

# Electric vehicle adoption and energy prices: Empirical evidence from four Nordic countries

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## ABSTRACT

While the transport sector accounts for around 25% of the EU's total GHG emissions, the adoption of electric vehicles (EVs) plays an important role in achieving the EU's net zero emissions goal. Alongside subsidies or tax exemptions for EV purchases, energy prices, i.e., electricity price and gasoline price, can also serve as policy instruments to encourage consumers to shift from internal combustion engine (ICE) vehicles to EVs. Using a unique panel of EV registrations at the product-level from four Nordic countries (Denmark, Finland, Norway, and Sweden), this paper investigates how electricity prices and gasoline prices stimulate the adoption of EVs. The results show that gasoline prices have a more statistically significant effect on the adoption of EVs (as a substitute for ICE vehicles), compared with electricity prices. On average, 1% increase in gasoline price would increase the sales of EVs by 0.85% and the effect is larger for EV models with relatively lower purchase cost (where the effect of electricity price is also found statistically significant) and those with less-known brands. Further simulation results show that a 1% increase in the gasoline price would reduce the lifecycle GHG emissions of new automobiles by 0.16%. Our study highlights the importance of energy prices in accelerating EV adoption and mitigating carbon emissions in the Nordic countries.

## 1. Introduction

The transport sector accounts for around 25% of the EU's total GHG emissions (European Environment Agency (EEA), 2025). To meet its environmental goal, the EU aims to increase the share of electric vehicles (EVs) in the transport sector. Meanwhile, since EVs are more energy-efficient than the internal combustion engine (ICE) vehicles (more than 85% efficiency for EV motors vs. around 20% for ICE vehicles), diffusion of EVs can also reap dividends in the form of energy efficiency improvement and energy saving (Thiel et al., 2016). Under the new regulation of EU, all new cars and vans registered in the EU are set to have zero emissions by 2035 (Haas and Sander, 2020; Mock and Díaz, 2021). Therefore, it is of great significance for the government to shape policies to stimulate the adoption of EVs. In this regard, energy prices, i.e., electricity price and gasoline price, which play a crucial role in determining the cost-saving potential of EVs, could be considered as instruments for the government to induce consumers into EVs over ICE

vehicles, beyond the widely used subsidies or tax exemptions for EV purchases.

The adoption of electric vehicles (EVs) can be situated within a broad conceptual framework that incorporates economic, infrastructural, and behavioral dimensions. On the economic side, consumers weigh automobile purchase options from both the upfront purchase cost and the expected operating costs, which together determine the total cost of ownership (Borenstein and Bushnell, 2022). Infrastructural conditions, such as the availability and accessibility of charging facilities, critically shape the convenience and reliability of EV ownership (Sierzchula et al., 2014; Li et al., 2017). In addition, behavioral and social influences — including environmental attitudes, perceptions of climate externalities, and peer effects — play an important role in shaping consumer choices (Axsen and Kurani, 2012). Energy prices, one important driver in the economic category of this conceptual framework, are directly related to the economic incentive (from energy saving) for EV adoption. More specifically, since the transition to EVs is attached with energy saving

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through energy efficiency improvement, the energy saving from EVs (compared with ICE vehicles) will be larger if gasoline price rises or electricity price decreases, which could incentivize consumers to switch to EVs.

Previous studies have documented the effectiveness of gasoline prices in improving the fuel economy of conventional vehicles and found that consumers tend to purchase more fuel-efficient vehicles when gasoline prices rise (e.g., Li et al., 2009; Klier and Linn, 2010; Busse et al., 2013; Xu et al., 2023). However, the evidence on the role of energy prices in EV adoption is still limited. Based on a monthly panel of EV registrations and gasoline/electricity prices in California from 2014 to 2017, Bushnell et al. (2022) found that a given change in gasoline prices has roughly four to six times the effect on EV demand as a similar percentage change in electricity prices. Very recently, Fei et al. (2025) examined the impact of gasoline price on EV adoption, based on the EV sales data from 36 cities in China over the period of 2017 to 2022, where they found positive effect of higher gasoline prices in stimulating EV adoption. Meanwhile, energy prices have been highly volatile during the past few years due to the Ukraine war, which provides an important practice to study how energy prices affect the EV adoption in more recent years.

Nordic countries are the world leaders in renewable energy and thus are highly motivated to accelerate EV adoption. As can be seen from Fig. 1, the market share of EVs has increased rapidly in recently years in the four Nordic countries and Norway is the first country where the sale of EVs surpass that of ICE vehicles (in the year 2019), earlier than Denmark, Sweden and Finland. A natural question would be whether energy prices play an important role in the transition, in addition to the policies implemented in different countries.

To this end, this study utilizes the EV registration data from four Nordic countries (Denmark, Finland, Norway, Sweden) to investigate how gasoline prices and electricity prices have stimulated the adoption of EVs (here we focus on the adoption of Battery Electric Vehicles (BEVs)). In this respect, our paper provides the first evidence from the Nordic countries on the role of energy prices in observed transition to EVs in most recent years. The paper provides insights, not only about how energy prices (taxes) could be used as instruments for promoting EVs, but also about how consumers perceive potential energy saving in EV purchases. Our results show that gasoline prices have a more statistically significant effect on the adoption of EVs, compared with

electricity prices. On average, 1% increase in gasoline price would increase the sales of EVs by 0.85% and the effect is larger for EV models with relatively lower purchase cost and those with less-known brands. Further simulation results show that a 1% increase in the gasoline price would reduce the lifecycle GHG emissions of new automobiles by 0.16%.

Our paper contributes to the existing literature in three aspects. First, we provide one of the first multi-country, product-level analyses of how electricity and gasoline prices shape the diffusion of EVs in the Nordic countries. Second, by showing consumers' response to energy prices is stronger for lower-cost EV models and for less-known brands, we highlight the heterogeneity in the impact of energy prices on EV adoption. Third, by quantifying the reduction in lifecycle GHG emissions resulting from higher gasoline prices, we underscore that energy price instruments, alongside subsidies and tax incentives, could be powerful tools for promoting EV uptake and decarbonization.

The rest of the paper is organized as follows. Section 2 reviews the related studies. Data and method are described in Section 3 and Section 4. Section 5 presents the results and Section 6 discusses the implications for carbon emissions. Section 7 concludes.

## 2. Literature review

### 2.1. The driving forces of EV adoption

There are many factors that could influence the uptake of electric vehicles (EVs), including not only economic and financial factors but also technical and psychological ones. For instance, vehicle-to-grid capability, charging time, and driving range are important technological factors that influence the adoption of EVs (Carley et al., 2013; Ito et al., 2013; Coffman et al., 2015; Chen et al., 2020). Meanwhile, individuals with positive attitudes towards environmental issues are found to be more likely to purchase environmentally friendly vehicles (Mohamed et al., 2016; Bosshard and Kolar, 2016; Afroz et al., 2015). Coffman et al. (2015) classified the factors that influence EV adoption as internal and external factors: Internal factors include battery cost, purchase price, driving range and charging time, while external factors include fuel prices, policy incentives, consumer preference and the availability of infrastructure.

Among these factors, the economic/financial factor is considered to be one of the most important driving forces in EV adoption (Ozaki and

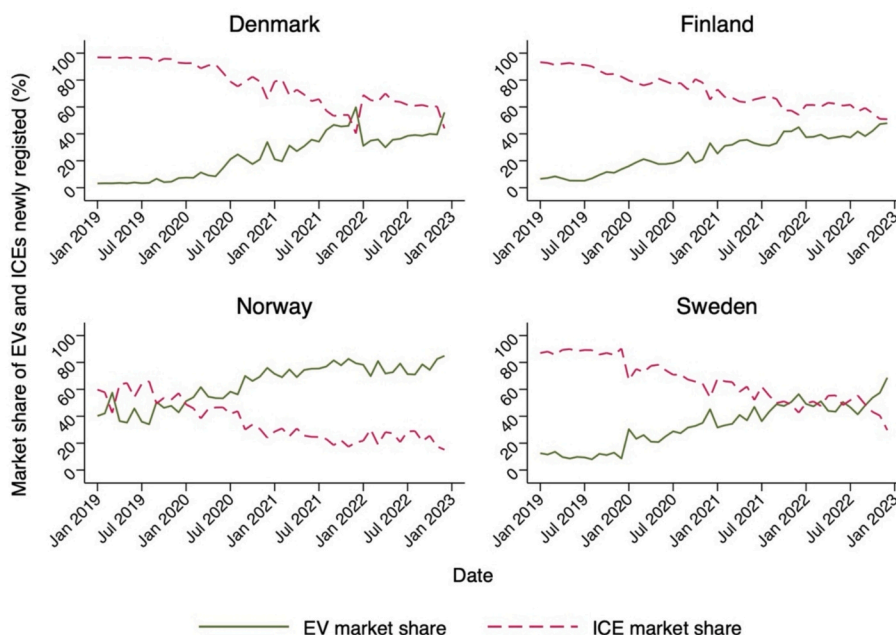


Fig. 1. Market shares of EV and ICE vehicles in four Nordic countries.

Sevastyanova, 2011). The economic/financial aspects encompass both the upfront fixed costs (e.g., purchase price) and the variable driving costs, which include fuel expenses and maintenance costs. Studies have found that high purchase prices and risks related to market infancy were identified as factors negatively affecting EV adoption (Hidrué et al., 2011; Carley et al., 2013; Tran et al., 2013). For instance, Carley et al. (2013) found that EV purchase price is the most dominant “major disadvantage”. Tran et al. (2013) highlighted that more than 63% of buyers cite purchase price as a large deterrent. However, some studies also indicated that consumers who value the benefits of electric vehicles are willing to pay a large premium (Hidrué et al., 2011). Meanwhile, it is worth noting that although EVs typically have higher purchase costs, they usually have a lower total cost of ownership over their lifespan, which is mainly due to the significantly reduced fuel costs compared with internal combustion engine (ICE) vehicles (Liu et al., 2021). Moreover, the maintenance costs associated with EVs are notably lower than those of traditional vehicles (Dutta and Tenpe, 2022; Bosshard and Kolar, 2016).

## 2.2. The effect of energy prices on EV adoption

While many studies have found that the purchase cost is an important barrier to EV adoption, less attention has been paid to the role of energy prices (fuel cost savings) in stimulating the adoption. Fluctuations in energy prices could change the potential cost savings with EVs (compared with ICE vehicles), thereby affecting the adoption of EVs. The increase in potential cost saving due to, e.g., the rising gasoline price, would enhance the attractiveness of EVs and thus stimulate the adoption of EVs.

Several studies have shown that higher gasoline prices stimulate interest in new energy vehicles by enhancing their perceived value proposition (Diamond, 2009; Beresteanu and Li, 2011; Gallagher and Muehlegger, 2011). For instance, Beresteanu and Li (2011) found that both gasoline prices and federal tax incentives increase the sales of hybrids, and that if the price of gasoline stays at 1999 levels, sales of hybrids would have declined by 37% in 2006. Gallagher and Muehlegger (2011) found that gasoline prices are positively correlated with hybrid car sales, although this effect works almost exclusively through the most fuel-efficient hybrids. Very recently, using empirical data on EV sales from 36 cities, Fei et al. (2025) found that gasoline prices have a positive effect on the adoption of EVs in China.

However, there is no consensus on the impact of different fuel prices on EV sales. On one hand, there are studies which reveal that changes in gasoline prices have a disproportionately larger impact on EV demand than changes in electricity prices (Bushnell et al., 2022; Leard et al., 2023; Gillingham et al., 2023; Klier et al., 2020). For instance, Bushnell et al. (2022) found that the impact of gasoline prices was approximately four times the impact of electricity prices and their results suggested that consumers are more responsive to changes in gasoline prices when considering the purchase of an EV. Based on the data of new passenger car transactions in Norway during 2002–2016, Fridstrøm and Østli (2021) estimated that own- and cross-prices elasticity of demand for gasoline, diesel, hybrid and battery electric cars, with respect to energy prices, and they found that the price elasticity of demand for battery electric vehicles (BEVs) with respect to gasoline price is 0.38 and electricity prices have a lesser impact on vehicle demand. This might stem from consumers' difficulty in accurately assessing the full costs and benefits of electricity as a transportation fuel (Ito, 2014; Davis and Metcalf, 2016). On the other hand, several studies have provided mixed results regarding the role of energy prices in EV adoption. Using agent-based simulations, Zhuge et al. (2020) found that electricity and petrol prices could have a negligible impact on the adoption of EVs at the macro level (city level), but they do affect the spatial distribution of vehicle owners, as well as the geographical distribution of vehicle emissions, and EV-related facilities.

Overall, understanding how consumers react to energy prices in EV

adoption is crucial for crafting future government policies that optimally leverage the synergistic relationship between energy costs and EV adoption, thereby enhancing the decarbonization efforts in the transport sector (Wappelhorst et al., 2018; Yan and Eskeland, 2018). A related concept in this regard is the “energy efficiency gaps”, which refers to the gap between actual and optimal investment in energy efficient technologies in the literature (see, e.g., Gerarden et al., 2017). In the context of EV adoption, the energy efficiency gap refers to the observation that consumers often fail to switch from ICE vehicles to EVs despite potential cost saving. Empirical studies have found that consumers tend to undervalue future energy costs (compared with upfront purchase cost) in the purchase of automobiles, which leads to under-adoption of more energy-efficient options (see, e.g., Allcott and Wozy, 2014; Grigolon et al., 2018). Therefore, if energy prices can play an important role in EV adoption, that would imply strong energy-price signal could make the cost saving from EV more salient and thus stimulate the adoption, which consequently improves the overall energy efficiency of transportation sector.

However, the studies on the effect of energy prices on EV adoption are still limited, especially for those from the Nordic countries, the world leaders in renewable energy adoption, and those covering very recent periods with high volatile energy prices (due to the energy crisis). This study aims to fill this gap by utilizing a unique panel of EV registrations at the product-level from four Nordic countries (Denmark, Finland, Norway, Sweden) during 2019–2022 to investigate the effect of energy prices on EV adoption. Our study fills the gap in the literature by providing a new piece of evidence on the role of energy prices in stimulating the adoption of EVs. Meanwhile, our study provides the most recent evidence from the Nordic countries regarding how the adoption of EVs responds to energy prices and highlights the role of energy prices in reducing carbon emissions in the transport sector.

## 3. Data

There are mainly two datasets in our studies. The first is the sales data of electric vehicles (EVs), which is obtained from JATO. JATO is a well-established global provider of automotive business data and its datasets are widely used in empirical studies of automobile markets (see, e.g., Xu et al., 2023; Fei et al., 2025). The JATO data we employed contains monthly model-level new car sales and registration records in the four Nordic countries (Denmark, Finland, Norway and Sweden), spanning from January 2019 to December 2022. These records are sourced from official registration authorities and industry reporting channels, ensuring comprehensive coverage of all new vehicle registrations. The dataset also contains detailed vehicle attributes for each vehicle model (e.g., size, battery range, battery capacity, and so on).

The second dataset is the electricity prices and retail gasoline prices in the four Nordic countries. The electricity prices are the retail electricity prices for households with normal consumption from the national statistical offices of each country (every half year), while the gasoline prices are retrieved from the European Commission's Directorate-General for Energy (ENER),<sup>1</sup> which are illustrated in Fig. A1 in the Appendix.

Table 1 contains the descriptive statistics of our data, where Panel A reports the battery electric vehicle (BEV) sales and energy prices and Panel B shows the statistics summary of variables at the product-model level. It can be seen that the retail gasoline prices of four Nordic countries range from 1.13 EUR/L to 2.53 EUR/L, with an average price of 1.65 EUR/L. The average retail electricity price is around 0.27 EUR/kwh, with the range from 0.17 kwh to 0.56 EUR/kwh. Besides, there are

<sup>1</sup> The gasoline price data used in our analysis refer to the average retail price of unleaded gasoline with a 95-octane rating. This grade is the benchmark product consistently reported by major statistical sources and international databases, and it is also the most commonly used in the Nordic countries.

**Table 1**  
Summary statistics.

VARIABLES	(1)	(2)	(3)	(4)	(5)
	N	Mean	SD	Min	Max
Panel A: Energy Prices and Sales Data					
Gasoline Price (EUR /L)	42,446	1.65	0.30	1.13	2.53
Electricity Price (EUR/kwh)	42,446	0.27	0.08	0.17	0.56
Market Total Sales (vehicle)	42,446	5,160	4,585	75	26,022
Monthly Sales (vehicle)	42,446	15.86	66.70	0	5,008
Panel B: Vehicle Characteristics					
BEV Price (EUR)	42,446	51,045	26,755	12,994	274,393
Battery Capacity (kWh)	40,313	63.02	21.32	14.50	111.50
Battery Range (km)	41,685	370.79	104.35	56	695
Electricity Consumption Rate (kWh/km)	39,566	0.17	0.04	0.09	0.41

Notes: The definitions, data sources, units and frequency of the variables can be found in [Table A2](#) of the Appendix.

in total 42,446 observations in our sample at the product level with 300 BEV models. The monthly sales of a specific BEV model in one country vary between zero to 5008 units, with an average monthly sale of around 16 units. The market total sales of BEVs (the total number of new BEV registrations across all models in a given country during a particular month) vary from 75 to 26,022 units. The battery capacity of different products averages around 63.02 kwh, and the average range of different BEV models is around 371 km, with a maximum value up to 695 km while the shortest range is only 56 km. The definitions, data sources, units and frequency of the variables are described in detail in [Table A2](#) of the Appendix.

#### 4. Empirical strategy

To utilize the product-level EV sales data, we follow [Bushnell et al. \(2022\)](#) to employ a two-way fixed effects model to examine the impact of energy prices on EV sales. The empirical specification is as follows:

$$\ln(Sales_{jct}) = \beta_1 \ln(Electricity\ price_{ct}) + \beta_2 \ln(Gasoline\ Price_{ct}) + \mu_t + \gamma_c \times Year_t + \lambda_j + \epsilon_{jct} \tag{1}$$

where the dependent variable  $\ln(Sales_{jct})$  is the logarithm of monthly sales of battery electric vehicle (BEV) model  $j$  in country  $c$  at time  $t$ . The subscript “ $t$ ” denotes a specific month-year observation (e.g., January 2020) and is indexed as the  $t$ -th month in our sample. Since our sample spans from January 2019 to December 2022, this means that  $t = 1$  corresponds to January 2019,  $t = 2$  corresponds to February 2019, ...,  $t = 13$  corresponds to January 2020, and so forth. The main explanatory variable is the logarithm of  $Electricity\ price_{ct}$  and  $Gasoline\ Price_{ct}$ .  $Electricity\ price_{ct}$  is the retail electricity price in country  $c$  at time  $t$ , measured in EUR/kwh.  $Gasoline\ Price_{ct}$  is the average retail gasoline price in country  $c$  at time  $t$ , measured in EUR/L. The coefficients of interest,  $\beta_1$  and  $\beta_2$ , are estimates of the energy price elasticity of EV sales. We expect  $\beta_1$  to be negative and  $\beta_2$  to be positive, as an increase in electricity prices could discourage the adoption of EV while an increase in gasoline price could stimulate consumers to shift to EVs from ICE vehicles. Our empirical specification (1) also incorporates a rich set of fixed effects, which include the month-by-year fixed effects to account for common time trends and seasonal variation across countries, the country-by-year fixed effect to control for time-varying country-level characteristics, such as annual GDP, national energy policies, and macroeconomic conditions, and finally a set of fixed effects for each vehicle model (detailed to each make-model-model year, e.g., Tesla

**Table 2**  
Baseline results: The effects of energy prices on new BEV sales.

VARIABLES	Dependent Variable: Log-transformed monthly sales			
	(1)	(2)	(3)	(4)
Electricity Price	0.014 (0.249)	-0.034 (0.228)	0.006 (0.262)	-0.027 (0.241)
Gasoline Price	0.714* (0.378)	0.857** (0.333)	0.710* (0.376)	0.846** (0.332)
Country-by-Year FE	✓	✓	✓	✓
Month-by-Year FE	✓	✓	✓	✓
Model FE		✓		✓
Observations	36,003	35,991	36,003	35,991

Notes: Columns (1) and (2) report the estimations for the impact of energy prices on BEV sales based on ordinary least squared (OLS) method and the results with IV method are presented in Columns (3) and (4). The dependent variable is the logarithm of the monthly sales of BEVs of a specific model in one country. Model FE refers to fixed effects included at the make-model-model year level. The robust standard errors are listed in parentheses. \*\*\*, \*\* and \* denote significance at the 1%, 5% and 10% levels, respectively.

Model X 2020), which control for time-invariant vehicle attributes (e.g., size, battery capacity, driving range, brand effects) as well as unobserved preferences associated with specific models.

However, there are potential observables affecting BEV demand, which may be correlated with changes in energy prices, as suggested by [Bushnell et al. \(2022\)](#). In this case, the endogeneity between BEV sales and energy prices would be a concern. For instance, higher BEV adoption could, in principle, reduce demand for gasoline and increase electricity demand, thereby influencing retail energy prices. To mitigate the concern of potential endogeneity issue, we employed a two-stage least squares (2SLS) estimation using an instrumental variable (IV) approach. Specifically, we utilized the average retail energy prices in other Nordic countries as instrumental variables for domestic retail energy prices, following Nevo (2001)’s approach. This IV strategy relies on two conditions. First, this instrument is relevant because energy prices across Nordic countries are highly correlated due to shared cost shifters such as global crude oil prices and integrated wholesale electricity markets. Second, the instruments satisfy the exclusion restriction: retail energy prices in other Nordic countries are unlikely to be directly affected by domestic EV sales in a given Nordic country, since EV usage is predominantly domestic and cross-border commuting or charging is relatively rare. Similar approaches have been employed in the literature, such as [Beresteanu and Li \(2011\)](#), who use fuel costs in other U.S. metropolitan areas as instruments, and [Fei et al. \(2025\)](#), who use average gasoline prices in other cities as an instrument for studying the effect of gasoline prices on EV adoption in China.

#### 5. Results

[Table 2](#) shows our baseline results on how energy prices would affect the EV sales in Nordic countries. Columns (1) and (2) report the estimation results based on the ordinary least squared (OLS) method and the results with IV method are presented in columns (3) and (4). It can be seen that from all the estimations (with and without product model fixed effect) that gasoline price has been shown to have a more statistically significant effect on the adoption of battery electric vehicles (BEVs), compared with electricity price. This indicates that consumers tend to switch into BEVs when gasoline prices rise. From column 4 of [Table 2](#), it can be seen that, on average, 1% increase in gasoline price would increase the sales of BEVs by 0.85%. Though the coefficient of electricity prices is negative when we control the product/model fixed effects ([Klier and Linn, 2010](#)), it is not statistically significant, which reflects the

**Table 3**  
Effect of energy prices on new BEV sales in different segments.

VARIABLES	Dependent Variable: Log-transformed monthly sales			
	Indicator: Brand		Indicator: Vehicle Price	
	Large brand	Small brand	Price>50000Euro	Price≤50000Euro
Electricity Price	0.162 (0.335)	-0.300 (0.344)	0.940** (0.407)	-0.826*** (0.295)
Gasoline Price	0.739 (0.484)	0.743* (0.443)	0.616 (0.519)	0.879** (0.440)
Country-by-Year FE	✓	✓	✓	✓
Month-by-Year FE	✓	✓	✓	✓
Model FE	✓	✓	✓	✓
Observations	19,975	16,016	13,293	22,695

Note: All results are based on the IV method. The dependent variable is the logarithm of the monthly sales of BEVs of a specific model in one country. Model FE refers to fixed effects included at the make-model-year level. The robust standard errors are listed in parentheses. \*\*\*, \*\* and \* denote significance at the 1%, 5% and 10% levels, respectively.

relatively less important role that electricity price is playing in EV adoption in the Nordic countries. Overall, our results indicate that the consumers are responding more actively to changes in gasoline prices than changes in electricity prices, which is consistent with the findings in California (Bushnell et al., 2022).

The less significant role that electricity prices are playing in EV adoption could reflect the fact that electricity prices may be less salient for consumers than gasoline prices. First, unlike gasoline, which is prominently displayed at roadside stations and frequently observed by drivers, retail electricity prices are rarely advertised in public in real time, reducing their visibility and salience (Busse et al., 2013; Ito, 2014). Second, electricity expenditures are typically embedded within complex monthly utility bills, making it difficult for households to disentangle the marginal cost of charging from other household electricity uses (Faruqui and Sergici, 2010; Allcott, 2011). Together, these institutional and behavioral factors could help explain why consumers' responses to electricity price fluctuations may be muted compared with the more immediate and salient effect of gasoline prices.

To investigate how the effects of energy price could vary with different segments of the BEVs, we divide the cars into two segments according to their brands (Table 3, Column (1)–(2)). We classify brands based on their total sales volume in our dataset, using 30,000 units as the cutoff. Brands with total sales of less than 30,000 is classified as “small brand” and those with total sales higher than 30,000 is classified as “big brand”. The rationale for choosing 30,000-unit as the threshold is twofold. First, this cutoff yields two subsamples of reasonably similar size, enabling meaningful comparison across groups. Second, the median total brand sales in our data are 31,518 units. Setting the threshold at 30,000 therefore provides a value that is both close to the empirical distribution's median value and intuitive for interpretation. We found that the effect of energy prices is more significant for small-branded EVs. Besides, we divide the cars into relatively cheap and expensive segments according to their manufacturer's suggested retail price (MSRP) (Table 3, Column (3)–(4)). It can be seen from the results that only for consumers of cheap cars, electricity prices seem to play an important role in discouraging the adoption and gasoline prices have a significantly positive effect on adoption.

Next, we conduct several robustness checks for our baseline results and the results are summarized in Table 4. First, we change the specification for model fixed effect in Column (1) from the product with the same “make” (“manufacturer”), “model”, and “model-year” in the baseline results to the product with the same “make” (“manufacturer”) and “model”. Second, we use the cluster standard error instead of the

**Table 4**  
Robustness check.

VARIABLES	Dependent Variable: Log-transformed monthly sales				
	(1)	(2)	(3)	(4)	(5)
	Different FE	Cluster at model level	Cluster at country level	Winsorized at 1%	Year Before 2022
Electricity Price	0.159 (0.238)	-0.027 (0.525)	-0.027 (0.193)	-0.048 (0.237)	0.074 (0.277)
Gasoline Price	0.610* (0.334)	0.846* (0.492)	0.846* (0.279)	0.923*** (0.324)	0.927* (0.495)
Country-by-Year FE	✓	✓	✓	✓	✓
Month-by-Year FE	✓	✓	✓	✓	✓
Model FE	Make × Model FE	✓	✓	✓	✓
Observations	36,000	35,991	35,991	35,572	35,991

Note: All results are based on the IV method. The dependent variable is the logarithm of the monthly sales of BEVs of a specific model in one country. The Model FE in Column (1) includes fixed effect at make-model level. Model FE in other columns refers to fixed effects at make-model-year level. The robust standard errors are listed in parentheses. \*\*\*, \*\* and \* denote significance at the 1%, 5% and 10% levels, respectively.

robust standard error, with Column (2) showing the results clustered at model level and Column (3) showing those clustered at country level. It can be seen that the coefficients of gasoline prices remain statistically significant at 10% level. Besides, we also conducted robustness tests on the 1% winsorized samples<sup>2</sup> (Column (4) of Table 4) and it can be seen that coefficient of gasoline prices is also statistically significant (at 1% level). We also checked whether our conclusions are affected by excluding the period of energy crisis, when Europe experienced a significant surge in energy prices. Column (5) of Table 4 shows the estimation results when excluding the sample in 2022 and it can be seen that the effect of gasoline prices remains more statistically significant than that of electricity prices.

## 6. Simulations on GHG emissions

Energy prices could affect electric vehicle (EV) sales, and thus over the long term would change the composition of the automobile fleet. This, in turn, has implications for greenhouse gas (GHG) emissions and climate change. It can then be expected that policy instruments such as increased fuel taxes, can promote the adoption of EVs and accelerate the decarbonization in EU (Wang et al., 2023; Peiseler and Serrenho, 2022; Wangness and Halse, 2021). In this section, we conduct simulations to estimate the effects of emission reductions if a policy with increased fuel taxes is implemented, based on our estimation results in Section 5. The quantitative results could help decision-makers better evaluate the potential impacts of a similar policy on GHG emission reduction and decarbonization in the transport sector.

Using the baseline estimation results in Column (4) of Table 2, we estimate the new EV sales for each model with a 1% increase in gasoline prices. The first row in Table 5 shows the average annual increase in sales across different segments (small, medium, SUV), with the total numbers calculated in the last column. The second row shows the increased GHG emissions resulting from the increased sales of BEVs when gasoline price rises by 1%. As discussed in Section 5, an increase in gasoline prices leads some consumers to shift their purchases from internal combustion engine (ICE) vehicles to battery electric vehicles (BEVs). The third row calculates the GHG emissions of ICE vehicles

<sup>2</sup> The values smaller than the 1st percentile are replaced by the 1st percentile, and the values larger than the 99th percentile are replaced by 99th percentile.

**Table 5**  
Average annual GHG emissions reduction of different segments.

Segment	Small	Medium	SUV	Total
Increased BEVs sales	38	113	184	335
Increased BEVs emission (t CO <sub>2</sub> eq.)	632	2,272	4,470	7,374
Substituted ICE vehicles emission (t CO <sub>2</sub> eq.)	1,700	6,706	13,212	21,618
Potential emission reduction (t CO <sub>2</sub> eq.)	1,068	4,434	8,742	14,244

Note: Small cars include small and mini cars. Medium cars include upper medium and lower medium cars. Sports utility vehicles (SUVs) include executive SUVs, luxury SUVs, large SUVs, medium SUVs, small SUVs and mini SUVs. As the lifecycle GHG emissions of battery electric vehicles are mainly dominated by these three segments in the literature, the GHG emissions calculations related to the segments are mainly dominated by these three segments. In addition, the vehicles of other segments have only a small share in our data set (less than 20%).

which are replaced by BEVs. Therefore, the potential emission reduction due to 1% increase in gasoline price would be the difference between the substituted ICE vehicles' emissions and the increased BEVs' emissions (see Eq. (2), where subscript "0" denotes initial state and "1" denotes simulated state).

$$\begin{aligned}
 \text{Potential Emission reduction} &= (\text{BEV emission}_0 + \text{ICE emission}_0) \\
 &- (\text{BEV emission}_1 + \text{ICE emission}_1) = (\text{BEV emission}_0 + \text{ICE emission}_0) \\
 &- \{ (\text{BEV emission}_0 + \text{Increased BEV emission}) + (\text{ICE emission}_0 \\
 &- \text{Substituted ICEs emission}) \} = \text{Substituted ICE emission} \\
 &- \text{Increased BEV emission}
 \end{aligned} \tag{2}$$

It can be seen from Table 5 that the SUV segment contributes more to GHG emission reduction when shifting from ICE vehicles to BEVs. The total average annual GHG emissions reduction across the three segments is approximately 14,244 tons of CO<sub>2</sub> equivalent.

It should be noted that we have made several assumptions here. First, with annual mileages for small, medium, and SUV segment cars of 11,000 km, 13,500 km, and 15,000 km, respectively, and an average lifespan of 18 years for cars in Europe, the lifetime mileages of small, medium, and SUV segment cars are estimated to be 198,000 km, 243,000 km, and 270,000 km, respectively (Bieker, 2021).

Second, we employed the lifecycle GHG emission of newly registered vehicles in the calculations. The lifecycle GHG emissions of average gasoline and diesel-powered ICE vehicles are 226 g CO<sub>2</sub> eq./km for small, 245 g CO<sub>2</sub> eq./km for medium and 266 g CO<sub>2</sub> eq./km for SUV vehicles. The lifecycle GHG emissions of average BEVs are 84 g CO<sub>2</sub> eq./km for small, 83 g CO<sub>2</sub> eq./km for medium and 90 g CO<sub>2</sub> eq./km for SUV vehicles.<sup>3</sup> The average lifecycle GHG emissions of ICEs and BEVs are 246 g CO<sub>2</sub> eq./km and 86 g CO<sub>2</sub> eq./km, respectively.

We also calculated the GHG emissions reduction that would result from a 1% increase in gasoline prices in four Nordic countries during the period from 2019 to 2022. The results are presented in Fig. 2, from which it can be seen that Norway and Sweden would see the largest reductions in GHG emissions as a result of the change in gasoline price, likely due to their existing efforts to promote BEVs. It is evident that a 1% increase in gasoline prices could bring the largest reduction in GHG emissions in 2021, while 2020 and 2022 would both experience a

<sup>3</sup> According to the International Council on Clean Transportation (ICCT), the lifecycle GHG emissions of average gasoline and diesel-powered ICE vehicles range from 226 to 227 g CO<sub>2</sub> eq./km for small, 245–246 g CO<sub>2</sub> eq./km for lower medium and 266–288 g CO<sub>2</sub> eq./km for SUV segment cars. The lifecycle GHG emissions of average BEVs registered in 2021 are estimated to be 77–84 g CO<sub>2</sub> eq./km for small, 76–83 g CO<sub>2</sub> eq./km for lower medium, and 82–90 g CO<sub>2</sub> eq./km for SUV segment cars. We use the minimum values of the ICE vehicles lifecycle GHG emissions and the maximum values of BEVs' in the calculation. Therefore, the emission reduction here are the minimum values.

smaller reduction in emissions, probably due to the impact of the COVID-19 pandemic and the reduced vehicle demand. The average elasticity of GHG emissions with respect to gasoline prices during the four years is  $-0.16$ , which means 1% gasoline prices increase would reduce GHG emissions by 0.16%. This result is slightly smaller than that found by Fridström and Østli (2021) in Norway ( $-0.19$ ), potentially due to that fact that our dataset includes three other Nordic countries where BEVs are not as popular as in Norway. The average elasticities of GHG emissions with respect to gasoline prices in Denmark, Finland, Norway, and Sweden during the four years are  $-0.07$ ,  $-0.21$ ,  $-0.26$ , and  $-0.11$ , respectively. This implies that the effect of increased gasoline price (through a higher tax) on GHG emission reduction would be larger in Norway than those in other Nordic countries.

## 7. Conclusions

As one of the most important measures to reach carbon neutrality in the transport sector, the adoption of electric vehicles (EVs) can also reap dividends in the form of energy efficiency improvement and energy saving. Therefore, it is of great importance to understand how policies can be shaped to stimulate the adoption of EVs. This paper investigates the role that energy prices can play in the transition to EVs, using a unique panel of EV registrations at the product-level from four Nordic countries.

The results show that gasoline prices have a more statistically significant effect on the adoption of EVs, compared with electricity prices. On average, 1% increase in gasoline price would increase the sales of EVs by 0.85% and the effect is larger for EV models with relatively lower purchase cost and those with less-known brands. In terms of the implications to emission reduction, our simulation results show that a 1% increase in the gasoline price would reduce the lifecycle GHG emissions of new automobiles by 0.16%.

Beyond the empirical patterns, our results also have important theoretical reflections. Gasoline is a complementary good to the traditional internal combustion engine (ICE) vehicles, while electric vehicles (EVs) are substitute goods for ICE vehicles. This implies that an increase in gasoline would reduce the demand for ICE vehicles but increase the demand for EVs. Our results are in line with this theoretical prediction and show that a higher gasoline price increases the adoption of EVs. On the other hand, electricity is a complementary good to EVs and thus a higher electricity price is expected to have a negative effect on EV adoption. However, electricity prices are typically less salient to consumers due to their complexity, billing structure, and lower frequency of observation compared with gasoline prices. As a result, the behavioral response to electricity price changes is more muted.

Our findings yield several policy implications. First, the strong and statistically significant responsiveness of EV adoption to gasoline prices suggests that fuel taxation remains a powerful policy lever for accelerating the transition to EVs. This instrument is particularly effective because gasoline prices are highly salient to consumers and directly influence their vehicle purchase decisions. Second, the relatively muted effect of electricity prices implies that policymakers cannot rely solely on electricity tariff structures to promote EV uptake. Instead, complementary measures—such as public information campaigns to raise awareness of the lower operating costs of EVs, or more transparent billing practices that highlight marginal electricity costs—could help increase the salience of electricity prices. Third, our heterogeneity analysis shows that the price effect is stronger for lower-cost EV models and less-established brands. This finding suggests that policies targeting these segments or support for smaller manufacturers may enhance both equity and efficiency in the EV transition. Finally, our simulation results indicate that higher gasoline taxes can contribute meaningfully to emission reduction, with a 1% increase in gasoline prices associated with a 0.16% decline in lifecycle GHG emissions. This underscores the dual role of fuel taxation in promoting EV adoption and mitigating climate change and highlights the importance of integrating carbon

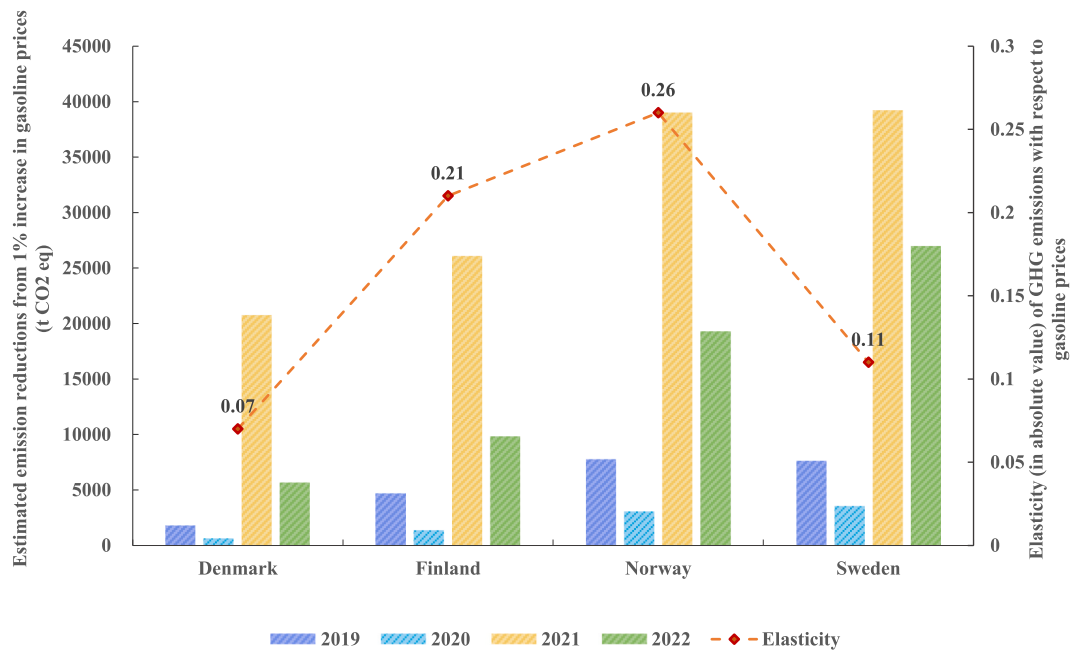


Fig. 2. Potential annual emission reduction and the elasticity of GHG emissions with respect to gasoline prices in four Nordic countries.

reduction objectives into transport and fiscal policy design.

However, this paper is not without limitations. First, our data are aggregated at the national level, which prevents us from distinguishing between urban and rural adoption patterns or capturing household-level heterogeneity in vehicle choice. Second, we cannot directly observe micro-level consumer behavior, such as differences in driving intensity or access to charging infrastructure, which may also influence adoption decisions. Third, our EV market data cannot facilitate the analysis on the importance of behavioral and social factors such as trust, environmental awareness, and peer influence in EV adoption. Future research using micro-level survey data would be valuable for examining heterogeneity in consumer responses to energy prices (e.g., across income groups or between urban and rural areas), as well as the role of behavioral and social factors in EV adoption.

**CRedit authorship contribution statement**

**Xiao-Bing Zhang:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Formal analysis, Conceptualization. **Jiayi Xu:** Writing – original draft, Visualization, Formal

analysis, Data curation. **Ying Zheng:** Writing – review & editing, Validation, Supervision, Methodology. **Ramazan Sari:** Writing – review & editing, Writing – original draft, Supervision, Methodology. **Yanlai Chu:** Writing – review & editing, Supervision, Data curation.

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**Appendix A. Energy prices in the Nordic countries**

Fig. A1 plots the retail gasoline and electricity prices in the four Nordic countries over the sample period (2019–2022). Several common patterns emerge. First, all four countries experienced a sharp increase in gasoline prices in early 2022, coinciding with the global energy crisis following Russia's invasion of Ukraine, with Denmark and Finland reaching peaks above EUR 2.5 per liter. By contrast, electricity prices rose more moderately during the same period. Second, despite cross-country variation in absolute price levels, the general co-movement across countries reflects their exposure to similar international energy market dynamics.

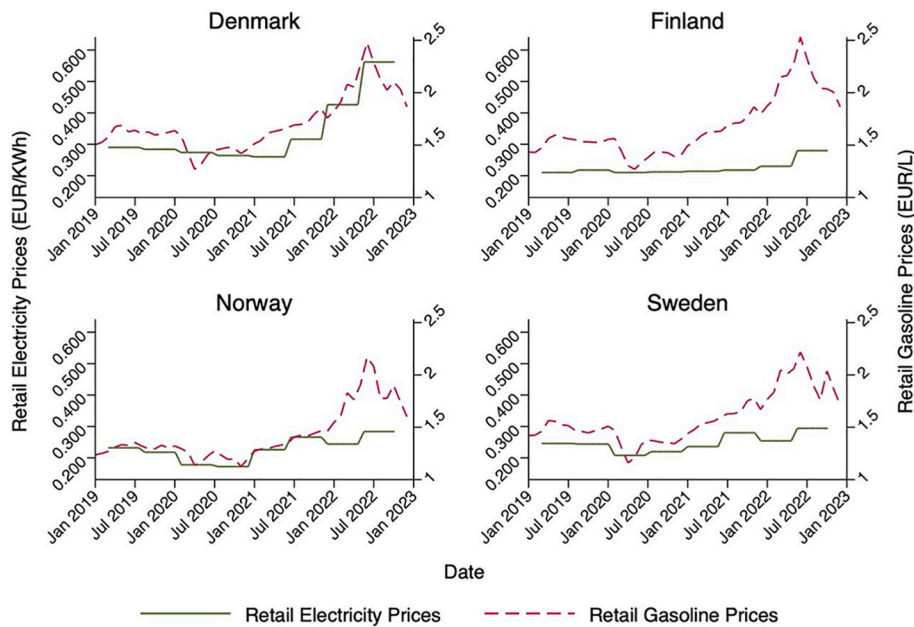


Fig. A1. Energy prices in four Nordic countries.

Appendix B. First-stage results of the 2SLS regression

Table A1 reports the first-stage estimation results of the 2SLS regression (in Table 2). The Cragg–Donald Wald F statistic is about 300,000 and the Kleibergen–Paap rk Wald F statistic is 88,669.63 for the regression of Column (6). Both values are well above the Stock and Yogo (2005) 10% maximal IV size critical value of 7.03, indicating that the instruments are strongly identified and the null hypothesis of weak instruments can be rejected.

Table A1  
The first-stage results of the 2SLS regression.

Dependent Variables	(1) (2)		(3)	(4) (5)		(6)
	First stage		Second stage	First stage		Second stage
	Retail Electricity Price	Retail Gasoline Price	Ln (Monthly Sales)	Retail Electricity Price	Retail Gasoline Price	Ln (Monthly Sales)
IV-Electricity prices (Other countries)	-2.642*** (0.006)	0.018*** (0.001)		-2.643*** (0.006)	0.017*** (0.001)	
IV-Gasoline Prices (Other countries)	0.047*** (0.005)	-3.165*** (0.001)		0.045*** (0.005)	-3.164*** (0.001)	
Retail Electricity Prices			0.006 (0.262)			-0.027 (0.241)
Retail Gasoline Prices			0.710* (0.376)			0.846** (0.332)
Country-by-Year FE	✓	✓	✓	✓	✓	✓
Month-by-Year FE	✓	✓	✓	✓	✓	✓
Model FE				✓	✓	✓
Observations	36,003	36,003	36,003	35,991	35,991	35,991

Note: Columns (1)–(2) and Columns (4)–(5) report the first-stage results of the estimation in Column (3) and (4) of Table 2. The dependent variables of the first-stage estimations are retail electricity prices and retail gasoline prices. The dependent variable of the second-stage estimation is the logarithm of the monthly sales of BEVs of a specific model in one country. Estimations of column (1)–(3) include country-by-year fixed effect and month-by-year fixed effect. Estimations of columns (4)–(6) include country-by-year fixed effect, month-by-year fixed effect and model fixed effect. The robust standard errors are listed in parentheses. \*\*\*, \*\* and \* denote significance at the 1%, 5% and 10% levels, respectively.

Appendix C. Variable definitions and data sources

Table A2 presents the definitions (with units) and data sources of the variables (with frequency).

**Table A2**  
Variable definitions and data sources.

VARIABLES	Definition	Sources	Frequency
<b>Panel A. Energy prices and sales data</b>			
Gasoline Price	Retail gasoline price (EUR /L)	European Commission's Directorate-General for Energy	Monthly
Electricity Price	Retail electricity price (EUR/kwh)	The national statistical offices of each country	Half-yearly
Market Total Sales	The total number of new BEV registrations across all models in a given country during a particular month. (vehicle)	Calculated by the authors, from JATO	Monthly
Monthly Sales	The number of new registrations of a specific BEV model in a specific country during a particular month (vehicle)	JATO	Monthly
<b>Panel B. Vehicle characteristics</b>			
BEV Price	The price of a specific model (EUR)	JATO	Product-specific
Battery Capacity	The capacity of battery of a specific model (kWh)	JATO	Product-specific
Battery Range	The maximum driving distance of a specific model on a full charge (km)	JATO	Product-specific
Electricity Consumption Rate	The amount of electricity used to travel one mile (kWh/km)	Calculated by the authors, from JATO	Product-specific

## Appendix D. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.eneco.2026.109148>.

## References

- Afroz, R., Masud, M.M., Akhtar, R., Islam, M.A., Duasa, J.B., 2015. Consumer purchase intention towards environmentally friendly vehicles: an empirical investigation in Kuala Lumpur, Malaysia. *Environ. Sci. Pollut. Res.* 22, 16153–16163.
- Allcott, H., 2011. Social norms and energy conservation. *J. Public Econ.* 95 (9–10), 1082–1095.
- Allcott, H., Wozny, N., 2014. Gasoline prices, fuel economy, and the energy paradox. *Rev. Econ. Stat.* 96 (5), 779–795.
- Axsen, J., Kurani, K.S., 2012. Interpersonal influence within car buyers' social networks: applying five perspectives to plug-in hybrid vehicle drivers. *Environ. Plan. A* 44 (5), 1047–1065.
- Beresteanu, A., Li, S., 2011. Gasoline prices, government support, and the demand for hybrid vehicles in the United States. *Int. Econ. Rev.* 52 (1), 161–182.
- Bieker, G., 2021. A global comparison of the life-cycle greenhouse gas emissions of combustion engine and electric passenger cars. *Communications* 49 (30), 847129–102.
- Borenstein, S., Bushnell, J.B., 2022. Do two electricity pricing wrongs make a right? Cost recovery, externalities, and efficiency. *Am. Econ. J. Econ. Pol.* 14 (4), 80–110.
- Bosshard, R., Kolar, J.W., 2016. Inductive power transfer for electric vehicle charging: technical challenges and tradeoffs. *IEEE Power Electron. Mag.* 3 (3), 22–30.
- Bushnell, J.B., Muehlegger, E., Rapson, D.S., 2022. Energy Prices and Electric Vehicle Adoption (No. w29842). National Bureau of Economic Research.
- Busse, M.R., Knittel, C.R., Zettelmeyer, F., 2013. Are consumers myopic? Evidence from new and used car purchases. *Am. Econ. Rev.* 103 (1), 220–256.
- Carley, S., Krause, R.M., Lane, B.W., Graham, J.D., 2013. Intent to purchase a plug-in electric vehicle: a survey of early impressions in large US cities. *Transp. Res. Part D: Transp. Environ.* 18, 39–45.
- Chen, C.F., de Rubens, G.Z., Noel, L., Kester, J., Sovacool, B.K., 2020. Assessing the socio-demographic, technical, economic and behavioral factors of Nordic electric vehicle adoption and the influence of vehicle-to-grid preferences. *Renew. Sust. Energ. Rev.* 121, 109692.
- Coffman, M., Bernstein, P., Wee, S., 2015. Factors affecting EV adoption: a literature review and EV forecast for Hawaii. *Electr. Veh. Transp. Cent. April* 2015, 1–36.
- Davis, L.W., Metcalf, G.E., 2016. Does better information lead to better choices? Evidence from energy-efficiency labels. *J. Assoc. Environ. Resour. Econ.* 3 (3), 589–625.
- Diamond, D., 2009. The impact of government incentives for hybrid-electric vehicles: evidence from US states. *Energy Policy* 37 (3), 972–983.
- Dutta, A., Tenpe, A., 2022. Design of a model for impact assessment of electric vehicles on day-to-day life & environment. In: 2022 10th International Conference on Emerging Trends in Engineering and Technology-Signal and Information Processing (ICETET-SIP-22). IEEE, pp. 01–06.
- European Environment Agency (EEA), 2025. Transport and Mobility. <https://www.eea.europa.eu/en/topics/in-depth/transport-and-mobility>.
- Faruqui, A., Sergici, S., 2010. Household response to dynamic pricing of electricity: a survey of 15 experiments. *J. Regul. Econ.* 38 (2), 193–225.
- Fei, Y., Qin, P., Chu, Y., Zheng, H., Tan-Soo, J.-S., Zhang, X.-B., 2025. Does high gasoline price spur electric vehicle adoption? Evidence from Chinese cities. *Energy Econ.* 142, 108188.
- Fridström, L., Østli, V., 2021. Direct and cross price elasticities of demand for gasoline, diesel, hybrid and battery electric cars: the case of Norway. *Eur. Transp. Res. Rev.* 13 (1), 3.
- Gallagher, K.S., Muehlegger, E., 2011. Giving green to get green? Incentives and consumer adoption of hybrid vehicle technology. *J. Environ. Econ. Manag.* 61 (1), 1–15.
- Gerarden, T.D., Newell, R.G., Stavins, R.N., 2017. Assessing the energy-efficiency gap. *J. Econ. Lit.* 55 (4), 1486–1525.
- Gillingham, K.T., Van Benthem, A.A., Weber, S., Saafi, M.A., He, X., 2023. Has consumer acceptance of electric vehicles been increasing? Evidence from microdata on every new vehicle sale in the United States. *AEA Pap. Proc.* 113, 329–335.
- Grigolon, L., Reynaert, M., Verboven, F., 2018. Consumer valuation of fuel costs and tax policy: evidence from the European car market. *Am. Econ. J. Econ. Pol.* 10 (3), 193–225.
- Haas, T., Sander, H., 2020. Decarbonizing transport in the European Union: emission performance standards and the perspectives for a European green deal. *Sustainability* 12 (20), 8381.
- Hidru, M.K., Parsons, G.R., Kempton, W., Gardner, M.P., 2011. Willingness to pay for electric vehicles and their attributes. *Resour. Energy Econ.* 33 (3), 686–705.
- Ito, K., 2014. Do consumers respond to marginal or average price? Evidence from nonlinear electricity pricing. *Am. Econ. Rev.* 104 (2), 537–563.
- Ito, N., Takeuchi, K., Managi, S., 2013. Willingness-to-pay for infrastructure investments for alternative fuel vehicles. *Transp. Res. Part D: Transp. Environ.* 18, 1–8.
- Klier, T., Linn, J., 2010. The Price of gasoline and new vehicle fuel economy: evidence from monthly sales data. *Am. Econ. J. Econ. Pol.* 2 (3), 134–153.
- Klier, T., Linn, J., Zhou, Y.C., 2020. The effects of fuel prices and vehicle sales on fuel-saving technology adoption in passenger vehicles. *J. Econ. Manag. Strateg.* 29 (3), 543–578.
- Leard, B., Linn, J., Zhou, Y.C., 2023. How much do consumers value fuel economy and performance? Evidence from technology adoption. *Rev. Econ. Stat.* 105 (1), 158–174.
- Li, S., Timmins, C., Von Haefen, R.H., 2009. How do gasoline prices affect fleet fuel economy? *Am. Econ. J. Econ. Pol.* 1 (2), 113–137.
- Li, S., Tong, L., Xing, J., Zhou, Y., 2017. The market for electric vehicles: indirect network effects and policy design. *J. Assoc. Environ. Resour. Econ.* 4 (1), 89–133.
- Liu, Z., Song, J., Kubal, J., Susarla, N., Knehr, K.W., Islam, E., Ahmed, S., 2021. Comparing total cost of ownership of battery electric vehicles and internal combustion engine vehicles. *Energy Policy* 158, 112564.
- Mock, P., Diaz, S., 2021. Pathways to Decarbonization: The European Passenger car Market in the Years 2021–2035. ICCT White Paper.
- Mohamed, M., Higgins, C., Ferguson, M., Kanaroglou, P., 2016. Identifying and characterizing potential electric vehicle adopters in Canada: a two-stage modelling approach. *Transp. Policy* 52, 100–112.
- Ozaki, R., Sevastyanova, K., 2011. Going hybrid: an analysis of consumer purchase motivations. *Energy Policy* 39 (5), 2217–2227.
- Peiseler, L., Serrenho, A.C., 2022. How can current German and EU policies be improved to enhance the reduction of CO2 emissions of road transport? Revising policies on electric vehicles informed by stakeholder and technical assessments. *Energy Policy* 168, 113124.

- Sierchula, W., Bakker, S., Maat, K., van Wee, B., 2014. The influence of financial incentives and other socio-economic factors on electric vehicle adoption. *Energy Policy* 68, 183–194.
- Stock, J.H., Yogo, M., 2005. Testing for weak instruments in Linear Iv regression. In: *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg*. Cambridge University Press, pp. 80–108.
- Thiel, C., Nijss, W., Simoes, S., Schmidt, J., van Zyl, A., Schmid, E., 2016. The impact of the EU car CO<sub>2</sub> regulation on the energy system and the role of electro-mobility to achieve transport decarbonisation. *Energy Policy* 96, 153–166.
- Tran, M., Banister, D., Bishop, J.D., McCulloch, M.D., 2013. Simulating early adoption of alternative fuel vehicles for sustainability. *Technol. Forecast. Soc. Chang.* 80 (5), 865–875.
- Wang, T., Deason, J., Shittu, E., 2023. The interplay of incentives, electricity price and demand on transport decarbonization: the case of electric vehicles in the US. *IEEE Eng. Manag. Rev.* 52 (2), 38–54.
- Wangsnæs, P.B., Halse, A.H., 2021. The impact of electric vehicle density on local grid costs: empirical evidence from Norway. *Energy J.* 42 (5), 149–168.
- Wappelhorst, S., Mock, P., Yang, Z., 2018. Using Vehicle Taxation Policy to Lower Transport Emissions. An Overview for Passenger Cars in Europe. International Council on Clean Transportation, Berlin.
- Xu, J., Tan-Soo, J.-S., Chu, Y., Zhang, X.-B., 2023. Gasoline price and fuel economy of new automobiles: evidence from Chinese cities. *Energy Econ.* 126, 107032.
- Yan, S., Eskeland, G.S., 2018. Greening the vehicle fleet: Norway's CO<sub>2</sub>-differentiated registration tax. *J. Environ. Econ. Manag.* 91, 247–262.
- Zhuge, C., Wei, B., Shao, C., Dong, C., Meng, M., Zhang, J., 2020. The potential influence of cost-related factors on the adoption of electric vehicle: an integrated micro-simulation approach. *J. Clean. Prod.* 250, 119479.