BEVs were not heavily dependent on the bonus, at the time of its removal, while the private

Table 3
Percentage impact of the bonus on consumer prices for purchases versus leasing.

Car model	Average full price EUR	Full price with bonus EUR	% price increase without bonus	Leasing price after bonus removal EUR/month	Leasing price before bonus removal EUR/month	% price increase without bonus
Renault Zoe	39,950	33,350	20 %	677	534	26 %
Volkswagen ID. 4	40,250	33,650	20 %	742	617	20 %
Volvo XC40	54,850	48,250	14 %	724	592	22 %

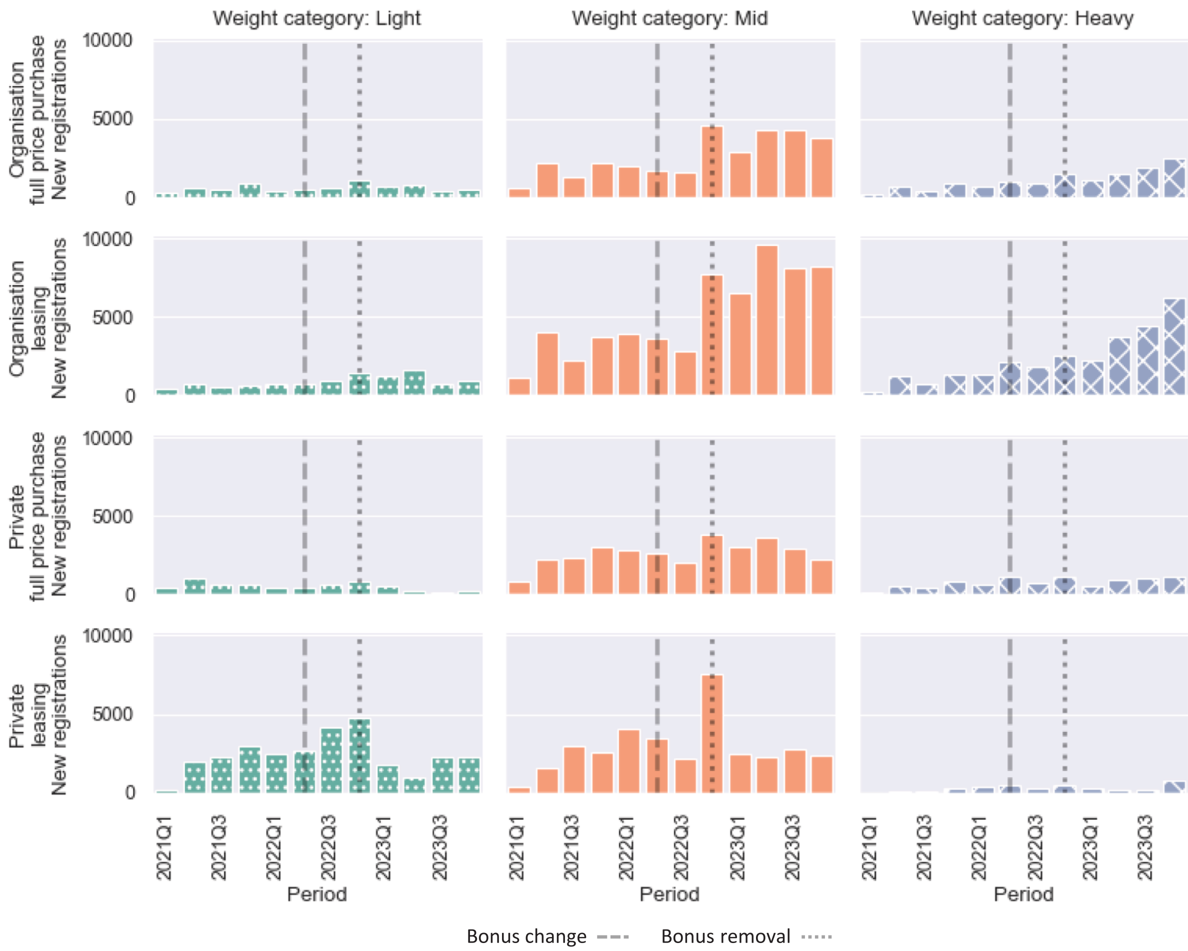

Fig. 4. Quarterly new registrations of BEVs in Sweden Q1 2021 to Q4 2023.

Fig. 5. Quarterly new registrations of BEVs in Sweden Q1 2021 to Q3 2023.

leasing segment was. Notably, the private leasing market was a primary driver in adding light weight BEVs to the Swedish vehicle stock, and after the bonus was removed this growth slowed down.

A likely explanation for the drop in BEV leasing is that average leasing prices for BEVs in the low and mid-price segments increased sharply directly after the bonus removal, with 185 respectively 140 EUR/month. This caused BEVs in these price segments to go from being less expensive than ICEV-diesels and PHEVs to becoming the most expensive leasing option.

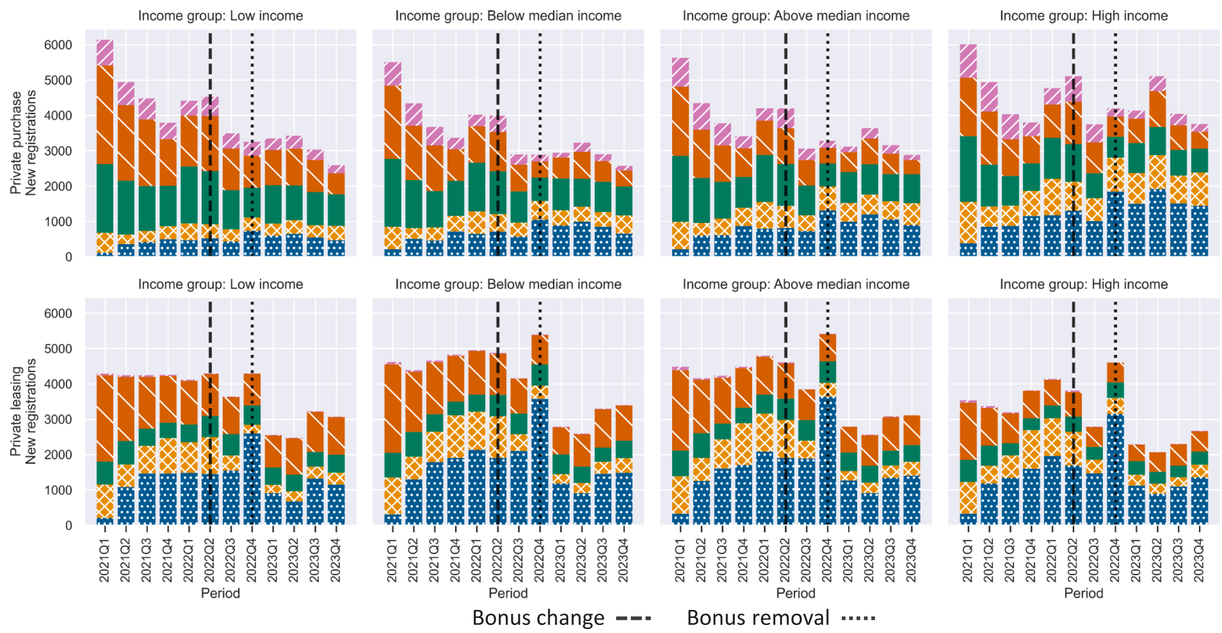

Fig. 6. Quarterly new registrations of privately owned vehicles in Sweden 2021Q1-2023Q4.

Our analysis comes with some limitations, primarily that our method does not take into account other economic trends, such as changes in diesel and gasoline prices and interest rates. Our comparison with other drive lines does to some extent address this but does not imply causal conclusions. There might also be limitations in the generalizability of our findings given that ownership and tax structures differ between countries. Moreover, while the current lack of empirical studies of BEV subsidy removals highlights the relevance of our analysis, it limits the possibility to assess the external validity of the results.

A key conclusion from this study is that ownership models play a crucial role in BEV adoption, a factor that has received insufficient attention in the scientific literature. Different market segments—such as private individuals or organizations and leasing or traditional full price purchase—face distinct challenges, barriers, and drivers, which policymakers should consider when designing BEV support policies. As observed in Sweden, the removal of the bonus primarily impacted private leasing, while other market segments remained unaffected. This highlights the need for more targeted policy interventions tailored to specific ownership models and consumer segments. As Sheldon et al. (2023) argue, countries with high BEV market shares might also need to shift policy priorities from promoting overall BEV adoption to supporting societal groups that require extra assistance in the climate transition. Evidence from the U.S. shows that subsidies are especially pivotal for lower-income households' EV decisions (Jenn et al., 2020) and that electrification can lower transportation costs for disadvantaged communities (Hardman et al., 2021). With fuel prices rising in many European countries, affordability and mobility access are increasingly central to public acceptance of climate policy—and likely to grow in salience (Bauer et al., 2021; Hardman et al., 2021).

Given that private leasing is a crucial entry point for low-income households and light weight BEVs —and that leased vehicles cycle into the second-hand market faster, expanding access to lower-cost BEVs (Tal et al., 2021)— reinstating or redesigning subsidies with this focus could balance environmental goals with social equity considerations.

In line with this, France piloted "social leasing" in 2024, offering subsidized BEV rentals at about €100 per month for low-income households and the program was relaunched in 2025 (EAFO, 2025a). Similar instruments have also been proposed in Germany (EAFO, 2025b), on an EU level (European Commission, 2025) and in recent policy briefs and reports (Transport & Environment, 2025; Unger et al., 2025). Sweden likewise plans a targeted EV bonus from January 2026—covering purchases and leases of new and used BEVs—aimed at lower-income and rural households (The Swedish Government, 2025).

Within this policy context, our analysis of the Swedish case shows that private BEV leasing dropped after the bonus removal and that leasing had been a key pathway for BEV uptake among low-income households. This provides empirical support for the targeted approaches now being piloted and debated across Europe. After the removal of the bonus, private BEV leasing did however fall across all income groups in Sweden, with only the highest-income group appearing to shift from leasing to purchasing. This suggests that targeting only the very lowest incomes may miss BEV leasing demand in other groups. A tiered or broadened design could therefore be warranted, though finite budgets may still justify prioritizing low-income households given their greater vulnerability in the transition.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT and Microsoft Copilot in order to refine wording, check grammar, and enhance overall readability of the manuscript; no substantive content was generated by these tools. After using this tool/service, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

CRediT authorship contribution statement

Liv Lundberg: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization. **Gustaf Bengtsson:** Writing – review & editing, Visualization, Methodology, Formal analysis, Data curation. **Frances Sprei:** Writing – review & editing, Supervision, Methodology. **Niklas Fernqvist:** Writing – original draft, Investigation. **Jonas Zetterholm:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trd.2025.105126.

Data availability

Leasing price data can be made available up on request. We are not allowed to share micro data for vehicle registrations.

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