Competition and consumer prices in the fuel market: insights from a small EU country

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Abstract

Purpose – This study aims to analyse the effect of competition on retail fuel prices in a small European Union (EU) country with high market concentration.

Design/methodology/approach – The researchers use a panel data set to estimate a fuel price equation that includes supply and demand factors as well as time-fixed effects.

Findings – The study finds that more competitors in the local market decrease prices, whereas the high market share of oligopoly brands does not condition this effect. Additionally, independent brands set lower prices than wholesalers, and gas stations located near the borders of almost all neighbouring countries are associated with higher prices.

Research limitations/implications – The study suggests that Slovenia's retail fuel market maintains competitive pricing despite high oligopolistic shares because of historical regulatory influences that shaped firm behaviour and pricing strategies, along with geographical and economic factors such as Slovenia's role as a transit country. External competitive pressures from neighbouring countries and high levels of traffic, combined with the remnants of regulatory structures, help prevent market abuses and keep fuel prices lower than in other EU countries.

Practical implications – It also indicates that policy should encourage fiercer competition in the local market by increasing the density of gas stations, especially from independent brands.

Originality/value – These findings may be associated with specific country characteristics. This paper introduces unique findings that shed light on the impact of a small market on competition, with a particular focus on highlighting the effect of oligopolistic brands.

Keywords Retail fuel market, Market competition, Market concentration, Station heterogeneity

Paper type Research paper

Highlights

- Investigates fuel market competition's impact on consumer prices.
- Panel data set of 554 gas stations with 280k+ daily price observations.

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- More competitors in the local market lead to lower prices.
- Oligopoly brands have an insignificant effect on fuel prices.
- Policy should encourage competition to increase the density of independent brands.

1. Introduction

The Organisation for Economic Co-operation and Development (OECD) has found that a lack of competition in retail markets for road transport fuels is a common problem across its member countries, with rising barriers to entry exacerbating the issue (OECD, 2022). This can lead to non-optimal retail fuel prices that can affect consumer welfare. In the European Union (EU), for instance, spending on electricity, gas and other fuels accounts for almost 4.5% of the consumer budget in 2021, whereas in Slovenia, the figure was 5.4% during the same period (Eurostat, 2021). Antitrust authorities and policymakers are examining the effects of insufficient competition on prices and have a long list of cases to date.

Although the Slovenian Government regulated retail fuel prices from 1999 to 2020 to decrease oligopoly behaviour in a concentrated market, the market was fully liberalized on 1 October 2020. However, the government re-regulated the prices of standard petroleum products, gasoline and diesel, on 15 March 2022, because of significant non-seasonal fluctuations in the market. The Slovenian Competition Authority found that competition in the fuel market had not increased since the regulation of fuel prices was abolished on 1 October 2020, despite expectations. The Authority believes that low-cost fuel stations would introduce more competition into the market and benefit consumers. However, high entry barriers and low potential for profits prevent new competitors from entering the market. Although the agency observed some anomalies in the market, there was no direct evidence of anti-competitive behaviour (Slovenian Competition Authority, 2021).

The objective of a study conducted in Slovenia is to examine the determinants of retail fuel prices empirically, focusing on the impact of local market competition and its composition. The proposed model considers that fuel prices are affected by the intensity of local competition, distance to the nearest neighbour, brand affiliation and type of competitors (wholesalers, independents, supermarkets). In addition to the competition indicators, the model controls for exogenous determinants such as fuel purchase price, traffic intensity, location, road type and time and location fixed effects. By identifying the key determinants of price changes and assessing the impact of competition in the local market, future antitrust regulation and other market interventions can be proposed. This research is particularly relevant for smaller countries such as Slovenia, which have a long history of market interventions resulting in the lowest profit margins in the EU.

The research assumptions are tested using a large panel data set consisting of daily diesel and gasoline prices collected from all gas stations operating in Slovenia. Although diesel accounts for the majority of fuels sold in Slovenia (79%), which is also because of a significant share of freight transport (FuelsEurope, 2022a), the study also estimates regressions for gasoline. The data were from 1 October 2020 to 15 March 2022 and include more than 280,000 price data from 554 gas stations. We use a radial distance of 3 km from the focal gas station as the boundary of a local market which is also typically used in other studies (Barron *et al.*, 2004; Kihm *et al.*, 2016).

In this study, the price equation is estimated in reduced form, assuming that price is influenced by several endogenous explanatory variables, such as competitive intensity, which is instrumented by the number of competitors in the local market and the distance to the nearest competitor. The identification strategy of this study further assumes that consumers' market-specific valuations are independent across local markets when controlling for the type of gas stations and the demographic characteristics of the local market. The endogenous variable instruments used in this analysis ensure that the information on the intensity of competition in the surrounding local markets with the same market conditions (entry regulation, cost conditions, etc.) is the same as in the focus market. To fulfil this assumption, the instrumental variable (IV) approach is applied.

This model encompasses a broad range of demand- and cost-based factors that determine retail fuel prices and account for external effects on pricing. Moreover, the model controls for demand-related factors, including traffic density, income (Chouinard and Perloff, 2007; Alm *et al.*, 2009) and time factors such as weekly cycles (Atkinson, 2009; Foros and Steen, 2013) and monthly cycles (Hastings and Washington, 2010). Furthermore, brand-specific indicators are incorporated to reflect the features of major suppliers. The model also considers supply-side characteristics such as input price fluctuations.

This research has three primary contributions. Firstly, it examines the impact of local market competition, revealing that a greater number of competitors within a 3-km radius is associated with lower prices, while the influence of distance to the nearest rival is not significant. Secondly, fuel prices at gas stations located near borders to neighbouring countries are significantly higher than those elsewhere, with this difference becoming more pronounced, as the price gap with the neighbouring country price grows. Thirdly, other factors that influence retail fuel prices are examined, including:

- ex-refinery prices and gas station type, which mainly affect retail fuel prices;
- higher prices at highways and expressways, with traffic intensity and income positively correlated with prices; and
- no effect of the share of oligopoly brands on prices.

In addition, the Slovenian retail fuel market presents a compelling case because of the existing puzzle: despite extremely high oligopolistic shares, there is no significant abuse of market power in terms of overcharging during the period of deregulation. Additionally, this market is among the most concentrated in the EU. Our findings provide valuable insights into how oligopolistic firms may or may not exercise their market power under such conditions, which are representative of many areas within the EU. This market also bears the marks of long-term regulation, and understanding the resulting effects can shed light on the impacts of regulatory inertia. Finally, although Slovenia is a small country, it occupies a crucial traffic route connecting the Adriatic Sea and Italy with Eastern Europe, as evidenced by one of the highest rates of road travel per resident in Europe.

This paper is structured as follows. Section 2 provides an overview of the key findings from prior research in this area. Section 3 describes the institutional framework and existing antitrust policy in Slovenia. Section 4 outlines the data and methodology employed in the empirical analysis. Section 5 presents and discusses the results, whereas Section 6 draws conclusions that include policy implications.

2. Literature review

The retail fuel market in the European Union has been widely researched because of its significant impact on the economy and the environment. Several empirical studies have identified various determinants of retail fuel prices, such as local market competition, market concentration, Herfindahl–Hirschman index (HHI), input prices, traffic intensity, brand name, highway location, population density, average local income, gas station characteristics and the number of competitors. Despite the extensive research on this topic, mixed results have been obtained, particularly with respect to market size, which has led to continued research interest among policymakers and researchers. Therefore, this literature review focuses on analysing the determinants of retail fuel prices in small economies and categorizes the determinants into four broad categories, including local demographics and station location, physical station characteristics, brand and contractual arrangements and station density and local concentration (Eckert, 2013).

Previous studies have identified the input price or ex-refinery price as the most significant determinant of retail fuel prices (e.g. Haucap *et al.*, 2017 for gasoline; González and Moral, 2023 for diesel). Although not readily observable to consumers, ex-refinery prices for gasoline and diesel products are a crucial factor influencing retail prices, as they represent a major input cost (Hosken *et al.*, 2008). In particular, Haucap *et al.* (2017) found that ex-refinery prices serve as a reliable predictor of daily input price changes, explaining the largest proportion of the variance in prices. Beside price, economic literature emphasizes the importance of heterogeneity of retailers and gas stations, while also problems with coordination are often mentioned. Eckert (2013) in his analysis focuses on market structure, which has been regarded as playing the crucial role in price dynamics, equilibrium selection and price differentials across local markets and gas stations.

The next group of determinants related to retail fuel prices focuses on local market competition and typically covers determinants related to the intensity of competition and competitors' brand affiliation. The intensity of competition is commonly measured by the number of competitors in the local market, defined as the geographic area within a circle of radius around 1–3 miles (Perdiguero and Borrell, 2019). Most studies found that longer distances between stations and smaller station densities increase fuel prices (Barron *et al.*, 2004; Clemenz and Gugler, 2009). For instance, Barron *et al.* (2004) used US data and found that markets with more competitors face, on average, smaller prices in comparison to other markets, resulting in an average 0.3%–0.6% decrease in price given a 50% increase in the number of competitors in a radius of 1.5 miles. Pennerstorfer *et al.* (2015) found similar results for Austria. Haucap *et al.* (2017) conducted a similar study in Germany and revealed that both the number of gas stations and the distance to the nearest gas station significantly decrease fuel prices, albeit by a very small amount. Lach and Moraga-González (2017) investigated the effect of competition intensity on the distribution of prices in The Netherlands and found that competition has a stronger impact on the medium-to-upper part of the price distribution.

Although previous studies assume that the number of competitors impacts prices equally, regardless of the characteristics and composition of incumbents and entrants, some studies suggest that the entry of new competitors in a market with only a few incumbents could expect a larger price decrease in comparison to a market with a larger number of competitors (Tappata and Yan, 2017). Moreover, not all competitors are equal. Two studies in Spain considered competitor characteristics and classified them into groups, such as low-cost, independent or premium-brand competitors. Balaguer and Ripollés (2020) and González and Moral (2023) found in their studies that premium brands soften competition in local markets by allowing other competitors to set higher prices. However, this effect changes whether their nearest competitor is selling the same brand or a different brand. Low-cost brands have been found to be effective in reducing prices for themselves as well as for other competitors (González and Moral, 2023).

In addition to the aforementioned studies, another line of research focuses on examining the impact of market concentration on fuel prices. Clemenz and Gugler (2009) use the HHI and concentration percentages of the main brand and four major oil companies to analyse 2,856 stations in Austria and find that concentration leads to an increase in prices. Similarly, Haucap *et al.* (2017) use a sample of stations in Germany and Remer (2019) uses market participation indicators for Kentucky and Virginia to conclude that concentration results in higher prices. On the other hand, some studies explore the effects of market opening through the presence of independent companies, such as Clemenz and Gugler (2009), who find that the participation of independent companies drives prices down, while Haucap *et al.* (2017) report the opposite result. Kihm *et al.* (2016) also use the Herfindahl index in conjunction with the Brent crude price for a sample of 13,000 stations in Germany and reach a similar conclusion that market concentration leads to higher prices.

While studies on the impact of gas station locations near country borders on fuel prices are relatively rare, a few examples do exist. Banfi *et al.* (2005) conducted a study which showed a significant impact of the gasoline price differential on demand. Specifically, a 10% decrease in the Swiss gasoline price led to an increase in demand in the border areas of nearly 17.5%. Moreover, cross-border effects are also observed in Spain, where Bajo-Buenestado and Borrella-Mas (2019) noted an increase in diesel sales in provinces along the Spanish–Portuguese border following the tax reform in Portugal. Additionally, González and Moral (2023) found that gas stations located near the border of a province are likely to compete with some stations located in the neighbouring province. Therefore, it is widely accepted that location is a crucial determinant of fuel prices and that gas stations situated near country borders are likely to face increased competition from nearby stations.

Retail fuel prices are affected by several factors, including traffic intensity, brand name, population density and average local income (e.g. recently by González and Moral, 2023). Information also plays a crucial role in determining the level of price dispersion in the retail fuel market (Pennerstorfer *et al.*, 2020). Furthermore, Haucap *et al.* (2017) found that fuel prices tend to be higher on highways. Higher-priced brands charge more, gas stations on highways have higher prices than those in urban or rural areas and densely populated areas or areas with a high number of cars in the local market tend to have an impact on prices (Perdiguero and Borrell, 2019). The level of service provided by gas stations could also affect fuel prices. Finally, seasonal fluctuations, as well as global market conditions, have an impact on fuel prices.

Our approach focuses on the impact of local competition, market concentration and cross-border effects

In the small EU country. Another key aspect of our study involves accounting for the endogeneity of local market competition. Specifically, we analyze the number of competitors, the characteristics of our own brand and the closest competitor's brand and estimate their effects on prices at all levels of the station market, rather than just average prices. Furthermore, cross-border effects have been rarely considered, especially their indirect influence on the impact of internal country market concentration on retail fuel prices. To the best of our knowledge, this approach has not been previously explored in the literature.

3. Slovenian retail fuel market

From 1999 to 2020, the Government of the Republic of Slovenia determined the highest retail prices for petroleum derivatives in accordance with regulation agreements. The prices of oil derivatives, including diesel fuel and 95-octane unleaded motor gasoline, were generally set per litre unit and updated every 14 days. In 2016, the government decided to gradually liberalize the market, starting with gasoline and diesel at gas stations in service areas of motorways and expressways. The full liberalization of the retail fuel market took place on 1 October 2020, when the government concluded that price control measures were no longer necessary. However, owing to changed market conditions causing large non-seasonal fluctuations, the government re-regulated the prices of 95 gasoline and diesel outside service areas of motorways and expressways on 15 March 2022. As a result, the period between 1 October 2020 and 15 March 2022 was the only fully liberalized period in Slovenia's history.

In 2002 there were only 5 providers of automotive fuels in Slovenia, which number gradually increased to 24 in 2015 with only a slight change until 2022 to 25 providers. Despite the relatively large number of providers, the market was highly concentrated in 2022, as the HHI index on the wholesale market is 3,394 and on the retail market is 3,968 points. The largest provider, Petrol, owns as much as 56.5% of gas stations; followed by OMV with 20.6% and MOL with 9.6%. There are also a few smaller providers such as M-Energija, LOGO and Shell Adria with market shares of 3.8%, 1.8% and 1.6%, respectively. Accordingly, the barriers to entry into the market for the sale of motor fuels are very high, and therefore it is assumed that the entry of new providers cannot be expected in a realistically short time, and for the same reason, a major expansion of operations is not expected even for existing providers.

The distribution across Slovenian regions shows that Petrol has the most gas stations in all regions, the exceptions being the Obalnokraška and Primorsko–Notranjska regions, in which OMV has more gas stations than Petrol. The larger providers (Petrol, OMV and MOL) have a relatively even distribution of their service stations across the regions, with the exception of OMV, which has the largest share of its service stations in the Obalnokraška region (these are service stations that were previously owned by Istrabenz with headquarters in Koper). As a rule, the business strategies of smaller providers are not based on a more intensive presence in a specific region, with M-Energija standing out in Jugovzhodna Slovenia, where it has a third of all its self-service gas stations. The spatial distribution of service stations shows that 12% of all service stations are located next to the highway, 12% of them are located in the border zone, while the other is located at least 6 km from the border.

In 2017, the Public Agency of the Republic of Slovenia for the Protection of Competition conducted research on the competitiveness of the motor fuel market in Slovenia. Based on data obtained from providers, they estimated that a 3%–5% change in the retail price would trigger the elasticity of demand or replacement of the fuel supplier (Slovenian Competition Authority, 2017). Customers choose service stations based on price, distance to an alternative service station and fuel quality. The report also estimated that a price difference of at least 5% of the retail price would lead people living near the border to buy fuel in neighbouring countries, while in the transport segment, a difference of just 1% of the price could be decisive. Given the large share of international freight transport, petrol stations in Slovenia, especially those in the area of the highways, compete with petrol stations throughout Europe. The Agency did observe certain anomalies in the market, such as simultaneous price changes and cancellation of roadside displays of motor fuel prices. However, despite the high market concentration, these actions cannot be directly attributed to anti-competitive activity or violations of Slovenian antitrust laws.

4. Data and methodology

4.1 Data

The data set used in this study is provided from the web page with real-time information about retail fuel prices (www.goriva.si), which was established in March 2019 by the Ministry of Economic Development and Technology of Republic of Slovenia for the purpose of informing consumers about the prices of petroleum products. Gas stations are obliged to instantaneously report any price change including a precise time. Web page beside prices also contains the name, brand name and geographical locations of every gas station located in Slovenia. We considered prices only in the period of total retail fuel market deregulation between 1 October 2020 and 15 March 2022. Final sample thus comprises a panel data set of 548 gas stations and consists of 288,233 diesel and 275,652 gasoline daily price observations that represent a comprehensive price data set across the country. Complete summary statistics of the samples used in the analysis are represented in Table 1.

Figure 1 shows the distribution of gas stations by municipalities and by brand. The largest three municipalities in Slovenia by population, municipalities of Ljubljana, Maribor and Celje account for 15.4% of all gas stations in Slovenia. Statistical regions where these municipalities are, have also the highest number of gas stations in the country and account for 45.1% share. Slovenian retail fuel market is very concentrated as indicated by the HHI,

Variables	Obs.	Mean	S.D.	Min.	Max.
Diesel price	288,233	1.267	0.158	0.940	1.830
Ex-refinery price	288,233	0.426	0.128	0.224	1.100
Number of competitors	288,233	2.683	3.467	0	20
Distance to nearest comp.	288,233	3.022	4.269	0.021	39.251
Traffic intensity	286,109	52045.74	82477.70	6.429	1399633.1
Income	288,233	2112.958	1692.73	131.496	30215.557
Wholesale	288,233	0.893	0.309	0	1
Supermarket	288,233	0.075	0.243	0	1
Independent	288,233	0.053	0.225	0	1
Share of oligopoly brands	288,233	0.867	0.211	0	1
Petrol – price	165,672	1.267	0.157	0.997	1.730
OMV – price	58,890	1.270	0.160	0.999	1.797
MOL – price	28,143	1.265	0.157	0.997	1.795
Highway	288,233	0.112	0.316	0	1
Border: Croatia	288,233	0.072	0.258	0	1
Border: Hungary	288,233	0.007	0.086	0	1
Border: Italy	288,233	0.094	0.292	0	1
Border: Austria	288,233	0.042	0.201	0	1
Public holiday	288,233	0.041	0.199	0	1
School holiday	288,233	0.235	0.424	0	1
Gasoline price	275,652	1.213	0.145	0.920	1.684
Ex-refinery price	275,652	0.427	0.116	0.218	0.858
Number of competitors	275,652	2.516	3.322	0	19
Distance to nearest comp.	275,652	3.108	4.333	0.021	39.251
Traffic intensity	273,528	52009.651	83737.131	6.429	1399633.1
Income	275,652	2117.641	1711.136	131.496	30215.557
Wholesale	275,652	0.911	0.285	0	1
Supermarket	275,652	0.056	0.23	0	1
Independent	275,652	0.033	0.18	0	1
Share of oligopoly brands	275,652	0.877	0.205	0	1
Petrol – price	165,672	1.212	0.144	0.950	1.628
OMV – price	56,676	1.217	0.146	0.959	1.684
MOL – price	28,143	1.210	0.143	0.952	1.669
Highway	275,652	0.118	0.322	0	1
Border: Croatia	275,652	0.073	0.26	0	1
Border: Hungary	275,652	0.008	0.087	0	1
Border: Italy	275,652	0.082	0.275	0	1
Border: Austria	275,652	0.042	0.201	0	1
Public holiday	275,652	0.041	0.199	0	1
School holiday	275,652	0.235	0.424	0	1

Source: Author's own work

Table 1.
Summary statistics

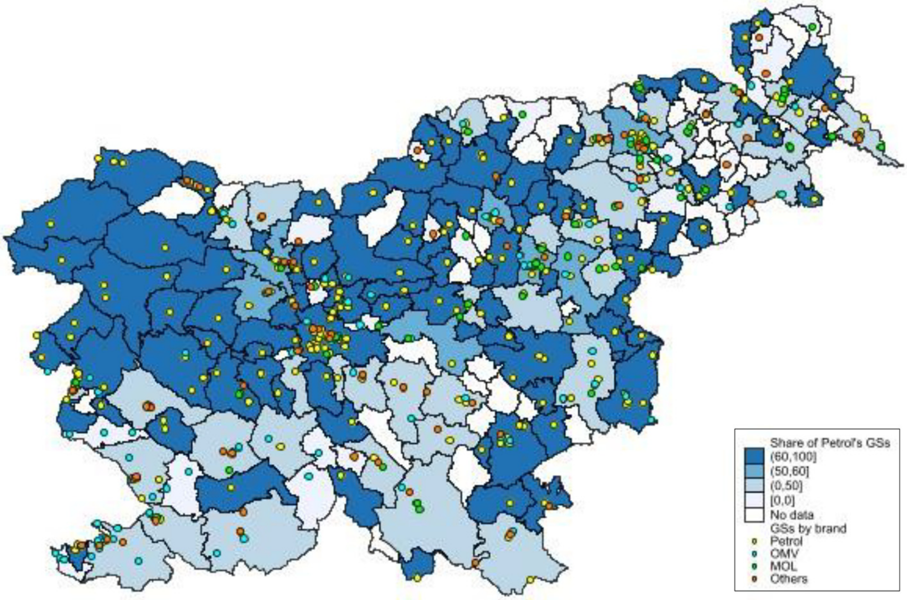


Figure 1. Distribution of gas stations by municipality and brand (in %)

Note: The color saturation in the graph depicts the market share of the largest brand, Petrol, for each municipality
Source: Author's own work

which equals to 3729.6, while the HHI_4 equals to 3721.4. Retail fuel markets are typically concentrated retail markets, where HHI_4 in the EU ranges from 230 to 2290 in the period 2012–2015 [1] (Nowakowski and Karasiewicz, 2016). In Slovenian retail fuel market, there are 3 major brands, Petrol, OMV and MOL, which together account for 86.6% of the market share.

On the other hand, the number of gas stations per capita in Slovenia is lower than EU average: Slovenia has 26.0 gas stations per 100.000 inhabitants while the EU average is 30.1 (FuelsEurope, 2022b). This number is larger mainly in countries in Southern Europe (Greece, Italy and Portugal) and Northern Europe (Estonia, Denmark, Norway, Finland and Latvia), while lower in Central Europe (France, Germany, Slovakia, Poland and Hungary). Densities of gas stations in neighbouring countries are similar: Croatia (21.5 per 100.000 inhabitants), Hungary (20.8), Austria (30.8) and Italy (36.7).

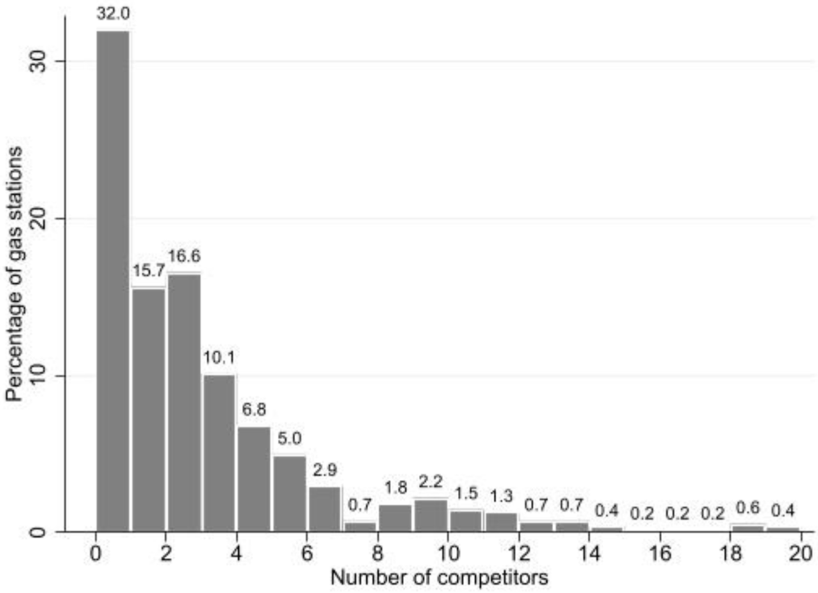
The information on geo-coordinates of gas stations was used to calculate the distance between gas stations to identify local competitors for each of gas stations. Geo-coordinates were further used to identify each gas station's statistical region and municipality depending on the availability and geographical proximity of the data on average income per capita on a monthly level. Furthermore, the exact geo-coordinates were available for the traffic intensity variables measured by the automatic traffic counters. This information was provided on a daily level. At the initial stage of analysis several other variables were considered such as number of people and cars in municipality, number of car accidents, however, owing to large multicollinearity, they were omitted from the further consideration.

Prices are typically influenced by the micro-locational economic conditions of each gas station, management costs, fuel purchase costs and the competitiveness of the environment. We expect slightly higher fuel prices in the area on the highway, flexible in the border areas and variable in the rest of the country, compared to before mentioned conditions. Other factors, such as proximity to competition, competition density, traffic intensity, income, possibility of development, additional offers and similar could also determine prices.

Next, retail fuel price in competitive setting are determined by the local market competition. Despite being present in the whole country or region, the local market competition has a major impact on price setting. This includes the number of competitors within local market, their type and brand. We define local market for each gas station as the geographic area within a radius 3 km centred at the location of gas station *i*. While some researchers considered local market as municipality or other administrative areas, the majority of the nowadays use the Euclidian or geodetic distance between 1 and 3 km (Hastings, 2004; Barron *et al.*, 2004; Haucap *et al.*, 2017; Lach and Moraga-González, 2017). Taking into account the geographical properties of Slovenian territory and the driving habits of those in Slovenia, the choice of 3 km radius around focal gas station seems reasonable. [2]

In the isolated local markets, the market concentration is high and hence the market power, while simultaneously the consumers' search costs for alternatives (Lach and Moraga-González, 2017). Therefore, a common result in the literature says that higher number of competitors in the local market leads to lower prices (e.g. Barron *et al.*, 2004; Hosken *et al.*, 2008; Pennerstorfer *et al.*, 2015).

Figure 2 shows the percentage of gas stations in Slovenia by the size of their local market (within a radius of 3 km). A total of 32.0% of gas stations have no competitor within 3 km radius, while only 35.7% of gas stations have more than 3 competitors within 3 km radius. For example, the former gas stations are located in rural areas or near highways, while the



Source: Author's own work

Figure 2. Intensity of competition in local markets (within a 3 km radius)

latter in the most populated areas. This is partially due to the characteristics of the terrain with a relatively low density of population in some parts of Slovenia.

The density plot in Figure 3 shows the distribution of prices for oligopoly brands with varying market shares in local markets. As illustrated in the figure, the distribution of prices appears to be similar across all levels of market concentration. This may be due to oligopoly brands engaging in tacit collusion, where competitors in an industry set prices at a similar level without direct communication (Byrne and De Ross (2019). This coordination stemmed from dominant firms leveraging their price leadership to establish "focal points," streamlining coordination and consequently bolstering profit margins. Alternatively, there could be some exogenous factors that reduce market power, such as cross-border competition and the absence of economies of scale, which are likely related to the small and open market economy.

4.2 Methodology

In this section, we will analyse the effect of various time-varying supply and demand-side controls, as well as different time-constant station characteristics, on the retail prices of gasoline and diesel products. The model assumes ex-refinery prices to be constant throughout the country, but its time variation significantly determines the retail price as it represents a major input cost. Besides ex-refinery prices, the model includes supply factors such as the number of competitors in the local market, the distance to the nearest direct competitor and the brand characteristics, including wholesale, supermarket or independent brands and the share of oligopoly brands in the local market. Additionally, we consider demand factors such as traffic intensity, and income in the municipality, as well as location-related characteristics such as highway location or proximity to the national borders of Austria, Croatia, Hungary, or Italy. Finally, we account for several time controls, such as weekly and monthly cycles, seasonal fixed effects and public and school holidays.

Although gasoline and diesel products are largely homogeneous, station heterogeneity induces price dispersion rather than physical product characteristics. To test the impact of observable station characteristics on price levels, we include variables representing brand structure, station location and amenities and spatial competition metrics in a random effects model setup. We acknowledge that there may be potential omitted variable bias; however, we assume a robust specification given the variety of control variables included, which is

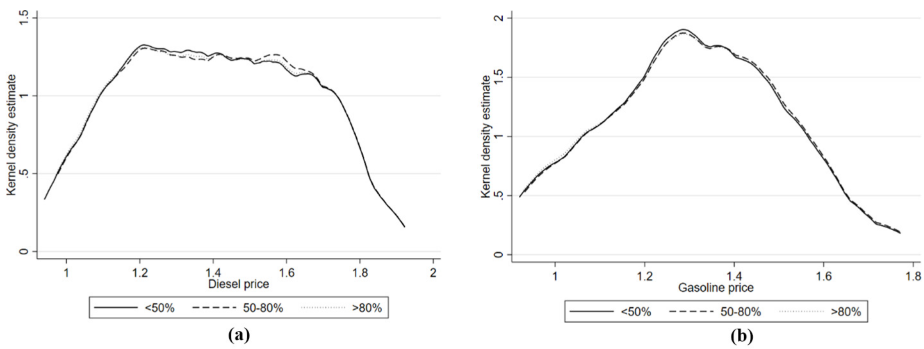


Figure 3.
Kernel density of retail fuel prices and share of oligopoly brands

Notes: (a) Diesel prices; (b) Gasoline prices
Source: Author's own work

similar to other empirical studies on gasoline markets estimating random effects models. Equation (1) describes the specified model.

$$p_{it} = \alpha + \beta c_t + x_{it}\gamma + y_i\delta + d_{it}\zeta + \epsilon_{it} \quad (1)$$

The retail price of gasoline at a specific gas station i on a given day t, calculated as a daily average, is denoted as p_{it}. The explanatory variables include both time-variant and time-invariant variables. Firstly, α represents the constant term. Secondly, c_t is the ex-refinery price that is time-variant but not cross-sectional-variant. Thirdly, x_{it} comprises all time-variant and cross-sectional-variant explanatory variables, while y_i contains only cross-sectional-variant explanatory variables. Finally, d_{it} includes dummy variables used to control for week and month cycles, seasonal fixed effects, as well as public and school holidays, which do not vary by the gas station.

First, we analysed the structure and dependency of the panel data variable price. Pesaran's test of cross sectional independence with test statistic equal to 7967.849, with p-value less than 0.01 indicated that panel data variable is strongly cross-sectional dependent. Next we test the presence of unit-root. We applied Im–Peseran–Shin unit-root test, which is suitable for unbalanced and cross-sectional dependent panel data. With a test statistic equal to -32.9945 and p-value less than 0.01 we reject the existence of unit-root in all panels.

Starting with the supply factors, the first explanatory variable is Δ*Ex-refinery price* of gasoline and diesel obtained from Refinitiv information provider using commodity codes "DL-CIF-MED" for diesel and "PU-C-MED" for gasoline, where Mediterranean notation and CIF (cost, insurance and freight) type of contracts were used. As the time series contained unit-root, we used first-differenced ex-refinery price for further analysis.

To assess competition levels, we use two variables. The first variable is the *Number of competitors*, which represents the number of gas stations within a 3-kilometer radius of station i that directly compete for the same customers. Based on oligopoly and spatial competition models, we anticipate that gas stations with fewer rivals will charge higher prices. The second variable, *Distance to the nearest comp.*, calculates the focal station's distance from its nearest local market competitor by computing geodetic distances to all potential rivals and selecting the nearest one. This variable measures horizontal differentiation and implies that station i's market power increases as the distance to its nearest competitor grows. [3] It also reflects consumer search costs, as greater distances between competitors make it more challenging to compare prices. Prior research has demonstrated that search costs are crucial in explaining the dispersion of gasoline prices. The characteristics of gas stations are represented by indicator variables group *Wholesale operator (reference category)* brands, *Independent* brands and *Supermarket* brands. *Share of oligopoly brands* captures potential effects oligopoly brands in local markets.

The demand-side explanatory variables in our model begin with the *Traffic intensity* variable, which represents the daily number vehicles recorded by the automatic counters in the proximity of gas station. The *Income* variable measures the average income per capita, which varies by municipality. Several explanatory variables related to the location of the gas station were identified using geo-coordinates. Gas stations located at *Highway* service areas typically have higher prices due to higher rent and maintenance costs. Finally, we include four dummy variables to indicate gas stations located within 6 km of the *Austrian, Croatian, Hungarian and Italian borders*.

However, some of the variables that we use cannot be considered exogenous without conditions. This is because the error term of our model may incorporate market-specific unobservable factors that influence either the cost or the willingness of consumers to pay, thereby impacting the number of gas stations in a given market. For example, markets with a higher consumer willingness to pay may attract more companies, leading to a weaker negative or even a positive correlation between the number of companies and the price. Conversely, if the unobservable factors are associated with lower costs, we anticipate lower prices in the presence of more companies, which could result in an overestimation of the impact of competition on prices. To address these concerns, we recommend using an IVs model that necessitates valid instruments affecting the entry or exit decisions of companies, which are exogenous in the pricing equation.

To select instruments for our study, we use information about market structure in nearby local markets that share similar entry regulations and cost conditions. Our identification strategy employs an IV approach inspired by Nevo's (2000, 2001) work on competition among firms in multiple geographic markets and recently applied by González and Moral (2023). We assume that consumers' market-specific valuations are independent across local markets after controlling for gas station type and demographics. Moreover, we assume that all local markets within the same municipality have the same entry regulations and similar characteristics, such as rental costs. Therefore, we expect competition intensity in the local market of station i to be correlated with competition intensity in other nearby geographic markets but not to affect prices in local market. [4]

Using instruments by municipalities provides considerable variability, given the approximately 212 municipalities in Slovenia. For each endogenous variable (number of competitors and distance to the nearest competitor), we compute one instrument. We calculate the average value of the variables number of competitors within a 3 km radius and the nearest distance to the closest competitor in other local markets in the same municipality, excluding the local market of interest and the markets of all direct competitors located within a 3 km radius. In addition, we included two additional instruments: the number of same-brand gas stations within the local market and the distance to the nearest same-brand gas station. These instruments help us to effectively capture both internal and external factors influencing market presence (Bergantino *et al.*, 2020). Nevertheless, the exclusion restriction should be met when choosing appropriate instruments. [5]

In order to incorporate the proposed instruments into the model, we utilized the generalized two-stage least squares random effects IV model (G2SLS RE IV), which is widely utilized in studies that involve multiple endogenous variables and instruments. This approach aims to estimate the causal effects of a set of explanatory variables on a set of outcomes where it uses the exogenous variables after they have been passed through the feasible GLS transformation. Originally proposed by Balestra and Varadharajan-Krishnakumar in 1987, the G2SLS model extends the traditional 2SLS model by accounting for heteroskedasticity and clustering of errors. The G2SLS estimator is both flexible and efficient, consistently providing robust results.

To account for time and seasonal fixed effects, we incorporated seven *Weekly-cycle* dummy variables to capture changes within a week and 31 *Monthly-cycle* dummy variables to account for seasonal changes in demand. Prior research suggests that the retail gasoline market exhibits distinctive cyclic patterns (Atkinson, 2009; Clark and Houde, 2014). For instance, prices may be higher on Mondays and then decline throughout the week (Foros and Steen, 2013). To capture this pattern, we introduced dummy variables for each day of the week. Moreover, we explored a monthly cycle since we anticipate a connection between spending and rent payment timing, known as the "first of the month" effect, which has been observed in consumer behaviour regarding food purchases (Hastings and Washington, 2010). We also incorporated dummy variables for *Public holidays* and *School holidays* to account for potential changes in price due to such events. A public holiday is a national holiday and a day off from work, while school holidays are days when primary and secondary education institutions are closed. [6] Finally, we include 12 monthly dummy variables to account for *Seasonal fixed effects*, which should capture the effects of tourism during summer months and increased winter demand due to higher consumption in the winter months.

5. Results

5.1 Basic model

This section details the outcomes of the regression analyses conducted for the two retail fuel types, diesel and gasoline, examined in this study. Two regression models, the ordinary least squares random effects (OLS RE) model and the generalized two-stage least squares random effects instrumental variables (G2SLS RE IV) model, were implemented for each fuel type. The G2SLS RE IV model considered the endogeneity in local competition variables, unlike the former. Our results indicate that endogeneity is highly probable in both models, and the efficacy of the instruments employed is verified. [7] Hence, we will base our interpretation on the G2SLS RE IV model specification. We provided robust standard errors in each model, clustered at the gas station. Therefore, correcting for any spatial correlation is not required, as the clustered standard errors are small. In general, the coefficients of the models are mostly significant with the expected signs. This is partly due to the large sample size, and the models explain a considerable proportion of the price variance (with an R-squared value above 0.90).

Table 2 illustrates the results of the regression analysis of diesel prices on their expected determinants. The estimated coefficients suggest a positive impact on prices with a rise in the differenced ex-refinery price of diesel derivatives, and vice versa, as anticipated. This is widely supported in the literature as the ex-refinery price is the major component of the final price (Haucap *et al.*, 2017). The estimated coefficient of the number of competitors in a local market is negative and significant, which is in line with the commonly held view that an increase in the number of competitors results in lower prices and benefits consumers. The coefficient's magnitude increases when endogeneity is considered, suggesting that the effect of this variable is underestimated when it is considered exogenous. This finding aligns with the results of Tappata and Yan (2017) and González and Moral (2023). Our G2SLS RE IV model's estimated parameter shows that an increase in competition by one gas station in a local market reduces the average price by 0.1 cents.

However, the estimated parameter of the variable distance to the first competitor is not significant, whereas the literature on spatial competition models generally reports significant positive effects. Nonetheless, our price regression shows that enhanced competition has a diminishing effect on market price levels on average, holding other factors constant.

Upon examining the gas station characteristics, we discovered that independent gas stations tend to charge lower prices compared to wholesale brands with an average of 0.4 cents. These results align with previous studies (Haucap *et al.*, 2017; González and Moral, 2023), as independent brands typically cannot charge higher prices than wholesale brands due to lower brand recognition.

Conversely, supermarket brands charge on average higher prices than wholesale brands, at 0.9 cents per litre of diesel fuel with similar characteristics, costs, competition, location, traffic intensity and time cycles. Supermarket brands tend to charge higher prices than wholesale brands, presenting a by-product bundled in a way that enables the brands to effectively capture consumer surplus with higher prices despite lower brand recognition prices (Haucap *et al.*, 2016).

Variables	Model 1: OLS RE Coefficient	Rob. SE	Model 2: G2SLS RE IV Coefficient	Rob. SE
Constant	−21.61***	(0.0312)	−21.61***	(0.0104)
ΔEx-refinery price	0.00455***	(0.000263)	0.00455***	(0.000248)
Number of competitors	−0.000314*	(0.000168)	−0.000553***	(0.000150)
Distance to nearest comp.	0.000108	(7.45e-05)	5.73e-05	(9.46e-05)
Supermarket	0.00585	(0.00480)	0.00629***	(0.00147)
Independent	−0.00492	(0.00340)	−0.00446***	(0.00151)
Share of oligopoly brands	0.000268	(0.00354)	0.000513	(0.00175)
Traffic intensity	1.26e-08**	(5.91e-09)	1.34e-08***	(2.15e-09)
Income	3.21e-06***	(1.01e-06)	3.21e-06***	(1.66e-07)
Highway	0.0388***	(0.00115)	0.0385***	(0.000973)
Border: Croatia	0.00256	(0.00159)	0.00228*	(0.00118)
Border: Hungary	0.00190	(0.00248)	0.00157	(0.00347)
Border: Italy	0.00340**	(0.00153)	0.00384***	(0.00106)
Border: Austria	−0.000665	(0.00179)	−0.000927	(0.00150)
Public holiday	−0.00110***	(9.42e-05)	−0.00109***	(0.000358)
School holiday	0.00401***	(8.00e-05)	0.00401***	(0.000237)
Weekly cycle	Yes		Yes	
Monthly cycle	Yes		Yes	
Seasonality fixed effects	Yes		Yes	
Number of observations	285,162		285,162	
Number of groups	544		544	
R^2	0.9566		0.9566	

Notes: Robust standard errors clustered by gas station are in parentheses; significance levels are denoted by: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$; Δ denotes first-differenced variables
Source: Author's own work

Table 2.
Regression of retail price of diesel

This price difference indicates that gas stations and their fuel are not entirely homogeneous and differ in amenities or convenience. Additionally, brands differ in reputation, particularly wholesale brands such as Petrol and OMV that sustain large marketing campaigns, including sports sponsorships, creating a perception of higher quality that consumers may pay a premium for. Consumer loyalty or heterogeneity in search costs may also explain the observed price differential among brands (Lewis, 2008).

Surprisingly, we found that the share of oligopoly brands in a local market does not influence fuel prices. The result is in line with the summary statistics reveal almost no difference between 80% and 100% local market oligopoly brand shares. Despite high market concentration, there is no positive impact on prices, which implies that oligopoly firms are not using market power to increase prices or do not compete between themselves nor respond to the entry of independent brands, contrary to what is commonly found in the literature (e.g. Haucap *et al.*, 2017).

Location is a crucial factor in determining prices, as is widely recognized. Gas stations situated in highway service areas tend to charge prices that are about 3.9 cents higher on average than other gas stations. This is because drivers on highways have higher search costs and opportunity costs of time, making them less inclined to change their routes to save a few cents on fuel. Conversely, gas stations located within 6 km of country borders are influenced by prices across the border. For instance, gas stations near the border with Croatia tend to charge on average 0.2 cents higher prices, while those near the border with Italy charge 0.4 cents more. However, there is no significant difference between gas stations near the border with Austria and Hungary and other gas stations.

Our demand control variables, traffic intensity and income, exhibit the expected positive signs. Gas stations near more intense traffic tend to have higher prices, as also found by González and Moral (2023), but not found by Haucap *et al.* (2017). Income effects are positive, as anticipated, as higher-income municipalities tend to support higher prices, as confirmed by previous results (González and Moral, 2023).

Additionally, our study found that school and public holidays, which are important demand-side controls, generally have the expected effects on diesel prices. During public holidays when traffic is low due to labour-free days, diesel prices tend to be lower as gas stations try to attract customers who stay at home. During school holidays when traffic is higher than average, diesel prices also tend to be higher as gas stations try to capitalize on the increased demand. However, the effects of holidays have been rarely investigated, and previous studies have produced mixed results. For example, while Hall *et al.* (2007) found no holiday effect, Haucap *et al.* (2017) found a positive effect for both types of holidays but noted that coefficient values were sometimes low or even negative in certain specifications, particularly for diesel fuel.

Finally, our estimated weekly cycle shows that diesel prices are 0.3 cents higher from Monday to Thursday than on Sundays, after which the gap narrows. This pattern has been reported in the literature (see e.g. Atkinson, 2009; Foros and Steen, 2013). Furthermore, the coefficients estimated for our day-of-the-month dummies indicate that prices may follow a fuel consumption cycle that is determined by available income (Hastings and Washington, 2010): prices rise in the middle of a month because this is when most workers are paid. Finally, the estimated seasonal fixed effects demonstrate that prices are highest in March and October and lowest in September (see Figure A1 in the Appendix).

In addition, our analysis revealed that diesel prices are lower in areas where competition is stronger. Therefore, gas station pricing strategies should take into account the number of competitors, the type of competitors, their location and timing.

The results of the regression analysis of gasoline prices on its expected determinants are displayed in Table 3, which is very similar to the diesel regression models. As expected, the positive impact of the difference in ex-refinery price of gasoline derivatives on the price of gasoline is consistent with previous research that suggests crude oil prices are the primary determinant of gasoline prices. Likewise, the negative impact of the number of competitors within a 3 km radius on the price of gasoline is in line with the literature that highlights competition as a significant factor affecting fuel prices. However, the actual effect of the number of competitors is similar in comparison to the diesel model, as an increase in the number of gas stations by one results in a price fall of only 0.1 cents in both cases. In line with the diesel model results, the distance to the nearest competitor variable is insignificant.

Moreover, the findings indicate that independent gasoline brands charge lower prices compared to wholesale brands by 1.6 cents, while there is no significant difference between supermarket and wholesale brands. The result on the pricing strategy of independent brands is consistent with previous research, which suggests that independent stations often charge lower prices to compete with larger chains. On the other hand, our result on the pricing strategy of supermarket brands is in line with some studies, which suggest that supermarket brands charge higher or same prices for gasoline while offering the explanation that gasoline sales are considered a by-product of their supermarket business and are priced as a convenience bundle that can capture consumer surplus more efficiently (Haucap *et al.*, 2016). By offering a bundled discount, supermarket brands introduce price discrimination that benefits the consumer who buys both at the supermarket and gas station in comparison to the one who buys a single product and pays a higher stand-alone price (Wang, 2015).

Variables	Model 1: OLS RE Coefficient	Rob. SE	Model 2: G2SLS RE IV Coefficient	Rob. SE
Constant	−19.30***	(0.0286)	−19.30***	(0.00774)
ΔEx-refinery price	0.00496***	(0.000242)	0.00496***	(0.000222)
Number of competitors	−0.000480***	(0.000167)	−0.000926***	(0.000167)
Distance to nearest comp.	0.000113	(7.80e-05)	2.61e-05	(0.000100)
Supermarket	0.000105	(0.00445)	0.000913	(0.00157)
Independent	−0.0164**	(0.00770)	−0.0159***	(0.00202)
Share of oligopoly brands	−0.00561	(0.00498)	−0.00545***	(0.00200)
Traffic intensity	1.54e-08***	(5.67e-09)	1.61e-08***	(1.60e-09)
Income	3.24e-06***	(1.19e-06)	3.19e-06***	(1.60e-07)
Highway	0.0447***	(0.00120)	0.0442***	(0.00102)
Border: Croatia	0.00341***	(0.00126)	0.00278**	(0.00125)
Border: Hungary	0.00253	(0.00279)	0.00186	(0.00363)
Border: Italy	0.00344*	(0.00177)	0.00396***	(0.00120)
Border: Austria	−0.00129	(0.00190)	−0.00181	(0.00161)
Public holiday	−0.00337***	(8.85e-05)	−0.00336***	(0.000254)
School holiday	0.00653***	(7.52e-05)	0.00654***	(0.000168)
Weekly cycle	Yes		Yes	
Monthly cycle	Yes		Yes	
Seasonality fixed effects	Yes		Yes	
Number of observations	272,546		272,546	
Number of groups	519		519	
R^2	0.9732		0.9731	

Notes: Robust standard errors clustered by gas station are in parentheses; significance levels are denoted by: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$; Δ denotes first-differenced variables
Source: Author's own work

Table 3.
Regression of retail price of gasoline

Previous research supports the finding of this study, a positive impact of traffic intensity on gasoline prices, indicating the role of convenience and transportation costs in fuel pricing. Furthermore, the study reveals that the income of the municipality has a positive effect on gasoline prices, possibly due to greater consumption in wealthier areas.

Location is also a crucial factor in gasoline pricing, with gas stations located on highways charging on average 4.4 cents higher prices than other gas stations. Cross-border differences also affect gasoline prices, with gas stations near the borders with Croatia and Italy charging on average 0.3 and 0.4 cents higher prices, respectively, than other gas stations, while there was no observed effect for gas stations near borders with Hungary and Austria.

The impact of holidays on gasoline prices is similar to that of diesel prices. During public holidays, gasoline prices are lower, likely because of lower traffic intensity, while prices are higher during school holidays when consumption is higher than on an average day. These findings suggest that gasoline prices, such as diesel prices, are seasonally related and depend on factors such as seasonal travel patterns and demand.

Finally, the study's estimated weekly cycle indicates that gasoline prices are only 0.1 cents higher on Mondays than on Sundays and 0.2 cents higher from Tuesday to Thursday than on Sundays, while prices on Fridays and Saturdays are similar to those on Sundays. Additionally, the estimated day-of-the-month dummies show that gasoline prices are highest in the middle of the month when most workers are paid. Finally, the estimated seasonal fixed effects demonstrate that prices are highest in March (higher by 8.6 cents than in January) and October (higher by 4.6 cents) and lowest in December (lower by 1.9 cents), which is similar to diesel prices, with more significant differences between months.

In summary, the study's findings underscore the importance of various factors such as competition, location and economic conditions in determining gasoline prices.

The regression analysis on the determinants of retail fuel prices largely confirmed expected results. The study found that fierce local competition decreases fuel prices, potentially due to retailers lowering their prices to attract customers and maintain market share. Additionally, retailers in highly competitive markets may be more efficient in their operations and supply chain management, resulting in lower costs and lower prices for consumers. Distance to the nearest competitor has no effect on pricing of retail fuels.

Gas stations run by supermarkets set higher prices than wholesalers and independent brands (for diesel only). Pricing strategies could differ between sales made to businesses and direct sales to consumers. Surprisingly, the study found no effect of the share of oligopoly brands in the local market on price. This finding challenges the conventional wisdom that higher market concentration leads to higher prices and highlights the need for a more nuanced understanding of the factors that influence retail fuel prices.

As expected, the study found a positive impact of traffic intensity and gas stations located on highways on retail fuel prices. This suggests that gas stations in high-traffic areas may have higher operational costs, leading to higher prices for consumers. This is because of higher search costs and opportunity cost of time for highway drivers. Additionally, higher income levels tend to support higher prices with higher purchasing power.

Cross-border differences in retail fuel prices are significant determinant of prices especially for gas stations near border with Croatia and Italy. Owing to significantly higher prices in neighbouring countries, the effect is positive. In a small country with large and positive cross-border differences in fuel prices, the positive impact on prices can be attributed to the competitive pressure exerted by cross-border competition. In this type of market, consumers from other countries have the option to purchase fuel at a lower price by crossing the border. This creates an upward pressure on prices in the local market, as retailers are compelled to compete with higher-priced cross-border fuel.

The study also found that retailers may adjust their prices based on changes in demand patterns during public and school holidays. During public holidays, when demand for fuel may be lower, retailers may lower their prices to attract customers. Conversely, during school holidays, when demand for fuel may be higher due to increased travel, retailers may raise their prices to maximize profits. The estimated weekly cycle showed that fuel prices were higher on working days than on weekends. Prices may also follow a fuel consumption cycle, rising in the middle of the month when most workers are paid. Finally, fuel prices exhibit seasonal fluctuations, with the highest prices occurring in spring and summer due to increased traffic, and the lowest prices prevailing in winter. This pattern can be attributed to the elevated travel activity during the warmer months and to lower winter prices, which are a result of seasonal formulation adjustments driven by environmental regulations. These regulations necessitate reduced evaporative components in summer to mitigate warm weather effects, leading refiners to opt for more expensive, less evaporative components.

5.2 Brand model

To investigate the impact of specific brands on fuel prices, we employed a G2SLS RE IV model and analysed the impact of dummies for the 11 most numerous brands. All previously discussed covariates were included, with the reference category for the brands being the 9 smaller brands. Table 4 presents brand-specific estimates for the same price metrics, and other coefficients not explicitly shown remain comparable in magnitude. On a high level, several brands show significant differences in magnitude across specifications. Our findings

Variables	Diesel Coefficient	Rob. SE	Gasoline Coefficient	Rob. SE
Constant	−21.62***	(0.0103)	−19.32***	(0.00788)
ΔEx-refinery price	0.00451***	(0.000248)	0.00495***	(0.000222)
Number of competitors	−0.000411***	(9.53e-05)	−0.000677***	(0.000122)
Distance to nearest comp.	4.43e-05	(5.52e-05)	4.79e-05	(6.92e-05)
Petrol	0.00294**	(0.00118)	0.00688***	(0.00229)
OMV	0.00489***	(0.00119)	0.0104***	(0.00231)
MOL	0.00518***	(0.00124)	0.0108***	(0.00236)
Shell Adria	0.00236	(0.00175)	0.00438	(0.00551)
M – Energija	0.0247***	(0.00143)	0.0230***	(0.00251)
FE – trading	−0.0263***	(0.00183)	−0.0197***	(0.00288)
LOGO	0.00329*	(0.00172)	0.00645**	(0.00298)
Agas	0.00795**	(0.00310)	−0.0229***	(0.00426)
Panvita	0.00297	(0.00311)	0.00595	(0.00424)
TehnoSTOR	0.00161	(0.00420)	0.00687	(0.00550)
HOJNIK oil	−0.0517***	(0.00309)	−0.0586***	(0.00435)
Other variables	Yes		Yes	
Weekly cycle	Yes		Yes	
Monthly cycle	Yes		Yes	
Seasonality fixed effects	Yes		Yes	
Observations	285,162		272,546	
Number of id	544		519	
R^2	0.9589		0.9751	

Notes: Robust standard errors clustered by gas station are in parentheses; significance levels are denoted by: ***$p < 0.01$, **$p < 0.05$, * $p < 0.1$; Δ denotes first-differenced variables; reference category for brands is other brands; other variables = traffic intensity, income, highway, border: Croatia, border: Hungary, border: Italy, border: Austria, public holiday, school holiday
Source: Author's own work

Table 4. Regression of diesel and gasoline prices on brands

largely support the Slovenian Competition Authority's (2021) classification of wholesale brands (Petrol, OMV, MOL and Shell Adria), which on average charge the highest prices. As expected, wholesale brands have in general positive effect on prices for both fuels, except Shell Adria. The coefficients on supermarket brands (M-Energija and FE-Trading) are ambiguous in direction, as M-Energija on average charges higher prices while FE-Trading charges lower prices. The independents (LOGO, Agas, Panvita, TehnoSTOR and HOJNIK Oil) have even more heterogeneous pricing strategies. This is partly due to their distinctive offer of by-products, which in some cases presents their main business activity.

Several results of this study which are not aligned with the majority of the literature can be partially attributed to the characteristics of the size of the country, its well traffic connectivity, cross-border price differences, which go beyond the high market concentration. In such a scenario, the presence of oligopoly brands in the local market may not have an effect on prices. These brands have the power to set prices above the competitive level. However, in the face of cross-border competition, oligopoly brands may not be able to exercise their market power to raise prices, as they risk losing market share to lower-priced cross-border competitors. [8] Furthermore, the oligopoly brands may also face competition from independent retailers in the local market, who may offer lower prices due to lower overhead costs or other advantages. This competition further restricts the oligopoly brands' ability to raise prices.

5.3 Robustness check

Defining the geographical market's boundaries is critically important. From an antitrust perspective, "The relevant geographic market encompasses an area where competitive conditions are sufficiently uniform and can be distinguished from neighboring regions" (Fletcher and Lyons, 2016). It is generally expected that competitors within this defined market contribute to maintaining competitive pricing, while those outside exert less influence over pricing strategies.

Most studies on fuel pricing assume that a station competes with all others within a 2 or 5 km radius. In this research, we investigate whether the results shown in Tables 2–3 change based on the geographical market size by comparing areas within a 5 km radius to those within a 3 km radius. The coefficients detailed in Tables 1 and 2 in the Appendix are largely consistent with those found in Section 5.1, though some parameters show slight differences. Notably, the coefficient for the number of competitors decreases, indicating that the introduction of a new competitor within a 3 km radius has a more pronounced effect on prices than within a 5 km radius.

As part of our robustness checks, we also estimated the models in Tables 2–4 using an alternative set of control variables that correlate with the existing ones, such as the number of cars and traffic accidents at the municipal level. However, the results have not changed significantly. Instead of using population density at the municipal level, we used land costs at the municipal level, where the results also remained largely unchanged. In all mentioned cases, the correlations between these variables were above 0.8.

6. Conclusions

In markets characterized by oligopoly selling a homogeneous good, an increase in the number of competitors fosters competition, lowers prices and ultimately benefits consumers. While retail fuels such as diesel and gasoline may be considered as homogeneous products, factors such as brand and location become critical differentiating dimensions when sold across different gas stations. This article seeks to examine the impact of the intensity and type of competition at a local level, competitors' brand affiliations, as well as other supply-side and demand-side characteristics on price differentials across gas stations.

We conducted a comprehensive analysis of the factors that influence retail gasoline and diesel prices in Slovenia, using a data set of price quotes from all gas stations in the country between 1 October 2020 and 15 March 2022. Unlike previous studies on retail fuel markets that are limited to specific regions or cities, our empirical study covers the entire country, providing extensive insights into the nature of competition and pricing in a small EU country. Although institutional environments and market structures may differ between EU countries, we believe that our results are generalizable to some extent because the similarities between fuel markets.

Our analysis allowed us to compare prices at different locations, times and market segments and to assess the impact of various station characteristics and spatial competition measures on price levels. We computed average daily retail prices based on precise intraday price quotes and tested them for price distribution, then regressed them on a range of supply- and demand-side controls using random effects models with IVs to account for endogeneity. Understanding the competitive dynamics in a market with a largely homogenous product requires accounting for differences between stations and brands, as well as variations in costs and locations. Competition authorities and policy makers should take note of these differences, which effectively lead to product differentiation.

Our analysis reveals that a significant portion of the daily price variation observed at gas stations can be attributed to observable station characteristics, as well as the ex-refinery price that affects all stations. Within the observable variables, distinguishing between highway and road stations is crucial. Brand recognition also has a significant impact on price levels, in line with existing classifications of wholesale brands. In a broader sense, we have discovered that the structure of local competition is an essential factor in addition to the number of brands. The more diverse the group of independent brands in a particular area, the lower the anticipated price levels. This indicates that concentrating solely on market shares is inadequate to explain the competitive dynamics, even at the local level. Additionally, we have found that border proximity subjects areas to cross-border competition, resulting in increased prices due to positive cross-border price differences in this study. Finally, the research also controls for several demand-side determinants related to traffic intensity (e.g. income, public and school holidays) and fixed effects at the weekly, monthly and seasonal levels. The results are comparable across fuel types and broadly support expectations on price determinants (Eckert, 2013), while specific impacts naturally vary.

The puzzle of why Slovenia's retail fuel market, despite having a high oligopolistic share, shows no significant abuse of market power in terms of overcharging during a period of deregulation, can be explained through a combination of factors. First, historical regulatory practices have influenced the behaviours and strategies of dominant firms, leading to potential underdevelopment in pricing strategies and market adaptation. Additionally, the geographical and economic characteristics of Slovenia, including its role as a transit country and the competitive pressure from neighbouring countries, contribute to maintaining competitive pricing. High levels of internal and cross-border traffic increase market demand variability, encouraging competitive pricing to attract a diverse customer base. Despite the dominance of a few firms, the external competitive pressures and the remnants of regulatory structures help prevent significant market abuses and maintain lower fuel prices relative to neighbouring countries and the broader EU context.

The findings of this study are highly relevant for policy debates regarding retail gasoline and diesel pricing, which is often poorly understood by policymakers and viewed with suspicion. The prevailing notion of competition applied in policymaking is often overly simplistic, failing to account for product differentiation that results from station heterogeneity. However, this study identifies several factors that influence price levels, including the type of brand, station location and ex-refinery prices. By considering these factors, a more complex picture emerges of the drivers behind retail gasoline and diesel prices. Importantly, the study finds that competitive forces are working, albeit to a measurable extent. This contradicts the suspicion sometimes voiced in policy circles that competition in the industry is inadequate. Nonetheless, the results suggest that the model of perfect competition may not be the most applicable at the retail level.

The results presented in this paper have certain assumptions and limitations, as expected. Additionally, the method used to calculate average daily prices could be improved upon in future research including the use of intraday price quotes. Further investigation in the field of retail diesel and gasoline pricing could explore specific aspects related to daily pricing patterns, such as in the context of the Edgeworth cycle theory. Furthermore, exploring the impact of opening hours, services offered and other competition-related variables on local pricing may be interesting avenues for future research.

Notes

1 Malta, Luxembourg and Slovenia were excluded from the analysis as their price levels were subject to price controls regulations.

2 We have also performed additional robustness checks to ascertain whether the results are influenced by the alternative local market definition of 5km (see Section 5.3).

3 Contrary to some studies (e.g. Gonzalez and Moral, 2023) that employed logarithmic distance to the nearest competitor, we posited a linear relationship between the effect and distance, assuming that the effects diminish more gradually.

4 Our selection of instruments relies on the premise that municipalities, as small topological units averaging 95.6 km^2, provide a coherent framework for analysing local market competition. Despite potential variations within municipalities, such as differences in entry costs and consumer willingness to pay between city centres and remote locations, municipalities are generally less populated (median size less than 5,000 inhabitants) and often encompass both densely and sparsely populated areas. This range tends to homogenize economic conditions across each municipality. Moreover, municipalities often include border markets that draw information from adjacent settlements, albeit not from neighbouring municipalities, but on average it still captures the majority of neighbouring local markets. The physical separation between municipalities due to rugged terrain, as the Slovenian territory has 58% of the area covered by forests and over 72% classified as mountainous, further diminishes cross-municipality effects, supporting the use of municipal data as instruments in our analysis.

5 Correlation between an instrument and another explanatory variable besides the endogenous variables may not be problematic if there are no direct effects on the dependent variable. In our case, correlations between explanatory variables and instruments are below critical values, suggesting that the exclusion restriction is met.

6 An overview of public holidays is available on the website of the Slovenian Ministry of Internal Affairs (https://www.gov.si/en/topics/national-holidays/) and school holidays can be found on the website of the Ministry of Education, Science, and Sport (https://www.gov.si/teme/solski-koledar-za-osnovne-sole/ (in Slovene)).

7 Tests for the strength and validity of instruments confirm their appropriateness. Specifically, the joint significance of the instruments in the regression for diesel is affirmed by the first-stage IV regression F-test, with a Kleibergen–Paap rk Wald F statistic of 23.57, well above the critical value of 5% maximal IV relative bias (13.97). Instruments were also found valid as indicated by the Sargan–Hansen test, with a test statistic value of 1.57 and a p-value of 0.67, allowing us to not reject the null hypothesis concerning the overidentifying restrictions of instruments.

8 If neighbouring countries were to have lower fuel prices, we would expect gas stations near the border in Slovenia to reduce their prices, although this adjustment may be limited due to the phenomenon of sticky prices.

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Appendix

Figure A1.
Regression coefficients of seasonal fixed effects and time cycles

Notes: (a) Monthly cycle (diesel); (b) Monthly cycle (gasoline); (c) Weekly cycle (diesel); (d) Weekly cycle (gasoline); (e) Seasonal FEs (diesel); (f) Seasonal FEs (gasoline)
Source: Author’s own work

Variables	Model 1: OLS RE Coefficient	Rob. SE	Model 2: G2SLS RE IV Coefficient	Rob. SE
Constant	−21.61***	(0.0310)	−21.61***	(0.0104)
ΔEx-refinery price	0.00455***	(0.000264)	0.00455***	(0.000248)
Number of competitors	−0.000300**	(0.000120)	−0.000212***	(7.86e-05)
Distance to nearest comp.	8.29e-05	(7.47e-05)	0.000135	(9.24e-05)
Supermarket	0.00559	(0.00470)	0.00546***	(0.00140)
Independent	−0.00496	(0.00302)	−0.00525***	(0.00143)
Share of oligopoly brands	−0.000517	(0.00384)	−0.000876	(0.00199)
Traffic intensity	1.37e-08**	(6.33e-09)	1.30e-08***	(2.15e-09)
Income	3.27e-06***	(1.05e-06)	3.23e-06***	(1.67e-07)
Highway	0.0388***	(0.00114)	0.0389***	(0.000961)
Border: Croatia	0.00223	(0.00161)	0.00237**	(0.00118)
Border: Hungary	0.00163	(0.00248)	0.00172	(0.00347)
Border: Italy	0.00340**	(0.00151)	0.00320***	(0.00104)
Border: Austria	−0.000933	(0.00181)	−0.000808	(0.00150)
Public holiday	−0.00109***	(9.87e-05)	−0.00110***	(0.000358)
School holiday	0.00401***	(8.01e-05)	0.00401***	(0.000237)
Weekly cycle	Yes		Yes	
Monthly cycle	Yes		Yes	
Seasonality fixed effects	Yes		Yes	
Number of observations	285,162		285,162	
Number of groups	544		544	
R^2	0.9566		0.9567	

Notes: Robust standard errors clustered by the gas station are in parentheses; significance levels are denoted by: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$; Δ denotes first-differenced variables
Source: Author's own work

Table A1. Regression of retail price of diesel (local markets of 5 km radius)

Table A2.
Regression of retail price of gasoline (local markets of 5 km radius)

Variables	Model 1: OLS RE Coefficient	Rob. SE	Model 2: G2SLS RE IV Coefficient	Rob. SE
Constant	−21.60***	(0.0312)	−21.60***	(0.0107)
ΔEx-refinery price	0.00567***	(0.000335)	0.00567***	(0.000315)
Number of competitors	−0.000292**	(0.000118)	−0.000211***	(7.66e-05)
Distance to nearest comp.	7.82e-05	(7.31e-05)	0.000125	(9.00e-05)
Supermarket	0.00568	(0.00468)	0.00556***	(0.00136)
Independent	−0.00494	(0.00302)	−0.00521***	(0.00139)
Share of oligopoly brands	−0.000416	(0.00382)	−0.000743	(0.00194)
Traffic intensity	1.32e-08**	(6.33e-09)	1.25e-08***	(2.14e-09)
Income	3.14e-06***	(9.94e-07)	3.10e-06***	(1.63e-07)
Highway	0.0388***	(0.00114)	0.0389***	(0.000936)
Border: Croatia	0.00216	(0.00160)	0.00228**	(0.00115)
Border: Hungary	0.00159	(0.00240)	0.00168	(0.00338)
Border: Italy	0.00326**	(0.00147)	0.00308***	(0.00101)
Border: Austria	−0.000850	(0.00175)	−0.000733	(0.00146)
Public holiday	−0.00113***	(9.87e-05)	−0.00114***	(0.000358)
School holiday	0.00403***	(8.02e-05)	0.00403***	(0.000237)
Weekly cycle	Yes		Yes	
Monthly cycle	Yes		Yes	
Seasonality fixed effects	Yes		Yes	
Number of observations	285,162		285,162	
Number of groups	544		544	
R^2	0.9567		0.9567	

Notes: Robust standard errors clustered by the gas station are in parentheses; significance levels are denoted by: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Δ denotes first-differenced variables
Source: Author's own work

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