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ANALYZING UNLEADED GASOLINE RETAIL PRICE PATTERNS IN GREECE: APR. 2011-DEC. 2012

ATHANASSIOS PETRALIAS[a]
SOTIRIOS PETROS[b]
PRODROMOS PRODROMIDIS[c*]
[a]Athens University of Economics and Business
[b]Greek Ministry for Development and Competitiveness
[c]Centre for Planning and Economic Research (KEPE),
and Athens University of Economics and Business

Abstract
The paper studies the daily price patterns of unleaded gasoline across fueling stations in Greece during April 2011-December 2012 by (a) econometrically estimating the impact of refinery prices, brands, geography, the number of competitors in the area, the day of the week, seasonality and transportation strikes on average gasoline prices at the local community level (194 thousand observations), and (b) exploring price-leadership among vendors in Athens, Thessaloniki and a number of other large municipalities via Granger causality tests.

JEL Classification: C23, D40, L81
Key words: Unleaded gasoline, Retail prices, Regression of disaggregated data, Granger causality, Greece

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* *Corresponding author*: Pródromos Prodromídis, KEPE, 11 Amerikis str., Athens 15342, Greece. e-mail: pjprodr@kepe.gr.

1. Introduction

The paper provides insights into two applied economics literature topics regarding the formation of gasoline prices. In particular, it investigates through standard OLS econometric regressions the factors that determine gasoline prices in Greece, and explores via Granger causality tests the price-setting behavior of retailers. To achieve these objectives it utilizes a rich database of daily observations reported between April 1st 2011 and December 31st 2012 from petrol stations across the country.

With the retail price of gasoline featuring among the most important determinants of rising consumer prices in Greece at a time when incomes have declined dramatically (Petralias and Prodromidis, 2014), and most studies on gasoline prices looking into aggregate (average) adjustments in retail vis-à-vis crude oil prices (Karagiannis *et al*., 2011; Bragoudakis and Sideris, 2012; and works cited therein), the paper visits the issue from a rather disaggregated, micro-regional angle that also pays attention to the distinct behaviors of the vendors who operate in local communities.

It is organized as follows: Section 2 presents the data and methods employed. Section 3 describes the market at the national and regional level. Section 4 engages in an econometric analysis of the average prices observed at the municipal level. Section 5 studies the price change patterns in the six largest towns of Greece; while Section 6 supplies the conclusions.

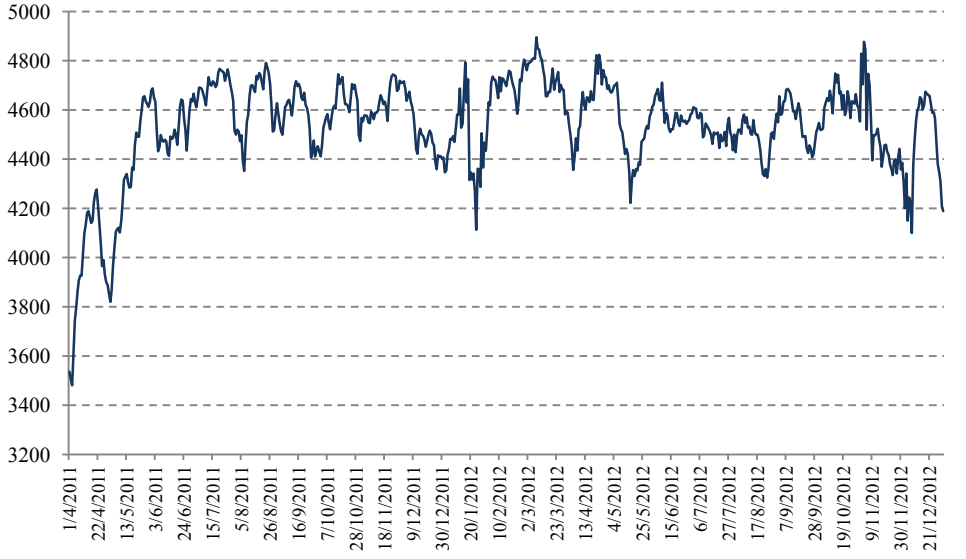
2. A short presentation of the data and of the methods employed

The paper makes use of the daily prices reported from a good number of petrol stations across the country via the Fuel Price Observatory (FPO) of the Ministry of Development and Competitiveness (www.fuelprices.gr) between early April 2011 (when petrol station participation in the FPO exceeded 50%)[1] and late December 2012 (see Figure 1). That is some 1.25 million observations in the form of unique prices solicited every 24 hours,[2] or some 194 thousand daily average prices esti-

1. According to the Hellenic Petroleum Marketing Companies Association (2010) there were approximately 7,000 petrol stations in Greece at the time.
2. Understandably, the number of observations would double or multiply if solicited twice or more times in a day. However, a preliminary investigation of the data showed a lack of multiple intraday price changes by participating stations. The remaining stations will be brought into the system in the immediate future together with the introduction of a real-time fuel input-output monitoring system.

mated by the FPO at the municipal level after the annual volumes consumed at the prefectural (NUTS 3) level.[3]

Figure 1: The number of petrol stations that participated in the FPO between Apr. 1st 2011and Dec. 31st 2012



Descriptives: Initial figure: 3,536. Lowest: 3481 (Apr. 3rd 2011). Highest: 4895 (Mar. 8th 2012). Final: 4,189.

The territorial dimension is probed to a considerable extent via two OLS regressions: one that relies on the conventional NUTS level 3 organization of the country and another that does not. (The juxtaposition reveals an interesting side issue, namely, that if the conventional spatial organization is not assumed or imposed on the data, then it may not emerge at all). The other determinants consist of refinery prices, seasonal and daily categorical (dummy) variables, market structure factors

3. The *Nomenclature des Unités Territoriales Statistiques* (NUTS) is the five-tier hierarchical structure used in the EU to standardize territorial units. In Greece, the administrative regions (*periferies*) correspond to NUTS level 2 sized-districts; prefectures (*nomoi*) correspond to NUTS level 3 sized-district; municipalities (demoi) to upper level local administrative units, occasionally termed NUTS level 4; and communities or wards to lower level local administrative units, occasionally referred to as NUTS level 5. The NUTS level 2 and 3 districts of Greece are supplied in the Appendix (in Map 1 and Table A, respectively).

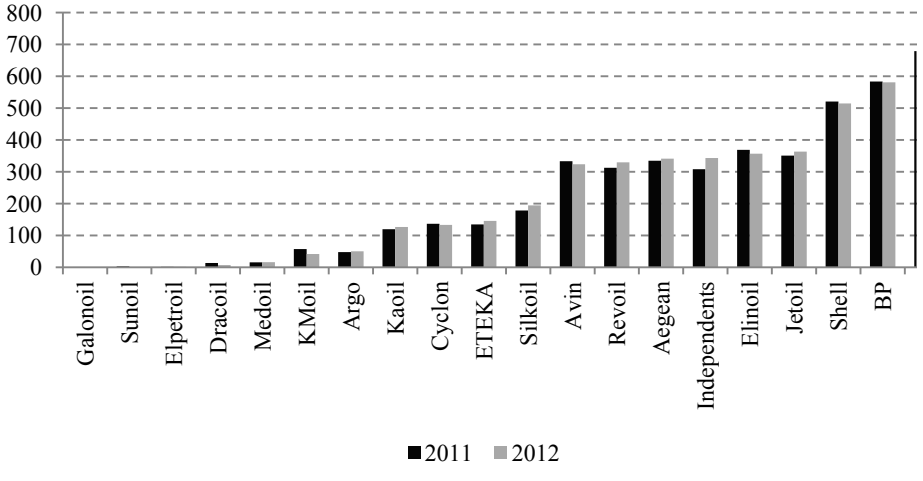
such as the number and brands of petrol stations in local communities, along with the strikes reported in the various modes of transportation.

The analysis is complemented by Granger causality tests on the price leadership roles of the distribution-and-trade companies; tests which are carried out (not at the national but rather) at the local level: one in Athens, another in Thessaloniki, additional tests in other large municipalities. The discovery of dissimilar results implies that the price-setting behavior under examination varies from one place to another.

3. Description of the market at the national and regional level

In Greece the demand for gasoline is accommodated by 18 distribution-and-trade companies, each with its own network of petrol stations, as well as independent retailers, all of which are ultimately supplied with fuel by two oil refinery companies, Hellenic Petroleum (ELPE) and Motor Oil Hellas (MOH), with the former setting the ex factory price: A market structure and practice which from time to time sparks off concerns regarding (implicit) anticompetitive agreements and concerted practices (e.g., Bragoudakis and Sideris, 2012).[4]

Figure 2: Number of chain-owned and independent petrol stations in the FPO database in 2011-12



4. A comprehensive overview of the industry is supplied by the IEA (2011). According to the figures cited in the report, in the second quarter of 2011 Greece had the second highest price and tax rate for unleaded gasoline among 24 OECD member-states.

According to the FPO database, about half the petrol stations (50% in 2011, 49% in 2012) operate under the trademarks of EKO and BP, owned by ELPE; and Shell, Avin and Cyclon, owned by MOH. (See Figure 2). The regional distribution of their outlets, both at the beginning and the end of the period, is supplied in Table 1. (a) The number of ELPE-owned stations increased considerably in Crete, the North Aegean, South Aegean, Ionian islands (by 46, 28, 24, 19, respectively), Central Macedonia, Western Greece, the South, Central and East Peloponnese (by 36, 24, 14); remained the same in Attiki; and decreased somewhat (by 3 to 11 stations) in the other regions of continental Greece. (b) The number of MOH-owned stations increased considerably in Central Macedonia, Western Greece, the South, Central and East Peloponnese, and Ionian islands (by 27, 25, 17, 10, respectively); increased somewhat (by 3 to 8) in Epiros, West Macedonia, the South Aegean islands, Crete, and Central Greece − Euboea; remained the same in Attiki, and the North Aegean islands; and decreased somewhat (by 5 to 4) in Thessaly and East Macedonia - Western Thrace. (c) The number of independently owned stations increased considerably in Western Greece, Central and West Macedonia (by 37, 37, 10, respectively); increased somewhat (by 3 to 9) in Attiki, the South, Central and East Peloponnese, the Ionian islands, East Macedonia - Western Thrace, Epiros, Crete; remained the same in Central Greece − Euboea, the North and South Aegean islands; and decreased somewhat (by 4) in Thessaly. (d) The number of stations owned by other companies increased considerably in Central Macedonia, Western Greece, Attiki, the Ionian islands (by 59, 58, 19, 12, respectively); increased somewhat (by 2 to 9) in the South Aegean islands, South, Central and East Peloponnese, and West Macedonia; decreased somewhat (by 1 to 3) in Crete and Central Greece - Euboea; and decreased considerably (by 12-50) in the other regions of Greece.

4. Econometric analysis of the price observed at the municipal level

From a microeconomic, theoretical point of view (e.g., Allen, 1967; Kreps, 1990), the factors that determine the price of any one good or service are associated with its demand (e.g., the number of consumers, their demographics, incomes and other characteristics), its cost of production and transportation, the amount supplied, the availability of information, the structure of the market (e.g., competitive, oligopolistic), the imposition of taxes and controls, as well as the manner in which bargaining between buyers and seller takes place.

Table 1: Distribution of FPO chain-owned and independent petrol stations at the beginning and at end of the period in April 1st 2001 and December 31, 2012

Apr. 1st 2011	Attiki	Central Macedonia	Central Greece and Euboea	Thessaly	East Macedonia and West Thrace	South, Central, East Peloponnese	Western Greece	Crete	West Macedonia	Epiros	North Aegean Islands	South Aegean Islands	Ionian Islands	***Total***
Aegean	56	58	12	7	65	21	16	18	12	7	3	4	5	**284**
Argo		10							14			7		**31**
Avin	42	29	28	17	13	48	19	9	9	11	3	4	6	**238**
BP	105	50	62	31	53	42	32	29	14	24	21	6	1	**470**
Cyclon	19	22	16	12	5	2	6	3	7	2	2	2		**98**
Dracoil	5	11	4	10			5		1	4			1	**41**
EKO	123	50	44	46	37	34	23	77	15	16	16	29	16	**526**
El Petroil														**0**
Elinoil	20	40	29	29	33	24	19	11	16	11	20	21	12	**285**
ETEKA	48	21	8	16		2	9			6				**110**
Galonoil	2		1											**3**
Jetoil	37	51	23	22	8	22	17	5	13	10	27	18	14	**267**
Kaoil		51	1	18	3				10					**83**
Kmoil	4	4	3	1		14	5		3	3				**37**
Medoil		2		1		7	2							**12**
Revoil	36	21	20	21	19	22	30	1	8	9	8	1	7	**203**
Shell	117	73	30	31	40	32	47	48	17	27	5	13	24	**504**
Silkoil	12	24	24	3	9	11	14	21	3	2	4	1	2	**130**
Sunoil			2							1				**3**
Independ.	28	38	29	38	14	7	22	13	11	7		1	3	**211**
Total	***654***	***555***	***336***	***303***	***299***	***288***	***266***	***235***	***153***	***140***	***109***	***107***	***91***	***3536***
Dec. 31st 2012														
Aegean	50	82	14	9	66	14	17	16	11	7	3	5	3	***297***
Argo		17	1	2					11			12		***43***
Avin	46	54	20	19	15	59	37	14	9	23	2	6	14	***318***
BP	104	64	53	29	46	48	46	45	13	20	19	8	14	***509***
Cyclon	16	31	19	10	3	6	8	4	9	2	3	2		***113***
Dracoil	1	4								2				***7***
EKO	125	72	42	40	33	42	33	107	13	13	46	51	22	***639***
El Petroil	1	1												***2***
Elinoil	24	55	36	28	34	28	26	21	18	8	15	23	16	***332***
ETEKA	57	32	10	18		4	14			6				***141***
Galonoil														***0***
Jetoil	31	73	30	19	12	29	40	6	15	10	24	22	24	***335***
Kaoil		72	1	18	7				15					***113***
Kmoil	2	1	1			19	6		1	3				***33***
Medoil		3				4	2							***9***
Revoil	55	47	22	22	25	30	55	3	17	12	3	3	11	***305***
Shell	98	66	38	24	35	34	52	46	20	23	5	15	26	***482***
Silkoil	18	47	23	3	9	16	32	25	5		5	1	2	***186***
Sunoil														***0***
Independ.	37	75	29	34	18	16	59	16	21	10		1	9	***325***
Total	***665***	***796***	***339***	***275***	***303***	***349***	***427***	***303***	***178***	***139***	***125***	***149***	***141***	***4189***

Accordingly, whenever disaggregated gasoline prices at the pump are empirically analyzed via single equation models (i.e., within a non-game framework), they tend to be explained in terms of: (i) brands (Eckert and West, 2004; Foros and Steen, 2009; Pennerstorfer, 2009); (ii) wholesale prices (Atkinson, 2009; Foros and Steen, 2009), taxes (Foros and Steen, 2009); (iii) average household incomes (Eckert and West, 2004) or territorial dummies (Eckert and West, 2004; Foros and Steen, 2009); (iv) population densities (or proxies, such as urban/rural and municipality-size classification measures) and the number of petrol stations per capita (Pennerstorfer, 2009); (v) the ratio of unbranded to branded or independent to allied (or chain-run) stations in the area (Eckert and West, 2004; Pennerstorfer, 2009); (vi) the attributes of the petrol stations involved (i.e., their sizes, the type of road by which they are located, the services they provide (Eckert and West, 2004; Pennerstorfer, 2009), the distance from competitors and from the refinery (Pennerstorfer, 2009)); (vii) the time of day (Eckert and West, 2004), the day of the week (Atkinson, 2009; Davis, 2010; Foros and Steen, 2009), holidays (Davis, 2010), as well as broader time-trends (Atkinson, 2009; Foros and Steen, 2009).

In the present case the data permit an OLS analysis of the unleaded gasoline price averages supplied by the FPO at the municipal level, in terms of (a) after-tax refinery prices (which include the cost of production and the profit or other optimization goals of the two producers);[5] (b) territorial idiosyncrasies (i.e., dummy variables associated with the product's transportation cost, the applicable VAT rates across the country, and local demand); (c) the number of independent and chain-run petrol stations in the area (capturing features of local competition and the marketing strategies of the distribution-and-trade companies); (d) the strikes in various modes of transportation (e.g., buses, trolleys, taxis, intercity rail etc., denoting the suspension of substitute forms of transportation); (e) the trend (capturing general economic developments); (f) the season and day of the week (associated with other demand- and supply related idiosyncrasies, such as daily routines, regular holidays, work patterns).

With regard to the spatial dimension, it turns out that the model which assumes a prefectural organization of the municipal data provides an inferior fit (R^2 = 81.4%

5. In Greece, after-tax refinery prices (i.e., prices that include special tax and surcharges) are nearly twice as high as pre-tax refinery prices, VAT notwithstanding. According to the Hellenic Petroleum Marketing Companies Association (2010), the distribution-and-trade margin accounted for (90:978 =) 9% of the average retail price. By contrast, in the UK the margin was in the order of 6% (United Kingdom Petroleum Industry Association, 2012).

by making use of 53 spatial dummies, see Appendix A) compared to a model that groups the data into territorial zones after the similitude of the disaggregated coefficients (R^2 = 92.6% by making use of just 25 spatial dummies). Against the tendency to rely on the conventional territorial division of the country, the implication is fairly clear: Retail prices vary across space and by and large do not follow the administrative delineation of the country.[6] In view of the above, the second model is the one that we will rely on, present and discuss below. See Table 2. According to its results, prices are:

(a) lowest in three western suburbs of Athens and a southern suburb of Thessaloniki (see coefficients #12-13); slightly higher across most of Athens' suburbs and the rest of the Attic peninsula, in the city of Thessaloniki and across most of the homonymous prefecture, the prefecture of Kilkis and neighboring areas; as well as in several towns and transportation junctions on the mainland (#14);

(b) progressively higher:

- on most of the mainland and parts of Euboea island, the islands of Salamis, Lefkas, Zakinthos (#16);
- in Athens and three eastern suburbs (#11);[7]
- in a number of remote areas of the mainland and Euboea island, and on the isles of Elafonisos and Meganision, off the mainland (#15);
- across Crete (#17-20),[8] the remaining Ionian islands (#21-23),[9] and most of the Aegean archipelago (#24-25, 30-32);[10]
- in a number of peripheral sites in the Aegean sea (#26-28, 33-34);[11]

6. The finding confirms the central result of other analyses regarding economic phenomena in Greece that also utilize disaggregated data (e.g., Prodromídis, 2006, 2012).
7. With space at a premium in Athens, understandably, rents are higher.
8. Lower in the island's two principal urban centers (Iraklion, Hania), higher in the central part, even higher in the eastern and western parts, highest in the southern municipality of Viannos. Each of the four estimated coefficients is statistically different from the others.
9. Namely, Corfu, Kefallinia, the smaller islands (Ithaca, Paxi), in this order. As in the previous footnote, each estimated coefficient is statistically different from the others.
10. Lower in the islands near the Attic peninsula (Aegina, Agkistrion, Spetse, Kea etc.) and progressively higher (i) across a group of islands immediately south of them (Paros, Antiparos, Naxos), (ii) the county's third-to-fifth largest islands (after Crete and Euboea), i.e., Lesvos, Rhodes, Hios, and the island of Thasos (where Greece's crude oil field is located), (iii) two islands off the coast of Asia Minor (Samos, Kos), and (iv) a few isles near them (Lipsi, Simi).
11. I.e., a group of islands south of those listed under (ii) in the previous footnote (i.e., Kithira, Astipalea, etc.), and two sets of islands situated one south of it (Karpathos, Tilos), the other north (Amorgos, Patmos, Ikaria), two islands in the north Aegean (Limnos, Samothrace), and the island of Skopelos is the central Aegean.

Table 2: Econometric analysis via a robust variance estimator of the average unleaded gasoline Retail prices in Greek municipalities as supplied daily by the FOP (in eurocents per litre, Apr. 2011-Dec. 2012)

Explanatory variables	*Estimated coefficients*	*p values*
1. Constant	17.74	0.000
2. Ex factory price (including taxes)	94.69	0.000
3. Time trend	0.00	0.000[1]
4. Time trend squared (to capture the rate of change)	-0.00	0.000
Seasonal factors (categorical dummies)		
5. Mid December – mid April (reference period)		
6. Mid April – end of June	1.97	0.000
7. Early July – mid September	0.34	0.000
8. Mid September – mid December	1.47	0.000
Daily factors (categorical dummies)		
9. Wednesday, Thursday	-0.02	0.078
10. Other days of the week (reference days)		
Spatial factors (categorical dummies)		
11. Athens and the eastern suburbs of Viron, Caesariani, Zografos (reference area)		
12. Thermi (a suburb of Thessaloniki near the airport)	-6.87	0.000
13. Agia Varvara, Haidarion, Perama (west Athenian suburbs near Elefsis refinery)	-6.28	0.000
14. Other areas near Athens and Thessaloniki, along with the main towns and transportation junctions on the mainland [a]	-4.18	0.000
15. Remote areas on the mainland and of Euboea island,[b] the isles of Elafonisos and Meganision off the mainland	1.93	0.000
16. Rest of the mainland and of Euboea, Lefkas (the islands of Euboea and Lefkas are linked to the mainland by bridges), the islands of Salamis (near Piraeus) and Zakinthos (in the Ionian sea)	-1.26	0.000
17. The towns of Iraklion and Hania in Crete	2.02	0.000
18. The central portion of Crete [c]	4.71	0.000
19. The eastern and western parts of Crete [d]	7.14	0.000
20. The municipality of Viannos in Crete	11.75	0.000
21. Island of Corfu (in the Ionian sea)	3.09	0.000
22. Island of Kefallinia (in the Ionian sea)	6.38	0.000
23. Islands of Ithaca and Paxi (in the Ionian sea)	11.46	0.000
24. Islands close to the Attic peninsula: Aegina, Agkistrion, Spetse, the northern Cyclades (Kea, Andros, Tinos, Siros)	6.67	0.000
25. Islands of the central Cyclades (Paros, Antiparos, Naxos) south of item #24	9.29	0.000
26. Belt of islands in the south Aegean Sea: Kithira, Astipalea, Kalimnos, Leros, the rest of the Cyclades except Sikinos and Amorgos	14.55	0.000
27. Group of islands north of those listed under item #26: Amorgos, Patmos, Ikaria	17.16	0.000
28. Group of islands south of those listed under item #26: Karpathos, Tilos	18.45	0.000
29. Remote isles in the south and central Aegean sea: Sikinos, Fourni	21.38	0.000
30. The 3rd-5th largest islands after Crete and Euboea (Lesvos, Rhodes, Hios), the medium-sized island of Thasos (off the northern part of the mainland)	7.37	0.000
31. The two Aegean islands closest to Asia Minor: Samos, Kos	10.91	0.000
32. Aegean isles close to those listed under item #31: Lipsi, Simi	13.05	0.000
33. Medium-sized islands in the north Aegean sea: Limnos, Samothrace	15.02	0.000
34. Medium-sized Skopelos island (off the Thessalian coast in the central Aegean)	16.12	0.000
35. The islands of Alonnisos, Skiathos, Skiros in the central Aegean sea	20.09	0.000
36. Remote isle of Agios Efstratios (along with #34-35 forms the Sporades group)	26.95	0.000

Table 2 (continued)

Explanatory variables	*Estimated coefficients*	*p values*
Commercial-competition factors: number of stations under a trade mark in the area		
37. Sunoil	-0.91	0.000
38. Medoil	-0.16	0.000
39. Aegean	-0.02	0.000
43. Independently owned stations	0.01	0.002
40. Elinoil	-0.02	0.000
41. EKO	-0.01	0.000
42. ETEKA	0.00	0.668
44. Shell	0.01	0.000
45. Silkoil	0.02	0.000
46. Jetoil	0.02	0.000
47. Revoil	0.03	0.000
48. Argo	0.03	0.000
49. BP	0.03	0.000
50. Avin	0.04	0.000
51. Cyclon	0.05	0.000
52. Kaoil	0.05	0.000
53. Galonoil	0.14	0.066
54. Dracoil	0.15	0.000
55. KMoil	0.21	0.000
56. El Petroil	0.38	0.000
Strikes in other modes of transportation measured in 24hour equivalents [e]		
57. Taxis (34 daily equivalents)	0.26	0.000
58. Coastal shipping [f] (23 daily equivalents)	-0.21	0.000
59. Suburban rail of Attiki and of neighboring prefectures [f] (23 daily equivalents)	0.39	0.000
60. Subway of Athens and its suburbs [f] (25 daily equivalents)	0.11	0.000
61. Lagged residuals by one day (to deal with autocorrelation in the dependent variable)	1.99	0.000

Number of observations: 193,656. Model fit: $R^2 = 92.55\%$.

Notes

[a] *The Attic peninsula excl. Megara, Mandra and Oropos, the prefecture of Thessaloniki excl. Volvi, the prefecture of Kilkis, the municipalities of Xanthi, Drama, Serre and Emmanuel Pappas, Almopia, Pella, Beria, Alexandria, Pidna-Kolindros, Katerini, Larisa and Tirnavos, Volos and Rigas Fereos, Lamia and Makrakomi, Karditsa, Trikala, Ioannina, Preveza, Patras and West Achaia, Kalamata, Nafplion, Velos-Voha.*

[b] *The municipalities of Orestias, Didimotihon, Souflion, Arriana, Miki, Kato Nevrokopion, Pogonion, Dodoni, Metsovo, Deskati, Limni Plastira, Agrafa, Amfilohia, Thermon, Karpenision, Doris, Meganision, Kalavrita, Pilos-Nestor, Mani (east and west), Elafonisos, Kinouria (north and south), Troezin, Karistos, south Pelion, Zagora-Mouresion, Agia.*

[c] *The municipalities of Apokoronos, Platanias, Agios Vasilios, Anogia, Amarion, Milopotamos, Rethimnon, Arhane-Asterousion, Gortin, Malevizion, Minoa-Pedias, Phaestos, Chersonesos.*

[d] *The municipalities of Kandanos-Selinos, Kissamos, Sfakia, Agios Nikolaos, Ierapetra, Oropedion, Sitia.*

[e] *Net of the effects #2-9 the vectors of which exhibited a modest level of correlation, 15-25%.*

[f] *Net of the strike effects listed above.*

- on the isles of Sikinos and Fourni in the south and central Aegean,respectively (#29), on the islands of Alonnisos, Skiathos, Skiros in the central Aegean (#35), and the isle of Agios Efstratios, the remotest of all (#36).

Overall there is noticeable intra-prefectual heterogeneity, with islands and inaccessible or remote inland areas being more expensive than the rest, the reduced VAT applied in the insular communities of the Aegean notwithstanding.

The spatial results aside: (i) A marginal increment in ex-factory (after-tax refinery) prices is generally passed on to the final consumer. (ii) The distribution-and-trade margin (from factory to pump) in the country's capital, Athens, is estimated at about 18 cents per litre or 18.7% on the after-tax refinery price. (iii) In the course of the twenty months under examination the margin increased over time at a decreasing rate, was subject to seasonality (generally lower from mid-December to early April and from early July to mid-September), and, possibly, daily patterns (lower in Wednesdays and Thursdays). (iv) Strikes in certain modes of urban transport (in particular, taxis, the capital's suburban-rail and subway system) appear to stimulate the public's need to use private vehicles, thus pushing the price of gasoline upwards. On the other hand, dock and other shipping-related strikes appear to discourage roaming and the use of private vehicles, thus affecting a reduction in demand for gasoline and, hence, gasoline price. (v) Price differentials do not appear to depend so much on the number of petrol stations operating in local communities as much as brands. Of the three major brands EKO's stations are generally cheaper, Shell's stations are more expensive, and BP's even more expensive.

5. Indications of price leadership exercised by some companies

Next, in order to gain additional insights into the operation of the market, we turn to Granger causality tests. Through these we may investigate the sequence of price or price-change patterns for evidence of systematic price leadership among distribution-and-trade companies (or chains of petrol stations) (Gujarati, 1995). In theory, price leadership may (a) be attributed to either market dominance (i.e., market power) or to a firm's ability to read market conditions and, therefore, act as a barometer which other firms follow or (b) serve to mask some sort of collusive behavior (in lieu of overt collusion) (Rotemberg and Saloner, 1986). Yet, in practice, Granger causality tests cannot tell which of the three takes place and, hence, of the presence of market power. As a result they ought to be treated as instruments which

may help competition authorities identify areas of further market investigation (Bishop and Walker, 2002).

In the paragraphs that follow, we look into whether the current price change of a seller, ΔY_t, depends not only on past price changes of the same seller, ΔY_{t-1}, ΔY_{t-2}, etc., but also on past price changes of other sellers, ΔX_{t-1}, ΔX_{t-2}, etc. and *vice versa*. We commence by carrying out regressions for each and every possible pair of sellers. Note that in order to prevent the violation of the stationary time series assumption we confine the analysis to price changes (i.e., to first differences between prices).[12] In terms of the shorthand notation employed in such cases, we specify two equations for every empirical test. In the first equation we check whether the lag of ΔX affects ΔY, and in the second equation the opposite: i.e., whether the lag of ΔY affects ΔX:

$$\Delta Y_t=b_0+b_1*\Delta Y_{t-1}+c*\Delta X_{t-1}+e_t \quad \textbf{(1)}$$

$$\Delta X_t=\beta_0+\beta_1*\Delta X_{t-1}+\gamma*\Delta Y_{t-1}+\varepsilon_t \quad \textbf{(2)}$$

with b, β, c and γ standing for coefficients, e and ε for random errors, and t denoting time (here: days). The Wald F test of the hypothesis $c = \gamma = 0$ is employed to ensure that price changes do not depend on one's own past price changes alone; while the notation associated with the price change of the other seller suggests the presence of a one-day time lag (i.e., that the price change carried out by the first seller at time t is to some or a considerable extent attributed to a price change carried out by the second seller on the previous day, $t-1$). Indeed, this is the case in Athens and the neighboring port of Piraeus. As we shall see just below, in other urban centers, an initial price change usually takes two or more days to be replicated by other vendors.

To determine the lag's duration, and to better study the effect of each and every seller not only separately but also simultaneously with the effects of other sellers we also turn to the multivariate, the so-called Vector Autoregressive (VAR), version of the Granger causality test. (For what may appear as a systematic causal relationship in a study of pairs, in a broader context may emerge as a pair of responses to the moves of third seller.) This allows us to consider:

12. The Levin et al. (2002) test suggests that while prices, i.e., X and Y, are not stationary their first differences, i.e. (X_t-X_{t-1}) και (Y_t-Y_{t-1}), are.

(a) VAR lag order selection criteria.[13] They reveal the presence of one lag in the cases of Athens and Piraeus, two lags in the cases of Thessaloniki and Heraklion, three lags in the case of Patras, five lags in the case of Larisa.

(b) The two causality test versions together. This way, instead of running the price-change regression on the lagged values first of one seller (or chain of petrol stations), then on the lagged value of another seller and so on, one can also run it on the lagged values of all (other) sellers, and by and large base the analysis on the shared (i.e., the common) results emerging from both versions of the causality test which are statistically significant at the 1% level. Thus, the effects that appear in the simple (i.e., the paired) causality tests but are not verified via the VAR causality test may be played down.

In mathematical form, the VAR-based Granger causality test can be expressed in terms of first differences between prices (or price changes) as follows:

$$\Delta Y_t = b_0 + b_1 \Delta Y_{t-1} + \sum_{j=1}^{k} \theta_{1j} \Delta X_{j,t-1} + e_t \,, \qquad \textbf{(3)}$$

$$\Delta X_t = \beta_0 + \beta_1 \Delta X_{t-1} + \sum_{j=1}^{k} \varphi_{1j} \Delta Y_{j,t-1} + u_t \,, \qquad \textbf{(4)}$$

with k standing for the number of all other sellers, and the significance of the statistical independence among these sellers being estimated via the Wald F test of $\theta_{11} = \theta_{12} = \ldots = \theta_{1j} = \varphi_{11} = \varphi_{12} = \ldots = \varphi_{1j} = 0$, for j ranging between 1 and *k*.

According to the data, Athens is served by twelve chains of petrol stations as well as independently owned petrol stations, with the latter being grouped into an additional vending channel for the purpose of our analysis. The shared results of the two causality tests which are statistically significant at the 1% level (see Table 3; there are no significant results present in one test that are not present in the other test) suggest that (a) Shell, Revoil and KMoil (listed here in the descending order provided in Figure 2) by and large change prices first; (b) BP, Jetoil, Aegean, ETEKA and Dracoil sometimes influence and at other times are influenced by other vendors' price-changes; (c) EKO, Elinoil, the independents, Silkoil and Cyclon systematically follow other vendors. Of the three major vendors, Shell systematically initiates price changes, BP sometimes leads and sometimes follows, while EKO generally follows.

13. Namely, the sequential modified Likelihood Ratio test statistic with significance level of 5%, the Final Prediction Error and the Akaike Information Criterion.

Table 3: Granger causality test results regarding retail gasoline price changes in Athens (as per the FOP dataset between April 1st 2011 and December 31st 2012)

i. Simple version. Pairs in which at least one result (rendered in bold) is statistically significant at the 1% level.

Ho: The price change by vendor A does not cause a price change by vendor B

A	B	p value	A	B	p value
Cyclon	Aegean	0.9929	Aegean	Cyclon	**0.0019**
Elinoil	Aegean	0.9406	Aegean	Elinoil	**0.0000**
Jetoil	Aegean	0.2799	Aegean	Jetoil	**0.0023**
Shell	Aegean	**0.0071**	Aegean	Shell	0.9777
Dracoil	ΑΠ	**0.0001**	ΑΠ	Dracoil	0.9999
Dracoil	BP	0.0278	BP	Dracoil	**0.0060**
ETEKA	BP	**0.0000**	BP	ETEKA	**0.0001**
Jetoil	BP	0.0355	BP	Jetoil	**0.0070**
Silkoil	BP	0.8613	BP	Silkoil	**0.0030**
ETEKA	Dracoil	**0.0003**	Dracoil	ETEKA	0.0480
Jetoil	Dracoil	**0.0009**	Dracoil	Jetoil	0.5857
KMoil	Dracoil	**0.0075**	Dracoil	KMoil	0.8847
Revoil	EKO	**0.0000**	EKO	Revoil	0.9677
Shell	EKO	**0.0004**	EKO	Shell	0.9799
Silkoil	ETEKA	0.9391	ETEKA	Silkoil	**0.0000**
Silkoil	KMoil	0.9986	KMoil	Silkoil	**0.0001**
Silkoil	Revoil	0.9804	Revoil	Silkoil	**0.0000**
Silkoil	Shell	0.0835	Shell	Silkoil	**0.0001**

ii. Multivariate version. Results which are statistically significant at the 1% level.

Ho: The price change by vendor A_i does not cause a price change by vendor B

A_1 (p value)	A_2 (p value)	A_3 (p value)		B
Shell (0.0034)				Aegean
Dracoil (0.0001)				Independ.
ETEKA (0.0000)				BP
Aegean (0.0011)				Cyclon
ETEKA (0.0054)	Jetoil (0.0064)			Dracoil
Revoil (0.0000)	Shell (0.0009)			EKO
Aegean (0.0000)				Elinoil
BP (0.0046)				ETEKA
Aegean (0.0004)				Jetoil
ETEKA (0.0051)	KMoil (0.0007)	Revoil (0.0000)	Shell (0.0004)	Silkoil

The neighboring municipality of Piraeus is served by seven chains of petrol stations and independently owned petrol stations which, much as in the analysis regarding Athens, are grouped into an additional vending channel. Likewise, the

shared results of the two causality tests which are statistically significant at the 1% level (see Table 4; once again, there are no significant results present in one test that are not present in the other test) suggest that (a) Shell, Aegean and Avin generally change prices first; (b) BP, the independents, Revoil and ETEKA generally follow other vendors; (c) EKO moves independently. Of the three major vendors, Shell sometimes leads and sometimes follows, BP generally follows, while EKO moves independently.

Table 4: Granger causality test results regarding retail gasoline price changes in Piraeus (as per the FOP dataset between April 1st 2011 and December 31st 2012)

i. Simple version. Pairs in which at least one result (rendered in bold) is statistically significant at the 1% level.

Ho: The price change by vendor A_i does not cause a price change by vendor B

A	B	p value	A	B	p value
BP	Aegean	0.0865	Aegean	BP	**0.0002**
Avin	Independ.	**0.0017**	Independ.	Avin	0.8039
BP	Avin	0.9572	Avin	BP	**0.0063**
ETEKA	Avin	0.3040	Avin	ETEKA	**0.0006**
ETEKA	BP	**0.0014**	BP	ETEKA	0.5460
Shell	Revoil	**0.0008**	Revoil	Shell	**0.0041**

ii. Multivariate version. Results which are statistically significant at the 1% level.

Ho: The price change by vendor A_i does not cause a price change by vendor B

A_1 (p value)	B
Avin (0.0023)	Independ.
Aegean (0.0011)	BP
Avin (0.0011)	ETEKA
Shell (0.0002)	Revoil

The municipality of Thessaloniki is served by twelve chains of petrol stations and independently owned petrol stations. The Granger causality tests suggest the presence of two time lags. As a result, instead of relying on expressions (1) - (4), here we rely on the following:

$$\Delta Y_t = b_0 + b_1 * \Delta Y_{t-1} + b_2 * \Delta Y_{t-2} + \theta_1 * \Delta X_{t-1} + \theta_2 * \Delta X_{t-2} + e_t \quad \textbf{(5)}$$

$$\Delta X_t = \beta_0 + \beta_1 * \Delta X_{t-1} + \beta_2 * \Delta X_{t-2} + \varphi_1 * \Delta Y_{t-1} + \varphi_2 * \Delta Y_{t-2} + u_t\,, \quad \textbf{(6)}$$

$$\Delta Y_t = b_0 + b_1 \Delta Y_{t-1} + b_2 \Delta Y_{t-2} + \sum_{j=1}^{k} \theta_{1j} \Delta X_{j,t-1} + \sum_{j=1}^{k} \theta_{2j} \Delta X_{j,t-2} + e_t \quad \textbf{(7)}$$

$$\Delta X_t = \beta_0 + \beta_1 \Delta X_{t-1} + \beta_2 \Delta Y_{t-2} + \sum_{j=1}^{k} \varphi_{1j} \Delta Y_{j,t-1} + \sum_{j=1}^{k} \varphi_{2j} \Delta Y_{j,t-2} + u_t \quad \textbf{(8)}$$

The statistically significant results which are common in both causality tests, along with the additional significant results obtained via the multivariate version (Table 5), suggest that: (a) Aegean and Revoil generally change prices first; EKO, BP, ETEKA and Kaoil sometimes influence and other times are influenced by other vendors; (c) Shell, Jetoil, Elinoil and Silkoil generally follow other vendors; (d) the independents, Avin and Cyclon move independently. Of the three major vendors, BP and EKO sometimes lead and sometimes follow, while Shell generally follows.

The municipality of Patras is served by ten chains of petrol stations and independently owned petrol stations. The Granger causality tests suggest the presence of three time lags. The statistically significant results which are common in both causality tests, along with the additional significant results obtained via the multivariate version (Table 6) suggest that: (a) Aegean generally changes prices first; (b) EKO, BP, Elinoil, the independents, Revoil, Silkoil and Cyclon sometimes lead and sometimes follow other vendors; (c) Jetoil and Avin generally follow other vendors; (d) Shell moves independently. Of the three major vendors, EKO and BP sometimes lead and sometimes follow, while Shell moves independently.

The municipality of Iraklion is served by eight chains of petrol stations and independently owned petrol stations. The Granger causality tests suggest the presence of two time lags (as in the case of Thessaloniki). The statistically significant results which are common in both tests, along with any additional significant results obtained via the multivariate version (Table 7), suggest that: (a) EKO and Silkoil generally change prices first; (b) Elinoil, the independents and Revoil sometimes lead and at other times follow other vendors; (c) Avin may act as either type (a) or type (b); (d) BP and Aegean generally follow other vendors; (e) Shell moves independently. Of the three major vendors, EKO generally leads, BP follows, while Shell moves independently.

The municipality of Larisa is served by 13 chains of petrol stations and independently owned petrol stations. The Granger causality tests suggest the presence of five time lags. The statistically significant results which are common in both tests, along with any additional significant results obtained via the multivariate version (Table 8) suggest that: (a) Jetoil, Avin and Cyclon generally change prices first; (b) EKO sometimes leads and at other times follows other vendors; (c) Revoil generally

Table 5: Granger causality test results regarding retail gasoline price changes in Thessaloniki (as per the FOP dataset between April 1st 2011 and December 31st 2012)

i. Simple version. Pairs in which at least one result (rendered in bold) is statistically significant at the 1% level.

Ho: The price change by vendor A_i does not cause a price change by vendor B

A	B	p value	A	B	p value
BP	Aegean	**0.0000**	Aegean	BP	**0.0000**
EKO	Aegean	**0.0000**	Aegean	EKO	**0.0000**
Elinoil	Aegean	**0.0000**	Aegean	Elinoil	**0.0000**
ETEKA	Aegean	**0.0000**	Aegean	ETEKA	**0.0004**
Jetoil	Aegean	**0.0000**	Aegean	Jetoil	**0.0000**
Kaoil	Aegean	**0.0000**	Aegean	Kaoil	**0.0000**
Shell	Aegean	**0.0000**	Aegean	Shell	**0.0000**
EKO	BP	**0.0000**	BP	EKO	**0.0000**
Elinoil	BP	**0.0001**	BP	Elinoil	**0.0093**
ETEKA	BP	**0.0000**	BP	ETEKA	**0.0011**
Jetoil	BP	**0.0000**	BP	Jetoil	**0.0010**
Kaoil	BP	**0.0046**	BP	Kaoil	**0.0000**
Revoil	BP	**0.0000**	BP	Revoil	0.9381
Shell	BP	0.0176	BP	Shell	**0.0000**
Elinoil	EKO	**0.0010**	EKO	Elinoil	**0.0005**
ETEKA	EKO	0.1213	EKO	ETEKA	**0.0000**
Jetoil	EKO	**0.0006**	EKO	Jetoil	**0.0000**
Kaoil	EKO	0.0136	EKO	Kaoil	**0.0000**
Revoil	EKO	**0.0000**	EKO	Revoil	0.8987
Shell	EKO	0.0814	EKO	Shell	**0.0000**
ETEKA	Elinoil	0.8287	Elinoil	ETEKA	**0.0000**
Jetoil	Elinoil	**0.0002**	Elinoil	Jetoil	**0.0071**
Kaoil	Elinoil	0.1491	Elinoil	Kaoil	**0.0000**
Shell	Elinoil	0.6308	Elinoil	Shell	**0.0000**
Jetoil	ETEKA	**0.0001**	ETEKA	Jetoil	0.1164
Kaoil	ETEKA	**0.0000**	ETEKA	Kaoil	0.0232
Shell	ETEKA	**0.0011**	ETEKA	Shell	0.0512
Kaoil	Jetoil	**0.0025**	Jetoil	Kaoil	**0.0000**
Shell	Jetoil	0.1417	Jetoil	Shell	**0.0000**
Revoil	Kaoil	**0.0000**	Kaoil	Revoil	0.9793
Shell	Kaoil	**0.0033**	Kaoil	Shell	**0.0000**
Silkoil	Revoil	0.9976	Revoil	Silkoil	**0.0000**

ii. Multivariate version. Results which are statistically significant at the 1% level.

Ho: The price change by vendor A_i does not cause a price change by vendor B

A_1 (p value)	A_2 (p value)	A_3 (p value)		B
Aegean (0.0008)	ETEKA (0.0060)	Revoil (0.0000)		BP
BP (0.0024)	Revoil (0.0000)			EKO
Aegean (0.0009)				Elinoil
Kaoil (0.0064)				ETEKA
Aegean (0.0000)	EKO (0.0067)	Revoil (0.0045)		Jetoil
Aegean (0.0012)	BP (0.0068)	EKO (0.0000)	Revoil (0.0000)	Kaoil
Aegean (0.0009)				Shell

Table 6: Granger causality test results regarding retail gasoline price changes in Patras (as per the FOP dataset between April 1st 2011 and December 31st 2012)

i. Simple version. Pairs in which at least one result (rendered in bold) is statistically significant at the 1% level.

Ho: The price change by vendor A_i does not cause a price change by vendor B

A	B	p value	A	B	p value
Aegean	Independ.	**0.0073**	Aegean	Independ.	0.1012
Avin	Aegean	0.1693	Aegean	Avin	**0.0010**
Cyclon	Aegean	**0.0073**	Aegean	Cyclon	0.0837
Elinoil	Aegean	0.0259	Aegean	Elinoil	**0.0000**
Jetoil	Aegean	0.0941	Aegean	Jetoil	**0.0000**
Shell	Aegean	0.6070	Aegean	Shell	**0.0036**
Silkoil	Aegean	**0.0024**	Aegean	Silkoil	0.7709
Avin	Independ.	0.0610	Independ.	Avin	**0.0000**
Cyclon	Independ.	**0.0000**	Independ.	Cyclon	0.0046
EKO	Independ.	**0.0067**	Independ.	EKO	**0.0094**
Elinoil	Independ.	0.0649	Independ.	Elinoil	**0.0000**
Jetoil	Independ.	0.0180	Independ.	Jetoil	**0.0001**
Revoil	Independ.	**0.0070**	Independ.	Revoil	**0.0061**
Silkoil	Avin	**0.0000**	Avin	Silkoil	0.0750
Cyclon	BP	**0.0006**	BP	Cyclon	0.2136
EKO	BP	**0.0000**	BP	EKO	**0.0012**
Elinoil	BP	**0.0000**	BP	Elinoil	**0.0028**
Revoil	BP	**0.0003**	BP	Revoil	**0.0010**
Shell	BP	0.1717	BP	Shell	**0.0002**
Silkoil	BP	**0.0029**	BP	Silkoil	0.0371
Jetoil	Cyclon	**0.0034**	Cyclon	Jetoil	0.1287
Revoil	Cyclon	**0.0000**	Cyclon	Revoil	**0.0026**
Shell	Cyclon	**0.0097**	Cyclon	Shell	0.0735
Silkoil	Cyclon	**0.0006**	Cyclon	Silkoil	**0.0000**
Elinoil	EKO	**0.0000**	EKO	Elinoil	0.0418
Revoil	EKO	**0.0004**	EKO	Revoil	0.0953
Shell	EKO	0.0566	EKO	Shell	**0.0001**
Silkoil	EKO	**0.0009**	EKO	Silkoil	**0.0003**
Jetoil	Elinoil	**0.0044**	Elinoil	Jetoil	**0.0000**
Revoil	Elinoil	0.0901	Elinoil	Revoil	**0.0000**
Shell	Elinoil	0.0447	Elinoil	Shell	**0.0054**
Silkoil	Elinoil	**0.0000**	Elinoil	Silkoil	0.2502
Revoil	Jetoil	0.0349	Jetoil	Revoil	**0.0030**
Silkoil	Jetoil	**0.0000**	Jetoil	Silkoil	0.0279
Shell	Silkoil	**0.0003**	Silkoil	Shell	0.1032

ii. Multivariate version. Results which are statistically significant at the 1% level.

Ho: The price change by vendor A_i does not cause a price change by vendor B

A_1 (p value)	A_2 (p value)	A_3 (p value)	B
Cyclon (0.0055)			Independ.
Independ. (0.0004)	Silkoil (0.0020)		Avin
EKO (0.0053)	Elinoil (0.0009)		BP
Revoil (0.0000)			Cyclon
BP (0.0000)	Elinoil (0.0006)		EKO
Silkoil (0.0002)			Elinoil
Independ (0.0072)	Aegean (0.0049)	Silkoil (0.0073)	Jetoil
BP (0.0073)	Elinoil (0.0002)		Revoil
Cyclon (0.0001)			Silkoil

Table 7: Granger causality test results regarding retail gasoline price changes in Iraklion (as per the FOP dataset between April 1st 2011 and December 31st 2012)

i. Simple version. Pairs in which at least one result (rendered in bold) is statistically significant at the 1% level.

Ho: The price change by vendor A_i does not cause a price change by vendor B

A	B	p value	A	B	p value
Independ.	Aegean	**0.0005**	Aegean	Independ.	0.2468
Revoil	Aegean	**0.0064**	Aegean	Revoil	0.6535
Silkoil	Aegean	0.1965	Aegean	Silkoil	**0.0024**
EKO	Independ.	**0.0000**	Independ.	EKO	0.5059
Elinoil	Avin	0.1576	Avin	Elinoil	**0.0091**
Elinoil	BP	**0.0015**	BP	Elinoil	0.0375
Revoil	BP	**0.0000**	BP	Revoil	0.2476
Shell	BP	0.0454	BP	Shell	**0.0068**
Silkoil	BP	**0.0001**	BP	Silkoil	0.1657
Revoil	Elinoil	0.4617	Elinoil	Revoil	**0.0043**
Silkoil	Elinoil	**0.0079**	Elinoil	Silkoil	0.0648

ii. Multivariate version. Results which are statistically significant at the 1% level.

Ho: The price change by vendor A_i does not cause a price change by vendor B

A_1 (p value)	A_2 (p value)	B
Independ. (0.0000)	EKO (0.0066)	Aegean
EKO (0.0000)		Independ.
Independ. (0.0031)		Avin
Revoil (0.0002)	Silkoil (0.0037)	BP
Avin (0.0052)	Silkoil (0.0028)	Elinoil
Elinoil (0.0056)		Revoil

follows other vendors; (d) Elinoil and the independents move independently; (e) Shell and Aegean either change prices first or move independently of other vendors; (f) Kaoil and Argo either sometimes lead and at other times follow other vendors or move independently of other vendors; (g) BP, Silkoil and ETEKA either follow other vendors or sometimes lead and at other times follow other vendors. Of the three major vendors, EKO sometimes leads and at other times follows other vendors, BP either does the same or follows other vendors, while Shell either leads or moves independently of other vendors.

Overall, the Granger causality tests suggest that: (a) Shell and smaller companies exercise price leadership in Athens and Piraeus, while EKO and smaller companies exercise price leadership in Iraklion, and smaller companies exercise price leadership

Table 8: Granger causality test results regarding retail gasoline price changes in Iraklion (as per the FOP dataset between April 1st 2011 and December 31st 2012)

i. Simple version. Pairs in which at least one result (rendered in bold) is statistically significant at the 1% level.

Ho: The price change by vendor A_i does not cause a price change by vendor B

A	B	p value	A	B	p value
Independ.	Aegean	0.0902	Aegean	Independ.	**0.0007**
Jetoil	Aegean	**0.0081**	Aegean	Jetoil	**0.0014**
Avin	Independ.	**0.0005**	Independ.	Avin	0.3275
Jetoil	Independ.	0.0102	Independ.	Jetoil	**0.0000**
Kaoil	Independ.	**0.0000**	Independ.	Kaoil	0.3164
Silkoil	Independ.	0.1745	Independ.	Silkoil	**0.0002**
Elinoil	Argo	**0.0000**	Argo	Elinoil	**0.0000**
Kaoil	Argo	**0.0007**	Argo	Kaoil	**0.0003**
Silkoil	Argo	0.0764	Argo	Silkoil	**0.0000**
BP	Avin	0.8417	Avin	BP	**0.0073**
EKO	Avin	0.0396	Avin	EKO	**0.0044**
ETEKA	Avin	**0.0016**	Avin	ETEKA	0.0355
Jetoil	Avin	0.2065	Avin	Jetoil	**0.0010**
Kaoil	Avin	0.0895	Avin	Kaoil	**0.0003**
Silkoil	Avin	0.1510	Avin	Silkoil	**0.0059**
EKO	BP	**0.0009**	BP	EKO	0.0148
ETEKA	Cyclon	**0.0000**	Cyclon	ETEKA	0.0855
Jetoil	Cyclon	0.3144	Cyclon	Jetoil	**0.0053**
Revoil	Cyclon	0.3889	Cyclon	Revoil	**0.0000**
Shell	Cyclon	0.8634	Cyclon	Shell	**0.0001**
Silkoil	Cyclon	0.0523	Cyclon	Silkoil	**0.0002**
Elinoil	EKO	**0.0001**	EKO	Elinoil	0.0169
Jetoil	EKO	0.0384	EKO	Jetoil	**0.0000**
Kaoil	EKO	0.0317	EKO	Kaoil	**0.0000**
Silkoil	EKO	0.1425	EKO	Silkoil	**0.0000**
Kaoil	Elinoil	**0.0013**	Elinoil	Kaoil	0.0211
Shell	Elinoil	0.1188	Elinoil	Shell	**0.0009**
Jetoil	ETEKA	**0.0006**	ETEKA	Jetoil	**0.0000**
Silkoil	ETEKA	0.0215	ETEKA	Silkoil	**0.0000**
Kaoil	Jetoil	0.2169	Jetoil	Kaoil	**0.0000**
Shell	Jetoil	0.0662	Jetoil	Shell	**0.0050**
Silkoil	Jetoil	**0.0038**	Jetoil	Silkoil	**0.0000**
Silkoil	Kaoil	**0.0003**	Kaoil	Silkoil	**0.0000**
Silkoil	Shell	**0.0019**	Shell	Silkoil	0.1587

ii. Multivariate version. Results which are statistically significant at the 1% level.

Ho: The price change by vendor A_i does not cause a price change by vendor B

A_1 (p value)	A_2 (p value)	A_3 (p value)	A_4 (p value)	A_5 (p value)	B
BP (0.0071)					Argo
EKO (0.0054)	Kaoil (0.0076)				BP
Avin (0.0032)	BP (0.0023)				EKO
Jetoil (0.0026)					ETEKA
ETEKA (0.0056)					Kaoil
Aegean (0.0006)	Argo (0.0000)	Avin (0.0020)	BP (0.0041)	Cyclon (0.0000)	Revoil
		Kaoil (0.0006)	Shell (0.0018)	Silkoil (0.0000)	Revoil
Jetoil (0.0002)					Silkoil

in Thessaloniki, Patras and Larisa. (b) A number of companies exercise occasional price leadership in certain localities. (c) EKO moves independently in Piraeus, Shell in Patras and Irakion, a couple of smaller companies in Thessaloniki, while a smaller company and the independents move independently in Larisa. (d) In Athens and Piraeus price changes are affected by changes occurring on the previous day (one-day lag), in Thessaloniki and Iraklion reactions are slower (take two-days), and in Patras and Larisa reactions even slower (they exhibit three- and five-day lags, respectively).

6. Conclusions

The empirical analysis reveals that: (a) A marginal increment in refinery prices is by and large passed onto the final consumer. (b) The average value from factory to pump in Athens (reference area) is about 18 cents per litre, which in turn is associated with a 18.7% distribution-and-trade margin on the after-tax refinery price. (c) Retail prices vary across space and generally do not follow the conventional (actually, administrative) delineation of the country. Indeed, there is noticeable intra-regional and intra-prefectural heterogeneity. As a rule, islands (despite the reduced VAT) and, especially, inaccessible or remote inland areas are more expensive. However, the price differentials do not seem to depend on the number of petrol stations operating in local communities as much as the brands. Hence, there is probably room for improving consumer welfare from increased competition in retail at the local level, tax reductions and/or the substitution of special taxes with lump-sum taxes or taxes on capital gains.

All retailers are supplied by refineries run either by ELPE or by MOH. The presence of a duopoly raises the question whether social welfare might be widened with increased competition in production. However, the duopolists are actively present in the retail market. Indeed, the retailers with the largest number of petrol stations are Shell, a MOH subsidiary, BP and EKO, two ELPE subsidiaries. Of these, EKO stations are generally cheaper, Shell stations more expensive, and BP stations even more expensive, while: (a) Shell operates as a price leader in Athens, Piraeus and maybe in Larissa, follows other retailers in Thessaloniki, and moves independently of other retailers in Patras and Iraklion. (b) EKO moves first in Iraklion, follows other retailers in Athens, and moves independently of other retailers in Piraeus. (c) BP follows other retailers in Piraeus and Iraklion. At the same time, three medium-size retailers, namely, Aegean, Revoil, and Avin, appear to be in a position to read local market conditions, sense (or signal) when it is time for price change in

(i) Thessaloniki, Piraeus, Patras and, maybe, Larisa, (ii) Athens and Piraeus, (iii) Piraeus, Larisa and, maybe, Iraklion, respectively. On the whole, the findings suggest that price leadership is local rather than nationwide. This means that (a) competition or (b) the ability of the three major and of the other distribution-and-trade firms to read market conditions or (c) the form of collusion among the distribution-and-trade firms (if any), varies across the country; while the occasional exercise of price leadership by some of these vendors might suggest fluctuations (perhaps not so much in (a) and (b), but rather) in (c). These are matters the Competition Authority might want to delve into and sort out.

It also appears that while in Athens and Piraeus price changes are affected by changes that occur on the previous day (one-day time lag), in Thessaloniki and Iraklion reactions are slower (take two days), in Patras reactions take three days and in Larisa five days: differences that may well reflect distinct business cultures across Greece.

According to the findings, in the period under examination distribution-and-trade margins increased at a decreasing rate, displayed seasonality and were probably lower in midweek. At the same time, strikes in the transportation sector (esp. taxis, and the capital's suburban rail and subway system) intensified the public's need to use private vehicles and pushed the price of gasoline upwards. On the other hand, dock and other shipping-related strikes seem to discourage the use private vehicles, resulting in reduced demand for gasoline and, hence, gasoline prices.

From a policy perspective, the advancement of competition in production, distribution and trade (esp. among brands) of unleaded gasoline, reductions in the special taxes levied on unleaded gasoline, and the adoption of collaborative approaches in resolving the kind of disputes that escalate to taxi, rail and subway strikes, would relieve the costs of production and living in Greece. The other important finding is that future studies ought to take into account the micro-regional dimension, as economic data appear to deviate from the conventional territorial organization of the country. Indeed, the price variations within the Attic peninsula, in other parts of the mainland, across Crete, the Aegean and Ionian islands are quite conspicuous.

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APPENDIX

Map 1: The administrative regions of Greece

Table A: Econometric analysis via a robust variance estimator of the average unleaded gasoline retail prices in Greek municipalities as supplied daily by the FOP (in eurocents per litre, Apr. 2011-Dec. 2012), based on the conventional territorial delineation of the country

Explanatory variables	*Estimated coefficients*	*p values*
1. Constant	22.70	0.000
2. Ex factory prices (including taxes)	89.33	0.000
3. Time trend	0.00	0.000[1]
4. Time trend squared (to capture the rate of change)	-0.00	0.000
Seasonal factors (categorical dummies)		
5. Mid November – mid April (reference period)		
6. Mid April – end of June	1.63	0.000
7. Early July – mid September	-0.10	0.000
8. Mid September – mid November	1.17	0.000
Daily factors (categorical dummies)		
9. Friday	0.00	0.153
10. Other days of the week (reference days)		
Spatial factors (categorical dummies)		
Attiki (subregions ordered as per the values of the coefficients)		
11. Athens pref. (reference areas)		
12. Eastern Attiki pref.	-0.02	0.241
13. Western Attiki pref.	0.61	0.000
14. Piraeus pref.	4.72	0.000
C. Greece and Euboea		
15. Fthiotis pref.	2.51	0.000
16. Boeotia pref.	2.90	0.000
17. Fokis pref.	5.39	0.000
18. Euboea pref.	5.52	0.000
19. Evritania pref.	6.91	0.000
C. Macedonia		
20. Thessaloniki pref.	-0.35	0.000
21. Imathia pref.	0.62	0.000
22. Pella pref.	1.12	0.000
23. Pieria pref.	1.38	0.000
24. Serre pref.	1.39	0.000
25. Kilkis pref.	1.49	0.000
26. Halkidiki pref.	3.24	0.000
Crete		
27. Rethimnon pref.	8.90	0.000
28. Hania pref.	9.58	0.000
29. Iraklion pref.	9.74	0.000
30. Lasithion pref.	11.85	0.000
E. Macedonia and W. Thrace		
31. Drama pref.	2.38	0.000
32. Xanthi pref.	3.13	0.000
33. Rodopi pref.	3.89	0.000
34. Kavala pref.	4.25	0.000
35. Evros pref.	8.25	0.000
Epiros		
36. Preveza pref.	2.64	0.000
37. Arta pref.	3.01	0.000
38. Ioannina pref.	3.71	0.000
39. Thesprotia pref.	3.99	0.000

Table A (continued)

Explanatory variables	*Estimated coefficients*	*p values*
Spatial factors(continued)		
Ionian Islands		
40. Zakinthos pref.	3.86	0.000
40. Lefkas pref.	4.56	0.000
41. Kerkira (Corfu) pref.	10.86	0.000
42. Kefallinia pref.	13.07	0.000
N. Aegean Islands		
43. Hios pref.	11.96	0.000
44. Lesvos pref.	15.12	0.000
45. Samos pref.	19.81	0.000
S. Aegean Islands		
46. Cyclades	17.69	0.000
47. Dodekanese	18.42	0.000
S., C. and E. Peloponnese		
48. Argolis pref.	1.82	0.000
49. Corinthia pref.	2.66	0.000
50. Lakonia pref.	4.68	0.000
51. Messenia pref.	4.77	0.000
52. Arkadia pref.	5.38	0.000
Thessaly		
53. Karditsa pref.	2.06	0.000
54. Trikala pref.	2.45	0.000
55. Larisa pref.	2.83	0.000
56. Magnesia pref.	9.44	0.000
W. Greece		
57. Achaea pref.	3.20	0.000
58. Aetolia and Akarnania pref.	3.87	0.000
59. Ilis pref.	3.92	0.000
W. Macedonia		
60. Kastoria pref.	2.84	0.000
61. Kozani pref.	3.51	0.000
62. Florina pref.	3.56	0.000
63. Grevena pref.	5.95	0.000
Commercial dimension: number of petrol stations in the area (ordered as per the values of each brand's coefficient)		
64. Sunoil	-0.45	0.000
65. Medoil	-0.27	0.000
66. Aegean	-0.08	0.000
67. Elinoil	-0.07	0.000
68. EKO	-0.07	0.000
69. ETEKA	-0.17	0.041
70. Independently owned stations	-0.02	0.001
71. Shell	-0.02	0.000
72. Silkoil	0.00	0.811
73. Jetoil	0.01	0.000
74. Revoil	0.02	0.008
75. Argo	-0.14	0.000
76. BP	-0.02	0.000
77. Avin	-0.04	0.000
78. Cyclon	0.05	0.000
79. Kaoil	0.05	0.000
80. Galonoil	-1.85	0.000
81. Dracoil	0.33	0.000
82. KMoil	0.17	0.000
83. El Petroil	0.98	0.000

Table A (continued)

Explanatory variables	*Estimated coefficients*	*p values*
Strikes in other modes of transportation measured in 24hour equivalents		
84. Taxis [a] (34 daily equivalents)	0.35	0.000
85. Subway of Athens and its suburbs [a,b] (25 daily equivalents)	-0.22	0.000
86. Lagged residuals by one day (to deal with autocorrelation in the dependent variable)	7.50	0.000

Number of observations: 193.656. Model fit: R^2 = 81.50%.

Notes
[a] *Net of the effects #2-9 the vectors of which exhibited a modest level of correlation, 15-25%.*
[b] *Net of the strike effects listed above.*