Fuel for thought: an empirical analysis of fuel prices and fuel economy preferences in vehicle sales

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Executive Summary

This study examines the extent to which fuel price fluctuations influence consumer choices over vehicle fuel economy in Great Britain (GB) between February 2020 and June 2024. The period captures volatility in global energy markets, persistent inflationary pressures and disruption within the automotive industry, providing a unique setting to assess consumer responsiveness to price signals. The analysis exploits a dataset of more than seven million new vehicle registrations, aggregated to a monthly panel across 205 local authorities. Vehicle fuel consumption, derived from manufacturer-reported CO_2 *emissions, serves as a proxy for fuel economy. The main explanatory variable is a three-month lagged average of petrol prices, designed to reflect short-term trends salient to consumers at the point of purchase. Several economic approaches were evaluated, including fixed effects and pooled ordinary least squares (OLS) models. The preferred specification employs a pooled OLS framework with year controls, enabling exploration of both temporal dynamics and regional heterogeneity. Results demonstrate a consistent, statistically significant relationship between fuel prices and vehicle fuel consumption. The estimated elasticity of -0.25 suggests that a 10% increase in petrol prices reduces the average fuel consumption of newly registered vehicles by 2.5%. This indicates that consumers do adjust vehicle choice in the short run in response to fuel price changes, albeit imperfectly. Interactions with regional mileage levels were insignificant, potentially reflecting data aggregation or unobserved local variation. The findings provide robust GB specific evidence that consumer vehicle choices remain sensitive to fuel price fluctuations, contributing to broader literature on fuel economy demand.*

AI Statement

I acknowledge the use of generative AI in literature search and code development in this paper. However, the work reported remains my own.

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1. Introduction and motivations

1.1. Background and context

In recent years, the global economic landscape has been significantly shaped by inflation, with the United Kingdom (UK) experiencing a "cost of living crisis", which has directly impacted consumer behaviour. Francis-Devine (2024) reports that although, inflation is falling, the cumulative effect of the UK's high inflation from 2021 to 2024 means that households face a much higher cost of living than in 2021.

Fuel price fluctuations have been a defining economic challenge over this period and were a significant factor driving the high inflation. The COVID-19 pandemic initially led to a sharp drop in fuel prices due to decreased demand. However, the post-pandemic economic recovery, coupled with geopolitical instability – including the Russia-Ukraine war – caused significant fuel price volatility.

The automotive industry has also been affected by significant change due to regulatory changes, technological development as well as wider economic disruptions. Vehicle manufacturers have been subject to a global semiconductor shortage. Modern vehicles rely heavily on these semiconductors; hence vehicle production has been affected by their rising cost and limited availability – with some manufacturers closing production lines or removing vehicle features (Burkacky, et al., 2022).

Meanwhile, the decarbonisation agenda has driven significant industrial change. In 2023, the UK government announced the Zero Emission Vehicle (ZEV) mandate, introduced in 2024, which requires manufacturers to sell an increasing percentage of ZEVs each year. Another key regulatory framework shaping vehicle efficiency are the Euro emissions standards, introduced to limit vehicle pollutant emissions and has progressively tightened over time. The current euro standard (Euro 6) has been in place since 2014, and regulators are developing the Euro 7 which was initially scheduled to come into effect in 2025. The government also influences consumer behaviour in the industry – vehicle excise duty ('road tax') depends on a vehicle's carbon emissions – with BEVs historically exempt from this tax.

1.2. Economic theory

1.2.1. Consumer Demand Theory

Consumer demand theory says that rational consumers seek to maximise their utility subject to their budget constraints i.e., it is assumed that consumers maximise value for money when making purchasing decisions (Mas-Colell, et al., 1995). Fuel and vehicles are complementary goods and hence a rise in fuel prices, increases the total cost of vehicle ownership. Fuel costs, while not a direct factor in the upfront cost of a vehicle, are the largest cost component of vehicle ownership (after the purchase price) (Yurday, 2025). Rational consumers should take adequate consideration of the fuel economy of a vehicle when making a purchasing decision (Hagman, et al., 2017). However, research into consumer behaviour finds evidence to suggest this doesn't hold true, and that most consumers do not consider (or sufficiently consider) fuel prices in vehicle purchasing decisions (Turrentine & Kurani, 2007), further discussed in 2.1 below.

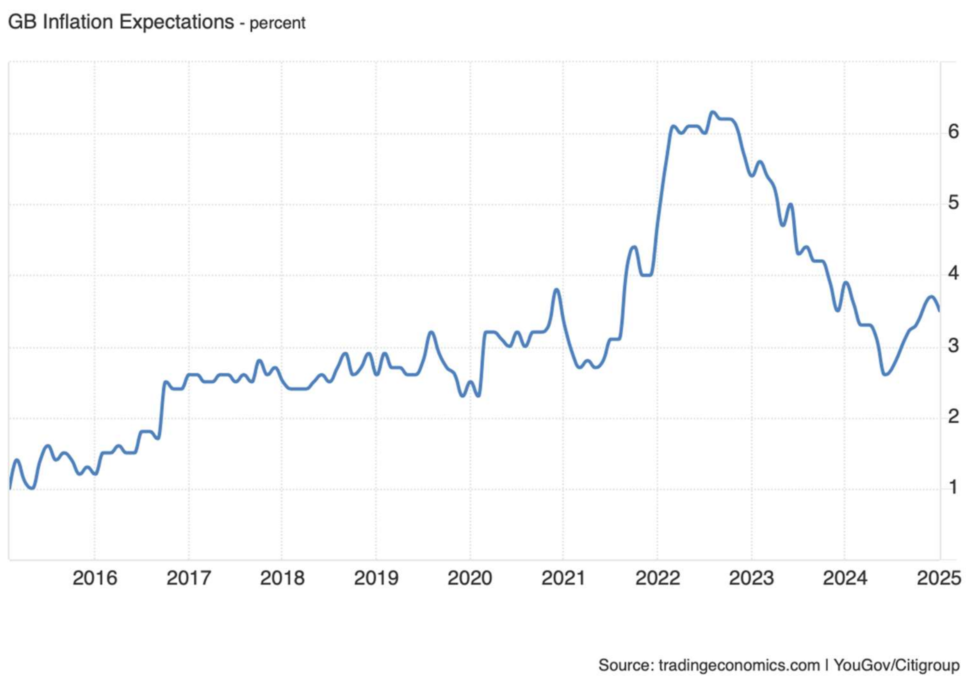
1.2.2. Price elasticity and substitution

Fuel is considered a normal good and its demand therefore is likely to have a positive relationship with income (Havranek & Kokes, 2014). Its price elasticity of demand, however, is more complex and significantly depends on the context. Fuel is often a necessity for people which could distort price response and make it inelastic in the short run as people adjust. Vehicle purchases (the focus of this paper), however, are a longer-term decision and therefore might allow for efficiency adjustments in response to price changes.

1.2.3. Inflation Expectations

Traditional theory assumes inflation expectations to be anchored and therefore relatively insensitive to short term fluctuations in inflation (Bonatti, et al., 2022). Hence, it could be reasonable to assume that during stable periods vehicle purchasing decisions aren't affected by fluctuations in fuel prices, given consumers' expectation for inflation to adjust. The UK's target inflation rate is 2% and therefore inflation expectation is usually anchored around this level. *Figure 1* (TradingEconomics, 2025), illustrates that inflation expectations have been volatile and have significantly increased in recent years, suggesting that consumers expect this high inflation to be persistent. The recent disruption, discussed above, coupled with sticky inflation could indicate that fuel price fluctuations are expected to sustain and therefore have greater salience in decision making.

Figure 1 Inflation Expectations in Great Britain, 2015-2025



1.3. Hypothesis and relevance of this paper

Given recent disruption in fuel markets and sustained inflationary pressures across the economy, consumers may respond by prioritising long-term financial savings – e.g., through the purchase of more fuel-efficient vehicles. Rising fuel prices increase the cost of ownership, making fuel economy a more salient factor in purchasing decisions. Existing research suggests that over a vehicle's lifetime, improved fuel economy can yield substantial savings, especially during periods of elevated fuel prices (Fulton, 2013).

The hypothesis of this study is that recent increases in fuel prices shift consumer preferences toward vehicles with better fuel economy[1]. While consumers may also respond to rising fuel costs through behavioural changes such as altering driving habits or switching to alternative transport modes (e.g., public transport, cycling), these adjustments fall outside the scope of this paper. Instead, the focus is on vehicle purchasing decisions, offering insights into whether price-based signals effectively encourage consumers to purchase vehicles with better fuel economy.

This question is particularly relevant in the context of the global agenda to reduce carbon emissions and transition to more sustainable transport. Domestic emissions from cars and taxis in 2021 was around 13% of the UK's total CO_2 emissions (Department for Transport, 2023). Since vehicle fuel consumption is directly linked to CO_2 emissions, consumer choices around fuel economy have significant environmental implications. Lowering fuel consumption reduces carbon per kilometre travelled, contributing to national and international climate targets. Understanding how fuel price signals influence these purchasing decisions can therefore inform the design of policies that aim to accelerate decarbonisation in the transport sector. If higher fuel prices increase uptake fuel-efficient vehicles this would support the case for price-based environmental policies, such as fuel duties or carbon pricing, as effective tools for reducing emissions.

2. Literature Review

An investigation of existing research reveals a nuanced relationship between fuel prices and consumer vehicle choices, shaped by behavioural biases, policy environments, and market characteristics. Despite its significance for decarbonisation, this relationship remains underexplored in the UK.

2.1. Observed behavioural bias

Antithetical to economic theory of rational consumers, several studies into consumer behaviour finds that consumers tend to undervalue fuel economy and discount future fuel savings . This undervaluation is likely a result of bounded rational behaviour hence representing a market failure where consumers are experiencing a welfare loss (Greene, et al., 2005). Consumers do not fully acknowledge or internalise the long-term benefits of fuel-efficient vehicles - Gillingham, et al., (2019) find evidence that consumers are willing to pay significantly less upfront for fuel economy than the equivalent discounted future fuel cost, suggesting a discrepancy in consumer valuation of long-term savings. This myopia could imply consumers may not shift preferences towards more fuel-efficient vehicles as strongly as rational economic theory would predict. This implies that fuel price changes could have, if any, a delayed or muted impact on vehicle sales.

[1] This study focuses on vehicle fuel economy (distance travelled per unit of fuel) and although technically distinct from fuel efficiency (energy output relative to energy input), the terms are often used interchangeably. Throughout this text, references to "more fuel-efficient vehicles" specifically refer to vehicles with better fuel economy.

Busse, et al., (2013) challenge this position. Whilst recognising that consumers do not respond fully rationally, they find minimal evidence of myopia in the United States (US) vehicle markets - consumers do adjust to fuel price changes by purchasing more efficient vehicles – albeit with a six-month lag. This aligns with Wozny and Allcott (2014), who identified "sticky information" in vehicle markets finding that the pricing of fuel-efficient vehicles responded to changes in fuel prices with up to a six-month delay. Additionally, both studies note strong correlation between used car prices, vehicle fuel economy and fuel prices – this motivates the inclusion of a variable to consider and control for used car prices (Wozny & Allcott, 2014); (Busse, et al., 2013).

2.2. Cross price elasticity of fuel economy demand

Empirical studies estimating the elasticity of fuel economy demand (with respect to fuel prices) reveal mixed results, shaped by methodological choices as well as regional and temporal contexts. A summary of estimated elasticities is presented in

Figure 2.

Figure 2 Estimates documented in the literature of the elasticity of fuel economy with respect to fuel prices

Reference	**Findings**	**Elasticity**	**Observation period**	**Geography**
(Rivers & Schaufele, 2016)	1% increase in fuel price increased fuel economy by 0.08%	0.08	2000 - 2010	Canada
(Atkinson & Halvorsen, 1984)	1% increase in fuel price increased fuel economy by 1.38%	1.38	1978	United States
(Alberini, et al., 2022)	1% increase in fuel price reduced fuel consumption by 0.31%	0.31	2004 - 2019	Germany
(Bonilla, 2009)	Demand for fuel economy was price inelastic in the short and long run	inelastic	1978 - 2005	United Kingdom
(Kilier & Linn, 2010)	1% increase in fuel price increased fuel economy by 0.12%	0.12	1978 - 2007	United States
(Fridstrøm & Østli, 2021)	1% increase in fuel price reduces CO2 emissions (can proxy for fuel consumption) by 0.19%	0.19	2002 - 2016	Norway
(Small & Dender, 2007)	1% increase in fuel price increased fuel economy by 0.04%	0.04	1966 - 2001	United States
(Gillingham, 2011)	In the medium term, a 1% increase in gas price elicits a 0.09% improvement in fuel economy	0.09	2001 - 2009	California

(Li, et al., 2012)	1% increase in fuel price increased fuel economy by 0.13%	0.13	1966 - 2008	United States

Elasticity estimates vary significantly across countries. In Canada, Rivers & Schaufele (2016) find a 10% increase in fuel price leads to a 0.8% improvement in new vehicle fuel economy. They also report that urban consumers are more responsive than rural ones, likely due to better access to alternatives. Similarly, Fridstrøm & Østli (2021) find a 10% increase in fuel price reduces average CO_2 emissions (a proxy for fuel consumption) by 1.9% in Norway. By contrast, Bonilla (2009) reports that fuel economy demand in the UK is price inelastic, suggesting limited responsiveness historically.

Differences in modelling strategies also shape reported elasticities. Fixed effects models dominate the literature (e.g., Kilier & Linn, 2010; Leard et al., 2019), controlling for unobserved vehicle or region-specific traits. Other approaches, like hedonic pricing (Atkinson & Halvorsen, 1984) or nested logit models (Fridstrøm & Østli, 2021), offer finer decompositions of consumer preferences. Atkinson & Halvorsen (1984) find very high elasticity (1.38) in the US, attributing this to demand shifts away from traditional styling towards fuel efficiency during periods of high fuel prices.

Most of these studies focus on short-run adjustments in consumer behaviour, capturing immediate changes in vehicle choice rather than longer-term shifts in travel behaviour or fleet composition. Leard et al. (2019) estimate, in the short run, that a $1 increase in fuel price raises household fuel economy by 0.39 mpg. They argue that responsiveness varies by consumer type and is stronger among households than institutional buyers. Other studies (e.g., Gillingham, 2011; Small & Dender, 2007) suggest that short-run elasticities are relatively low, increasing over longer horizons as consumers internalise fuel costs more fully.

This paper adds to the literature by estimating short-run responsiveness in Great Britain (GB) during a period of exceptional fuel price volatility and economic uncertainty. Compared to prior work, it offers a GB-specific elasticity estimate, using a large dataset and focusing on fuel economy as stated at the point of vehicle registration.

2.3. Inflation expectations and fuel price salience

Inflation expectations play a pivotal role in shaping long-term purchasing decisions. While traditional models assume expectations are anchored

(Bonatti, et al., 2022) (at around 2% in the UK), recent shocks have destabilised this. Kilian & Zhou (2022) estimated that nominal gasoline price spikes explain 42% of household inflation expectations, suggesting that fuel costs are a salient driver of economic sentiment. This suggests that consumers may adjust their economic expectations and potentially their purchasing behaviour, such as vehicle choices, in response to fuel price volatility. The paper's findings on the time-varying impact of gasoline price shocks suggest that consumer preferences for fuel economy may not be constant but instead fluctuate with changes in fuel prices. This can help explain shifts in vehicle sales patterns in response to fuel price changes over time.

During the 2021–2024 UK cost-of-living crisis, inflation expectations surged (*Figure 1*), likely amplifying consumer attention to fuel economy as a hedge against future price volatility. Prolonged inflation can risk de-anchoring of inflation expectations – this makes consumers more attentive to inflation and can make inflation and inflation expectations more persistent (International Monetary Fund, 2023). For vehicle markets, this implies that consumers may prioritise fuel economy more during periods of perceived persistent inflation. If UK consumers treat recent fuel volatility as structural (not transitory), demand for efficient vehicles could rise faster and more significantly than historically estimated. During the empirical estimation an inclusion of year dummies would isolate any year-specific macroeconomic impacts.

2.4. Policy interventions and market imperfections

As noted earlier, many studies attempt to assess whether government intervention in fuel prices is justified to reduce fuel consumption and support broader decarbonisation objectives. Leard, et al., (2019) conclude that fuel- based taxes have limited effectiveness in influencing fuel economy. Comparably, Kilier & Linn (2019) argue that while fuel prices moderately influence consumer behaviour, regulatory measures (e.g. Euro standards) may produce stronger and more consistent improvements in fleet-wide efficiency. In contrast, Li, et al., (2012) find that even modest fuel price increases can elicit meaningful changes in consumer preferences – for example, a $0.05 increase in gasoline prices is associated with a 0.19% increase in mpg – arguing that fuel taxes might be more effective than previously thought. Likewise, Atkinson & Halvorsen (1984) provide evidence that market-driven fuel price changes can be as influential as regulatory interventions, highlighting the long-term potential for price-based mechanisms to guide consumer preferences toward energy-efficient vehicles.

Government policies such as the ZEV mandate and CO_2 based regulations are designed to influence vehicle adoption. This study adds to the wider evidence base by providing insights into how fuel price fluctuations affect vehicle choices in GB. A key question in the literature is whether behavioural responses to tax-induced price changes differ from those triggered by market-driven fluctuations. Findings on this remain mixed, Rivers & Schaufele (2016) report that consumers are significantly more responsive to tax changes, whereas Anderson et al. (2013) find no difference. These contrasting results highlight the importance of further context-specific research, particularly in the UK, where fuel prices are already high by international standards.

2.5. Heterogeneity in responses

A consistent finding across the literature is that consumer responsiveness to fuel price fluctuations if far from uniform. Instead, it varies significantly by consumer type, regional context and vehicle characteristics. Rivers & Schaufele (2016) for instance, find that urban consumers in Canada exhibit stronger behavioural response to fuel price changes than their regional counterparts – likely due to better access to fuel-efficient alternatives or public transport. Jiang & Gao (2024) find notable heterogeneity by income – fuel price responsiveness is greater in low- and middle-income cities, while high-income areas appear less sensitive – potentially due to weaker budget constraints or differing mobility needs.

Leard, et al., (2019) disaggregate by buyer type, reporting that households respond more strongly than fleet or government purchasers, whose decisions may be constrained by institutional procurement policies.

Fridstrøm & Østli (2021) use a nested logit framework to disaggregate vehicle sales, identifying differentiated elasticities across powertrains. Their analysis shows that consumers are more price-sensitive when purchasing conventional petrol vehicles compared to hybrids or BEVs. This heterogeneity poses an empirical challenge; hence any estimation strategies must be sensitive to this.

Accounting for this heterogeneity is also critical for informing targeted and effective policy design, particularly considering evolving consumer demographics and regional disparities in transport behaviour. This investigation studies regional heterogeneity explicitly through differences in average mileage across local authorities.

2.6. Other responses to fuel price changes

It is reasonable to expect that drivers exhibit different responses to fuel price increases – e.g., improve driving style to conserve fuel consumption. (Bonilla, 2009) notes that the observed driving behaviour of UK motorists suggests that on-road fuel economy is not a primary concern for many drivers. For instance, although the optimal speed for fuel economy lies between 55 and 62 mph, UK drivers often exceed these speeds. Whilst speeding has marginally decreased since that observed by Bonilla (2009), in 2023, 44% of GB car drivers exceeded the speed limit on 30mph roads compared to 45% on motorways (Department for Transport, 2024). Supporting conclusions are drawn by Alberini, et al., (2022) who examine whether German drivers respond to rising fuel prices by altering driving behaviour or reducing mileage. They find that on-road fuel economy remains largely unresponsive to fuel price changes; however, mileage reductions *are* observed among petrol vehicle drivers – but not by diesel drivers. This may be because individuals who rely heavily on their vehicles already opt for diesel, given its lower per-mile cost.

Although diesel now represents a shrinking share of new sales (illustrated below in *Figure 3*), Bonilla (2009) comments on the rapid and widespread uptake of diesel vehicles in the late 1990s to early 2000s – often referred to as the 'Diesel Boom' (RAC, 2025). Kurani & Sperling (1988) attribute this surge to expectations of cost savings. Taken together, this evidence suggests that while drivers may consider fuel costs in their overall travel decisions, these considerations appear to carry greater weight at the point of vehicle purchase than in everyday driving. Whilst this analysis does not directly control for driving style, previous studies have attempted to – Alberini, et al., (2022) aim to address this by including a vector of vehicle characteristics and assuming these characteristics reflect the driving preferences of the owner.

Overall, while existing studies consistently show a link between fuel prices and vehicle purchasing behaviour, much of the literature is derived from North America, where fuel prices are lower and vehicle preferences differ (i.e., the US has an SUV preference). Gaps remain in UK-specific evidence, particularly during periods of sustained economic volatility – an issue this study seeks to address.

3. Data and Empirical Approach

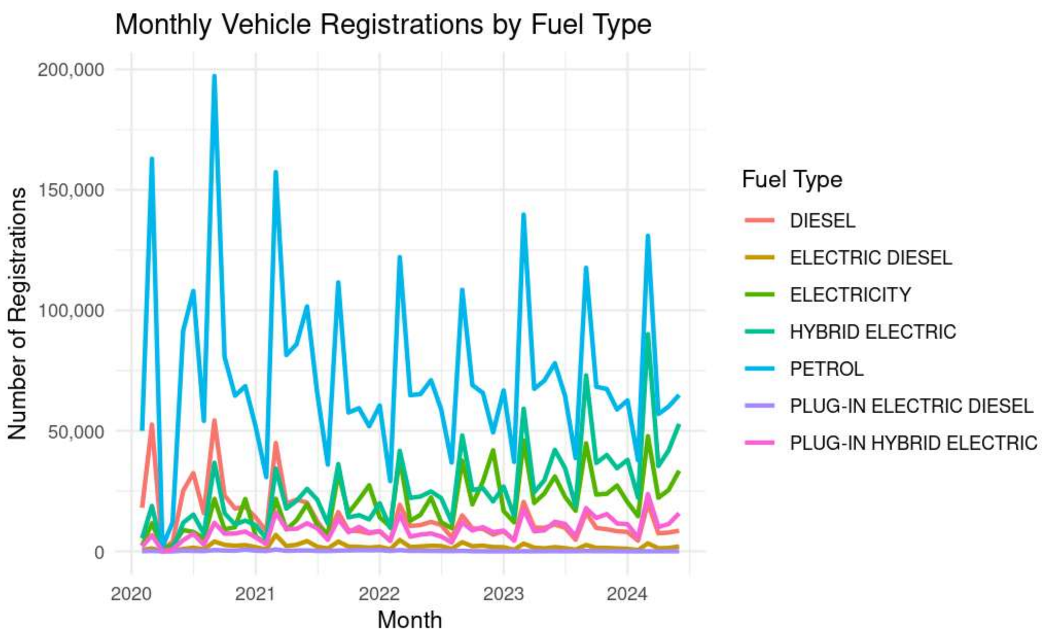
3.1. Data

The primary data source for this research project is the Driver and Vehicle Licencing Authority's (DVLA) Vehicle Registration Database, obtained through data request to the Department for Transport. The DVLA record vehicle characteristics at the date of registration (a legal requirement for all vehicles that have been bought, built, altered or imported), these characteristics include make and model of the vehicle, engine size, CO_2 emissions and location of the registered keeper. The personal nature of this data means it is subject to strict GDPR restrictions – no data was obtained for this analysis that is personal to (i.e., tax class), or could enable identification of, the registered keeper. This dataset provides a rich illustration of the types of vehicles being registered across the UK.

To keep this investigation specific and relevant, the data has been refined so that the analysis was restricted to new cars bought in GB between February 2020 and June 2024. To keep the scope to the conventional vehicle market, registrations with a body type of 'Hearse' and 'Limousine' were removed.

Figure 3 depicts registration data aggregated by month and fuel type. The spikes in March and September are expected, as new registration plates are released in these months creating an incentive to buy vehicles when the newest plates are available. The peak in September 2020 is likely the result of the relaxing of 'lockdown' restrictions causing a surge in demand – a trend also observed in the European Union (ACEA, 2020). The graph also illustrates that petrol continues to dominate the share of vehicles being bought. Finally, it is notable that no 'plug-in hybrid electric diesel' and few 'electric diesel' vehicles were registered, this is expected as most manufacturers offer hybrids as petrol vehicles.

Figure 3 Monthly vehicle registrations (Feb 2020 – June 2024)



This data was supplemented with weekly fuel price data published by the (Department for Energy Security and Net Zero, 2025), used car prices provided by (Autotrader, 2025) and annual mileage data published by the (Department for Transport, 2024). The granularity of the registration data and its analysis is unique; hence this paper provides a novel investigation into consumer response to fuel price changes.

Initially, the intention was to perform the regression analysis at the vehicle-specific level to capture the nuance of the dataset, which comprised over 7 million individual vehicle registrations. However, during model estimation, further discussed in 3.4 below, the preferred approach was to aggregate the data by local authority (LA) and month, creating a panel structure that allows for the identification of temporal and regional variation in consumer behaviour.

3.2. Variables

Figure 4 lists the variables employed in this analysis and precedes some discussion on their relevance and construction.

Figure 4 – Variable Dictionary

Name in the model	Definition	Source
mass	*Vehicle mass (kg)*	DVLA
registration_year	*Registration Year*	
is_luxury	*Luxury dummy variable*	Constructed
ln_fuel_consumption	*Estimated logarithmic fuel consumption of vehicle (litres/100km)*	Constructed
ln_lagged_petrol_price	*Logarithmic 3 month lagged petrol price at pump (pence per litre)*	Constructed
million_vehicle_miles	*Annual vehicle mileage by local authority (000,000miles)*	(Department for Transport, 2024)
average_asking_price	*Average asking price for used vehicles – across all powertrains*	(Autotrader, 2025)

The dependent variable**,** fuel consumption, serves as a proxy for a vehicle's fuel economy – lower fuel consumption implies greater fuel economy. This was constructed by converting the vehicle's assigned carbon emissions value, using this equation:

$$Fuel\ Consumption\ (L/100\ km) = \frac{CO2\ Emissions\ \left(g\,\frac{CO2}{km}\right)}{Emission\ Factor\ (kg\ CO2e/L) \times 10}$$

These emissions values are recorded in vehicle registration data and are derived from the 'World Harmonised Light Vehicle Test Procedure' (WLTP), a standardised testing protocol that simulates real-world driving conditions. While it is well recognised that WLTP results often underestimate real-world emissions and fuel consumption, vehicle manufacturers and dealers are legally required to display this data, including WLTP-based fuel consumption estimates, to consumers. Hence, it is reasonable to assume that this is the information influencing consumer decisions at the point of purchase and therefore the analysis captures the impact of fuel prices on perceived rather than actual fuel economy.

BEVs do not emit carbon and therefore don't have a CO_2 emission value, preventing the estimation of fuel consumption in the same way as other vehicles. To account for this, all BEVs were assigned a petrol-equivalent fuel consumption value based on an estimated average energy consumption figure of 19kWh/100km (Weiss, et al., 2024), then converted to L/100km (ARBA, 2024). While this approach ensures comparability with internal combustion engine (ICE) vehicles, it does not capture model-specific efficiency differences. However, since BEV registrations inherently signal improved fuel economy, this proxy allows for their inclusion in the analysis while maintaining consistency across fuel consumption measures.

The main independent variable of interest is lagged petrol price, which is constructed from DESNZ' published weekly fuel prices as a three-month rolling average of petrol prices, where *t* refers to the month of vehicle registration:

$$lagged\_petrol\_price_t = \frac{petrol\_price_{t-1} + petrol\_price_{t-2} + petrol\_price_{t-3}}{3}$$

This approach smooths short-term volatility and serves as a proxy for how consumers perceive recent price trends. Rather than reacting to transitory price shocks, consumers are assumed to base their vehicle purchasing decisions on more sustained movements in fuel costs. The use of a rolling average reflects the notion that recent petrol prices have greater cognitive salience and that individuals are more likely to respond to perceived patterns in price behaviour rather than to individual monthly fluctuations.

This empirical strategy is motivated by findings from (Wozny & Allcott, 2014), who identify delayed responses to fuel prices in vehicle markets, with evidence of a 4 – 6-month lag. Since this study focuses on shorter-term volatility, the use of a three-month lag allows for the incorporation of delayed responses while still maintaining relevance to recent market conditions.

While this study investigates the impact of 'fuel prices' on vehicle fuel economy, the analysis uses petrol prices to estimate the relationship. This is justified by the high correlation between petrol and diesel prices (0.97), indicating that they move almost identically over time. *Figure 5* illustrates this relationship, showing monthly fuel prices for both petrol and diesel over the observation period. Additionally, diesel vehicles account for only 10% of total sales in the dataset, making petrol prices a more relevant factor for consumers. Existing literature on fuel price elasticity predominantly focuses on gasoline (petrol) prices, reinforcing the relevance of this choice. Although the exclusion of diesel prices simplifies the analysis, petrol prices provide a robust and interpretable proxy for general fuel prices.

Figure 5 Monthly fuel prices by fuel type

The other variables outlined in *Figure 6* were introduced as control variables in the final model specification to improve the validity of estimates and prevent endogeneity. To isolate the impact of the fuel prices, control variables were selected by considering the literature discussed above and factors influencing a vehicle's fuel consumption.

The heterogeneity found by the existing literature, incentivised the inclusion of 'million vehicle miles' which is represents the annual mileage by LA. This variable enables an investigation into whether high-mileage areas respond differently to fuel prices than low-mileage areas. Higher mileage areas could signal a reliance on vehicles (e.g., rural areas due to a lack of alternatives) and hence consumers could be expected to be more salient to fuel price changes as fuel is likely to be a greater expense for people in these areas.

Upfront vehicle price is a significant consideration for consumers when making purchasing decisions and can influence the fuel economy of the vehicle they choose, as more fuel-efficient vehicles tend to be relatively more expensive (Alberini, et al., 2019). In the absence of actual vehicle price data, this analysis uses the average price of used vehicles sold each month as a proxy. Used vehicle prices are closely linked to overall market conditions and consumer preferences, making them a reasonable proxy for vehicle prices. By controlling for used vehicle prices, the analysis accounts for the fact that consumers may prioritise fuel economy differently depending on the affordability of the vehicle.

A dummy variable indicating whether the vehicle is luxury was constructed for the individual vehicle data and applied to vehicles with manufacturers such as *Rolls Royce, McLaren and Lamborghini* – among others[2]. This controls for the fact that these vehicles have significantly different fuel consumption patterns to standard vehicles – typically featuring larger, more powerful engines that result in high fuel consumption. Moreover, consumers purchasing luxury vehicles are likely less sensitive to fuel prices and may place greater value on

[2] The following manufacturers were considered to make luxury cars: *Porsche, Jaguar, Rolls Royce, Bentley, Aston Martin, Ferrari, Maserati, Lamborghini, Cadillac, McLaren, Bugatti, Lotus, Koenigsegg, Alpine, Dodge, Daimler*

performance or brand prestige than on fuel economy. When the data is converted to a panel, the luxury dummy becomes the proportion of luxury vehicles sold in each LA-month, rather than a simple binary indicator. Other studies, e.g., (Wozny & Allcott, 2014), exclude luxury vehicles – however find their inclusion does not change the result.

Mass of the vehicle is also incorporated as a control variable as the vehicle's weight is directly related to its fuel consumption. Heavier vehicles generally require more energy to move and therefore are expected to be less fuel-efficient than lighter vehicles, ceteris paribus.

Finally, year fixed effects are included in the model (through the inclusion of dummies), to control for unobserved, time-specific factors that could influence fuel consumption across all regions and vehicles. These may include changes in technology, environmental regulations, macroeconomic conditions, or shifts in consumer preferences that vary systematically from year to year. Since the fuel prices vary at the monthly level, there remains sufficient within-year variation to separately identify their impact on fuel consumption.

3.3. Summary statistics

Figure 6 provides descriptive statistics for both the vehicle-level and panel-level datasets considered by this analysis. Revealing that fuel prices varied between 107.26 to 182.81 pence per litre over the observation period.

Figure 6- Descriptive Statistics

Data level	Variable	Observations	Mean	Min	Max	Std Dev.
Vehicle level data	mass	*7,361,070*	*1,559.74*	*505.00*	*6,600.00*	*358.71*
	is_luxury	*7,361,070*	*0.02*	*-*	*1.00*	*0.16*
	fuel_consumption	*7,361,070*	*5.45*	*0.04*	*25.73*	*2.33*
	lagged_petrol_price	*7,361,070*	*139.61*	*107.26*	*182.81*	*19.28*
	average_asking_price	*7,361,070*	*16,236.45*	*13,600.82*	*18,119.22*	*1,652.53*
	million_vehicle_miles	*7,361,070*	*2,412.93*	*0.80*	*7,811.40*	*2,138.99*
Panel data	mass	*10,801*	*1,528.08*	*1,049.00*	*2,572.00*	*109.10*
	is_luxury	*10,801*	*0.03*	*-*	*1.00*	*0.03*
	fuel_consumption	*10,801*	*5.69*	*1.70*	*10.66*	*0.63*
	lagged_petrol_price	*10,801*	*139.54*	*107.26*	*182.81*	*19.44*
	average_asking_price	*10,801*	*16,201.50*	*13,600.82*	*18,119.22*	*1,662.38*
	million_vehicle_miles	*10,801*	*1,287.88*	*0.80*	*7,811.40*	*1,421.87*

While the vehicle-level data offers granular insight into the distribution of vehicle characteristics, aggregating to a panel level – by averaging variables within each month and LA – provides a more manageable modelling framework[3]. This approach also mitigates the influence of extreme outliers (evidenced by reduced standard deviations) and better aligns with the objective of estimating average demand responses and behavioural trends. As fuel prices and average asking prices are not vehicle specific they show consistent distributions

[3] The size of the vehicle-specific data challenged the computational power of the hardware employed.

across both datasets, while the low average values for the luxury indicator variable reflect the predominance of non-luxury vehicles in the sample.

Prior to aggregation, initial data cleaning was conducted to ensure robustness of the analysis. Outliers in fuel consumption (largely stemming from implausible CO_2 values) and vehicle mass were examined against known expectations for specific vehicle types and excluded if deemed erroneous[4]. Variables such as engine size, weight, and vehicle length, though initially considered as potential controls, were removed due to a high proportion of missing observations. These steps helped refine the dataset to reflect realistic market dynamics and enhance the reliability of the econometric results that follow.

3.4. Model Specification

The objective of this analysis is to quantify how fuel price fluctuations influence consumer preference for vehicle fuel economy in GB. Given the granularity and scale of the dataset, the empirical strategy is designed to control for temporal variation in consumer responsiveness to fuel prices and, in its preferred specification, to observe regional heterogeneity through interactions with local mileage data.

3.4.1. Model selection and functional form

Following initial data preparation, a progressive model selection process was undertaken to arrive at the preferred specification. Guided by both the data and the relevant literature, the modelling strategy began with simple specifications and was gradually expanded to incorporate additional controls, fixed effects, and panel structures. Throughout this process, model validity and performance were evaluated using diagnostic tests (including the RESET test for misspecification and Breusch-Pagan test for heteroskedasticity) and the stability of results were assessed across specifications.

Alternative functional forms were evaluated during model selection. The log-log specification was adopted as it enables direct estimation of elasticities, offering an interpretable measure of consumer responsiveness to price changes. This approach aligns with economic theory and is widely used in the literature on fuel economy demand (e.g., Rivers & Schaufele, 2016).

As such, the baseline model estimation is expressed as:

$$(1)\ \ln(fuel\_consumption_{it}) = \beta_0 + \beta_1 \ln(lagged\_petrol\_price_t) + \epsilon_i$$

As the dependent variable was constructed it may be subject to measurement error. In the absence of benchmark fuel consumption values, the analysis assumes classical measurement error – i.e., the errors are random and uncorrelated with other variables. Under this assumption, the coefficient estimates remain unbiased but may be less precise.

[4] Any fuel consumption greater value than 26l/100km and mass values of less than 500kg or greater than 7,000kg were considered errors

The baseline model was extended to include additional covariates. For instance, the number of seats was initially considered as a control but ultimately excluded due to its limited explanatory power and negative impact on model fit (reflected by a lower R^2 value). Interaction terms between fuel prices and vehicle efficiency groups were also explored but yielded unstable estimates and raised concerns regarding multicollinearity and endogeneity.

3.4.2. Estimation Strategy

Two main estimation strategies were considered to leverage the granularity of the data while balancing computational feasibility and interpretability:

i. Vehicle-level regressions using microdata, and
ii. Panel data models aggregated by LA and month.

Early models using individual vehicle registrations offered high granularity and variation but were subject to several limitations. Most notably, they prohibited the inclusion of regional or mileage-based variables that did not vary at the vehicle level. Additionally, robust clustering of standard errors at the vehicle level was computationally infeasible due to dataset size, leading to risk of inaccurate inference due to heteroskedasticity. These concerns prompted a shift to a panel framework for more flexible estimation.

To address these issues, the data was aggregated to the LA-month level, producing a balanced panel with mean values for each region (205 LAs) and month (53 observation periods). This aggregation facilitated the inclusion of regional contextual variables, mitigated the influence of extreme outliers, and enabled more policy-relevant interpretation of regional fuel price responsiveness[5].

Initial model estimations for the panel level data considered pooled OLS, fixed effects (FE) and random effects (RE) specifications. Whilst Lagrange Multiplier test indicated that random effects were preferred over pooled OLS, the Hausman test rejected the validity of RE, supporting fixed effects instead. Both the pooled OLS and FE models were taken forward as preferred specifications for the panel data.

A one-way FE model was employed to control for unobserved, time-invariant characteristics specific to each LA, such as geographic, socioeconomic, or infrastructure-related factors that might affect fuel consumption patterns. By focusing on within-region variation over time, this model removes bias from omitted, constant regional characteristics, yielding more accurate estimates of the effect of time-varying explanatory variables.

The preferred FE specification is:

$$
\begin{aligned}
(2)\ \ln(fuel\_consumption_{it}) &= \beta_1 \ln(lagged\_petrol\_price_t) \\
&+ \beta_2 avg\_asking\_price_{it} \\
&+ \beta_3 is\_luxury_{it} + \beta_4 mass_{it} + \beta_5 factor(registration\_year) + \mu_i + \epsilon_{it}
\end{aligned}
$$

[5] The effect of fuel price changes is isolated by controlling for unobserved, time-invariant differences between local authorities (e.g., geography, infrastructure, or demographic composition),

Where μ_i captures time-invariant regional effects, and the registration year is included as a factor variable to control for trends in vehicle technology and fuel economy over time.

Despite the methodological strengths of FE and popularity amongst the existing literature, it prevents the inclusion of the time-invariant regional variable million_vehicle_miles. This variable, which reflects regional driving intensity, is of interest in this research - regions with higher vehicle usage (often rural or commuter-heavy) are likely to be more sensitive to fuel price changes.

To allow for its inclusion, the preferred model adopts a pooled OLS specification with year fixed effects to control for temporal shocks. The final specification is:

$$
\begin{aligned}
(3)\ \ln(fuel\_consumption_{it}) &= \beta_0 + \beta_1 \ln(lagged\_petrol\_price_t) * million\_vehicle\_miles_i \\
&+ \beta_2 avg\_asking\_price_{it} \\
&+ \beta_3 is\_luxury_{it} + \beta_4 mass_{it} + \beta_5 factor(registration\_year) + \epsilon_{it}
\end{aligned}
$$

The inclusion of an interaction term between fuel prices and regional mileage allows for estimation of heterogeneous fuel price sensitivity across regions with differing vehicle usage intensity. This interaction is theoretically grounded: in areas where average mileage is higher, fuel costs constitute a larger share of vehicle operating expenses and are thus more salient to consumers.

To ensure valid inference, standard errors are clustered at the LA level, accounting for potential heteroskedasticity and serial correlation within clusters. Given the estimation strategy, the preferred model could suffer from bias from unobserved variables, to check robustness, results from the FE specification will also be reported – which accounts for unobserved heterogeneity.

To test the robustness of results and address heterogeneity across powertrain types, an additional model was estimated using a restricted sample of only ICE vehicles (i.e., petrol and diesel). This was motivated by the literature, e.g., (Fridstrøm & Østli, 2021), (Alberini, et al., 2022), which find that consumers respond differently to fuel prices depending on the powertrain of the vehicle. Since the adoption of Electric Vehicles (EVs) often reflects broader lifestyle factors, infrastructure readiness, or environmental values, their inclusion may obscure the specific relationship between fuel prices and fuel economy preferences[6]. The ICE-only regression, therefore, serves both as a robustness check and as a targeted investigation into fuel price responsiveness among consumers choosing between comparable technologies. This model uses the same pooled OLS framework and variable specification as the main model and is discussed alongside the main results below.

[6] EVs refer to BEVs and hybrid vehicles

4. Results

The results from the pooled OLS and FE models (reported in *Figure 7*) provide consistent evidence than consumer preferences for fuel economy in GB are responsive to changes in fuel prices.

Figure 7 Effect of petrol prices on fuel consumption

Variable		*Pooled OLS*	*Within FE*	*Pooled OLS (ICE Vehicles)*
Intercept		***5.061******	*(NA)*	*2.118****
		(0.071)		*(0.000)*
ln_lagged_petrol_price		***-0.249******	*-0.250 ****	*-0.223****
		(0.015)	*(0.011)*	*(0.047)*
million_vehicle_miles		***-0.000***		*-0.000*
		(0.000)		*(0.000)*
ln_lagged_petrol_price * million_vehicle_miles		***0.000***		*0.000*
		(0.000)		*(0.000)*
average_asking_price		***-0.000******	*-0.000****	*-0.000****
		(0.000)	*(0.000)*	*(0.000)*
is_luxury		***1.509******	*0.929****	*0.421****
		(0.143)	*(0.182)*	*(0.037)*
mass		***-0.001******	*-0.001****	*0.000****
		(0.000)	*(0.000)*	*(0.000)*
year dummy	***2021***	***0.040******	*0.036****	*0.021****
		(0.005)	*(0.005)*	*(0.002)*
	2022	***0.217******	*0.211****	*0.099****
		(0.009)	*(0.008)*	*(0.003)*
	2023	***0.205******	*0.198****	*0.082****
		(0.008)	*(0.008)*	*(0.003)*
	2024	***0.166******	*0.155****	*0.089****
		(0.008)	*(0.008)*	*(0.000)*
Number of observations		***10,812***	*10,812*	*10,812*
R-Squared		***0.51***	*0.40*	*0.68*

**** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level*
standard errors are clustered by local authority

4.1. Discussion of Results

The estimated fuel price elasticity of approximately -0.25 in both specifications demonstrates that a 1% increase in petrol prices leads to a 0.25% reduction in average fuel consumption of newly registered vehicles. This implies that consumers respond to higher fuel costs by purchasing more fuel-efficient vehicles, consistent with theoretical expectations and prior findings. The fuel price variable, constructed as a three-month rolling lag, captures short-run adjustments to recent price fluctuations rather than long-term behavioural shifts – such as transitions to public transport or changes in driving habits – which may unfold over longer horizons.

The stability of the elasticity estimate in the FE model, which controls for unobserved time-invariant heterogeneity across local authorities (e.g., persistent differences in public transit access or urban density), signifies the robustness of this relationship. While the FE approach mitigates bias from regional confounders, it necessitates the exclusion of the regional mileage variable due to collinearity with fixed effects. This trade-off motivated the retention of the pooled OLS as the primary specification, enabling exploration of regional heterogeneity through the interaction between fuel prices and mileage.

Notably, the interaction term – designed to test whether consumers in high-mileage areas exhibit stronger responsiveness to fuel prices – was statistically insignificant. This null result may reflect the limitations of aggregate regional mileage data, which fails to capture intra-regional variation in driving behaviour or infrastructure. Moreover, variance inflation factor diagnostics (VIF > 35) indicated that its inclusion introduced multicollinearity into the model (as it is derived from the main independent variable). Multicollinearity could weaken the precision of, and confidence in, estimated coefficients. However, given the robustness across the pooled OLS and FE model (which excludes the interaction) this is not perceived to be a significant limitation of this model.

While the estimated coefficient of the interaction term may still capture some degree of regional heterogeneity, the pooled estimation is ultimately naïve to behavioural and infrastructural drivers of price sensitivity that are not captured by mileage alone. This naivety was acknowledged by Rivers and Schaufele (2016) who ultimately employed a FE model as their preferred specification due to potential for bias from unobserved factors in their pooled estimation.

Other covariates offer further insight into consumer preference. Luxury vehicles are associated with 93% - 151% (FE and pooled OLS respectively) higher fuel consumption – as expected, reflecting both larger engine sizes and heavier vehicle weights. While this effect is robust across both specifications, the attenuated effect in the FE model likely accounts for unobserved brand or regional preferences that inflate the pooled estimate.

An unexpected finding arises in the coefficient on vehicle mass, which implies that heavier vehicles are, on average, more fuel-efficient – a finding countering intuition (Natural Resources Canada, 2014). One possible explanation driving this inverse relationship is the inclusion of EVs, which tend to be heavier due to battery weight but consume less energy, this hypothesis is evidenced by the ICE only specification – discussed below.

Although not central to this analysis, the coefficient on average asking price (negative and highly significant) is also unexpected - it was expected that higher vehicle prices might correlate with less concern for fuel economy. However, this relationship might be reflective of the pricing of electric and hybrid vehicles – which are typically more efficient and more expensive.

The inclusion of year fixed effects captures temporal trends in vehicle registrations and fleet composition relative to the 2020 baseline. The fuel consumption of vehicles registered in 2022 was 22% greater than 2020, with a partial recovery in 2023-2024. This possibly reflects supply chain disruptions, limited availability of efficient models, or delayed consumer responses. These patterns support the hypothesis that fuel price shocks have lagged effects on consumer behaviour, consistent with previous studies.

The ICE-only model, included for robustness, yields a fuel price elasticity of -0.22, slightly lower in magnitude than the full sample but is directionally consistent and significant at the 1% level, reinforcing the finding that consumers respond to fuel price signals by opting for vehicles with better fuel economy. The reduction in the coefficient may suggest that including EVs, which are typically more efficient and potentially more price-sensitive due to higher upfront costs and running cost considerations, strengthens the overall relationship. Interestingly, within the ICE-only sample, the mass variable exhibited a positive and significant relationship with fuel consumption, aligning more intuitively with theoretical expectations than the full model, where heavier EVs distorted this trend.

4.2. Limitations

Despite the robustness of findings across models, several limitations must be acknowledged. First, the reliance on national fuel price averages obscures local price variation that could refine elasticity estimates. Second, the absence of detailed vehicle attributes (e.g., engine size) and buyer demographics (e.g., income) may introduce omitted variable bias, though the FE model partially mitigates this by absorbing time-invariant confounders.

Third, the analysis does not consider behaviour post-registration, which could, instead, change in response to increased fuel prices (e.g., driving style, or route choice).

An additional limitation of the analysis lies in the non-continuous distribution of fuel economy across powertrain types. The dataset includes two distinct clusters: one for ICE vehicles and another for EVs. These groups differ not only in their underlying technologies but also in the behavioural drivers behind their adoption. Given the estimation strategy for the fuel consumption of BEVs, the analysis also does not consider heterogeneity in the fuel economy of BEVs. To somewhat understand the impact of this, an ICE-only specification was adopted, its results support the robustness of the main findings and highlight the importance of future research disaggregating by powertrain to refine elasticity estimates further.

Despite these limitations, the consistency of the results across both modelling strategies, its alignment with existing literature and the significance of key variables lends credibility to the findings – that consumers shift towards improved fuel economy in response to fuel price rises. The slightly larger elasticity observed here, relative to historical estimates (

Figure 2), may reflect the unique macroeconomic conditions of the study period, where inflationary pressures heightened the salience of operating costs.

4.3. Policy Implications

The empirical findings have several implications for understanding consumer behaviour in the context of transport decarbonisation. The observed elasticity (–0.25) indicates that consumers are moderately responsive to changes in fuel costs when purchasing vehicles, suggesting that fuel prices remain a salient factor in vehicle choice. The absence of strong regional heterogeneity (as measured by mileage) implies that responses are relatively consistent across areas, though unobserved local factors may still play a role. The correlation between fuel economy and vehicle price highlights the importance of affordability in shaping consumer decisions, with more efficient models often concentrated at higher price points. Finally, the increasing share of electric vehicles in new registrations suggests that the relevance of petrol price signals may decline over time, shifting the focus toward other determinants of efficiency and emissions.

5. Conclusions

This investigation, into fuel price fluctuations and consumer preference for vehicle fuel economy, finds that consumers exhibit moderate responsiveness to fuel prices: a 1% increase in petrol prices is associated with a 0.25% reduction in average fuel consumption of newly registered vehicles. This elasticity is consistent across pooled OLS and FE estimations, reinforcing the robustness of the result. The preferred model adopts a pooled approach to accommodate time-invariant regional variables, particularly annual mileage, while the FE model serves as a robustness check, controlling for unobserved regional characteristics.

Although theoretically plausible, the interaction between regional mileage and fuel prices was statistically insignificant. This likely reflects the aggregate nature of the mileage data, which may not capture household-level exposure or behavioural differences within local areas.

Several limitations must be acknowledged. The analysis does not control for vehicle-specific characteristics such as fuel type or engine size, nor does it account for buyer attributes like income or environmental preferences. While fixed effects mitigate some omitted variable bias, the pooled approach remains naïve to deeper heterogeneity in consumer behaviour. Additionally, the assumption of uniform national fuel prices may obscure regional variation in price salience.

Despite these caveats, the findings align with international literature and suggest that price-based instruments remain an effective lever for influencing vehicle purchasing decisions. The slightly higher elasticity observed here may reflect heightened fuel cost salience during the cost-of-living crisis.

Future research could benefit from disaggregating the analysis by powertrain, income, geographic unit, and from incorporating electricity prices to reflect the evolving fuel economy landscape. As ICE vehicles are gradually replaced by EVs, the relevance of fuel price signals may decline, making other factors such as lifecycle emissions, affordability, and electricity costs increasingly important areas of investigation.

This paper contributes GB-specific empirical evidence to the growing literature on consumer response to energy prices, with implications for transport decarbonisation and taxation.

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