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Watt drives my car:
A study on energy prices and BEV adoption in Sweden through fixed effects and the role of border proximity

Krish Uttamchandani (25360) and Tania Safavi Homami (25477)

Abstract: This study investigates the impact of fuel prices, electricity prices, and cost savings on battery electric vehicle (BEV) adoption in Sweden, particularly focusing on the under-explored role of spatial heterogeneity in electricity prices. Building on existing literature, we employ a panel data fixed effects model with municipality-level data from 2021-2023. Our findings reveal that rising fuel prices significantly incentivize BEV adoption, supporting the substitution effect and the effectiveness of fuel taxation policies. However, electricity prices and cost savings do not show a significant influence, suggesting that upfront costs may be a dominant factor in consumer decision-making. Furthermore, we uncover a novel finding for Sweden– a negative and significant impact of cross-border electricity price differences on BEV adoption in municipalities bordering adjacent bidding zones. Our study solidifies the positive impact of fuel prices on BEV adoption, while contesting the effect of electricity prices in existing literature.

Keywords: Electric Vehicles, Gasoline Prices, Electricity Prices, Bidding Zones, Border Treatment Effects

JEL: Q40, Q41, Q48, Q49, Q58, R42, C13, C31, C33

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Discussants:	Axel Jonsson & Katarina Li Qiu
Examiner:	Johanna Wallenius

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Abbreviations

EV	Electric vehicle
BEV	Battery electric vehicle
HEV	Hybrid electric vehicle
PHEV	Plug-in hybrid electric vehicle
PEV	Plug-in electric vehicle

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1. Introduction

The detrimental consequences of climate change necessitate urgent action to reduce emissions. A critical stepping stone is the global transition of the transportation sector to electric vehicles. Transport accounts for approximately 24% of the global CO2 emissions (Ritchie, 2020), calling for significant attention from individuals and policy makers alike. To facilitate a shift, governments worldwide have implemented various exemptions and subsidies, which have been widely recognized as key drivers in the transition to an electrified transportation sector. The literature has recognized a range of key drivers, including state-provided economic and regulatory incentives, increasing environmental awareness, and infrastructural development. There is less agreement, however, on the role that the fuel and electricity prices play in the consumer decisions to choose electric vehicles.

The adoption of BEVs and the impact of fuel and electricity prices are particularly significant in Sweden, a country with a high share of renewable energy and ambitious environmental targets. Sweden has achieved the third-largest EV fleet globally (Jaeger, 2023), largely due to extensive governmental efforts to promote and incentivize EV uptake through tax exemptions and subsidies. While the effect of some of these instruments has been studied, for example, Eisner Sjöberg's (2023) investigation of the impact of eliminating the climate bonus, there is limited research on the influence of fuel and electricity prices on BEV adoption in Sweden. Addressing this question is crucial for two reasons: first, it provides valuable insights into consumer behavior in light of recent shocks to oil prices and electricity costs; second, it informs the understanding of recent price-based policy tools employed by the Swedish government, such as the reduction of taxes on diesel and petrol in 2022 and 2024.

This thesis aims to address this knowledge gap by investigating the relationship between changes in fuel and electricity prices and BEV adoption in Sweden. We exploit temporal and cross-sectional variations in fuel and electricity prices across Swedish municipalities. First, we employ a panel fixed effects approach to understand the relationship between fluctuating energy prices and BEV adoption. The panel data structure and fixed effects allow us to control for unobserved municipality-specific factors and time-invariant characteristics that might influence BEV sales. Second, we utilize the structure of the Swedish electricity market and its bidding zones to isolate the effect of price variations on EV adoption, employing an approach akin to a regression discontinuity design.

Our analysis reveals fuel prices as a significant predictor of BEV adoption in Sweden, aligning with prior research (Soltani-Sobh et al., 2017). In contrast, we find that electricity prices lack a direct effect, which contends with some existing literature (Mauritzen, 2023). Further, examining spatial price variations, we find that the effect of electricity price differences on EV adoption seems less pronounced for municipalities bordering lower-priced zones.

This paper begins by providing a comprehensive background on Sweden's existing policies related to electric vehicles and energy pricing, setting the context for our analysis. This is followed by a thorough literature review, systematically examining the existing research on the factors influencing BEV adoption, with a particular focus on the role of energy prices. Next, we describe our dataset, detailing the variables employed in our model. The methodology section follows, outlining the panel data fixed effects model and the specifications used to investigate the impact of fuel prices, electricity prices, cost savings, and cross-border electricity price differences on BEV adoption. Subsequently, we present our empirical results, highlighting the key findings and their statistical significance. The paper concludes with an in-depth discussion of the implications of our findings, situating them within the broader context of EV adoption literature and policy.

2. Background

In this section, we describe the different types of EVs and the current EV uptake in Sweden, followed by a background on how the government has attempted to increase EV adoption. Lastly, we focus on electricity and fuel prices.

2.1 Different types of EVs

There are several types of electric vehicles (EVs) in the market, one of them being Battery Electric Vehicles (BEVs) that are completely reliant on electricity and charge their battery by plugging them into charging stations. In contrast, Hybrid Electric Vehicles (HEVs) have an internal combustion engine with an electric motor. HEVs operate with fuel, and some of it gets converted to energy, which is added to the battery. HEVs are Plug-in Hybrid Electric Vehicles (PHEVs) that can charge their battery by plugging them into charging points while also relying on fossil fuels (Lewald & Bergman, 2024). Since PHEVs and BEVs can be recharged by being plugged in to an energy source they are known as Plug-in Electric Vehicles (PEV) (U.S Environmental Protection Agency, 2023).

2.2 EV adoption and infrastructure in Sweden

The PEV uptake in Sweden has increased over the past years. From 2013 to 2024 PEVs experienced an increase of 224% (from 2 594 to 583 740 BEVs & PHEVs)(Figure 1)(Power Circle, n.da). Despite the significant growth, the uptake seems to have slowed between 2022 and 2023. This could be the general result of an unstable economic climate but also due to the elimination of a government subsidy that was aimed at making the purchase of EVs more lucrative (the so-called bonus-malus system) (Power Circle, n.db).

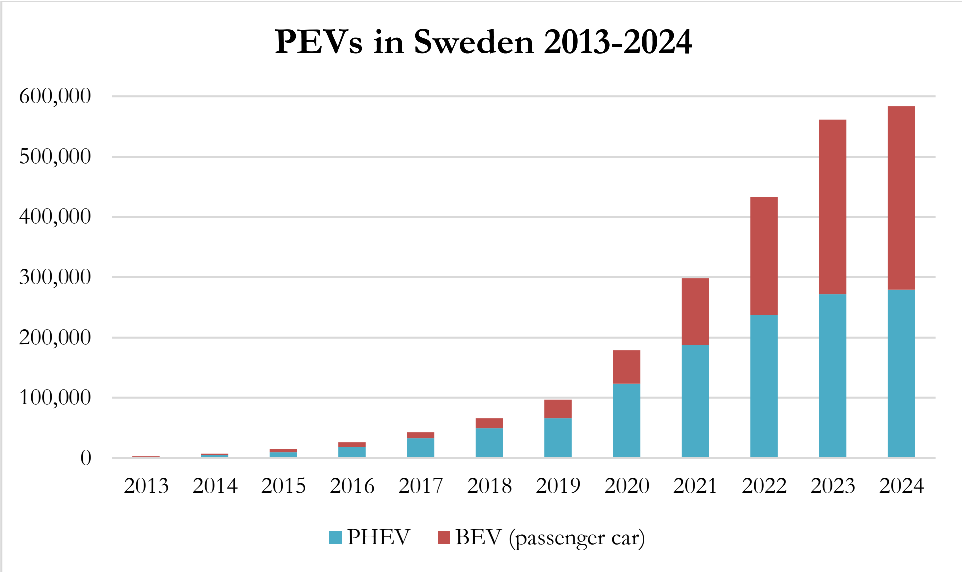

Figure 1, Number of PHEV and BEV (passenger car) (Power Circle, n.d) [1].

An important change to achieve electrification in the transport sector is the availability of charging stations. Today there are 34 529 charging points and over 4 717 charging stations. The charging stations are divided into two categories: public and private. The public stations refer to those available at, for example, shopping centers and parking lots and accessible to anyone, while private stations are used by a household or workers depending on where they are placed (Energimyndigheten, 2024). For instance, the region of Stockholm has approximately 20 PEVs/charging point whereas the region of Skåne has 12 PEVs/charging point (Stockholms Handelskammare 2020, p.13).

2.3 Relevant policies and attempts to lower CO2 emissions

In an attempt to adjust to the climate targets according to the Paris Agreement Sweden imposed the National Climate Framework effective in 2018. Consisting of three parts, it aims to ensure the climate policies are pursued in order to achieve the National Climate Targets for 2030, 2040 and 2045 (Naturvårdsverket, 2024). In each milestone the road sector is within the focus area to achieve the target of net-zero GHG emissions. Currently, it represents 90% of emissions from Sweden's domestic transports. Between 2022 and 2023 the emissions from the transportation sector did in fact decrease and the vehicle fleet became more energy efficient. However, this benefit was offset by increased traffic activity suggesting that there is a low probability that Sweden will achieve its goals for 2030 with the current level of emissions (Lindblom & Selin 2024, p. 2, 12).

Among policies, taxes, and incentives to reduce the CO2 emissions related to the road sector, there are two prominent ones. First, the emission-reduction obligation that since 2018 requires petrol and diesel suppliers to increase biofuel blending. For instance, in 2018 the suppliers were obliged to reduce emissions from diesel and gasoline by 19.3% and 2.6% respectively (International Energy

[1] Graph based on data from Power Circle (n.da), which showed different types of PEVs (PHEV, MC, BEV passenger car and light truck).

Agency [IEA] 2019, p. 44). A study by Konjunkturinstitutet explored the expected CO2 emissions (CO2e) with a 6% reduction obligation and showed that by 2030 the emissions will be approximately 12 (MTon CO2e) (Carlén & Hill 2023, p. 10-12). Nevertheless, the required level of emission reduction needed to reach the National Climate Targets for 2030 is dependent on other factors in the transport sector e.g., the growth in the EV market (IEA 2019, p. 44).

Besides implementing the obligation, a bonus-malus system was implemented at the same time. The purpose of the system was to incentivize drivers to switch to low-emission vehicles. It was divided in two parts, a bonus for vehicles with low CO2 emissions and a penalty (malus) for vehicles that release high CO2 emissions. The vehicles covered by the bonus-malus system were light-duty and of model 2018 or later. For BEV owners this meant that they were qualified to 100% of the bonus i.e., 60 000 SEK (IEA 2019, p. 45). The bonus was later increased to 70 000 SEK in 2021 (Transportstyrelsen, 2021). Regarding 'malus', all vehicles were subject to at least 360 SEK/year and light petrol and diesel vehicles were subject to higher taxes for the first three years. Vehicles powered by gas or ethanol were exempted from raised taxes. However, in 2022 the government decided to withdraw the bonus-malus system which has slowed down the electrification pace (Report for Sweden on climate policies and measures and on projections, 2023, p. 33) (Naturvårdsverket 2023, p.119).

2.4 Electricity prices

Electricity distribution is the base of a functioning electricity market - which Svenska kraftnät (Svk) ensures. An important aspect of electricity distribution is the balancing of production and consumption of electricity that is carried out by balance responsibility parties (BRP). Svk takes an overall responsibility to provide reserves when electricity producers cannot match consumption which they only find out an hour before the operational moment when the BRPs have sent their plan to Svk (Svensk kraftnät, 2023a).

As the Swedish market is part of a larger market covering the Nordics and Baltics where power grids are connected, the supply and demand imbalances create bottlenecks (Svensk kraftnät, 2023b). To reflect that, the Nordic-Baltic electricity market is divided into fifteen bidding areas where Sweden has four (SE1-SE4) and each area faces a particular price that reflects supply and demand (Holmberg & Tangerås 2023, p. 13-14). For instance, SE3 needs more electricity than available while in SE2 the production of electricity exceeds the demand therefore, the producer in SE2 sells its excess on the market. While SE2 sells the electricity to the lower price, the price that households in SE3 face is higher due to demand being higher than supply, which explains why some bidding areas have higher prices (Svensk kraftnät, 2022).

A key aspect of ensuring balance is the ability to trade electricity, which is done at a marketplace, Nord Pool. The trading between electricity providers and producers occurs on the "day before market", normally referred to as spot market, where the prices are set per hour and delivery on the next day (Svensk kraftnät, n.d). The driver of the market prices is demand and supply. Producers establish the supply curve by proposing hourly spot prices while providers establish the demand curve by quoting how much electricity they would like to purchase hourly and at preferred price. The final price that a geographical area faces at a certain hour the next day is where supply meets demand; that is when the bids from producers are compounded and similarly for providers. Consequently, households face the spot prices and a markup.

Households can, based on their needs, sign different types of contracts for electricity with providers such as fixed and flexible contracts. A fixed contract gives the household the ability to pay the electricity bills with the same rate over the time of the subscription with the electricity provider whereas the flexible contract is based on the monthly average rate on the spot market including a markup (Energimarknadsinspektionen, 2024).

2.5 Fuel prices

In addition to being a strong indicator of the global economy, crude oil is widely used across society. As gasoline and diesel are produced through refined crude oil, their prices are driven by fluctuations in crude oil prices (Lundbeck & Nordin, 2022). In the short term, this means that fuel prices are influenced by regional economic development and availability (Preem, n.d).

There are a few suppliers in Sweden that provide fuel to Swedish customers where 97 percent of the volume of fuel sold in 2021 was by Circle K, OK-Q8, Preem and St1. There are two types of prices that the suppliers display; recommended and pump price, the first is given as general information and the latter the actual prices that customers face in gas stations. Pump prices are a result of, among other things, competition (Konkurrensverket 2023, p. 6, 8)(Lundbeck & Nordin, 2022). What can be said about fuel prices is that price variations are lowest in 'high price' areas and greatest in 'low price' areas. For example, Stockholm and sparsely populated areas have high prices yet the price variation between those areas are low due to the types of competition they face. Although the variations are perceived to be large between geographical areas in Sweden, the differences are relatively small (Konkurrensverket 2013, p.111-112).

3. Literature Review

The following literature review systematically examines the existing research on factors influencing electric vehicle adoption, focusing specifically on the role of fuel prices and electricity prices. This section concludes with expanding on our contribution to this body of literature, having identified gaps.

3.1 Fuel prices

The present literature on conventional vehicles suggests that fuel costs are a critical consideration for prospective vehicle purchasers, but no specific conclusions have been drawn for their relationship with EVs. In fact, it has been found that consumers' demand for high fuel-economy vehicles, i.e., vehicles that have the most efficient fuel consumption, increase with rising gasoline prices (Gallagher & Muehlegger, 2011). Alongside prices, it is suggested that providing consumers with accessible information about fuel costs may be a way to encourage higher PHEV market penetration. Consumers are mindful of financial implications, and in the absence of said information, would not consider the financial benefits of PHEVs. (Eppstein et al., 2011). Moreover, with high fuel prices the operating cost of EVs is less than the cost of conventional vehicles in Europe which will affect the total cost of ownership for EVs (Automotive World UK, 2010, cited in Zubaryeva et al., 2012). Gallagher and Muehlegger (2011) also concluded that annual savings of $100 on fuel increases HEV sales by 13%.

Another critical aspect of the relationship between gasoline prices and EV adoption is that trip costs for conventional vehicles increase with increasing gasoline prices. This consequently induces positive effects on EV adoption. It has found that gasoline prices are significantly correlated with electricity prices, which results in an indirect negative effect of high gasoline prices on EV adoption (Soltani-Sobh et al., 2017). However, their data has a correlation of 0.414 between gasoline and electricity prices, negating their findings in part. Their findings round back to those of Diamond (2009) whose research also led to seeing increased gasoline prices as a strong driver of HEV adoption. To postulate this better, Prud'homme and Koning (2012) showed EVs would become an economical choice to consumers once oil prices reach $470/barrel, assuming there would be cost reductions for manufacturing an EV.

Extending this analysis, Tseng et al. (2013) showed the effect that different gasoline prices have on the total cost of ownership of different electric cars compared to a conventional car in the United States. They find that when the price of gasoline rises from $4.5/gallon to $6/gallon, it results in the difference in ownership between an HEV and CV decreasing from 5% to 2%. Similar results also appear with BEV, which decreases by 2%. If federal tax credits are included in the calculations, the difference between the vehicles generally decreases further. For example, under a price scenario of $6/gallon, it means that PHEV35 costs decrease from 25% to 11% while for BEVs from 16% to 2%. That difference indicates that tax creates resistance for price fluctuations (Tseng et al., 2013).

There exists another study where the relationship between financial incentives and EV adoption are studied across 30 countries in 2012 (Sierzchula et al., 2014). In the results, Sierzchula et al. (2014) found that gasoline prices could not predict a country's EV market share. This contrasts previous studies by Beresteanu & Li, 2011; Diamond, 2009; and Gallagher & Muehlegger, 2011, where a strong relationship between HEV adoption and fuel prices was observed. Sierzchula et al. (2014) suggest the difference may be due to the fact that the previous studies have been done on a different scale (several countries over one year compared to one country over several years) and thereby captured more variation in the data. In order to be able to clarify the difference that has arisen between the various studies, the author believes that more research is required.

The disagreement among extant literature on the relationship between gasoline prices and EV adoption calls for a comprehensive empirical analysis in a setting with an established electricity market structure experiencing variation in prices to allow for reliable analysis. The Swedish context provides this opportunity, whilst enabling for potential controls and/or secondary predictors such as electricity prices, enhancing the robustness of our conclusions.

3.2 Electricity prices

Literature about the relationship between electricity prices and EV adoption is broadly inconclusive, context-dependent, and focuses on relative differences to other factors. Hidrue et al. (2011), in a stated preference study using a national survey in the United States, argue that cost savings associated with EVs are not uniform across regions, with the variation stemming from considerable discrepancies in electricity and gasoline prices. In tandem, Diamond (2009) finds that per-mile operational cost advantages of EVs are heavily influenced by two key factors, namely regulated electricity prices and gasoline taxes. Furthermore, studies like Beresteanu & Li (2011) argue that such factors must not be considered without also considering environmental and economic externalities. Mauritzen (2023), through a study done on electricity price differences in Norway, also concludes that electricity price is a significant predictor of EV adoption.

Given EV operational cost considerations, consumer sensitivity to electricity prices also appears to be lower compared to gasoline prices. Studies by Leard et al. (2021) and Gillingham et al. (2021) support this notion in the context of conventional vehicles. Consumers have a well-established understanding of the direct relationship between gasoline prices and driving habits. In contrast, the link between electricity use, home charging, and electricity bills for EVs might be less clear (Egbue & Long, 2012). This lack of transparency could limit the perceived cost advantage of EVs for some consumers.

Several studies have employed spatial discontinuity approaches to isolate the impact of electricity prices on EV adoption. These studies leverage the existence of clear price differences between neighbouring utility service territories (Bushnell et al., 2022). By comparing geographically close areas with contrasting electricity prices, but likely similar unobserved factors (e.g., commuting patterns, charging infrastructure density), we can isolate the effect of electricity prices on EV adoption, an approach we adopt later in the paper. Bushnell et al. (2022), focusing on the United States, also found that gasoline prices have a stronger influence on EV adoption compared to electricity prices, and that the relative impact of gasoline prices can be four to six times greater than that of electricity prices.

The existing literature on electricity prices and EV adoption paints a complex picture. While studies mentioned above acknowledge the potential cost savings associated with EVs due to lower electricity costs compared to gasoline, the overall impact on adoption remains inconclusive, for a variety of factors including consumer sensitivity to electricity prices and the perception of electricity as a "fuel". Our study leverages Sweden's electricity market structure with four bidding zones to conduct a more focused analysis, isolating the impact of electricity price variations on EV adoption decisions.

3.3 Other factors

Another critical control when studying EV adoption is charging infrastructure, where previous research (Mersky et al. 2016; Narassimhan & Johnson, 2018) fails to reach a clear consensus, with a risk of reverse causality as well. In fact, Mersky et al. (2016) pointed out that the causal direction between EV sales and charging infrastructure is unclear, since the government could be expected to provide more charging stations in regions where there was a higher estimated EV demand.

Consumer preferences and perceptions also play a critical role. Range anxiety, the fear of running out of battery power before reaching a charging station, remains a significant concern for potential EV buyers (Bakker & Trip, 2013). Moreover, the perception of electricity as a "fuel" in EVs is also influenced by factors such as charging infrastructure availability and the overall sustainability of electric mobility. Research by Funke et al. (2019) indicated that consumers' perceptions of EVs are shaped not only by the energy source but also by the supporting infrastructure and convenience of charging. This is further supported by a study by Axsen and Kurani (2013), who emphasized that consumers tend to view electricity as a secondary energy carrier rather than a primary fuel source for transportation.

Income emerged as another significant factor featured in the majority of literature addressing these subjects. Münzel et al. (2019) find that for European countries, disposable income plays a major role for EV sales share. Hidrue et al. (2011) and Mandys (2021) found that a high level of education and environmentalism are associated with positive effects on EV adoption. Soltani-Sobh et al. (2017) found that income per capita is positive and significant, representing an increase of EV share with increased income growth.

Following previous literature and rationale, income and population are the controls of choice for our model. Charging infrastructure, for a lack of foundation, reliable cross-sectional data, and a risk of reverse causality, has been excluded.

3.4 Contribution

Previous research investigating energy prices and EV adoption often employs panel data with fixed effects models (Bushnell, 2022; Sierzchula et al., 2014; Narassimhan & Johnson, 2018). Building on this approach, this study utilizes panel data and fixed effects to examine the relationship between electricity prices, gasoline prices, and EV adoption in Sweden. We address shortcomings identified in prior literature, such as the high correlation between gasoline and electricity prices (Soltani-Sobh et al., 2017) and conflicting findings on the impact of energy prices (Sierzchula et al., 2014; Beresteanu & Li, 2011; Diamond, 2009; Gallagher & Muehlegger, 2011).

To our knowledge, no prior study has comprehensively examined the combined effects of temporal and cross-sectional variations in diesel, petrol, and electricity prices across all Swedish municipalities. While existing research explores local policies and incentives in Sweden, none definitively establish whether energy price variations substantially predict EV adoption.

To further investigate this relationship and contribute to the existing literature, we employ an approach similar to a quasi-discontinuity design to analyze the spatial heterogeneity in the effect of electricity prices on EV adoption. By examining how a municipality's proximity to the electricity bidding zone influences the relationship between electricity prices and EV adoption, we can determine whether the impact of price differences varies for municipalities bordering the zones compared to those further away. This approach allows for a more nuanced understanding of the research question and the influence of other factors in the relationship between energy prices and EV adoption in Sweden.

4. Data

Our empirical methodology capitalises on both temporal and cross-sectional variations in diesel and petrol prices, as well as electricity contract prices, across various municipalities in Sweden. This section offers a comprehensive overview of the dataset and variables integral to our primary panel analysis. It outlines the dimensions of data, selection of variables, and sources of data.

4.1 Panel data

The panel data employed in this study consists of two primary dimensions: entity and time. The entity dimension is represented by all 290 Swedish municipalities (Statistikmyndigheten [SCB], n.a), while the time dimension was carefully selected to effectively address the research question. Initially, the period from 2013 to 2019 was considered an appropriate timeframe to analyse BEV registrations and price fluctuations in electricity and fuel prices. However, upon further examination, it was determined that low BEV adoption in Sweden and a lack of significant variation in electricity price contracts across Sweden's four bidding zones during the 2013-2019 period makes it unsuitable, (Figure 2, a). To address this issue, extending the data to more recent years was considered (Figure 2, c). However, the externalities associated with the COVID-19 pandemic in 2020 posed a risk of confounding the desired variation. As a result, the years 2021-2023 were selected, effectively excluding the majority of the pandemic's impact on Sweden while also ensuring the availability of data for a wide range of variables, as data for the current year was limited.

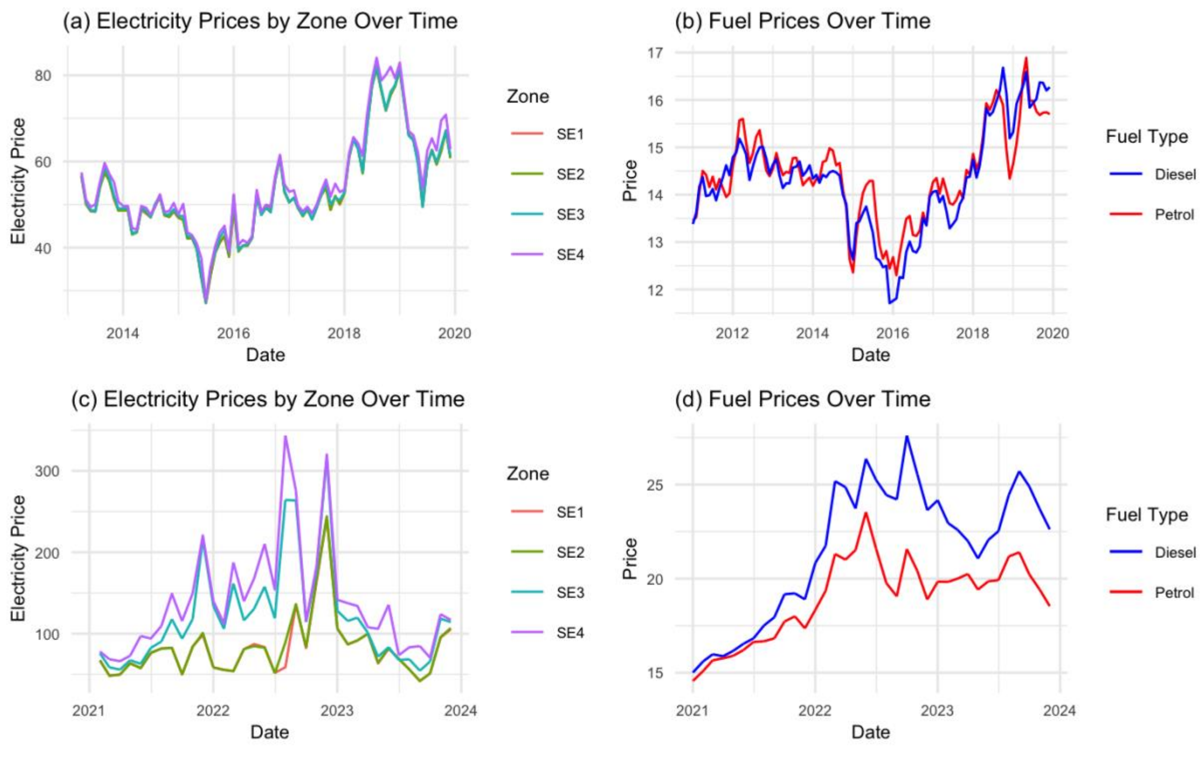

Figure 2, Shows fuel and electricity prices over time. (a) Covers electricity prices 2013-2020 whereas (c) covers 2021-2024. (b) Looks at diesel and petrol prices during 2011-2020 while (d) covers the years 2021-2024 (Authors' own).

4.2 Electricity prices

Sweden's Bureau of Statistics database, SCB, was used to gather data on electricity prices across zones SE1 to SE4 (Figure 3) and months. The available data included four types of electricity contracts: standard price agreement, flexible price agreement, one-year agreement, two-year agreement, and three-year agreement. Additionally, four types of customers were considered:

dwelling/flat, one or two dwelling houses without heating, one or two dwelling houses with heating, and large dwelling houses. Ideally, the distribution of customers across municipalities according to contract and customer type would be available, allowing for a weighted average to minimise variation loss. However, much of this data is unavailable.
Fortunately, a primitive measure of the distribution of contracts and customer types is available, indicating that dwelling/flat customers are the most numerous and flexible price agreements are the most common type of contract. Based on this rationale, our regressions primarily use electricity price contracts for dwelling/flat customers, and flexible price agreement prices are considered on a month-on-month basis. Although a common approach in papers about electricity prices in Sweden is to use Nord Pool and spot prices, we firmly believe that the contract price approach better suits our purpose of dealing with household electricity consumption used to charge BEVs.

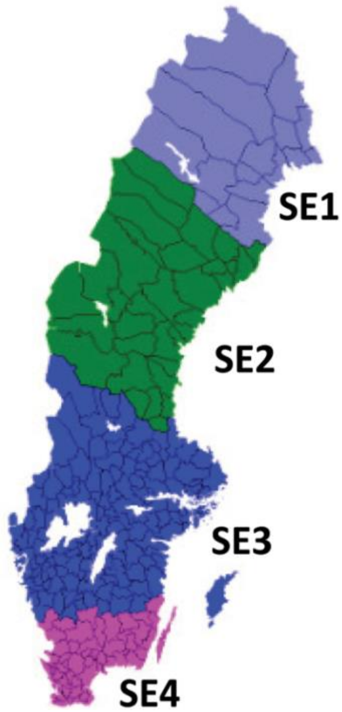

Figure 3, Division of Sweden's bidding zones, from SE1 to SE4 (Hansson et al., 2017).

4.3 Fuel prices

Fuel prices are reported by multiple sources in Sweden, but none at the municipality level since providers had negligible price differences with their pump offerings nationwide. Moreover, the price differences between the top providers that dominate Sweden's fuel market: OKQ8, Q-Star, Preem, Circle K, and Ingo (Drivkraft Sverige, 2023), are also negligible, as confirmed by analysing individual datasets for prices offered to private customers from these providers, where available. Consequently, we sought a verified source of nationwide price data that varies only along the time dimension. Initially, the EU weekly oil bulletin was considered as a source of fuel price data. However, it presented prices per gallon and had exchange rate complications, leading to its exclusion. Ultimately, Drivkraft Sverige, member organisation for the country's fuel and biofuels industry, provided monthly price deviations for petrol and diesel (Figure 2, d). This data varies only over the time dimension and was assumed to be consistent across Sweden, given the aforementioned negligible price differences among providers. Drivkraft Sverige specified that they calculate prices as "Sales prices for fuel at manned stations. Prices are calculated as unweighted averages of daily national list prices for OKQ8, Preem and Circle K." (Drivkraft Sverige, 2024).

4.4 Controls

The main control variables we aimed to include were income and population. As mentioned in the literature review, papers also use a proxy to measure BEV charging infrastructure. However, as mentioned earlier, this is a controversial variable, and cross-sectional data by entity and time is scarce. Therefore, we obtained a measure of income from SCB, which provides each municipality's mean and median incomes over the years. Since the rest of the variables were on a monthly basis, the yearly income data had to be disaggregated over months. The data constituted median and mean income for 20-64 year olds across municipalities and years. Since both measures are highly correlated, only median income was considered in the specifications, chosen purely for its superior explanatory power,based on adjusted R-squared performance compared to income mean.

Population, the other control variable of interest, was obtained with an added layer of granularity instead of using total population metrics for each municipality. We acquired data in ten-year intervals, ranging from 20-29 years old to 60-69 years old (CTEK, n.d), representing the main buyers of BEVs. This approach adds nuance to our regressions through additional variation. The population data was sourced from SCB, covering municipalities and months.

The following table (Table 1) is a comprehensive list detailing all variables:

No.	Variable	Unit	Source	Notes
1	New BEVs registered	Absolute	SCB (SCB, 2024a)	-
2	Electricity prices	Average price, CSEK per kWh	SCB (SCB, 2024b)	Chosen highest percentage for both types, flexible contracts and dwellings
3	Fuel prices	SEK per liter	Drivkraft (Drivkraft Sverige, 2024)	Diesel, Petrol prices, disaggregated from national to municipality level
4	Income (median)	SEK (thousands)	SCB (SCB, 2024c)	Disaggregated from yearly to monthly
5	Population (10 year intervals)	Absolute	SCB (SCB, 2024d)	-

Table 1, Comprehensive list detailing all variables, their sources, and potential notes.

Further, summary statistics for all variables have been attached for better understanding of the data in the Appendix (A). A normalised graph that isolates price trends for electricity and fuel prices follows in the Appendix (B) as well to help visualise price trends.

5. Methodology

This section covers how fixed effects function in our area of study, the variation they control for, the additional controls employed, and the remaining variation being explained by our model. We further mention the specifications used to address our research question.

5.1 Fixed effects model

This study leverages panel data analysis with fixed effects to address biases stemming from unobserved factors that might influence BEV adoption rates across Swedish municipalities. The choice of a panel structure allows us to incorporate both temporal and cross-sectional variation in the data. This permits us to exploit the within-municipality variation of fuel and electricity prices while effectively controlling for unobserved regional characteristics that could potentially be correlated with BEV adoption.

We use entity fixed effects that account for time-invariant factors, specific to each municipality, that independently influence BEV adoption rates. This accounts for a lot of variation that induces noise, including but not limited to regional economic conditions, infrastructure development related to charging stations, local government policies and even local cultural attitudes towards BEVs or sustainability broadly. This ensures that our estimates capture the isolated impact of energy price variations on BEV adoption, independent of the pre-existing regional differences between Swedish municipalities.

In addition, we also use time fixed effects to account for national-level factors that simultaneously affect all municipalities in Sweden within a specific month. These control for factors such as changing national economic conditions and national policy changes regarding BEVs. By using time fixed effects in our model, we ensure our estimates isolate the impact of energy price variations over time on BEV adoption within each municipality.

On having controlled for entity and time fixed effects, this study also incorporates income median and population as additional control variables. While municipality fixed effects account for average regional economic conditions, using income median allows us to control for variations in consumer purchasing power within a municipality over time. Wealthier regions with higher income medians could hypothetically have a larger proportion of their population being able to afford BEVs, independent of the economic conditions of the municipality. Similarly, population size influences BEV adoption rates beyond regional differences captured by fixed effects. Densely populated areas might have a higher demand for BEVs due to factors like better access to public charging infrastructure, skewing the effect we are trying to isolate.

The remaining variation in our model in theory captures the residual variation in BEV registrations that can be attributed to within-region fluctuations in fuel and electricity prices over time. This variation isolates the dynamic changes in energy prices unique to each municipality and how these fluctuations influence BEV adoption within that region. In essence, our model leverages this residual variation, net of the controlled effects, to draw robust conclusions on the relationship between energy price fluctuations and BEV uptake in Sweden.

Our panel data fixed effects model excludes the price of BEVs as an explanatory variable for two key reasons. Firstly, fixed effects control for all time-invariant unobserved factors at the municipality level. Since BEV prices are unlikely to drastically change within a municipality over the time frame of the study, this approach inherently accounts for some of the price variation. Secondly, including income median helps capture the affordability of BEVs, which is often closely linked to their price. While not a perfect substitute, it indirectly controls for some of the price effect on BEV adoption decisions.

The baseline fixed effects specification is given by:

$$EV\_reg_{it} = \beta_0 + \beta_1 Fuel\_price_{it} + \beta_2 Electricity\_price_{it} + Controls_{it} + \alpha_i + \lambda_t + \epsilon_{it} \quad (1)$$

$$EV\_proportion_{it} = \beta_0 + \beta_1 Fuel\_price_{it} + \beta_2 Electricity\_price_{it} + Controls_{it} + \alpha_i + \lambda_t + \epsilon_{it} \quad (2)$$

EV_reg_{it}, represents the absolute number of new BEVs registered for a given municipality for a given month. In specification (2), EV_reg_{it} is replaced by $EV\_proportion_{it}$, which accounts for potential variations in the overall car market. While absolute numbers (EV_reg_{it}) might be influenced by general economic trends, the proportion of new BEVs ($EV\_proportion_{it}$) isolates the impact of price fluctuations on consumer preferences for BEVs, independent of broader market fluctuations. We include both dependent variables for robustness and consistency.

This study considers effects in the context of both petrol and diesel. Accordingly, both specifications (1) and (2), account for petrol and diesel, represented by the variable $Fuel\_price_{it}$. These have been reported in the results tables to indicate robustness of results, regardless of the fuel in question.

Furthermore, to assess the potential cost savings associated with BEV adoption, we calculated additional variables representing cost differentials for each month. This process involved using the average mileage values for both conventional fuel cars (Transport Analysis, 2024) and BEVs (Electric Vehicle Database, n.d), yielding figures of 0.12 litres per kilometre and 0.2 kilowatt-hours per kilometre, respectively. These standardised mileage values were then used to calculate the cost per kilometre, using the given fuel and electricity prices for a month. To determine the difference in the price of fuel and electricity, a comparative evaluation was conducted. The results demonstrated positive savings consistently across all months, indicating the cost-effectiveness of electricity in contrast to conventional fuel.

$$EV\_reg_{it} = \beta_0 + \beta_1 Savings\_over\_Diesel + Controls_{it} + \alpha_i + \lambda_t + \epsilon_{it} \quad (3)$$

$$EV\_proportion_{it} = \beta_0 + \beta_1 Savings\_over\_Diesel + Controls_{it} + \alpha_i + \lambda_t + \epsilon_{it} \quad (4)$$

Further, regressions involving the constituent cost per km for all energy prices were run to ensure prices for respective energies normalised per kilometre are consistent with previous results, reported in the Appendix (C).

Given specifications (1) and (2), the coefficients of interest are those of β_1 and β_2. We should expect to see varying levels of significance between them, but an expected positive sign on the fuel coefficient given the substitution effect and a negative sign on the electricity coefficients given the laws of demand. Given specifications (3) and (4), we should expect to see a positive coefficient, since an increased amount of operational savings should logically lead to an increased amount of BEV adoption.

Building on the panel structure with fixed effects, we now focus on the impact of spatial variation in electricity prices on BEV adoption at the municipal level. Specifically, we investigate whether electricity price differences across adjacent borders influence adoption rates, emphasising the role of border proximity. This approach allows us to isolate the effect of residing near a different bidding zone, providing insights into the significance of spatial price heterogeneity for BEV adoption decisions.

5.2 Effect of border proximity

Previous research has employed border discontinuity designs to investigate the impact of electricity price differences on BEV adoption across regions (Bushnell et al. 2022). Drawing inspiration from this approach, we introduce another specification focusing on the border between bidding zones SE2 and SE3 in Sweden, where the most significant price discrepancies are observed (Figure 2).

Due to the presence of multiple dummy variables, including the panel structure in the model led to multicollinearity issues. To address this, we disregard the panel structure and treat the data as a pooled cross-section. The specification is an ordinary least squares (OLS) regression with fixed effects, accounting for municipalities in close proximity to the SE2-SE3 border.

The model is specified as follows:

$$EV\_proportion = \beta_0 + \beta_1 (Zonedummy * Price\_differences) + \beta_2 (Price\_differences * Treatment) + \beta_3\, Price\_differences + \beta_4\, Zonedummy + \alpha_{municipality} + \alpha_{date} + \epsilon \quad (5)$$

Where *Zonedummy* is a binary variable indicating whether a municipality is in the SE3 price zone or SE2 price zone. *Price_differences* is the difference in electricity prices between the zones SE3 and SE2. "Treatment" is a binary variable indicating whether a municipality shares a border with the other price zone or not. Fuel prices are not included as a control variable in this model. Since they are uniform across municipalities within our study timeframe, time fixed effects already account for their variation. The following is a table explaining dummy encoding:

Topic	**Variable**	**Description**
Bidding zones	Zonedummy	0 if in SE2 1 if in SE3
Municipality sharing border with other bidding zone	Treatment	0 it does not share a border 1 it does share a border

Table 2, Description of what the dummy variables used in the equations mean.

Interaction terms (*Zonedummy* * *Price_differences*) and (*Price_differences* * *Treatment*) examine how bidding zones and border proximity moderate the effect of price differences on BEV adoption. Municipality and date fixed effects control for unobserved heterogeneity.

β_2 in specification (5) is our key coefficient. A negative and significant β_2 suggests weaker impacts of price differences for municipalities bordering a different price zone. While not a formal discontinuity design, this specification aims to capture the potential moderating effect of border proximity on the relationship between electricity price differences and BEV adoption within municipalities.

6. Results

The result tables reported in the following section correspond to the specifications labelled previously.

Given specification (1) reported in Table 3 and Table 4, β_1 indicates the change in the number of new BEVs registered per municipality per month for every unit increase in given fuel price, holding all other variables constant. β_2 indicates the change in the number of new BEVs registered per municipality per month for every unit increase in electricity price, holding all other variables constant.

Table 3: New BEVs registered regressed on Petrol and Electricity prices

	Dependent variable:	
	Number of new BEVs registered	
	Without Controls	With Controls
	(1)	(2)
Petrol	10.045***	14.383***
	(2.609)	(3.698)
Electricity Prices	-0.006	-0.012
	(0.015)	(0.015)
Municipality Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
R^2	0.045	0.252
Adjusted R^2	0.014	0.214
F Statistic	13.339*** (df = 35; 9859)	73.722*** (df = 29; 6351)

Note: Specification (1) reported for Petrol. Controls include income median and population for people aged 20-70. Standard errors are clustered at the municipality level, and are heteroskedasticity robust.

*p<0.1; **p<0.05; ***p<0.01

Table 4: New BEVs registered regressed on Diesel and Electricity prices

	Dependent variable:	
	Number of new BEVs registered	
	Without Controls	With Controls
	(1)	(2)
Diesel	4.929***	6.789***
	(1.281)	(1.745)
Electricity Prices	-0.006	-0.012
	(0.015)	(0.015)
Municipality Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
R^2	0.045	0.252
Adjusted R^2	0.014	0.214
F Statistic	13.339*** (df = 35; 9859)	73.722*** (df = 29; 6351)

Note: Specification (1) reported for Diesel. Controls include income median and population for people aged 20-70. Standard errors are clustered at the municipality level, and are heteroskedasticity robust.

*p<0.1; **p<0.05; ***p<0.01

The coefficient for both fuels, petrol and diesel is positive and statistically significant in both models. This implies that a one-unit increase in fuel prices is associated with an increase of 14.383 in the absolute number of new BEVs registered per month for petrol and 6.789 for diesel. This positive coefficient implies that higher fuel prices are correlated with higher BEV registrations, indicating a substitution effect between conventional fuel vehicles and BEVs. Notably, the coefficient for electricity prices is negative in both models and not statistically significant. Without statistical significance, we cannot draw a definitive conclusion about the relationship between electricity prices and new BEV registrations. However, the negative sign suggests that, if significant, higher electricity prices would be associated with lower BEV registrations.

The adjusted R-squared increases in both models when controls are included. This increase in the adjusted suggests that the additional variables contribute to explaining the variation in new BEV registrations.

Given specification (2) reported in Table 5 and Table 6, β_1 denotes the change in the proportion of new BEVs registered per municipality per month for every unit increase in a given fuel price, holding all other variables constant. β_2 shows the change in the proportion of new BEVs registered per municipality per month for every unit increase in electricity price, while controlling for other factors.

Table 5: Proportion of BEVs regressed on Petrol and Electricity prices

	Dependent variable:	
	Proportion of BEVs within newly registered vehicles	
	Without Controls	With Controls
	(1)	(2)
Petrol	0.127***	0.173***
	(0.004)	(0.008)
Electricity Prices	-0.00002	-0.0001
	(0.0001)	(0.0001)
Municipality Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
R^2	0.400	0.495
Adjusted R^2	0.380	0.469
F Statistic	184.047*** (df = 35; 9675)	211.232*** (df = 29; 6256)

Note: Specification (2) reported for Petrol. Controls include income median and population for people aged 20-70. Standard errors are clustered at the municipality level, and are heteroskedasticity robust.

*p<0.1; **p<0.05; ***p<0.01

Table 6: Proportion of BEVs regressed on Diesel and Electricity prices

	Dependent variable:	
	Proportion of BEVs within newly registered vehicles	
	Without Controls	With Controls
	(1)	(2)
Diesel	0.062***	0.082***
	(0.002)	(0.005)
Electricity Prices	-0.00002	-0.0001
	(0.0001)	(0.0001)
Municipality Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
R^2	0.400	0.495
Adjusted R^2	0.380	0.469
F Statistic	184.047*** (df = 35; 9675)	211.232*** (df = 29; 6256)

Note: Specification (2) reported for Diesel. Controls include income median and population for people aged 20-70. Standard errors are clustered at the municipality level, and are heteroskedasticity robust.

*p<0.1; **p<0.05; ***p<0.01

The coefficient for both fuels, petrol and diesel is positive and statistically significant in both models. This implies that a one-unit increase in fuel prices is associated with an increase of 0.173 in the proportion of BEVs within newly registered vehicles per month for petrol and 0.082 for diesel. This positive coefficient suggests that higher fuel prices are correlated with a higher proportion of BEVs within newly registered vehicles, indicating a substitution effect between traditional fuel vehicles and BEVs. Contrastingly, the coefficient for electricity prices is negative in both models, but it is not statistically significant. Without statistical significance, we cannot draw a definitive conclusion about the relationship between electricity prices and the proportion of BEVs within newly registered vehicles. However, the negative sign suggests that, if significant, higher electricity prices would be associated with a lower proportion of BEVs within newly registered vehicles.

The adjusted R-squared increases in both models when controls are included. This increase in the adjusted suggests that the additional variables contribute to explaining the variation in the proportion of BEVs within newly registered vehicles.

Table 7: New BEVs registered regressed on Savings per km for Diesel

	Dependent variable:	
	Number of new BEVs registered	
	Without Controls	With Controls
	(1)	(2)
Savings per km, Electricity over Diesel	2.832	6.088
	(15.111)	(11.107)
Municipality Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
R^2	0.045	0.252
Adjusted R^2	0.014	0.214
F Statistic	13.339*** (df = 35; 9859)	73.722*** (df = 29; 6351)
Note: Specification (3) reported for Diesel. Controls include income median and population for people aged 20-70. Standard errors are clustered at the municipality level, and are heteroskedasticity robust.		*p<0.1; **p<0.05; ***p<0.01

Table 8: Proportion of BEVs regressed on Savings per km for Diesel

	Dependent variable:	
	Proportion of BEVs within newly registered vehicles	
	Without Controls	With Controls
	(1)	(2)
Savings per km, Electricity over Diesel	0.009	0.073
	(0.045)	(0.047)
Municipality Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
R^2	0.400	0.495
Adjusted R^2	0.380	0.469
F Statistic	184.047*** (df = 35; 9675)	211.232*** (df = 29; 6256)
Note: Specification (4) reported for Diesel. Controls include income median and population for people aged 20-70. Standard errors are clustered at the municipality level, and are heteroskedasticity robust.		*p<0.1; **p<0.05; ***p<0.01

Table 7 and Table 8 reporting results for specifications (3) and (4) respectively show an insignificant estimate for cost savings per kilometre, regardless of the choice of dependent variable. This indicates that our data does not show support for operational cost savings offered by a BEV being a significant predictor for BEV adoption.

Table 9 : Similar to a discontinuity approach with interaction terms

	Dependent variable:
	Proportion of BEVs within newly registered vehicles
Zone Dummy	0.133***
	(0.040)
Electricity Difference	-0.324***
	(0.012)
Treatment	0.001
	(0.040)
Zone Dummy * Electricity Difference	-0.0002
	(0.0001)
Electricity Difference * Treatment	-0.0004**
	(0.0002)
Municipality Fixed Effects	Yes
Time Fixed Effects	Yes
R^2	0.494
Adjusted R^2	0.476
Residual Std. Error	0.166 (df = 7104)
F Statistic	27.939*** (df = 248; 7104)

Note: Reported for specification (5) where treatment is coded 1 for municipalities sharing borders with bidding zones, zone dummy is coded 1 for SE3 and 0 for SE2. Pooled OLS model. Interaction term between zone dummy and treatment not included since irrelevant.

*p<0.1; **p<0.05; ***p<0.01

In Table 9, the results for specification (5), the coefficient for electricity difference is negative and significant. This indicates an average of 0.324 decrease in proportion of newly registered vehicles that are BEVs given a unit increase in electricity price difference between bidding zone SE3 and SE2. The interaction term between electricity difference and treatment (for border proximity) is negative and significant. This suggests that the effect of electricity price difference on BEV adoption is weaker for municipalities bordering a lower-priced zone.

Robustness checks for multicollinearity and heteroskedasticity have been run. A correlation matrix has been reported in the Appendix (D). Given the Breusch-Pagan test, the p value for each reported model was less than 0.001, indicating no issues with heteroskedasticity.

7. Discussion

Tables (3)-(6) consistently show that coefficients on fuel prices are positive and significant. This is grounded in economic rationale, suggestive of the substitution effect. In our case, specifically, this implies that rising fuel prices incentivizes consumers to choose BEVs as a substitute for gasoline-powered vehicles. These results are in consonance with existing literature that analyses the relationship between fuel prices and BEV sales (Beresteanu & Li, 2011; Springel, 2021; Muehlegger & Rapson, 2022). Our findings in the Swedish context align with existing research suggesting that fuel taxation policies can be an effective tool to incentivize BEV adoption (Münzel et al., 2019; Yan & Eskeland, 2018). All in all, high fuel prices, constituently high fuel taxation policies, have helped drive EV sales in Sweden (Barisa, 2022) and could continue doing so according to our results.

Tables (3)-(6) also show the coefficients on electricity prices are negative and insignificant. The negative sign is also grounded in economic rationale, since price increases for a complementary good (electricity prices as fuel) lead to a decrease in demand for BEVs. Unfortunately, the insignificance prevents us from making concrete conclusions. The insignificance does, however, raise interesting questions about the relevance and perception of electricity prices when it comes to BEV uptake and purchase decisions. In line with existing literature, consumers might not have fully internalised the operating costs associated with owning a BEV (Hagman et al., 2016). Existing literature also suggests that upfront purchase costs often dominate consumer decision rationale, while ongoing expenses, such as electricity, may be considered to a smaller degree (Dumortier et al., 2015). Consumers may struggle to perceive "electricity" as a fuel the same way they view traditional fuels like gasoline, possibly leading to a misinterpretation of the true total cost of ownership for EVs (Krause et al., 2013; Sierzchula et al., 2014).

Interestingly, this insignificance could also be attributed to existing Swedish policies that promote affordable BEV charging. Since electricity price fluctuations, in part, get mitigated for consumers, it leads to a lower weight of importance given to electricity prices when purchasing a BEV. The Swedish government's policies only lower upfront and fixed costs for BEV adoption, but local municipality programs offering free charging for hybrid and electric vehicles, to an extent, also explain the insignificance of electricity prices as a variable cost for EV adoption.

The insignificance of the cost savings variable reported in Table 7 and Table 8 is interesting and in tandem with our previous results of the electricity prices being insignificant. The insignificance can, in part, be attributed to the phenomenon of rational inattention (Sallee, 2014). The theory suggests that consumers make decisions focusing on the most relevant information, in our case the upfront purchase costs, while strategically neglecting less crucial details, such as electricity prices, as the cognitive costs of gathering and processing this information may outweigh the potential benefits.

This is supported by existing literature which finds that consumers tend to focus more on upfront costs and gasoline prices when evaluating BEVs, potentially neglecting the long-term impact of electricity costs (Dumortier et al., 2015). She et al. (2017) also suggest that consumers might simplify their decision-making by overlooking the complexities of electricity tariffs and charging infrastructure.

The interaction term between border proximity and electricity price difference is found to be negative and significant at the 5% level in Table 9. This novel finding suggests that a higher electricity price difference between adjacent bidding zones in Sweden has a negative impact on the proportion of newly registered BEVs in municipalities that share a border with the adjacent bidding zone. This result aligns with existing literature that emphasizes the role of energy prices in shaping consumer behavior and technology adoption across regions (Sierzchula et al., 2014; Mersky et al., 2016). However, the specific focus on cross-border price differences and their impact on municipalities adds a new dimension to the discussion, highlighting the importance of considering spatial heterogeneity in electricity prices when analyzing EV adoption patterns.

The policy implications of this finding warrant further exploration. Policymakers could consider measures to mitigate the impact of electricity price differences across regions to ensure a more even distribution of EVs. This could involve targeted subsidies, incentives, or infrastructure investments in areas with higher electricity prices to make EVs more attractive to consumers (Münzel et al., 2019). Moreover, efforts to harmonize electricity prices across bidding zones or to develop more localized renewable energy systems could help reduce price disparities and promote a more equitable transition to electric mobility.

All in all, this study contributes to the existing body of literature by reinforcing the significance of fuel prices as a predictor in BEV adoption, providing further evidence to claims made by existing literature (Beresteanu & Li, 2011; Springel, 2021; Muehlegger & Rapson, 2022), while also differing from some previous results (Sierzchula et al., 2014). It also contributes to existing literature by showing the lack of significance of electricity prices as a factor influencing BEV adoption, differing from existing papers (Mauritzen, 2023). Further, it adopts a novel approach yielding results that open new avenues of research for spatial heterogeneity of BEV adoption given difference of electricity prices between adjacent price bidding zones.

8. Conclusion

This study investigates the impact of fuel prices, electricity prices, and cost savings on the adoption of EVs in Sweden, while also exploring the role of cross-border electricity price differences. The findings consistently demonstrate that rising fuel prices have a positive and significant effect on EV adoption, supporting the substitution effect and highlighting the effectiveness of fuel taxation policies in incentivizing consumers to choose EVs over gasoline-powered vehicles. However, the insignificance of electricity prices and cost savings raises questions about the perception and relevance of these factors in consumer decision-making, suggesting that upfront costs may dominate the evaluation process, while operational costs like electricity are given less weight. The study also uncovers a novel finding regarding the negative and significant impact of cross-border electricity price differences on EV adoption in municipalities bordering adjacent bidding zones, emphasizing the importance of considering spatial heterogeneity in electricity prices when analyzing EV adoption patterns.

8.1 Limitations

This study tries to be as robust as possible but has certain limitations that should be acknowledged. First, the model does not include lagged variables for electricity and fuel prices, which may better capture the impact of expected future prices on consumers' purchase decisions. There is likely a lag between price changes and consumer behaviour, as people's decisions may be motivated by both current and expectation of future prices. Second, the dependent variable used in the analysis is newly registered BEVs, which may not perfectly coincide with the actual purchase date due to the potential gap between buying a BEV and registering it. This lag could potentially introduce some bias in the results. Third, the model does not explicitly and completely control for the price of EVs themselves as mentioned earlier, which is an influential factor in consumers' decision-making process. Finally, the study does not completely account for the availability and density of charging infrastructure for reasons mentioned earlier. Including these variables in future research could provide a more comprehensive understanding of the factors driving EV adoption in Sweden. The lack of inclusion of lags, once again, roots from the fact that no particular period of lag could be motivated more than others. The choice of a one month lag over a twelve month lag would be unfounded and hence compromise the results. We do encourage future research to adopt some variation of it, maybe in a dynamic model. However, this thesis does not use lagged values for any variable, given the lack of foundation of choice for a particular lag value.

Despite these limitations, the panel data fixed effects model employed in this study, using municipality-level data over several months, provides valuable insights into the relationship between energy prices and EV adoption.

8.2 Further research

In addition to resolving the limitations, future research should focus on expanding the scope of this study by incorporating a wider range of variables that may influence EV adoption, such as consumer preferences, demographic factors, and the availability of charging infrastructure. Future studies could employ more advanced econometric techniques, such as spatial autoregressive models or dynamic panel data analysis, to better capture the spatial and temporal aspects of EV adoption. Moreover, conducting comparative studies across different countries or regions with varying policy landscapes and market conditions could help identify best practices and inform the design of more effective EV promotion strategies. Finally, qualitative methods, such as surveys or interviews with various stakeholders could shed light on the underlying motivations, perceptions, and barriers related to EV adoption, uncovering driving forces beyond the quantitative findings of this study and providing a more comprehensive understanding of the factors influencing the transition to electric mobility not only in Sweden, but beyond.

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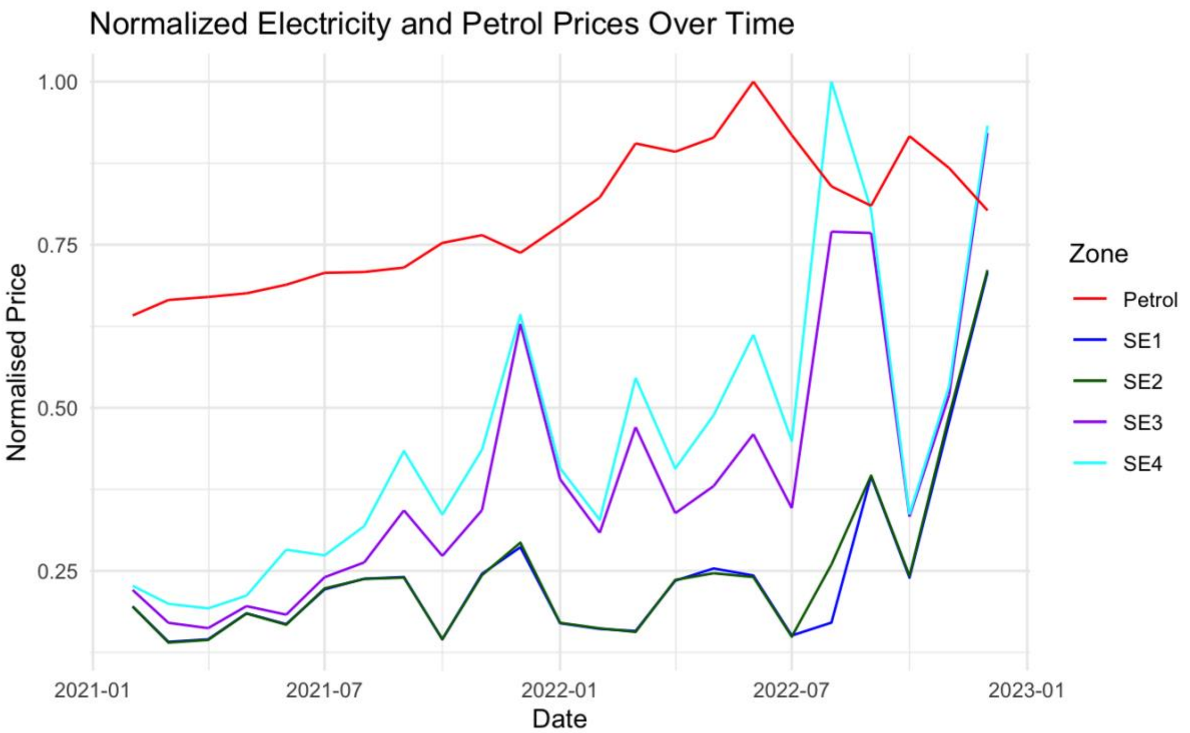
Appendix

Appendix A: Summary statistics

Variable	Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
Elpris_flat (SEK/kWh)	41.7	71.7	106.2	117.6	134.1	343.4
Petrol (SEK/liter)	14.56	17.23	19.42	18.96	20.29	23.54
Diesel (SEK/liter)	15.01	18.66	22.56	21.58	24.44	27.6
Electricity_reg	0	2	6	25.47	19	2979
Prop_electricity	0	0.2273	0.4	0.3926	0.5454	1

Note: The summary statistics table reflects the extent of variation in fuel and electricity prices, observed in the difference between their minimum and maximums. These summary statistics are across all months and municipalities.

Appendix B: Normalised electricity and petrol prices over time



Note: Since units for both of these energy prices are different, a normalised graph (max = 1) to visualise variation and price trends better (Authors' own).

Appendix C: Results for fuel prices and electricity prices per km

Absolute number of EVs regressed on price of petrol and electricity per km

	Dependent variable:	
	Absolute number of EVs	
	Without Controls	With Controls
	(1)	(2)
Petrol per km	83.710***	119.860***
	(11.425)	(15.953)
Electricity per km	-2.832	-6.088
	(15.111)	(11.107)
Municipality Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
R^2	0.045	0.252
Adjusted R^2	0.014	0.214
F Statistic	13.339*** (df = 35; 9859)	73.722*** (df = 29; 6351)

Note: Results align with specification (1) *p**p***p<0.01

Absolute number of EVs regressed on price of diesel and electricity per km

	Dependent variable:	
	Absolute number of EVs	
	Without Controls	With Controls
	(1)	(2)
Diesel per km	41.079***	56.572***
	(5.607)	(7.529)
Electricity per km	-2.832	-6.088
	(15.111)	(11.107)
Municipality Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
R^2	0.045	0.252
Adjusted R^2	0.014	0.214
F Statistic	13.339*** (df = 35; 9859)	73.722*** (df = 29; 6351)

Note: Results align with specification (1) *p**p***p<0.01

Appendix D: Correlation matrix

	Electricity price	Petrol	Diesel	Number of BEVs	Proportion of BEVs
Electricity price	1	.	.	.	.
Petrol	.20	1	.	.	.
Diesel	.34	.95	1	.	.
Number of BEVs	.06	.05	.06	1	.
Proportion of BEVs	.29	.40	.46	.14	1