Competitive strategies of national border gasoline stations: the impact of regional policies on gasoline price

Angela S. Bergantino, Mario Intini, Federica Nuzzo
Department of Economics, Management and Business Law
University of Bari Aldo Moro, Italy

Abstract

For several years, the price difference in gasoline between Italy and the neighbouring countries has encouraged residents in border regions to refuel abroad. In response to this issue, certain Italian border regions have implemented discount policies for local residents to discourage "fuel tourism", which is considered detrimental to both the national economy and the environment. Our objective is to assess the potential impact of these regulatory changes on retail gasoline prices. Specifically, we examine variations in discount policies across neighbouring areas, such as Area 0 vs. Area 1 and Area 2, within the same Italian region (Friuli Venezia Giulia). Using a dataset containing weekly gasoline prices for the universe of gasoline stations in Friuli Venezia Giulia from the first quarter of 2022 to the first quarter of 2023, our findings provide evidence that gasoline stations do respond to changes in discount policies.

Keywords: Gasoline prices; Policy evaluation; Fuel tourism

1. Introduction

Since fuel is an almost homogeneous product, it is reasonable to assume that drivers make rational choices when it comes to selecting gasoline stations according to the price. Consequently, the noticeable differences in fuel prices between Italy and its neighbouring countries have led to a considerable amount of fuel tourism from Italy's border regions to neighbouring countries. The closer one is to the border, the greater the attraction for drivers to refuel abroad. The cross-border fuelling is being closely monitored by policymakers and it is the subject of a heated debate.

The cross-border fuelling represents a form of competition that has undesirable side effects (Zaccomer and Bressan, 2021). Firstly, in the country with the most favorable prices, a higher density of retail outlets is observed, which has positive employment implications in the distribution sector. Second, there are reductions in government revenues due to this phenomenon, with public coffers losing around 120 million euros every year, considering VAT and excise duties[1]. Finally, the extra kilometres driven contribute significantly to a country's national greenhouse gas emissions. These negative impacts induced some Italian regions' government to adopt measures to prevent fuel tourism. However, in 2018 the European Union raised concerns about related regional policies[2]. The political debate on fuel prices in Friuli Venezia Giulia remains contentious to this day[3].

In this paper, our aim to analyze the pricing behavior of gasoline stations near the border and evaluate the potential side effects of the policies introduced to discourage fuel tourism. To address these issues, we collected data from the «Osservatorio Prezzi Carburanti» of the Italian Ministry of Economic Development (MISE). Our focus is on Friuli Venezia Giulia (FVG), a region located in northeastern Italy, which borders with Croatia, Austria and Slovenia. This is an interesting case study as its regional government introduced a system of discounts on motor fuel purchases for the benefit of residents to prevent fuel tourism. The objective outlined by policymakers is to encourage refuelling at a competitive price compared to border states. The discounts are determined for each of the three contribution areas into which the regional territory is divided: Area 0 (which, starting from 23/01/2023, is an extra discount area), Area 1 with an increased contribution, and Area 2 with a regular contribution. Therefore, this is a

[1] Source: https://www.consiglio.regione.fvg.it/pagineinterne//Portale/comunicatiStampaDettaglio.aspx?ID=802821

[2] Source: https://ec.europa.eu/commission/presscorner/detail/it/MEMO_18_6247

[3] Source: https://www.ilgoriziano.it/articolo/cala-vendita-carburante-gorizia-fascia-zero-confine-basta-4-settembre-2023

suitable geographical context to analyse the behavior of border retailers and evaluating the impact of regional discount policies on gasoline prices in the context of fuel tourism.
The paper is structured as follows: Section 2 discusses the literature on fuel tourism, while in Section 3 we illustrate the research context, market characteristics and the data. Section 4 describes the empirical design and discusses the main results. In Section 5, we summarize the main conclusions and policy implications.

2. Literature overview

Economists have conducted analyses on the economic phenomenon of fuel tourism, also known as cross-border shopping. This phenomenon occurs when consumers strategically choose to purchase goods such as fuel, alcoholic beverages, or tobacco in administrative zones different from their own due to lower prices. This situation is particularly appealing to residents living in proximity to the border and to individuals who frequently cross borders for work or travel between regions without formal trade barriers. Numerous empirical studies have attempted to estimate the importance of the cross-border shopping. Regarding fuel, research reveals three distinct effects (Romero-Jordán et al., 2013):

(i) Regarding drivers' behavior, there is a clear incentive for them to cover more kilometres to refuel. Manuszak and Moul (2009) found that, in the case of Chicago, the willingness of a driver to travel an additional mile to buy gasoline corresponds to about $0.065 to $0.084 per gallon. Michaelis (2004) demonstrated that Germans are willing to drive an additional 2–4 kilometers to a neighbouring country for each 1 euro-cent reduction in diesel prices. Rietveld et al. (2001) found that approximately 30% of the Dutch car owners living at the border would fuel in Germany with a price difference of about 5 cent per litre. Notably, Jansen and Jonker (2018) find evidence that price differentials lead to cross-border fuelling by Dutch consumers living within 10 km of the German border.

(ii) The relationship between fuel tourism and gasoline station sales has been widely explored. Banfi et al. (2005) estimates the crossborder fuelling behavior for Switzerland. They observed that a 10% decrease in gasoline prices in the Swiss gasoline price led to a nearly 17.5% increase in demand in adjacent areas, including Germany, Italy, and France. In the Spanish context, Leal et al. (2009) found that a 1% increase in fuel prices in one region could result in an increase in fuel consumption ranging from 0.59% to 1.6% in neighboring regions. Romero-Jordán et al. (2013) found that higher excise duties price shocks are not fully passed on to consumers in order to minimize the effects of fuel tourism.

(iii) The implications of fuel tourism on the flow of tax revenues from one jurisdiction to another are of significant concern. Bleijenberg (1994) estimated that the additional fuel tourism resources contributed significantly to Luxembourg's Gross Domestic Product (GDP), ranging from 2% to 3%. In Germany, a study by the Institute for Finances at the University of Leipzig indicated that the loss of tax revenue due to fuel tourism in 2005 amounted to 2.3 billion Euros compared to 1999 (as cited by the European Commission in 2007). In the United States, Manuszak and Moul (2009) concluded that regions with higher taxes could experience a 40% reduction in tax revenues compared to a scenario where tax differences did not exist, while Tiezzi and Verde (2016) show that A 13.2 ¢/gallon tax increase is found to cause, in the long run, a large reduction in gasoline demand.

In conclusion, while there is ongoing research to be conducted, the evidence underscores the significance of fuel tourism in economic dynamics. However, to the best of our knowledge, this is the first paper that tries to evaluate any side effects resulting from a regional policy aimed at discouraging fuel tourism.

3. Research context and market characteristics

3.1. Regulatory framework

Compared to the rest of the EU, Italy is among the countries in which the retail prices of gasoline and diesel are higher: this discrepancy can be attributed to the tax component, which is higher than the European average. Conversely, the industrial price component is among the lowest within the EU.

In Italy, the retail prices of gasoline are the result of two main elements[4]: (i) the fiscal component (VAT and excise duties), which account for over 50% of the consumer price; (ii) the industrial component, which is influenced by international reference prices for refined products (Platts CIF Med for Italy), itself influenced by crude oil prices (Brent). This industrial component makes up over 30% of the consumer price. Additionally, there's the "gross margin", comprising less than 20% of the final price, comprising costs and provide remuneration for downstream activities of refining.

Italian regional authorities are not permitted to impose their excise taxes on hydrocarbons. Nevertheless, regions and provinces can determine, through their own legislation and within the reserved excise quota, a reduction in gasoline prices at the gasoline station solely for their

[4] Bulletin Year XXXIII - Ordinary Supplement to N. 25 - 2023 of "Autorità garante della concorrenza e del mercato". Source: www.agcm.it

resident citizens. The negative impact of fuel tourism on the government revenues induced the North Italian province of Friuli Venezia Giulia to adopt measures to mitigate fuel tourism (in Italy, similar measures have already been adopted in the North Italian province of Lombardy in 2000). In FVG, two significant economic measures have influenced the regional fuel market, aimed at stimulating regional fuel demand (Zaccomer, and Bressan, 2021):

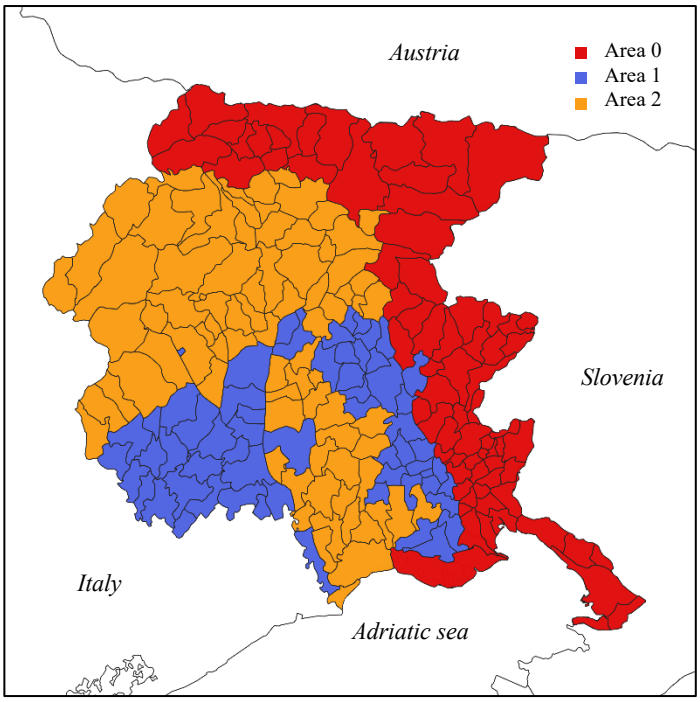
(i) In 1995, the national legislature introduced Article 3, paragraph 15 of Law No. 549, granting territorial entities, including autonomous regions like FVG, the authority to lower gasoline prices at the fuel station. FVG promptly seized this opportunity by enacting Regional Law No. 47 in 1996. This law established the framework for the first regional policy to reduce gasoline prices for automotive use. FVG was divided into five discount zones, offering decreasing discounts based on proximity to the Slovenian border.

(ii) In August 2010, the regional legislature enacted Regional Law No. 14, which served as the reference framework for the second policy measure. From a territorial perspective, the zoning was completely revised, creating Area 1 with a greater contribution than Area 2[5].

Starting from 23/01/2023, considering the significant price increases, a new extra discount of ten cents per liter has been implemented for both gasoline and diesel fuel in the 74 municipalities (Area 0) situated within a distance of less than ten kilometers from Slovenia (Fig. 1).

[5] To assist the more disadvantaged areas, particularly the mountainous ones, the municipalities listed in Directives 273/1975/EEC and 75/268/EEC were included in Area 1, totalling 149 municipalities out of 215.

Figure 1. Friuli Venezia Giulia divided into discount areas (from 23/01/2023 to 31/03/2023). Source: authors' own elaboration.



Regional Law No. 14/10 began to take effect in November 2011. The contributions practiced from the beginning to the present day, expressed in euros, are represented in Table 1.

Table 1. Discounts by area (from 01/01/2011 to 01/09/2023).

		Area 0	*Area 1*	*Area 2*
01/11/2011	01/02/2012	0	0,21	0,14
02/02/2012	31/03/2012	0	0,27	0,15
01/04/2012	24/04/2012	0	0,21	0,14
25/04/2012	31/05/2012	0	0,27	0,15
01/06/2012	30/08/2020	0	0,21	0
01/06/2012	30/04/2021	0	0	0,14
31/08/2020	30/04/2021	0	0,29	0
01/05/2021	31/03/2022	0	0,21	0,14
01/04/2022	22/01/2023	0	0,29	0,22
23/01/2023	31/05/2023	0,39	0,29	0,22
01/06/2023	30/06/2023	0,38	0,28	0,21
01/07/2023	31/07/2023	0,37	0,27	0,2
01/08/2023	31/08/2023	0,36	0,26	0,19
01/09/2023	-	0,35	0,25	0,18

Source: http://carburanti.regione.fvg.it/riduzioni.asp[6]

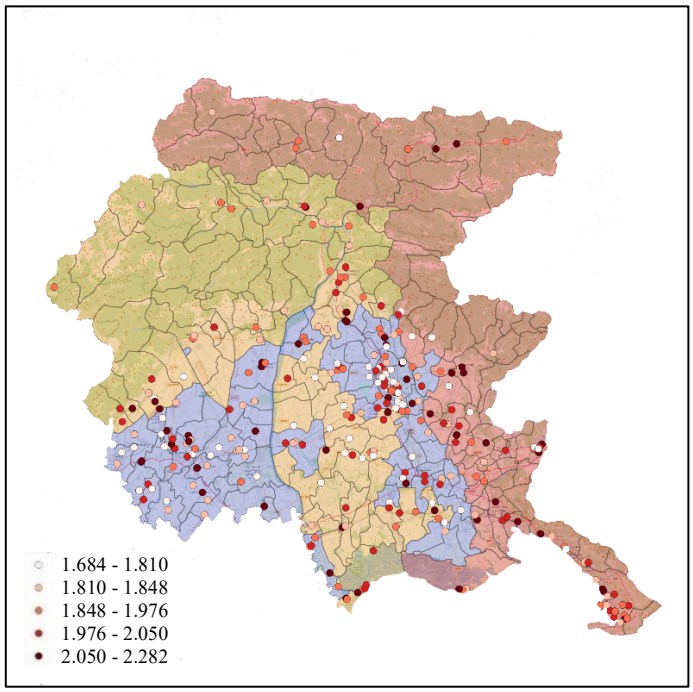
[6] The data in the table have been downloaded on 07/09/2023.

In our study, we focus on the period from 1 January 22 to 31 March 2023. The period has been chosen due to a significant change in the discount policy, which affected numerous municipalities. Specifically, until 22/01/2023, the municipalities belonging to Area 1 and Area 0 shared the same level of discount. However, starting from 23 January 2023, in response to substantial price increases, a new extra discount of ten cents per liter was implemented. It is worth noting that the European Union has recently expressed a critical view about the gasoline discount card. In November 2018, the UE sent a formal notice to Italy[7] regarding fuel pricing discount policy in the Lombardy region. This practice is seen as creating competition distortions and violating EU regulations, specifically the VAT Directive (Council Directive 2006/112/EC), which prohibits differential treatment of similar goods for VAT purposes among member states. Nevertheless, the local governments vehemently defended the fuel discount card[8].

3.2. Market characteristics and price data analysis

Considering the average prices for the entire analyzed period, from 1 January 22 to 31 March 2023, we show the geographic distribution of gasoline prices charged by stations in FVG, categorised by quintiles (Figure 2). Notably, gasoline stations located near the main urban centers appear to charge higher prices than those located in more peripheral areas of the region. Furthermore, higher prices are also charged in the eastern area of the region (Area 0, in red).

Figure 2. Gasoline prices (01/01/2022 - 31/03/2023). Source: authors' own elaboration.



[7] Source: https://ec.europa.eu/commission/presscorner/detail/it/MEMO_18_6247
[8] Source: https://www.varesenews.it/2018/11/bruxelles-la-carta-sconto-benzina/771423/

Despite the competitive pressure exerted by gasoline stations in neighbouring countries, which generally maintain lower average prices compared to Italy, the average gross prices of gasoline stations located in municipalities within Area 0 (municipalities within 10 km from the border with Slovenia) are, on average, higher than those in the other two areas. Table 2 provides some descriptive statistics, considering separately the quarter after the introduction of the extra discount, the 1st quarter 2023, and the same quarter of a previous year, 1st quarter 2022. It should be noted that in the 1st quarter of 2022, municipalities in Area 0 and Area 1 benefited from the same level of discount.

Table 2. Descriptive statistics.

Gasoline price		1st Quarter 2022	1st Quarter 2023
	Austria[9]	**1,5791**	**1,5824**
	Slovenia	**1,4399**	**1,3534**
Gross Price	**Overall FVG**	**1,9763**	**1.9687**
	Area 0	2,0102	1.9964
	Area 1	1,9730	1.9633
	Area 2	1,9603	1.9563
Price Discounted	**Overall FVG**	**1.8000**	**1.6851**
	Area 0	1.8002	1.6064
	Area 1	1.7630	1.6733
	Area 2	1.8203	1.7363

Considering the gross prices, the gasoline stations in the municipalities of Area 0 charge slightly higher prices compared to the other two areas in both the 1st quarter of 2022 and the 1st quarter of 2023. However, considering the discounted prices, as expected, Area 0 becomes the one with the lowest prices. It is worth noting that, despite the discounts, prices in this region remain significantly higher than those recorded in Austria and Slovenia during the same periods.

3.3. Data and variables' construction

The data come from the "Osservatorio Prezzi Carburanti" of the Italian Ministry of Business and Made in Italy (MISE). As mandated by the Development Law (Article 51 of Law No. 99 of July 23, 2009), it is mandatory for anyone engaged in the retail sale of motor vehicle fuels for civilian use to report the prices charged for each type of fuel (gasoline, diesel, LPG, etc.) for vehicles, for the purpose of their publication on the Ministry's website. Gasoline stations are required to submit these reports on a weekly basis, within eight days of the previous submission, even in cases where there are no price fluctuations to report.

[9] Source: TheGlobalEconomy.com provided data on weekly average gasoline prices for Austria and Slovenia.

The database contains data from all 316 gasoline stations in FVG, with the name of gasoline station brand. Regular gasoline prices without excise duties were obtained for the period from 1st January 2022 to 31st March 2023. All gasoline stations were geographically located, and all distances (in terms of car journey time) from one gasoline station to all other stations were computed. Using the excise data for each week, the net prices for each week were then calculated for each gasoline station.

The consideration of prices net of excise duties is crucial due to significant regulatory interventions that have significantly impacted the trends in gasoline prices in Italy, including the implementation of temporary tax discounts on fuels through the modification of excise duties (initiated in March 2022) and their subsequent elimination (from January 2023). Table 3 shows the distribution of gasoline stations by brand and provides the mean and standard deviation of net prices for each brand within each area.

Table 3. Gasoline stations by brand (01/01/2022 - 31/03/2023).

Brand	Area 0			Area 1			Area 2		
	Stations (n)	**Mean**	**SD**	**Stations (n)**	**Mean**	**SD**	**Stations (n)**	**Mean**	**SD**
Agip Eni	32	1.4554	0.1640	19	1.4469	0.1625	42	1.4517	0.1628
Api-Ip	16	1.3290	0.2010	22	1.3027	0.1859	42	1.3050	0.1870
Esso	13	1.3332	0.1918	11	1.3512	0.1585	16	1.3162	0.1641
Tamoil	6	1.3249	0.1837	3	1.2452	0.1419	8	1.2970	0.1808
Oil Italia	5	1.2650	0.1565	1	1.2794	0.1558	-		
Q8	3	1.3952	0.1563	6	1.3442	0.1681	4	1.2940	0.1647
AF Petroli	-			2	1.4513	0.1651	1	1.2260	0.1954
Kerotris	2	1.5902	0.1562	-			2	1.6092	0.1571
White pumps	1	1.3566	0.1349	6	1.2642	0.1521	8	1.2475	0.1446
Costantin	1	1.2741	0.1464	-			8	1.2218	0.1451
Repsol	1	1.3690	0.1445	2	1.2285	0.1332	6	1.2861	0.1574
San Marco Petroli	1	1.2030	0.1293	1	1.2519	0.1369	2	1.2482	0.1487
Sia Fuel	1	1.3688	0.1500	1	1.2633	0.1000	2	1.2494	0.1488
Som/Omv	1	1.5483	0.1533	-			-		
Total Erg	1	1.4555	0.1617	3	1.3423	0.1843	1	1.2318	0.1297
Trivengas	1	1.2431	0.1395	-			-		
Eugas	-			1	1.2957	0.1490	-		
Italia Carburanti	-			1	1.1674	0.0762	2	1.1719	0.0669
Loro	-			1	1.2406	0.1518	2	1.2317	0.1385
Retitalia	-			1	1.2800	0.1722	-		
Sarni Oil	-			2	1.5400	0.1496	1	1.5663	0.1497
Termoveneta Srl	-			1	1.2106	0.1391	1	1.1941	0.1462
AP Stazioni di servizio	-			-			1	1.3886	0
Bogoni	-			-			1	1.1977	0.1465
Energyca	-			-			2	1.2194	0.1418
GNP	-			-			1	1.1898	0.1462
Total	**85**	**1.3814**	**0.1914**	**84**	**1.3472**	**0.1824**	**153**	**1.3335**	**0.1897**

Across all areas, the three brands with greater market shares are the same, Agip Eni, Api-Ip, and Esso. The majority of gasoline stations are concentrated in Area 2, approximately double

the number in comparison to Area 0 and Area 1. When examining the average prices charged, a notable difference is observed between the prices charged by vertically integrated distributors and those offered by independent distributors, in particular the so-called "white pumps", i.e. the gasoline stations of unbranded operators.

These price differentials closely mirror the national trends in Italy. In fact, during the period between 1st January 2022 and 31st March 2023, an average price difference of approximately 0.14 euros was recorded between the daily average prices of gasoline charged by the main integrated operators and the average prices of independent operators[10]. It's worth noting that gasoline stations in Area 0, i.e. those located within a distance of fewer than ten kilometers from the border, are found to set higher prices in comparison to those in Area 1 and Area 2.

4. Empirical design

In this study, we aim to assess the influence of evolving discounts on net gasoline prices over time. Firstly, we employed a panel model analysis, with separate evaluations for each of the three Areas. The study period considered was from January 1, 2022, to March 31, 2023. During this timeframe, discounts in area 0 ranged from 0.21 to 0.39 cents, the discounts in Area 1 from 0, 21 cents to 0.29 cents, in Area 2 from 0.14 to 0.22 cents. The results show a significant impact of discounts on price trends and the impact is greater in the area closer to the border.

Furthermore, we focus on the comparison between Area 0 and Area 1 since both Areas experienced identical discounts until January 22, 2023. After this date, Area 0 benefited from an additional discount of 10 cents, while Area 1 municipalities discounts remained unchanged. We employed Propensity Score Matching to compare the average gasoline prices of the station in Area 0 with the most similar gasoline station belonging to Area 1 (as detailed in Section 4.2). We computed the average prices for both Areas, both after the introduction of the extra discount in the first quarter of 2023[11] and during the same period of the previous year. The results show that before the introduction of the extra discount, when the gasoline stations in both Areas benefited from the same level of discount, no significant differences in prices were observed between the gasoline stations belonging to the two areas. However, after the introduction of the extra discount exclusively for Area 0 stations, significant price differences emerged between the two gasoline stations.

4.1. Baseline model

To account for potential local market effects and heterogeneity across stations, a fixed-effect model was conducted using ordinary least squares (OLS) estimation, with standard errors. The

[10] Bulletin n. 25 of 7 July 2023 of "Autorità garante della concorrenza e del mercato". Source: www.agcm.it

[11] It generally indicates the quarter but refers to the period between 23 January and 31 March.

panel data analysis used data from the first quarter of 2022 to the end of the first quarter of 2023. Given that we have an unbalanced panel with a significant number of consecutive observations for only some stations, it was not imposed an autoregressive process (Foros and Steen, 2013). We estimate the following model:

$$Ln\ Net\ Price_{it} = \alpha_i + \beta Discount_{it} + \rho Ln\ Nearest\ Price_{\ it} + \gamma Brand_{\ it} + \varepsilon_{it} \qquad (1)$$

in which Ln Net Price_{it} indicates the net price observed for gasoline station i in the t-th week; $\text{Discount}_{\text{it}}$ represents the discount in each area in the t-th week.

Since price changes could be due to local specificities of consumers, competitors and production costs, we include Ln Nearest Price_{it} which captures the dynamic of the prices of that gasoline at the closest 'rival' service station located in FVG. To obtain the above information, the gasoline stations' coordinates have been used.

Further, we include Brand_{it} variable to account for price fluctuations resulting from any brand changes during the study period. β, ρ and γ stand for the coefficient of each variable; α_{i} represents an unknown station-specific constant, and ε_{it} is the error term. The description and summary statistics of variables employed in the panel data analysis are reported in Table 4.

Table 4. Description and summary statistics of variables employed in the panel data analysis.

Variable	Description and source	Area 0		Area 1		Area 2	
		Mean	SD	Mean	SD	Mean	SD
Ln Net Price	Logarithm of the price net of excise duties, MISE	0.3136	0.1378	0.2890	0.1342	0.2779	0.1404
Discount	Discount in each Area in the t-th week, FVG website[12]	0.2937	0.0517	0.2774	0.0291	0.2067	0.0298
Ln Nearest Price	Logarithm of the price net of excise duties of the nearest gasoline station, MISE	0.3340	0.1381	0.2813	0.1345	0.2763	0.1391

The econometric framework of panel data is mainly based on two principal approaches, fixed- and random-effects estimators. To determine the appropriateness of fixed-effects panel data estimation, the Hausman test is usually employed. The results of the test reveal that the fixed-effect model was the appropriate choice[13].

[12] Source: http://carburanti.regione.fvg.it/riduzioni.asp
[13] Results are available from the authors.

Table 5 presents coefficients and associated standard errors for the estimations in three different panel regressions, one for each Area. The first regression the appropriate choice all gasoline stations in Area 0, the second regression focuses on those in Area 1, and the third to those in Area 2.

Table 5. Panel regressions FE.

Ln Net Price	Area 0		Area 1		Area 2	
Discount	*0.3254***	*(0.0775)*	*0.2773***	*(0.0768)*	*0.2055***	*(0.0633)*
Ln Nearest Price	*0.0719***	*(0.0167)*	*0.1150***	*(0.0168)*	*0.1054***	*(0.0127)*
Brand	*Included*		*Included*		*Included*	
Time dummy	*Included*		*Included*		*Included*	
Constant	*0.1021***	*(0.0266)*	*0.1073***	*(0.0201)*	*0.1364***	*(0.0142)*
R^2	*0.87*		*0.90*		*0.90*	
Observations	*3,333*		*3,762*		*6,233*	

Standard errors are reported in parentheses. The symbols *** and ** indicate significance at the 1% and 5% levels, respectively.

The study assessed the associations between the net price charged by each gasoline station in each Area and the level of discount benefited using a panel data analysis with the fixed-effect model. The results indicate a statistically significant positive effect of the discount on prices. Consequently, an increase in the discount appears to positively influence prices, suggesting that gasoline stations reduce the effect of the discount by raising the gross prices paid by consumers. Furthermore, the analysis show that prices of gasoline stations located in Area 2 are much less sensitive to changes in the discount compared to those closer to the border (Area 0). Regarding *Ln Nearest Price*, the price–price elasticity is positive and significant. This result confirms the 'dependence' of gasoline stations' prices on the closest 'rival' service station.

4.2. Propensity score matching

In recent times, the propensity score matching (PSM) technique has been widely applied in cross-sectional studies to draw causal inferences. PSM control causal interferences and self-selection biases by placing them into a nonrandom assignment (Rosenbaum & Rubin, 1983). Furthermore, PSM does not impose any specific linearity assumptions on the treatment effects, which are intrinsic in the regression-based modelling (Böckerman & Ilmakunnas, 2009). The primary objective of PSM is to control for selection bias and confounding variables that may arise due to the non-random assignment of municipalities to different discount areas. This

technique becomes particularly relevant in our context because specific geographic characteristics, such as mountainous and rural areas, may influence the assignment of municipalities to higher discount areas. Mountainous areas typically exhibit lower economic development compared to flat areas within the same region.

To apply the matching technique to the present context, we define Area 1 as the control group and Area 0, i.e. the municipalities with the gasoline extra-discounts, as the treatment group. Firstly, we use the probit model to estimate the conditional probability, the propensity score, indicating the likelihood of a particular gasoline station being assigned to the treatment group. To fit the binary model, we considered specific characteristics to match gasoline stations that are not affected by the status of the treatment. Therefore, we match gasoline stations with specific gasoline station information and socio-demographic characteristics of the municipalities in which they are located.

The specific gasoline station information included in the analysis are "Brand dummies" to account for brand-related price differences; since the prices on the motorway tend to be higher than on ordinary roads, "Toll Motorway/ Highway" and "Urban Road" have been included to control for differences in prices due to the kind of road where the station is located (Bergantino et al., 2020); "Competitors" is the number of competitors within a radius of 6 minutes around the observed station, which could be considered the relevant geographic market (Perdiguero and Borrell, 2019).

Moreover, station-level data are matched with data at the micro-territorial level. We consider several variables characterizing the municipality. As a proxy of local residential demand, we considered both the resident population (*Population*) and a proxy for demand from foreign visitors (*Visitors*). Finally, to seize the richness of the territory and a proxy of the overall willingness to pay of inhabitants, we consider the variable *Income*.

Secondly, after estimating the propensity score, a single nearest-neighbor matching is adopted in order to estimate the missing counterfactual for each treated. The nearest-neighbor method finds the control observation with a propensity score closest to each treated observation. Upon pairing zones, identification of the treatment effects rests on the mean comparison of several measures of gasoline prices across the matched pairs. We calculated the average prices for each gasoline station both for the first quarter of 2022 and the first quarter of 2023. The cross-sectional dataset includes only information on gasoline stations in Area 0 and in Area 1 as they benefited from the same discount in the first quarter of 2022. In the first quarter of 2023 area 0 benefited from an extra discount of 10 cents.

Table 6. Description and summary statistics of variables employed in the PSM.

Variable	Description and source	1st quarter 2022		1st quarter 2023	
		Mean	SD	Mean	SD
Avg. Gasoline price	Average gasoline price, MISE	1.9831	0.1195	1.9809	0.1180
Road type	Type of Road, MISE				
Toll Motorway/ Highway	Equal to 1 if the gasoline station is located on a toll motorway or highway, 0 otherwise.	0.4726	0.5010	0.4726	0.5010
Urban Road	Equal to 1 if the gasoline station is located on urban road, 0 otherwise	0.5274	0.5010	0.5274	0.5010
Competitors	Number of competitors within 6 minutes, Author's own elaboration on MISE	2.4726	2.1470	2.4726	2.1470
Population	Population by municipality, ISTAT	29,601.79	61,920.42	29,601.79	61,920.42
Income	Per capita income by municipality, ISTAT	19,832.48	1,770.93	19,832.48	1,770.93
Visitors	Dummy equal to 1 if the municipality received more than 5,000 visitors from Austria, Slovenia and Croatia in 2022, Author's own elaboration[14]	0.7260	0.4475	0.7260	0.4475

Specifically, the matching equation that we estimate for gasoline station *i* is as follows:

$$Treated_i = \beta_0 Brand_i + \beta_1 TypeRoad_i + \beta_2 Competitors_i + \beta_3 Population_i + \beta_4 Income_i + \beta_5 Visitors_i$$

The results from the first-stage probits are displayed in Table 7.

We consider two models separately, Model I Model I is estimated using only the average price of the first quarter of 2022 (Model I), Model II is estimated for the first quarter of 2023.

[14] Data extracted from the report FVG "Movimenti transfrontalieri verso località commerciali e turistiche della regione. Un'analisi a partire dai dati di telefonia mobile". Available on: www.regione.fvg.it/statistica

Table 7. Matching estimates of Area 0 versus Area 1.

Parameter	Dependent variable	
	Model I Avg. Gasoline price 1st quarter 2022	*Model II* Avg. Gasoline price 1st quarter 2023
t_{TT}	-0.002	0.059*
	[-0.062;0.057]	[-0.003;0.121]
Variables balanced	Population; Brand; Type; Competitors; Avg.Income; Visitors	Population; Brand; Type; Competitors; Avg.Income; Visitors
Variables not balanced	-	-
	{51}	{58}

* Indicates significant at the 10% level. ''Variables Balanced'' implies that means are not significantly different across the matched treatment and control group at the 10% level using a t-test; ''Variables Not Balanced'' implies the means are significantly different. Number of matched pairs or regression observations is in curly brackets.

Table 7 shows that all the included covariates are balanced. In terms of the actual treatment effects, the estimates of t_{TT} for each of the two dependent variables are reported in the Table 7. The results for PSM also support the overall conclusion from the baseline analysis that gasoline discount has a positive effect on prices. Specifically, in the first quarter 2022, gasoline stations in Area 0 have lower gasoline prices compared to those of Area 1, and the effect is not statistically significant at the 90% confidence level. However, after the introduction of the extra-discount area, in the first quarter 2023, the prices in Area 0 were about 5.9 cents per liter higher on average.

Figures 3 and 4 display the distributions of the estimated propensity scores of the full treatment and control groups before the imposition of the common support and matching (Model I: 1st quarter 2022; Model II 1st quarter 2023). Therefore, the quality of the matches, as measured by the differences in propensity score, is sufficiently high.

Figure 3. Distributions of the estimated propensity scores Model I (1st quarter 2022).

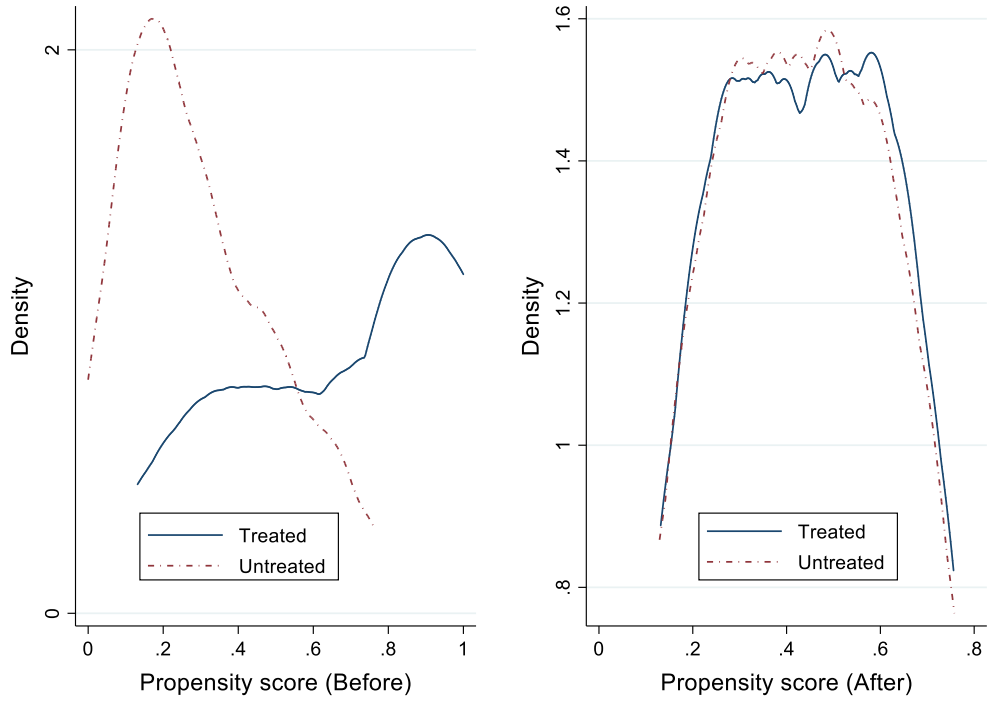
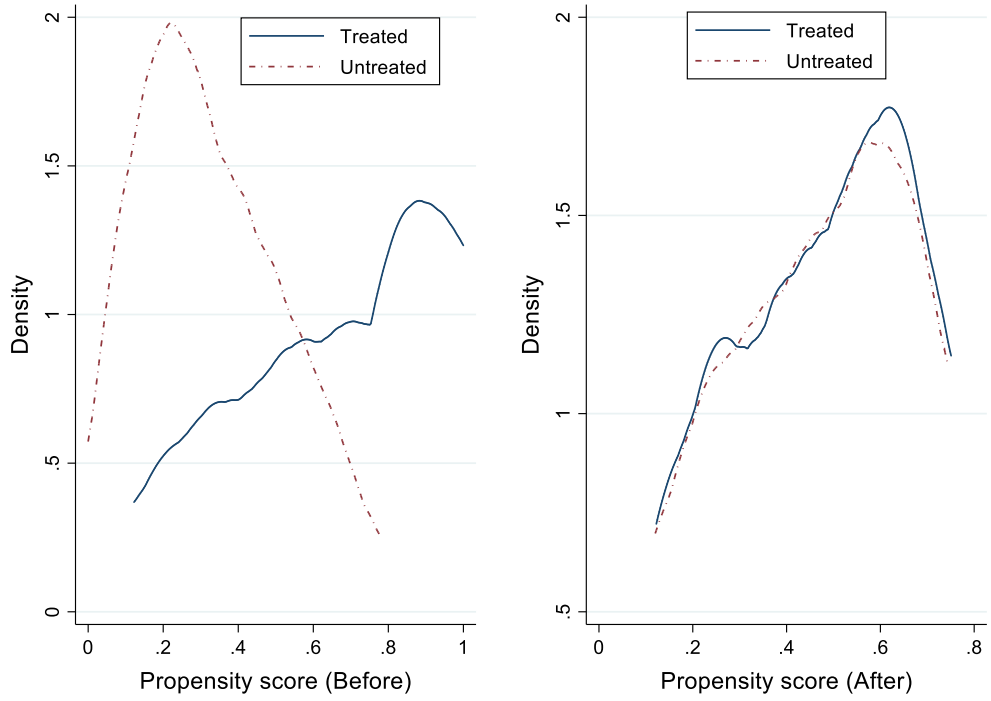


Figure 4. Distributions of the estimated propensity scores Model II (1st quarter 2023).



5. Concluding remarks

The phenomenon of cross-border shopping, also known as fuel tourism, has garnered the interest of economists and policymakers in recent years. Fuel tourism is a phenomenon that occurs when drivers strategically choose to purchase fuel in administrative zones different from their own due to lower prices.

This study focused on analyzing the impact of regional policies aimed at discouraging fuel tourism in Friuli Venezia Giulia, a region located in northeastern Italy bordering Slovenia, Austria, and Croatia. The regional policies in FVG aimed to encourage competitive pricing and reduce fuel tourism by dividing the region into discount bands for residents. To evaluate the effectiveness of these policies, this study employed panel data analysis, focusing on the dynamic effects of discounts on net fuel prices at individual gasoline stations during the period 1st January 2022- 31st March 2023. The results revealed a positive effect of discounts on fuel prices. Notably, the price sensitivity to discounts was more pronounced in areas near the border, highlighting the significant role of geographic proximity in influencing pricing strategies.

In addition, we consider a cross-sectional specification. Unlike the municipalities in Area 2, which have consistently maintained lower discount levels compared to the other two zones, Area 0 and 1 shared the same discount level until a certain date. Afterward, only one of the two (Area 0) benefited from an additional discount. For this reason, it is relevant to focus on these two areas. The findings revealed that differences in prices between these two areas were not statistically significant prior to the introduction of the extra discount, observed in the first quarter of 2022. However, these disparities became significant following the introduction of the extra discount in Area 0 during the first quarter of 2023.

In summary, the two sets of results complement each other and collectively reveal that offering gasoline discounts can have an adverse effect on the consumer. The panel model analysis, encompassing all the gasoline stations in the FVG region, underscores the influence of discount fluctuations on overall net price trends. On the other hand, the Propensity Score Matching analysis, focusing on a specific subset of stations in Area 0 and 1, clearly demonstrates that significant price disparities emerge only following the introduction of the extra-discount, contrasting with the pre-discount period when such disparities were not observed in the discounts. These findings emphasize the consumer's disadvantageous position in the presence of discounts and highlight the importance of examining their impacts on price dynamics.

In conclusion, this study contributes to the ongoing research on fuel tourism and its economic implications and provides valuable insights into the intricate relationship between fuel tourism,

government policies, and gasoline station pricing strategies. It sheds light on the effectiveness of regional policies in addressing this issue and provides insights into the behavior of gasoline stations in response to pricing regulations.

5.1. *Policy implications*

The contribution of this paper, which explores a not yet investigated role of regional policies regarding gasoline discount, should be useful for understanding the effect of this policy pricing strategies at the border. Our findings carry crucial policy implications, offering insights into the intricate interplay between such measures and the phenomenon of fuel tourism. Crucially, our results underscore the unintended consequences of discounts on consumers, emphasizing the necessity for a thorough understanding of their impacts on pricing dynamics. The identification of negative effects on consumers highlights a potential need for policy adjustments to mitigate negative outcomes. Policymakers may need to explore alternative approaches that strike a balance between fostering local gasoline stations and ensuring fair treatment of consumers.

In conclusion, although the policy strives to strengthen the competitiveness of border gasoline stations, a careful evaluation of its distorting impacts is essential. Policymakers should be aware of the unintended consequences on prices and consider recalibrating strategies for a more balanced and effective approach. This study supports a comprehensive understanding of the multiple repercussions of discounting policies, encouraging an adaptive policy to achieve optimal outcomes for both border gasoline stations and drivers.

5.2. *Limitations and future development*

While our study provides valuable insights into the impact of regional policies on fuel tourism in Friuli Venezia Giulia, it is essential to acknowledge certain limitations that warrant consideration. Firstly, our analysis is specific to the FVG region and may not be entirely generalizable to other regions with different socio-economic and geographical characteristics. The temporal scope of our study, covering the period from January 2022 to March 2023, may not capture more extended trends or account for potential fluctuations in price-setting behavior over more extended periods. Another limitation lies in the assumption that the regional discount uniformly influences consumer choices and gasoline station behaviors. It is possible that other external factors, not accounted for in our study, may also contribute to fluctuations in fuel prices and consumer decisions.

Further research in this area can shed more light on the evolving dynamics and help implement policies to mitigate the undesirable side effects of fuel tourism. Specifically, future research could build upon our study by expanding the geographical scope to include other border regions

and assessing the transferability of regional policies to diverse contexts (for instance, another Italian border region, Lombardy, has implemented a similar discount policy). Longitudinal studies covering longer periods could provide a more comprehensive understanding of how consumer behavior and pricing strategies evolve over time in response to regional policies. Furthermore, exploring the broader economic implications of fuel tourism, such as its impact on local economies and businesses, could improve our understanding of the holistic effects of cross-border shopping. Investigating the role of additional factors, such as economic conditions, demographic characteristics, and environmental considerations, could contribute to a more nuanced understanding of the multifaceted dynamics at play. Finally, while our study effectively examines the direct impact of regional policies on overall net price trends, a more detailed exploration of pass-through effects of subsidies on the final price will contribute to a nuanced understanding of the fuel market.

References

Austrian Energy Agency (2009). Energy efficiency policies and measures in Austria: monitoring of energy efficiency in EU-27, Norway and Croatia (OdyseeeMure), Austrian Energy Agency.

Balaguer, J., & Ripollés, J. (2018). Revisiting the importance of border effect in sub-national regions. Evidence from a quasi-experimental design. Papers in Regional Science, 97(4), 1113-1130.

Banfi, S., Filippini, M. and Chunt, L. (2005). Fuel tourism in border regions: the case of Switzerland, Energy Economics, 27, 689–707.

Bergantino, A. S., Capozza, C., Intini, M., 2020. Empirical Investigation of Retail Fuel Pricing: The Impact of Spatial Interaction, Competition and Territorial Factors. Energy Economics, 90:104876.

Bleijenberg, A. N. (1994). Internaliser les couts sociaux des transports, in Conference Europeenne des Ministres des Transports (CEMT), L'art de l'internalisation, OECD.

Blok, P. M. and Muizer, A. P. (1990). Nederlands Economisch Instituut, TK 1990–1991, 21.665 No. 3.

Böckerman, P., & Ilmakunnas, P. (2009). Unemployment and self-assessed health: Evidence from panel data. Health Economics, 18(2), 161–179. https://doi.org/10.1002/hec.1361.

Engel C, Rogers JH (1996). How wide is the border? American Economic Review 86: 530–546.

European Commission (2007). Commission staff working document accompanying document to the proposal for a Council Directive amending Directive 2003/96/EC.

Fitz-Gerald, J., Bergin, A., Conefrey, T., Diffney, S., Duffy, D., Kearney, I., Lyons, S., Malaguzzi, L., Mayor, K. and Tol, R. (2008). Medium Term Review 2008–2015, The Economic and Social Research Institute.

Foros, Ø., & Steen, F. (2013). Vertical control and price cycles in gasoline retailing. The Scandinavian Journal of Economics, 115(3), 640-661.

Jansen, D. J., & Jonker, N. (2018). Fuel tourism in Dutch border regions: Are only salient price differentials relevant?. Energy Economics, 74, 143-153.

Leal, A., Lopez-Laborda, J. and Rodrigo, F. (2009). Prices, taxes and automotive fuel cross-border shopping. Energy Economics, 31, 225–34.

Manuszak, M. D. and Moul, C. C. (2009). How far for a Buck? Tax differences and the location of retail gasoline activity in southeast Chicagoland, The Review of Economics and Statistics, 91, 744–65.

Michaelis, P. (2004). Anktourismus–eine szenario-analyse, Zeitschrift fur Verkehrswissenschaft, 75, 110–25.

OECD (1997). CO2 Emissions from road vehicles, Annex I Expert Group on the United Nations Framework Convention on Climate Change, Working Paper No. 1, Paris.

Perdiguero, J., & Borrell, J. R. (2019). Driving competition in local markets with near-perfect substitutes: an application on the Spanish retail gasoline market. Empirical Economics, 57(1), 345-364.

Pereira, R. H. M., Saraiva, M., Herszenhut, D., Braga, C. K. V., & Conway, M. W. (2021). r5r: Rapid Realistic Routing on Multimodal Transport Networks with R5 in R. Findings, 21262.

Rietveld, P., Bruinsma, F. R. and van Vuuren, D. J. (2001). Spatial graduation of fuel taxes: consequences for cross-border and domestic fuelling, Transportation Research Part A, 35, 433–57.

Romero-Jordán, D., García-Inés, M. J., & García, S. Á. (2013). The impact of fuel tourism on retailers' diesel price in Spanish neighbouring regions. Applied Economics, 45(4), 407-413.

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. Biometrika, 70(1), 41–55.

Samuelson PA (1952). Spatial price equilibrium and linear programming. The American Economic Review 42: 283–303.

Tiezzi, S., & Verde, S. F. (2016). Differential demand response to gasoline taxes and gasoline prices in the US. Resource and Energy Economics, 44, 71-91.

Zaccomer, G.P., Bressan, G. (2021). Le manovre di riduzione dei prezzi dei carburanti in Friuli Venezia Giulia tra feedback passati e futuri: considerazioni all'epoca della pandemia di Covid-19. In F.M. F. Dini (a cura di), Oltre la globalizzazione: Feedback (pp. 83-89). Firenze: Società di Studi Geografici.

Zaccomer, G. P., & Bressan, G. (2023). La mobilità per l'acquisto oltreconfine dei carburanti per autotrazione in Friuli-Venezia Giulia: un'analisi dei dati ufficiali dal 2012 al 2020. In Oggetti, merci, beni. L'impronta materiale del movimento nello spazio (pp. 181-187). Coop. Libraria Editrice Università di Padova.