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Liquid fuel price adjustment in Greece: a two-stage, threshold cointegration approach

A Bachelor thesis of

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Contents

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"Economic theory suggests no pervasive tendency for prices to respond faster to one kind of cost change than to another. However, after an examination of literally hundreds of markets, it is proven that the person in the street is right and we [economists] are wrong".

Sam Peltzman

Liquid fuel price adjustment in Greece: a two-stage, threshold cointegration approach[1]

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Abstract

Greek consumers often complain that fuel prices in the domestic market adjust more quickly to crude oil price increases than decreases and characterize this pricing pattern as market power exploitation. This article attempts to investigate the issue of asymmetries in a two-stage price-adjusting mechanism able to indicate the source of price asymmetries, either in the refining or in the distribution stage. The sample consists of daily data covering the period of January 2012 to November 2018 and it has been split into two subsamples due to a structural break October 2014. Using threshold and momentum models of cointegration at different stages in the distribution chain, we find that transmission is mostly symmetric for the period between 2012 and 2014 and asymmetric in the first stage of refining for the recent period between 2014 and 2018.

Keywords: Asymmetry, Error correction models, Threshold cointegration Retail fuel price

JEL Classification numbers: Q40, L11

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[1] This paper has been presented by the first author in the 5th International Conference on Applied Theory, Macro and Empirical Finance, Thessaloniki 2019 as his undergraduate thesis.

1. Introduction

Greek consumers have been regularly complaining for unreasonably high prices of retail liquid fuels like gasoline and diesel. These issues have become subject of extensive public discourse depicted in numerous articles in the press and reports on television. Most of them focus on cases of fuel adulteration as well as the amount of taxes imposed by the government. The latter, in February 2019, according to the European Commission constitute this approximately 67% and 51% (See appendix) of the consumer price at the pump for unleaded 95 gasoline and diesel respectively. For the Unleaded 95 gasoline Greece has the second highest percentage of taxation as share of the final consumer price, where the 51% in the Diesel is below the EU average of 55%. However little attention is paid to the efficiency of the market in terms of competition and the existence of potential oligopolistic behavior on behalf of oil companies. Under these circumstances the oil companies often collude in defining fuel prices. Thus, retail fuel prices usually respond faster to input cost (i.e. crude oil price) increases compared to cost reductions. For this reason, the purpose of this paper is to examine the adjustment dynamics between retail prices of liquid fuels and international oil prices in and across Greece. Since unleaded gasoline and diesel constitute the main oil products in Greece, this paper focuses on them.

The majority of previous studies investigated the adjustment path between crude oil and retail gasoline or diesel prices as a single stage process (Al-Gudhea et al. 2006, Asane-Otoo and Schneider 2015). However, this assumption is simplistic as the industry has a more complex structure, with country-specific characteristics. In this paper we attempt to move beyond this and assume the existence of two stages in the production and distribution process: the first one roughly includes the refinery process whereby crude oil is transformed into the refined product, while the second one concerns the distribution of gasoline to petrol stations. The relevant prices involved in the first stage, therefore, are crude oil price and ex-refinery price, while the subsequent stage investigates the dynamics between ex-refinery and retail prices. We consider this strategy as more realistic representation of the complex chain linking crude oil to pump prices. Thus, we believe that it is of great interest to identify whether the source of asymmetry originates upstream[2] or downstream[3] of the transmission process. In the case of suspicions of collusive behavior that leads to increases in retail liquid fuel prices, the

[2] An **upstream price** is the price of one of the main inputs of production (for processing/manufacturing etc.) or a price quoted on higher market levels (e.g. wholesale markets). Upstream prices are the prices paid by producers (as opposed to consumers) and are directly related to the cost of production.

[3] **Downstream prices** are the prices paid by consumers at the retail level.

two-stage nature of our investigation is clearly useful. Moreover, this issue is of utmost importance for Greece, since it is a small highly dependent, oil importing country for which international crude oil prices are clearly exogenous. At the same time, the price of crude oil attracts a lot of attention and interest from the public, making the link between the cost of inputs and the price of outputs a close one, readily visible to consumers. This text is novel in the way that it uses for the first time in the analysis of the Greek liquid fuel market a daily dataset that covers the volatile period of 2012 to 2018.

The remainder of the paper is organized as follows: Chapter 2 describes the structure and the characteristics of the oil sector in Greece, Chapter 3 covers the theoretical perspective of the price asymmetries in oil markets according to the economic science, Chapter 4 offers a brief overview of the relative literature, Chapter 5 describes the data and introduces the econometric approach, while the results are presented and discussed in Chapter 6. Finally, Chapter 7 offers concluding remarks and discusses potential policy implications. The tables that include the empirical results are presented in the Appendix.

2. The oil Sector in Greece[4]

The consumption of the petroleum derivatives per sector in Greece is structured as follows: the 30% corresponds to road transportations where household consumption is at 26.8% and industrial at 18.6%. The rest accounts for 11.9%. On the other hand, almost the whole amount of gasoline consumed is for road transportation.

2.1 Structure of the domestic liquid fuel market

The domestic petroleum market is operating on three levels, since crude oil production in Greece is almost negligible and the domestic demand is essentially covered by imports.

2.1.1 Oil Refining

According to the current legislation, refining is defined as: “processing of crude oil or semi-finished products carried out in special installations (refineries) for the production of petroleum products” (ΦΕΚ Αρ.Φύλλου 230, 2/10/2002, “ΝΟΜΟΣ ΥΠ’ ΑΡΙΘ. 3054 Οργάνωση της αγοράς πετρελαιοειδών και άλλες διατάξεις“). At the refining stage, crude oil is imported from the oil-producing countries and after being refined in domestic units,

[4] This content and the data of this chapter are based on the sector study of ICAP for liquid and gas fuels, Athens 2017

whether it is sold in the Greek market or exported. Holders of refining licenses may sell petroleum products in the domestic market to:

1. Companies that have trading authorization
2. Large end consumers and in the armed forces
3. Independent Gas Stations

In addition, crude oil and petroleum products, including semi-finished products, may be marketed or traded between holders of a Refining License. Two refining companies operate in the Greek market, with four refineries in total in the country. According to Polemis (2012) these two companies (Hellenic Petroleum S.A. and Motor Oil Hellas S.A.) cover the 90% of the oil demand in Greece while the rest is imported from the wholesale companies.

2.1.2 Wholesale Trading of Petroleum products

The second stage of the market for petroleum products includes wholesalers who receive the refined products from domestic refineries, although sometimes they also import fuel directly from foreign markets. The supplies from Greek refineries are made based on annual contracts. Then from their warehouses the trading companies can either export or supply fuel to :

1. Other wholesalers
2. Holders of a Retail Trading License,
3. Large final consumers

The current legislation distinguishes between five types of wholesale licences:

- A. Trading licence for petroleum products. (Gasoline, diesel fuel, heating oil, fuel oil).
- B1. Trading licence for tax-free marine fuels (oil and mazut)
- B2. Trading licence for tax-free aviation fuels (jet fuels)
- C. Trading licence for liquid gas
- D. Trading licence for asphalt

2.1.3 Retail fuel filling stations

In particular, retail fuel filling stations can be divided into:

1. Stations with the trademark of one of the trading companies and are supplied exclusively by it (i.e. no other trading company, wholesaler or refinery can supply

them). Branches of the network of trading companies are in turn categorized according to their operating status:

   a. Company Owned - Company Operated/Managed (COCOs ή COMOs): These are self-operating stations. They belong to the trading company (in the sense that either the land belongs to the marketing company or has a long-term lease agreement) and the later manages them itself, which also determines the price at the pump.
   b. Company Owned Dealer Operated/Managed (CODOs): These gas stations belong to the trading company, but they are operated by an independent gas station operator who determines price at the pump.
   c. Dealer Owned Dealer Operated/Managed (DODOs): These service stations belong to the operator (in the sense that either the land belongs to the operator or has a long-term lease with the owner) and manages them himself independent entrepreneur, by freely determining the pump price.

2. Independent outlets ("Α.Π."), which are not branded and can be supplied with fuel either directly from refineries or from trading companies.

According to figures from the Pan-Hellenic Federation of Fuel Station Operators (ΠΟΠΕΚ), it is estimated that at the end of 2015 the number of service stations in Greece were around 5,000 against around 8.500 in 2012,(Polemis (2012), having decreased significantly in recent years. The overwhelming majority of the retail fuel filling stations are CODO and DODO and are located close to the Attica region, and a small percentage are gas stations operated by the trading companies themselves (COCO category). Consequently, in the overwhelming majority of service stations the final price at the pump is determined by the gas-station operators. In conclusion, several different entities are participating in formulation of the pricing of gasoline, diesel and other petroleum products at the pump. When fuel is sold from the refinery to the wholesale oil company, the price for this transaction is called ex-refinery price. The price charged for the fuel by the refiner or the wholesale company to the independent and branded petrol stations respectively is called the wholesale price. Finally, the price the consumer realizes at the pump is called the retail price.

2.2 Sector Competition Analysis.

2.2.1 Entrance of new competitors to the market

A) Refining Oil

At the refining level, the competitive pressures that can be created by the threat of new entrants into the industry are not considered strong. Any new entrants are called upon to deal difficulties stemming from cost advantages of the enterprises in the industry, the strong reputation of existing companies and established access to suppliers and customers, the existing institutional framework, etc. It is stressed that the capital requirements are particularly high, with the result that initial investment costs for setting up refinancing facilities are "dissuasive".

B) Wholesale Market of Petroleum Products

In the Wholesale Market, there are no high legal barriers to the entry of a new business. Entry into this market requires the issuance of the appropriate license, storage space and the expense of significant capital (for investments in facilities and transport, working capital, development of a network of service stations, etc.). Also, due to the existing competition on the market (especially in certain product categories), there is a shrinking both of profit margins and of total demand, which is a deterrent for a new business to enter the industry.

2.2.2 Negotiating Power of Suppliers

A) Refining Oil

Refining companies in Greece supply crude oil from foreign markets, as domestic crude production is negligible. Procurement can be made either based on long-term agreements / contracts, through transnational agreements or on the spot market. In any case, the prices at which Greece's refineries buy are determined to a large extent by international crude oil prices and, consequently, the bargaining power of their suppliers is strong.

B) Wholesale of Petroleum Products

Wholesalers are supplying petroleum fuels mainly from Greek refineries. Although trading companies are free to import petroleum products, imports are not considered cost-effective (transport costs, inventory costs security etc.) and are limited. As the refineries are a duopoly, they have, in theory, a significant bargaining power. However, for refining prices a formula (notified to the companies) is used, which takes into account the Platts international prices, the cost of storage, the conversion of the price from dollars to euros, etc. The price is published daily and is therefore known to oil trading companies.

2.2.3 Negotiating Power of the Byers

A) Refining Oil

The buyers of the refining companies are mainly wholesalers and large final consumers. Their bargaining power concerns any discounts or facilities and depends on the volume of sales they make to them.

B) Wholesale of Petroleum Products

Buyers of wholesalers are mainly gas stations, industrial companies, airlines and shipping companies and, to a lesser extent, heating resellers. The bargaining power of the above varies and depends mainly on the size of the orders. In particular, with regard to service stations, their bargaining power is significantly influenced by their location and volume of orders.

2.2.4 Competition between Businesses in the Sector

A) Refining Oil

Two companies are active in the refining sector, and after the absorption of Petrola Hellas SA. in 2003 by EL.PE. It is therefore a duopoly sector, which is often controlled by the Competition Commission and the other competent bodies, in order to comply with the rules and the required transparency. As has already been mentioned, refining companies sell their products on the basis of price fluctuations observed on the international market. Consequently, competition between companies focuses on other factors (e.g. increasing their production capacity, technological upgrading of refineries, developing retail networks through their affiliate marketing companies, etc.). Finally, it is noted that the profitability of the refining companies depends mainly on the evolution of the international refining margins (the difference in the international prices of petroleum products from the international crude oil prices), the euro exchange rate against the dollar, the volume of sales they make.

B) Wholesale of Petroleum Products

The liquid fuels received by the companies are standardized products and there is no substantial diversification, so competition focuses on the development of the distribution network, the promotional activities, the service and the pricing policy of each company (the basic criterion for the choice of service station is the price). The competition of wholesalers is intense. In particular, the number of companies with a Type A marketing authorization is quite large for the Greek market. In recent years, some domestic marketing companies have been forced out of the market. In addition, the multinationals BP and Shell, after many years of significant presence in the Greek fuel market, have sold the specific activities.

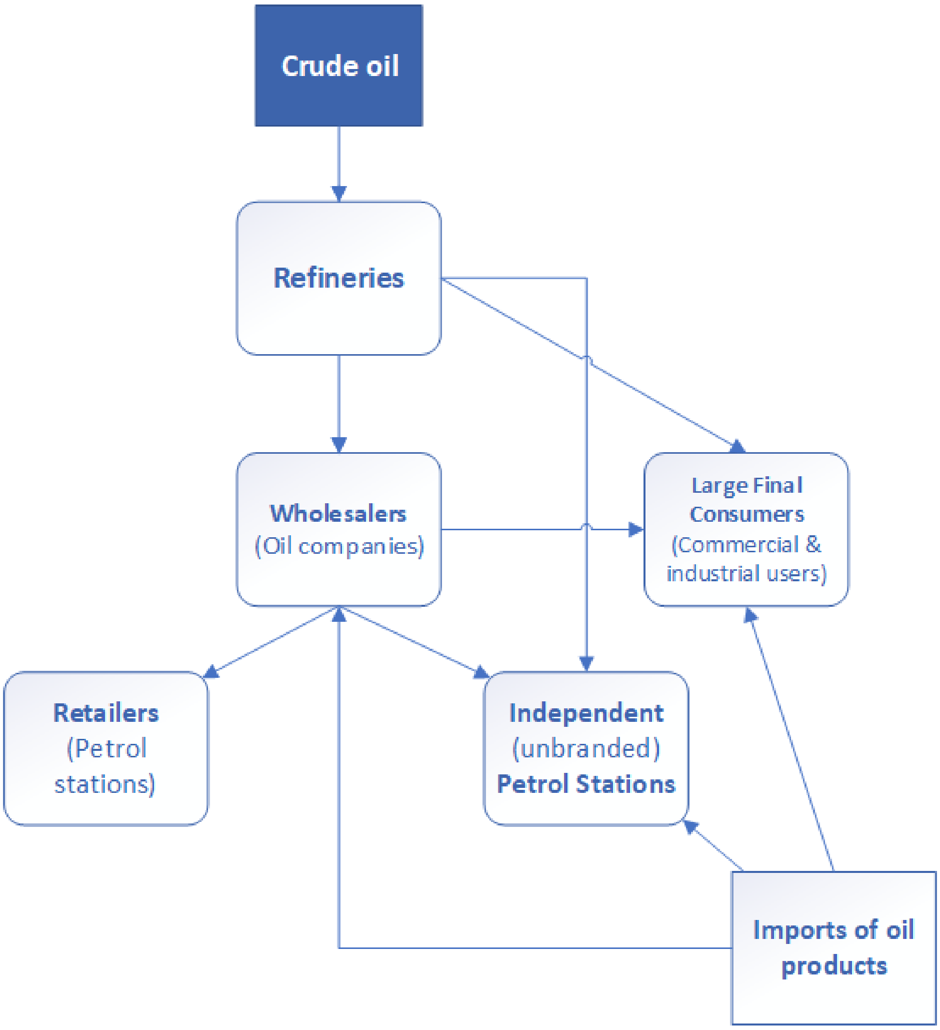


Figure 1: Structure of oil sector in Greece

3. Price asymmetries in fuel markets: what economic theory says

According to the economic literature price rigidity is an essential condition for the presence of asymmetric effects in prices which yield to a slow pace of adjustment of downstream prices to shocks in cost conditions. However, according to Peltzman (2000) “economic theory suggests no pervasive tendency for prices to respond faster to one kind of cost change than to another” (p.467). Nevertheless, a number of more or less standard arguments could provide the foundations for the theoretical support of asymmetric adjustment. Initially, profit maximizing behavior obliges firms that act in competitive markets to adjust their prices to new input costs immediately, and presumably symmetrically. This holds when frictions and imperfections are absent from markets. Although, menu costs, impede instantaneous price adjustment even if the market power of the firm is limited. In similar manner, inventory valuation and accountancy rules may be accountable for the sluggish adjustment of downstream prices with respect to increase or decrease of major exogenous variables. Market power is presumably the major concern to those who observe that fuel prices are unable to respond in the same manner and adjust quickly to oil price fluctuations. The main argument has the following rational. Retailers reputedly try to maintain their “normal” profit margins when prices rise, but they try to capture the larger margins that result transitorily, when upstream prices fall. In both cases the situation is temporary because, for instance, consumer search costs are present. When costly search is completed, profit margins revert and prices tend converge to competitive levels.

Another version of this story that epitomize the tacit collusion in oligopolistic markets states that, when upstream prices rise, each firm is quickly responding by increasing its selling price in order to signal its competitors that it is dedicated to the tacit agreement; when input cost fall, it is sluggish adjusting its price because it does not want to run the risk of selling a signal that it is cutting its margins and breaking away from the agreement. Another argument is the fact that adjusting the production to price increases or decreases is costly. When a cost shock occurs profit maximizing competitive firms respond and mitigate part of the shock by depleting inventories when input prices fall and storing output when they rise. This ends up to a process without instant adjustment to cost shocks even in competitive markets, although it is perfectly consistent with firms enjoying market power. According to Borenstein, Cameron, and Gilbert (1997), asymmetry is consistent with the above story if the net marginal convenience yield (the change in net distribution costs resulting from a change in inventory levels) is convex. In this case cost increases will be accommodated more quickly.

Another potential source of asymmetric adjustment especially in the second stage of distribution is the lack of ability on behalf of the consumer to treat retail fuels as homogenous product; and therefore, the only determinant for the choice of the retailer to be the price. In the reality the selection of the retail store is sometimes dependent to the trust to the retailer, the brand name of the store, advertisement or any other loyalty cards and small gifts that retail fuel stores usually have. Additionally, Peltzman (2000)'s examination of "literally hundreds of markets" (p.469), also states that neither inventory holdings nor menu costs seem a key ingredient in producing price asymmetries. The hypothesis of asymmetric costs of input adjustment appears to be more consistent with price asymmetry. More generally, price asymmetry is as characteristic of competitive as oligopoly market structures.

4. Overview of the literature

A sizable segment of the literature has analyzed the tendency of some economic variables, such as real GDP, unemployment, and industrial production, to follow asymmetric adjustment paths over the business cycle. *Neftci (1984)* argued in favor of the asymmetric behavior of U.S. unemployment over the business cycle whereas *Falk (1986)* found little evidence supporting the asymmetries when he applied Neftci's methodology to GNP (Gross National Product), investment and productivity of the United States and to the productivity of United Kingdom, France, Germany, Italy, and Canada. *DeLong and Summers (1988), Terasvirta and Anderson (1992), Sichel (1993), Beaudry and Koop (1993), Potter (1995), Ramsey and Rothman (1996) and Bradley and Jensen (1997)* all argue in favor of various forms of asymmetric behavior in one or more of these variables. *Bacon (1991)* was pioneer in developing a methodology suitable for testing whether the adjustment paths of retail fuel prices with the price of gasoline as sold by refineries are asymmetric (but limited to the second stage of the distribution) in the United Kingdom, naming this phenomenon as "rockets and feathers". Under these circumstances the retail prices of gasoline shooting up like rockets for positive oil price movements and floating downward like feathers as a reaction to negative oil price shocks. Now there is extensive literature that examines the phenomenon of asymmetric behavior of retail fuel prices to changes in either crude oil prices or wholesale fuel prices. These studies generally differ in one or more of the following aspects: the country under scrutiny; the time frequency and period of the data used; the focus on wholesale and retail gas prices or on oil and gasoline prices; the dynamic model employed in the empirical investigation.

Galeotti et al. (2003) make an international comparison between the markets of Germany, France, United Kingdom and Italy in order to test for the “rockets and feather” hypothesis. He uses a sample of weekly data from 1985 to 2000. In the empirical part after examining whether the series are I(1) and cointegrated by Eagle-Granger representation theorem, he employs an asymmetric Error Correction Model to capture the short-run asymmetries. The process of transmission of oil price movements to gasoline prices is conducted in two stages, roughly corresponding to a first refinery stage and then to a second distribution stage so as to be identified the source of asymmetry. Additionally, Galeotti et al. allow for a potential asymmetric role of the exchange rate, as crude oil price is paid for in dollars whereas fuels are being sold in national currencies. The models of the empirical investigation generally indicate widespread differences both in adjustment speeds and short-run elasticities when input prices rise or fall. In summary, Galeotti et al. find that price adjustment mechanism is characterized by widespread price asymmetries in many European countries.

Manera and Grasso (2005) in their paper provide a detailed comparison of the three most popular models designed to describe asymmetric price behavior, namely asymmetric ECM, autoregressive threshold ECM and ECM with threshold cointegration. Each model is estimated on a common monthly dataset for the gasoline markets of France, Germany, Italy, Spain and UK. The sample period includes data from January 1985 to March 2003 and the frequency of observations is monthly. The transmission of changes in upstream prices to downstream prices is investigated at different stages of the process of price formation. All models are able to find the temporal delay in the reaction of retail prices to changes in spot gasoline and crude oil prices, as well as some evidence of asymmetric behavior. However, the type of stages and the number of countries which are characterized by asymmetric oil-gasoline price relations vary across models. The asymmetric ECM supports some evidence of asymmetry for all countries, mainly at the distribution stage. The threshold ECM strongly rejects the null hypothesis of symmetric pricing behavior, particularly in the case of France (all stages) and Germany (distribution level). Finally, the ECM with threshold cointegration captures long-run asymmetry for each country in the reaction of retail prices directly to oil price changes.

The main objective of the paper of *Salim Al-Gudhea, Kenc, and Dibooglu (2006)* is to examine crude, spot, wholesale and retail gasoline price adjustments in the U.S. for the period from December 1998 to January 2004. Using threshold and momentum models of cointegration and daily data at different stages in the distribution chain, they reach out to the conclusion that adjustment dynamics between upstream and downstream prices is mostly asymmetric in the momentum model: increases in upstream prices are transferred to downstream prices faster than decreases. Moreover, they distinguish between small and large shocks and they conclude that the asymmetry is more pronounced for small shocks, something that they attribute to consumer search costs.

Asana-Otoo, Schneider (2014). This paper is focused on the adjustment of retail fuel prices (gasoline and diesel) in the German market to international crude oil price movements. The authors use both weekly national and daily city-specific (for the cities of Berlin, Hamburg, Munich and Cologne) data to analyse the extent to which retail fuel prices in Germany adjust symmetrically to changes in the international crude oil price. The authors employ an error correction model with threshold cointegration to investigate the price dynamics. At the national level with weekly prices, they find positive asymmetries for both gasoline and diesel within the period 2003–2007, indicating that retail prices react more quickly to crude oil price increases than decreases. On the contrary, for 2009–2013, they observe symmetric adjustment and negative asymmetry for retail diesel and gasoline prices, respectively.

4.1 The case of Greece

Angelopoulou and Gibson (2010) focus their research only to the case of Greece and specifically to the relationship between retail prices of liquid petrol and diesel and international crude oil prices while incorporating in their analysis the determinant of the amount of taxes. They examine not only the hypothesis that retail prices act asymmetrically to crude oil price changes and the pass-through rates of tax increases, but also use the cross-sectional dimension of the data to explore whether the existence or otherwise of market power affects retail prices. They estimate four sets of panel regressions for each of the four fuel types including many explanatory variables to control for the other factors that could influence the retail price of fuel, including taxes so as to reach to a more robust estimate of the impact of changing international oil prices on fuel prices in Greece. The results provide little evidence for asymmetric behavior. However, the degree to which prices overreact to tax changes and the significance of market power across the different regions suggests that the market for petrol/diesel is not very competitive.

Polemis (2012) attempts to investigate the issue of asymmetries in the transmission of shocks to upstream prices and exchange rate onto the wholesale and retail price of gasoline respectively. For this purpose, the author utilise the error-correction methodology in the Greek gasoline market and also tries to analyse the effect of competition on the dynamic adjustment of gasoline price by using impulse response functions. The results verify the common perception that retail gasoline prices adjust asymmetrically to cost increases and decreases for both long and short-term horizon. At the wholesale segment, there is asymmetric response of the spot prices of gasoline towards the adjustment to the short-run responses of the exchange rate. Lastly, after the deregulation legislation in 1992, the author claim that wholesale prices of gasoline tend to gradually restore to the equilibrium more swiftly compared to the regulated period. The sample includes monthly data starting from January 1988 up to June 2006.

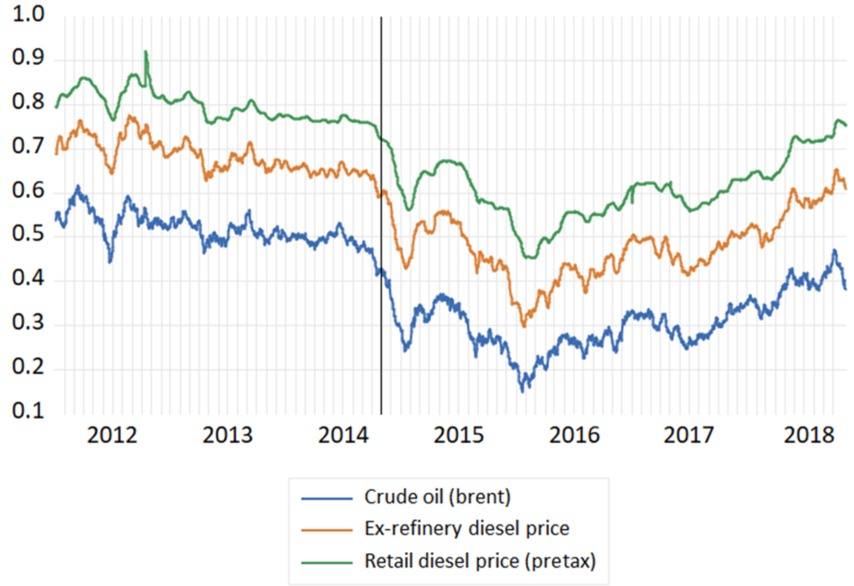
Apergis and Vouzavalis (2018) make a comparative analysis of pass-through of crude oil to gasoline prices for the markets of US, the UK, Spain, Italy and Greece. The paper investigates the asymmetric pass-through of oil prices to gasoline prices under the nonlinear autoregressive distributed lags (NARDL) model. The period under examination is from January 2009 to July 2016. These countries have been selected on the basis that fuel markets are differentiated by the structure of retail markets. The analysis considers markets that their structure has significant differences. Both short- and long-run non-linearity are tested by deriving both the positive and negative partial sum decompositions of the dependent variable. Moreover, the authors estimated the responses to positive and negative oil price shocks from the asymmetric dynamic multipliers. The findings lead to mixed evidence of an asymmetric behavior of oil and gasoline prices. Short-run asymmetry is found in the Italian market, while in the Spanish market there is evidence of both short- and long-run asymmetry. Greece as the country of our interest in classified among U.K. and U.S. that illustrate a symmetric pass-through scheme of oil to retail gasoline prices.

A literature review matrix, summarizing the main points from this chapter, can be found in the appendix of the paper.

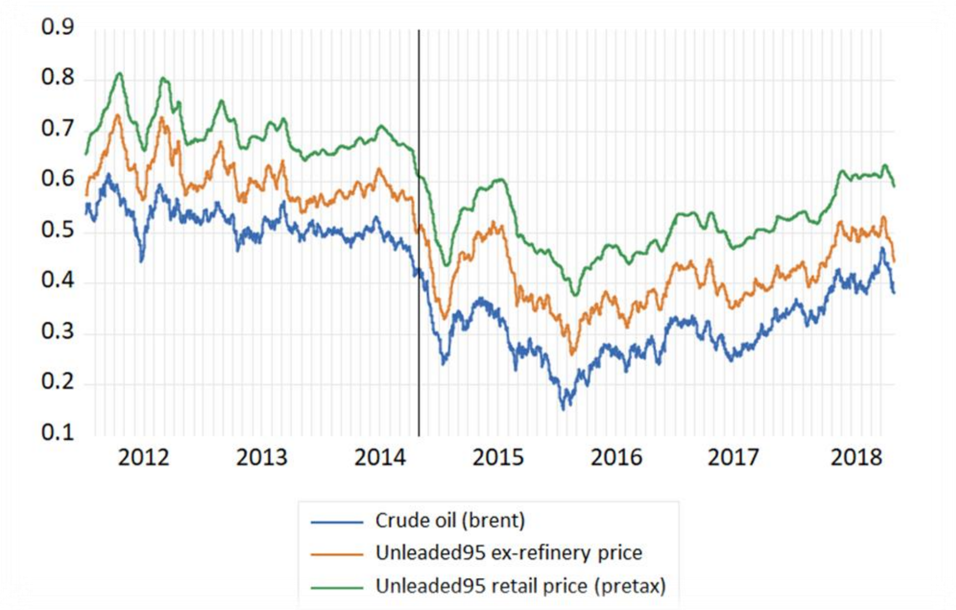
5. Empirical methodology

5.1 Data and Unit root tests

The price transmission dynamics of crude oil to refinery and distribution stage are examined with a daily dataset covering the period from 1/1/2012 until 9/11/2018. The prices of the Brent crude, that serves as a benchmark price for purchases of oil worldwide, have been obtained from the database of the Research division of the Federal Reserve Bank of St. Louis (FRED), whereas the prices of diesel and unleadead95 have been officially requested from the Secretariat-General for Trade and Consumer Protection of the Greek Ministry of Economy and Development (see Appendix). Accordingly, Brent crude that it is measured in US dollars



Graph 1 :Diesel prices



Graph 2 : Unleaded 95 prices

per barrel is converted into Euros per litre using the exchange rate as provided by the database of the European Central Bank (ECB). Lastly all the prices are log-transformed and without taxes.

The estimation period for this study covers a somewhat volatile time of significant oil price decreases especially during the period 2014–2016. Starting in June 2014, the nominal price of Brent crude oil began a sharp decline, falling from $112 in June to $62 in December, yielding to a 6-month drop of 44%. The downward trend persisted in 2015 and 2016, reaching a low of $31 in January 2016, a cumulative decrease of more than 70%. Assessing the root causes for this decline that can only be compared to the one during the financial crisis of 2018, Arezki and Blanchard (2014) suggest the importance of the shock to oil price expectations occurred in late November 2014 when OPEC announced that it would maintain current production levels despite the steady increase in non-OPEC oil production. They also underline the importance of the increased oil production by Libya, Iraq and United States. On the other side, Prest (2018) and Baumeister and Kilian(2016) present evidence in favor of the "demand-side" explanation and more specifically the role of the weakening global economic conditions and demand for commodities, including but not limited to oil. Hence, it is crucial to check the cointegration relationships for the existence of structural breaks. As Perron (1989) points out, structural change and unit roots are closely related, making conventional unit root tests are biased toward a false unit root null hypothesis when the data are trend stationary with a structural break.

Table 1. Descriptive statistics
Sample: 1/01/2012 11/09/2018

	Diesel Refinery	Diesel Retail Pretax	Diesel Retail After-tax
Mean	0.563	0.687	1.308
Maximum	0.775	0.923	1.601
Minimum	0.298	0.454	0.973
Std. Dev.	0.117	0.108	0.150
Sum Sq. Dev.	24.472	20.934	39.875
Observations	1784	1783	1783
	Unleaded95 Refinery	Unleaded95 Retail Pretax	Unleaded95 Retail After-tax
Mean	0.490	0.591	1.581
Maximum	0.731	0.815	1.854
Minimum	0.259	0.375	1.296
Std. Dev.	0.111	0.105	0.128
Sum Sq. Dev.	22.085	19.746	29.051
Observations	1787	1786	1786

Thus, based on the theoretical framework provided in the international literature, we are creating 2 subsamples for the 2 sub-periods before and after the structural break in October 2014 and we are performing Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root test to each series for both periods. Accordingly we present tables with descriptive statistics for both the total sample considering the taxes and for the 2 sub-samples, having subtracted the taxes. The first table (Table 1) provides a better representation of the market whereas the second (Table 2) focuses on the input we have used to the empirical investigation. The second table additionally includes the results from the unit root tests that show that all the series are integrated of order one whereas their differential is stationary. The descriptive statistics for the whole sample show that the means of the Unleaded95 ex-refinery and retail price are lower than the diesel ex-refinery and retail price respectively, although gasoline prices at the pump in Greece are generally higher compared to diesel prices. Additionally, based on the value of standard deviation reported on the table below diesel prices in both refinery and distribution stage are more volatile than the corresponding ones for Unleaded95.

Table 2 Descriptive Statistics and Unit root tests of the sub-samples

Sample: 1/10/2012 9/30/2014 "Period 1"				**KPSS (log of €/litre)**	
Prices	**Obs.**	**Mean(€/litre)**	**Std. Dev.**	**Levels P_t**	**First differences $\Delta(P_t)$**
Brent crude oil	684	0.520	0.032	1.822	0.027***
Diesel Refinery	713	0.686	0.036	2.205	0.050***
Diesel Retail	713	0.798	0.033	2.207	0.073***
Unleaded95 refinery	716	0.608	0.043	1.494	0.066***
Unleaded95 retail	716	0.701	0.040	1.351	0.092***
Sample: 10/09/2014 11/09/2018 "Period 2"					
Brent crude oil	1043	0.310	0.064	1.188	0.256***
Diesel Refinery	1071	0.482	0.074	1.031	0.344***
Diesel Retail	1071	0.612	0.074	1.051	0.522**
Unleaded95 Refinery	1071	0.412	0.062	0.765	0.190***
Unleaded95 Retail	1070	0.518	0.062	0.875	0.290***

Note: ***, ** denote 1% and 5% significance levels levels, respectively.
KPSS critical values (with intercept):1% 0.739, 5% 0.463 and 10% 0.347
Null Hypothesis: series is stationary

5.2. Test for threshold cointegration

Having established the integration property of each of the price series, we employ the Enders and Siklos (2001) threshold cointegration approach to capture non-linear price relationships between retail and upstream fuel prices. The Enders and Siklos (2001) test extend the Engle and Granger (1987) approach which assumes symmetric price transmission by proposing a regime switching cointegration approach capable of capturing possible asymmetries. The test focuses on the residuals from the estimation of the long-run causal relationship between the refinery price P^{ref} and crude oil price P^{brent} for the first stage that corresponds to the refinery process and P^{retail} and P^{ref} that covers the distribution stage. All the series are integrated of order one I(1). For this study the cointegrating relationship for "Stage 1" is expressed as:

$$P_t^{ref} = a_0 + a_1 P_t^{brent} + u_t \qquad (1.1)$$

For "Stage 2" it is expressed as follows:

$$P_t^{retail} = a_2 + a_3 P_t^{ref} + w_t \qquad (1.2)$$

where a_0, a_1, a_2, and a_3 are coefficients and u_t, ε_t the residual which captures the gap from the long-run equilibrium. For the two pairs of price series to be linearly cointegrated, the estimated error-term should be stationary. However, to incorporate asymmetric adjustment dynamics, the deviation from the equilibrium u_t is modeled as a threshold autoregressive process as follows:

$$\Delta u_t = \rho_1 I_t u_{t-1} + \rho_2 (1 - I_t) u_{t-1} + \sum_{i=1}^{n} \varphi_i \Delta u_{t-i} + \omega_t \qquad (2)$$

where I_t is a Heaviside indicator function which depends on the lagged values of the error term in Eq.(1)according to the specification:

$$I_t = 1 \text{ if } u_{t-1} \geq \tau, 0 \text{ otherwise} \qquad (3.1)$$
$$I_t = 1 \text{ if } \Delta u_{t-1} \geq \tau, 0 \text{ otherwise} \qquad (3.2)$$

In Eq. (2), p denotes the lag length; ρ_1 , ρ_2 and φ_i are coefficients and τ is the estimated threshold. The value of ρ_1 and ρ_2 signifies the rate at which positive and negative deviations or shocks are respectively adjusted. The expression $u_{t-1} \geq \tau$ or $\Delta u_{t-1} \geq \tau$ represents positive gaps or deviations equal or above the threshold whereas $u_{t-1} \leq \tau$ or $\Delta u_{t-1} \leq \tau$ captures negative deviations from the estimated threshold. A positive deviation therefore implies a reduction in crude oil price, while a negative deviation signifies an increase in crude oil price. In other words, a positive gap implies a higher retail price above its equilibrium level, while a negative disequilibrium epitomizes a smaller retail price compared to its equilibrium. Eq. (2) is augmented with the lag difference of the residual to control serially correlated errors and the optimal lag length is selected using the Akaike Information Criterion (AIC). Following Enders and Siklos (2001), models estimated using Eqs. (1), (2) and (3.1) are termed

"Threshold Autoregressive models" (TAR) while those of Eqs. (1), (2) and (3.2) are called "Momentum Threshold Autoregressive models" (MTAR). As indicated by Enders and Granger (1998) and Enders and Siklos (2001), the TAR model captures possible "asymmetric deep movements" while the MTAR accounts for "steep variations" in the series. For example, if the autoregressive decay within the TAR model is large when the retail price is above its equilibrium, negative deviations below the threshold will exhibit more persistence. However, the MTAR model allows differential amounts of autoregressive decay contingent on whether the retail price is increasing or decreasing. Thus, the MTAR model not only captures spiky asymmetric movements in the price series, but also captures the transmission mechanism if the adjustment of fuel prices at the pump to crude oil price changes exhibits more "momentum" in one direction relative to the other. A formal test for threshold cointegration within both the TAR and MTAR specifications is performed to examine:

Null hypothesis H_0: $\rho_1=\rho_2=0$: no cointegration, against
Alternate hypothesis H_1: $\rho_1 \neq \rho_2$ and/or $\rho_2 \neq 0$ and/or $\rho_1 \neq 0$: TAR/MTAR cointegration adjustment process

The F-statistic (Phi) is compared with the appropriate critical values calculated by simulations since the test does not follow a standard distribution.

Alternative to the case where the threshold value is specified as zero, Chan (1993) proposed a grid search approach which facilitates a consistent estimation of the threshold. This involves arranging the threshold variable i.e. the series of ξ_{t-1} or $\Delta\xi_{t-1}$ for the respective TAR and MTAR models in an ascending order and excluding the highest and lowest 15% of the values. Since the threshold value τ is expected to fall within this range, the search for the consistent estimate of the threshold is conducted by using each of the inner 70% values to estimate the TAR or MTAR model in Eq. (2). The threshold value in the trial that yields the lowest residual sum of square is then considered as the consistent threshold.

Table 3 summarizes the nonlinear cointegration test results of the different price pairs, assuming TAR and MTAR adjustments as specified in Eq. (2). We report the values of the threshold τ, the adjustment parameters ρ_1 and ρ_2 with their significance level and the F-statistics of the no cointegration null hypothesis. All the F-statistics for the 10/2014-11/2018 daily prices are above the respective 5% critical values for both diesel and Unleaded95 for Stage 1 and Stage 2. Consequently, we find cointegration with asymmetric processes given that the no cointegration null hypothesis is rejected. For Period 1, we also find similar evidence for Diesel in Stage 1 and Stage 2. However, for Unleaded95 in the Stage 1 crude oil and refinery price are not threshold cointegrated. In Stage 2 we can also detect nonlinear threshold cointegration.

Table 3. Results of Enders-Siklos cointegration test

Sample: 1/10/2012 9/30/2014 "Period 1"						
Upstream price: crude oil(brent) **Downstream price: refinery price**	Model	Threshold value(τ)	ρ_1	ρ_2	F-joint(Phi) $\rho_1 = \rho_2 = 0$	Critical value for 5% sign. level
Diesel	TAR	0.031	-0.055 *	-0.099926 ***	8.612	(7.349)[1]
Diesel	MTAR	−0.004	-0.060 **	-0.12294 ***	9.228	(8.122)[1]
Unleaded95	TAR	0.021	−0.080	−0.028072	5.432	(7.282)[1]
Unleaded95	MTAR	−0.000	−0.006	−0.082746	7.320	(8.184)[1]
Upstream price: refinery price **Downstream price: retail price**						
Diesel	TAR	0.014	-0.129 ***	-0.06332 ***	22.758	(7.428)[1]
Diesel	MTAR	−0.003	-0.075 ***	-0.149234 ***	22.311	(8.336)[1]
Unleaded95	TAR	−0.016	-0.069 ***	-0.120057 ***	18.826	(7.350)[1]
Unleaded95	MTAR	−0.002	-0.065 **	-0.105459 ***	18.620	(8.326)[1]
Sample: 10/09/2014 11/09/2018 "Period 2"						
Upstream price: crude oil(brent) **Downstream price: refinery price**	Model	Threshold value(τ)	ρ_1	ρ_2	F-joint(Phi) $\rho_1 = \rho_2 = 0$	Critical value for 5% sign. level
Diesel	TAR	−0.032	-0.143 ***	-0.106678 ***	22.241	(7.292)[1]
Diesel	MTAR	0.012	-0.159 ***	-0.118141 ***	22.262	(8.350)[1]
Unleaded95	TAR	0.040	-0.029 **	-0.060043 ***	8.371	(7.343)[1]
Unleaded95	MTAR	−0.001	−0.023000	-0.058856 ***	8.802	(8.367)[1]
Upstream price: refinery price **Downstream price: retail price**						
Diesel	TAR	−0.016	-0.039 ***	-0.052157 ***	15.698	(7.383)[1]
Diesel	MTAR	−0.006	-0.038 ***	-0.096597 ***	19.094	(8.317)[1]
Unleaded95	TAR	−0.022	-0.057***	-0.045697 ***	15.825	(7.302)[1]
Unleaded95	MTAR	0.008	-0.085 ***	-0.046305 ***	17.090	(8.318)[1]

[1] :Number of simulations for critical values:10000
Note: ***, ** denote 1% and 5% sign. levels.

5.3. Asymmetric error correction model (ECM)

Having established the existence of cointegration, the Granger representation theorem (Engle and Granger, 1987) warrants the estimation of an error correction model (ECM). The symmetric ECM has however been extended to capture asymmetric adjustments (Granger and Lee, 1989) where the error correction term and first differences of the price variables are separated into negative and positive variables. The second extension incorporates threshold effects where the error correction term is not just segregated into positive and negative components, but the decomposition is based on deviations from a threshold or equilibrium (Balke and Fomby, 1997; Enders and Granger, 1998). These extensions allow a detailed examination of the asymmetric effects of upstream price changes on the dynamic adjustment of downstream prices. In this study, the asymmetric ECM is specified as follows:

$$\Delta P_t^{ref} = c_1 + \delta^+ E_{t-1}^+ + \delta^- E_{t-1}^- + \sum_{i=1}^{p} a_i^+ \Delta P_{t-i}^{brent+} + \sum_{i=1}^{p} a_i^- \Delta P_{t-i}^{brent-} + \sum_{i=1}^{p} b_i^+ \Delta P_{t-i}^{ref+} + \sum_{i=1}^{p} b_i^- \Delta P_{t-i}^{ref-} + \nu_t \quad (4.1)$$

$$\Delta P_t^{retail} = c_2 + \gamma^+ E_{t-1}^+ + \gamma^- E_{t-1}^- + \sum_{i=1}^{p} g_i^+ \Delta P_{t-i}^{ref+} + \sum_{i=1}^{p} g_i^- \Delta P_{t-i}^{ref-} + \sum_{i=1}^{p} d_i^+ \Delta P_{t-i}^{retail+} + \sum_{i=1}^{p} d_i^- \Delta P_{t-i}^{retail-} + \varepsilon_t \quad (4.2)$$

where ΔP^{ref} and ΔP^{brent} are the refinery and crude oil prices in first difference, segregated into positive ($\Delta P_t^+ = P_t - P_{t-1} > 0$) and negative ($\Delta P_t^- = P_t - P_{t-1} < 0$) variables, respectively. ν_t, ε_t represent the error terms where the subscript t denotes time and i represents lags.

The coefficients δ^+, δ^- and γ^+, γ^- determine the long-run adjustments of refinery and retail prices respectively. The coefficients a^+, α^- , b^+ , b^- denote the short-run adjustment of crude oil to refinery price changes, while g^+ , g^- as well as and d^+, d^- denote the short-run adjustment of refinery price to retail price changes. The error correction term E_{t-1} which is defined as $E^+_{t-1} = I_t u_{t-1}$ where I_t is contingent on whether $u_{t-1} \geq \tau$ or $\Delta u_{t-1} \geq \tau$ and $E^-_{t-1} = I_t u_{t-1}$ where I_t hinges on whether $u_{t-1} < \tau$ or $\Delta u_{t-1} < \tau$ emanates from Eqs. (2), (3.1), and (3.2). Similar to the cointegration test, we estimate TAR ECM and MTAR ECM which capture different asymmetric adjustments based on the definition of the Heaviside indicator It in Eq. (4). However, the choice of the appropriate adjustment mechanism (TAR or MTAR) is determined by selecting the model with the smallest AIC and Bayesian Information Criterion (BIC) values since there is no presumption as to which model is appropriate. Moreover, we use the AIC and BIC and to select the maximum lag (p) of the explanatory variables to avoid serially correlated residuals. The specification in Eq. (4) permits us to distinguish between long-run and short-run adjustments and also perform a formal test of the asymmetry adjustment hypothesis. The test for long-run symmetric adjustment is examined with:

Null hypothesis H_{01}: $\delta^{+}=\delta^{-}$, $\gamma^{+}=\gamma^{-}$: Symmetric adjustment for (4.1) , (4.2) respectively

Alternate hypothesis H_{11}: $\delta^{+}\neq\delta^{-}$ and $\gamma^{+}\neq\gamma^{-}$: Equilibrium asymmetry in price adjustment.

The Granger causality test is also performed based on the F-test for the hypotheses:

Null Hypothesis H_{02}: $a_i^{+} = a_i^{-}$, $g_i^{+} = g_i^{-}$

Alternate Hypothesis: H_{12}: $a_i^{+} \neq a_i^{-}$, $g_i^{+} \neq g_i^{-}$

Null Hypothesis H_{03}: $b_i^{+} = b_i^{-}$, $d_i^{+} = d_i^{-}$

Alternate Hypothesis H_{13}: $b_i^{+} \neq b_i^{-}$, $d_i^{+} \neq d_i^{-}$

for all lags i simultaneously for (4.1), (4.2) respectively

A rejection of H_{02} and H_{03} respectively implies that upstream price changes and lagged downstream price changes Granger cause the downstream price.

6. Results and discussion

The estimation results of the TAR or MTAR asymmetric error correction models are reported in tables in the Appendix. Aside the long-run and short-run adjustment parameters reported in each table, we also present the values of the AIC, the F-statistics and p-Values of the symmetric adjustment and Granger causality tests.

6.1. Daily diesel and gasoline prices for "Period 1"

In the Appendix, we show the corresponding results for the period 2012–2014 for both the stage of refining and distribution and only the best asymmetric error correction model for each price pair is presented. In Table 4 where we report the results for the adjustment of diesel ex-refinery price to crude oil price changes, the p-Values for the Granger causality tests (H_{02} and H_{03}) show that the lagged values of crude oil Granger cause refinery diesel prices (H_{02}) whereas the lagged values of refinery diesel prices Granger cause refinery diesel prices only in 10% of significance level (H_{03}). Within the MTAR framework, twelve coefficients are found to be significant at the 10% % level and the equilibrium symmetric adjustment hypothesis (H_{01}) could not be rejected at the 5% significance level. Hence refinery diesel prices react equivalently to both deviations below or above the equilibrium level.

The results for the second stage of the distribution process of diesel are reported in Table 5. We observe that both lagged values of refinery product and retail diesel prices Granger cause retail diesel prices. In this case the TAR model has been selected based on the AIC information criterion and within the model four coefficients are significant at 5% level of significance. The p-Value (0.00) of the equilibrium symmetric adjustment hypothesis test indicates the rejection of symmetric adjustment in favor of asymmetric adjustment. The estimated long-run adjustment coefficients suggest that the positive adjustment parameter (-0.115) is larger in absolute terms than the negative one (-0.098) while both of the parameters are statistically significant. The magnitude of the point estimates suggest that retail diesel prices adjust to a unit positive deviation at a rate of 11.5% per day and 9.8% to negative deviations. With an adjustment rate slightly higher that of negative deviations, a unit positive shock is eliminated fully within nine days while negative shocks take approximately eleven days to be fully transmitted. Thus, the retail price of diesel in the distribution stage has the tendency to revert faster to equilibrium level after incidence of positive shocks while negative shocks tend to be slightly more persistent.

As indicated in table 3, no non-linear long-run relationship between crude oil and Unleaded95 refinery price was detected and therefore we move on in the examination of the “Stage 2” of the distribution process. The MTAR error correction model that is presented in Table 6, was found to better capture the dynamic relationship between changes in retail Unleaded95 gasoline prices and refinery prices. The result suggests that only positive deviations equal or above the threshold ($\omega_t \geq -0.001832$) due to decreases in refinery diesel price are statistically significant at the 1% level and are transmitted at a rate of 5,6% per day. However, the coefficient for the negative adjustment parameter is smaller in absolute terms and statistically insignificant indicating a high degree of persistence. Given that the symmetric adjustment hypothesis is rejected at the 1% significance level, our estimates show that Unleaded95 gasoline prices at the pump react more swiftly to decreases in refinery price.

6.2. Daily gasoline and diesel prices for “Period 2”

For the period 2012–2014 in Table 7, the estimated long-run adjustment coefficients for the “Stage 1” in diesel suggest that the negative adjustment parameter is larger in absolute terms than the positive adjustment parameter. The P-value (0.0156) of the equilibrium symmetric adjustment hypothesis test shows a rejection of symmetric adjustment in favor of asymmetric adjustment. The coefficients of the adjustment parameters suggest that 4,9% of a unit negative deviation from the equilibrium ($\omega_t \geq -0.31708$) due to an increase in crude oil price is transmitted per day while a 1% decrease in crude oil price change leading to a positive deviation from the equilibrium adjust at a rate of 1,6% per day. Consequently, refinery diesel prices for the period 2014–2018 appear to adjust significantly more swiftly, approximately three times faster, to negative disequilibrium compared to positive gaps from the equilibrium.

In contrast, regarding the second stage of the distribution of refinery diesel and the pass-through to the retail prices (Table 8), the P-value (0.6551) of the symmetric adjustment hypothesis strongly suggests absence of potential asymmetries. Hence diesel prices at the pump react equivalently to both deviations below or above the equilibrium level.

In the case of Unleaded95 gasoline in Table 9, the TAR model has been chosen to examine the adjustment dynamics of the ex-refinery price to international crude oil changes. The symmetric adjustment hypothesis H_{01} is rejected according to the P-value (0.0056) in favor of the asymmetric process. Within the TAR model only the long-run coefficient for negative deviations is found to be significant for 5% while the positive one is not statistically different from zero. The adjustment parameters indicate that about 3.5% of any negative deviation from the equilibrium caused by an increase in crude oil price is eliminated within a day. With the extremely low and insignificant value for positive deviations, it is obvious that positive deviations from the equilibrium exhibit high degree of persistence.

Lastly, Table 10 presents the results for the second stage of distribution of Unleaded95 gasoline, where we experience the same pattern as in pass-through of the diesel prices where asymmetries were identified only in the “Stage 1”. The long-run symmetric adjustment hypothesis H_{01} could not be rejected for the “Stage 2” according to the P-value of H_{01} (0.3887) and therefore the we observe equivalent reaction of Unleaded95 gasoline prices to both positive and negative deviations caused by changes in the refinery gasoline prices.

7. Conclusions and policy implications

This paper has re-examined the issue of potential asymmetries in the transmission of shocks to crude oil prices onto ex-refinery prices and finally to the retail price of gasoline and diesel. Especially in periods of volatile international markets, this is an issue which both public opinion in general and policy makers are interested in, since the vast majority of the population drives a car but also trucks and transportations account for a considerable part of the economy. It has therefore attracted the interest of energy economists, who have conducted several empirical researches on liquid fuel markets with a core interest in the hypothesis that prices rise faster than they fall. Asymmetric price adjustment in the retail fuel market is often construed as an abuse of market power given that varying degrees of price rigidity characterizes monopolistic and oligopolistic markets. Our estimates indicate widespread differences with respect to the speed of adjustment and asymmetries in the fuel market in Greece.

Focusing on the first period that our sample was split into (2012–2014), the results from the daily national level prices lead to the conclusion that diesel pricing appears to be competitive, notwithstanding the oligopolistic market structure. The findings suggest that the market setup and regulatory mechanisms seem capable of controlling potential positive asymmetries that may have existed in the retail market. Regarding the case of Unleaded95 gasoline the results indicate a downstream source of asymmetry. Thus, the widespread public opinion that fuel prices adjust more swiftly to increasing than decreasing input prices is not supported by the empirical evidence for the case of diesel, but it can be confirmed for the distribution stage of Unleaded95 gasoline.

On the other hand, examining the results from the second period of our sample that covers the volatile period of 2014 to 2018, we reach out to more unambiguous and straightforward conclusions about the nature and the source of asymmetries in the country. In both diesel and Unleaded95 gasoline we observe negative price asymmetries in the first stage of the refinery process. More specifically the ex-refinery price responds faster to negative gaps from the equilibrium caused by increases in the crude oil comparing to the positive ones. Thus, for this period the source of asymmetry can be identified in the upstream phase of the transmission process for both liquid fuels. Our results are not totally in line with the findings of Apergis and Vouzavalis (2018). The authors report symmetric adjustment of gasoline to crude oil changes in a single stage process and for a dataset covering the period from January 2009 to July 2016. In that sense although we cannot detect asymmetric adjustment from 2012 to 2014, in our second subsample until 2018 there are clear evidence in favor of asymmetric responses of ex-refinery prices to crude oil changes.

It is important underline that defining the root cause for the observed asymmetries or symmetry is beyond the scope of this paper. This is mainly for the reason that the empirical models used to capture asymmetric transmission do not allow explicit modeling and differentiation of different potential causes. Nonetheless, the symmetry observed in the distribution stage and the negative asymmetries in the refinery stage particularly in the most recent sub-period may be attributed to an increasing search intensity and decreasing search cost for consumers. Given the differences in signals conveyed by price increases and decreases (Cabral and Fishman, 2012), input price changes that induce retail price increases tend to cause a surge in search intensity beyond regular levels and hence shrinks retail margins and price dispersion. Additionally, decreasing search cost due to stronger price transparency and monitoring institutions (i.e. mobile applications and websites) that allow consumers to compare fuel prices at different fuel stations should also increase the search intensity, and thus strengthen competition among retailers and decrease wide spread of prices. At this point it is worth mentioning that the Ministry of Development, Competitiveness, Infrastructure, Transport and Networks contributed crucially towards a transparent and frequent price reporting within its website (www.fuelprices.gr).

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Appendix

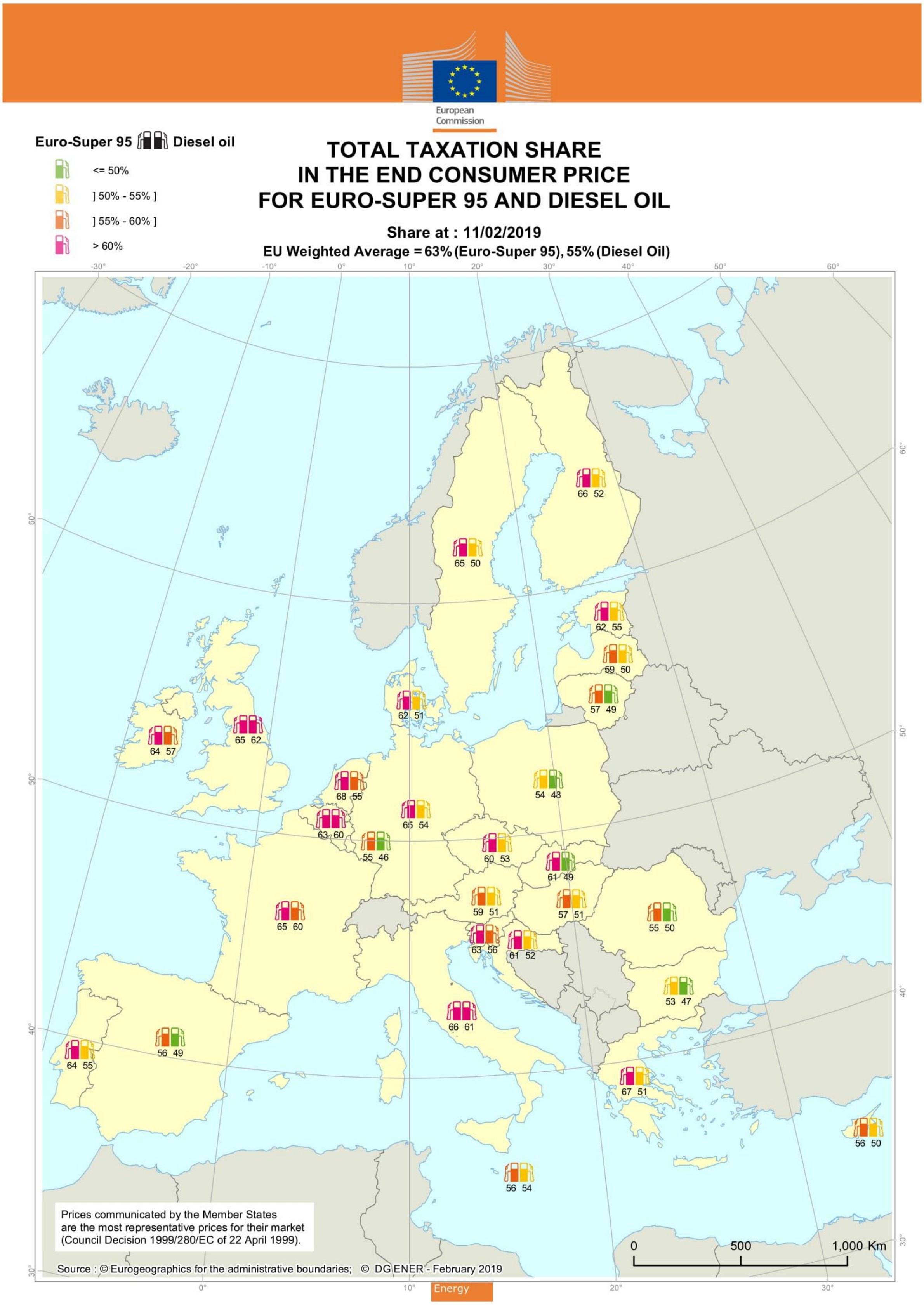
European Commission
Euro-Super 95 Diesel oil
<= 50%
] 50% - 55%]
] 55% - 60%]
> 60%
TOTAL TAXATION SHARE
IN THE END CONSUMER PRICE
FOR EURO-SUPER 95 AND DIESEL OIL
Share at : 11/02/2019
EU Weighted Average = 63% (Euro-Super 95), 55% (Diesel Oil)
66 52
65 50
62 55
59 50
57 49
62 51
65 62
64 57
68 55
54 48
65 54
63 60
55 46
60 53
61 49
65 60
59 51
57 51
55 50
63 56
61 52
53 47
66 61
56 49
64 55
67 51
56 50
56 54
Prices communicated by the Member States
are the most representative prices for their market
(Council Decision 1999/280/EC of 22 April 1999).
0
500
1,000 Km
Source : © Eurogeographics for the administrative boundaries; © DG ENER - February 2019
Energy

Table 4: Error Correction Model Diesel, Period 1, "Stage 1"

Dependent Variable: Diesel ΔP_t^{ref}
Sample : 1/12/2012 9/30/2014 "Period 1"   Model : MTAR

Variable	Coefficient	t-Statistic
c_1	-0.001 *	-1.854
E_{t-1}^{+}	-0.038 ***	-3.598
E_{t-1}^{-}	-0.014	-1.049
ΔP_{t-1}^{brent+}	0.031	1.162
ΔP_{t-2}^{brent+}	0.162***	5.919
ΔP_{t-3}^{brent+}	0.163***	5.727
ΔP_{t-4}^{brent+}	0.163 ***	5.378
ΔP_{t-5}^{brent+}	0.114 ***	3.689
ΔP_{t-6}^{brent+}	0.025	0.840
ΔP_{t-1}^{brent-}	-0.029	-0.965
ΔP_{t-2}^{brent-}	0.140 ***	4.896
ΔP_{t-3}^{brent-}	0.110 ***	3.790
ΔP_{t-4}^{brent-}	0.093 ***	3.377
ΔP_{t-5}^{brent-}	0.151 ***	5.404
ΔP_{t-6}^{brent-}	-0.040	-1.459
ΔP_{t-1}^{ref+}	-0.047	-0.650
ΔP_{t-2}^{ref+}	0.194 ***	3.025
ΔP_{t-3}^{ref+}	0.029	0.466
ΔP_{t-4}^{ref+}	-0.052	-0.830
ΔP_{t-5}^{ref+}	-0.028	-0.460
ΔP_{t-6}^{ref+}	0.101	1.600
ΔP_{t-1}^{ref-}	0.115 *	1.865
ΔP_{t-2}^{ref-}	0.078	1.376
ΔP_{t-3}^{ref-}	-0.037	-0.704
ΔP_{t-4}^{ref-}	0.001	0.021
ΔP_{t-5}^{ref-}	0.058	1.184
ΔP_{t-6}^{ref-}	-0.063	-1.272
Adjusted R-squared	0.540	
Akaike info criterion	-8.367	
Schwarz criterion	-8.142	
H01: Null Hypothesis:	**Value**	**Probability**
$\delta^+ = \delta^-$		
F-statistic	2.441	0.119
H02 Null Hypothesis:	**Value**	**Probability**
$\sum_{i=1}^{6} a_i^+ = \sum_{i=1}^{6} a_i^-$		
F-statistic	18.188	0.000
H03 Null Hypothesis:	**Value**	**Probability**
$\sum_{i=1}^{6} b_i^+ = \sum_{i=1}^{6} b_i^-$		
F-statistic	1.640	0.077

Table 5: Error Correction Model Diesel, Period 1, "Stage 2"

Dependent Variable: Diesel ΔP_t^{retail}
Sample: 1/05/2012 9/30/2014 "Period 1" Model:TAR

Variable	Coefficient	t-Statistic
c_2	$-1.21E-05$	-0.064
E_t^+	-0.115 ***	-4.341
E_t^-	-0.098 ***	-5.814
ΔP_{t-1}^{ref+}	0.148 ***	3.074
ΔP_{t-1}^{ref-}	0.013	0.287
$\Delta P_{t-1}^{retail+}$	0.003	0.067
$\Delta P_{t-1}^{retail-}$	0.320 **	2.414
Adjusted R-squared	0.230	
Akaike info criterion	-8.461	
Schwarz criterion	-8.416	
H01: Null Hypothesis:	**Value**	**Probability**
$\gamma^+ = \gamma^- = 0$		
F-statistic	22.760	0.000
H02: Null Hypothesis:	**Value**	**Probability**
$g_1^+ = g_1^-$		
F-statistic	5.146	0.006
H03: Null Hypothesis:	**Value**	**Probability**
$d_1^+ = d_1^-$		
F-statistic	3.395	0.034

Table 6: Error Correction Model, Unleaded95, Period 1, "Stage 2"

Dependent Variable: Unleaded 95 ΔP_t^{retail}		
Sample: 1/10/2012 9/30/2014 "Period 1"	Model:MTAR	
Variable	**Coefficient**	**t-Statistic**
C	$4.43E-05$	0.319
E_{t-1}^{+}	-0.055 ***	-5.014
E_{t-1}^{-}	-0.004	-0.301
ΔP_{t-1}^{ref+}	0.217 ***	8.796
ΔP_{t-2}^{ref+}	0.069 ***	3.015
ΔP_{t-3}^{ref+}	-0.025	-1.088
ΔP_{t-4}^{ref+}	-0.062 ***	-2.805
ΔP_{t-5}^{ref+}	0.078 ***	3.752
ΔP_{t-1}^{ref-}	0.092 ***	4.277
ΔP_{t-2}^{ref-}	0.093 ***	4.612
ΔP_{t-3}^{ref-}	0.001	0.083
ΔP_{t-4}^{ref-}	-0.037 *	-1.885
ΔP_{t-5}^{ref-}	0.094 ***	5.346
$\Delta P_{t-1}^{retail+}$	0.159 **	2.459
$\Delta P_{t-2}^{retail+}$	0.184 ***	2.826
$\Delta P_{t-3}^{retail+}$	-0.033	-0.513
$\Delta P_{t-4}^{retail+}$	-0.027	-0.417
$\Delta P_{t-5}^{retail+}$	0.088	1.610
$\Delta P_{t-1}^{retail-}$	0.220 ***	3.534
$\Delta P_{t-2}^{retail-}$	0.040	0.640
$\Delta P_{t-3}^{retail-}$	0.115 *	1.859
$\Delta P_{t-4}^{retail-}$	-0.095	-1.563
$\Delta P_{t-5}^{retail-}$	0.191 ***	3.501
Adjusted R-squared	0.766	
Akaike info criterion	-9.861	
Schwarz criterion	-9.712	
H01 : Null Hypothesis:	**Value**	**Probability**
$\gamma^{+} = \gamma^{-} = 0$		
F-statistic	16.121	0.000
H02 : Null Hypothesis :	**Value**	**Probability**
$\sum_{i=1}^{5} g_i^{+} = \sum_{i=1}^{5} g_i^{-}$		
F-statistic	19.952	0.000
H03: Null Hypothesis:	**Value**	**Probability**
$\sum_{i=1}^{5} d_i^{+} = \sum_{i=1}^{5} d_i^{-}$		
F-statistic	12.335	0.000

Table 7: Error Correction Model Diesel, Period 2, "Stage 1"

Dependent Variable: Diesel ΔP_t^{ref}
Sample: 10/09/2014 11/09/2018 "Period 2" Model: TAR

Variable	Coefficient	t-Statistic
c_1	0.001	1.291
E_{t-1}^{+}	-0.016 *	-1.743
E_{t-1}^{-}	-0.049 ***	-4.233
ΔP_{t-1}^{brent+}	-0.010	-0.653
ΔP_{t-2}^{brent+}	0.130 ***	8.055
ΔP_{t-3}^{brent+}	0.0999 ***	6.056
ΔP_{t-4}^{brent+}	0.115 ***	7.221
ΔP_{t-5}^{brent+}	0.119 ***	7.449
ΔP_{t-1}^{brent-}	0.025	1.402
ΔP_{t-2}^{brent-}	0.112 ***	6.493
ΔP_{t-3}^{brent-}	0.171 ***	9.728
ΔP_{t-4}^{brent-}	0.145 ***	7.953
ΔP_{t-5}^{brent-}	0.101 ***	5.599
ΔP_{t-1}^{ref+}	-0.065	-1.476
ΔP_{t-2}^{ref+}	0.131 ***	3.141
ΔP_{t-3}^{ref+}	0.010	0.230
ΔP_{t-4}^{ref+}	-0.056	-1.371
ΔP_{t-5}^{ref+}	0.098 **	2.432
ΔP_{t-1}^{ref-}	-0.106 **	-2.405
ΔP_{t-2}^{ref-}	0.1350 ***	3.267
ΔP_{t-3}^{ref-}	0.065	1.604
ΔP_{t-4}^{ref-}	0.008	0.197
ΔP_{t-5}^{ref-}	0.027	0.705
Adjusted R-squared	0.598	
Akaike info criterion	-7.495	
Schwarz criterion	-7.374	
H01 Null Hypothesis:	**Value**	**Probability**
$\delta^+ = \delta^-$		
F-statistic	5.868	0.016
H02 Null Hypothesis:	**Value**	**Probability**
$\sum_{i=1}^{5} a_i^+ = \sum_{i=1}^{5} a_i^-$		
F-statistic	38.359	0.000
H03 Null Hypothesis:	**Value**	**Probability**
$\sum_{i=1}^{5} b_i^+ = \sum_{i=1}^{5} b_i^-$		
F-statistic	5.143	0.000

Table 8: Error Correction Model Diesel, Period 2, "Stage 2"

Dependent Variable: Diesel ΔP_t^{retail}
Sample: 10/10/2014 11/09/2018 "Period 2" Model:TAR

Variable	Coefficient	t-Statistic
c_2	0.0001	0.699
E_{t-1}^{+}	-0.034 ***	-3.979
E_{t-1}^{-}	-0.039 ***	-4.245
ΔP_{t-1}^{ref+}	0.131 ***	6.069
ΔP_{t-2}^{ref+}	0.039 *	1.847
ΔP_{t-3}^{ref+}	0.009	0.413
ΔP_{t-4}^{ref+}	-0.040 *	-1.890
ΔP_{t-5}^{ref+}	0.053 **	2.510
ΔP_{t-6}^{ref+}	-0.020	-0.971
ΔP_{t-1}^{ref-}	0.0821 ***	4.360
ΔP_{t-2}^{ref-}	0.093 ***	4.823
ΔP_{t-3}^{ref-}	0.052 ***	2.641
ΔP_{t-4}^{ref-}	-0.040 **	-2.044
ΔP_{t-5}^{ref-}	0.070 ***	3.587
ΔP_{t-6}^{ref-}	0.063 ***	3.156
$\Delta P_{t-1}^{retail+}$	-0.010	-0.139
$\Delta P_{t-2}^{retail+}$	0.100	1.353
$\Delta P_{t-3}^{retail+}$	0.051	0.706
$\Delta P_{t-4}^{retail+}$	0.147 **	2.066
$\Delta P_{t-5}^{retail+}$	0.090	1.264
$\Delta P_{t-6}^{retail+}$	-0.016	-0.273
$\Delta P_{t-1}^{retail-}$	-0.238 ***	-6.029
$\Delta P_{t-2}^{retail-}$	-0.033	-0.728
$\Delta P_{t-3}^{retail-}$	0.061	1.360
$\Delta P_{t-4}^{retail-}$	0.105 **	2.397
$\Delta P_{t-5}^{retail-}$	0.114	2.619
$\Delta P_{t-6}^{retail-}$	0.108 **	2.531
Adjusted R-squared	0.476	
Akaike info criterion	-8.833	
Schwarz criterion	-8.705	
H01 Null Hypothesis:	**Value**	**Probability**
$\gamma^{+} = \gamma^{-} = 0$		
F-statistic	0.200	0.655
H02 Null Hypothesis:	**Value**	**Probability**
$\sum_{i=1}^{6} g_i^{+} = \sum_{i=1}^{6} g_i^{-}$		
F-statistic	12.185	0.000
H03 Null Hypothesis:	**Value**	**Probability**
$\sum_{i=1}^{6} d_i^{+} = \sum_{i=1}^{6} d_i^{-}$		
F-statistic	6.662	0.000

Table 9: Error Correction Model, Unleaded95, Period 2, "Stage 1"

Dependent Variable: Unleaded 95 ΔP_t^{ref}
Sample: 10/09/2014 11/09/2018 "Period 2" Model:TAR

Variable	Coefficient	t-Statistic
c_1	0.000	0.513
E_{t-1}^{+}	−0.001	−0.118
E_{t-1}^{-}	-0.035 ***	−3.807
ΔP_{t-1}^{brent+}	0.026	1.272
ΔP_{t-2}^{brent+}	0.166 ***	7.830
ΔP_{t-3}^{brent+}	0.097 ***	4.392
ΔP_{t-4}^{brent+}	0.106 ***	4.894
ΔP_{t-5}^{brent+}	0.099 ***	4.574
ΔP_{t-1}^{brent-}	0.022	0.950
ΔP_{t-2}^{brent-}	0.142 ***	6.319
ΔP_{t-3}^{brent-}	0.173 ***	7.502
ΔP_{t-4}^{brent-}	0.137 ***	5.698
ΔP_{t-5}^{brent-}	0.077 ***	3.214
ΔP_{t-1}^{ref+}	0.016	0.321
ΔP_{t-2}^{ref+}	0.186 ***	3.868
ΔP_{t-3}^{ref+}	0.081 *	1.663
ΔP_{t-4}^{ref+}	-0.123 ***	−2.659
ΔP_{t-5}^{ref+}	−0.031	−0.679
ΔP_{t-1}^{ref-}	0.054	1.214
ΔP_{t-2}^{ref-}	0.201 ***	4.685
ΔP_{t-3}^{ref-}	0.085 **	1.975
ΔP_{t-4}^{ref-}	0.003	0.072
ΔP_{t-5}^{ref-}	−0.052	−1.251
Adjusted R-squared	0.504	
Akaike info criterion	−6.841	
Schwarz criterion	−6.720	
H01 Null Hypothesis:	**Value**	**Probability**
$\delta^{+} = \delta^{-}$		
F-statistic	7.723	0.006
H03 Null Hypothesis:	**Value**	**Probability**
$\sum_{i=1}^{5} a_i^{+} = \sum_{i=1}^{5} a_i^{-}$		
F-statistic	29.572	0.000
H03 Null Hypothesis:	**Value**	**Probability**
$\sum_{i=1}^{5} b_i^{+} = \sum_{i=1}^{5} b_i^{-}$		
F-statistic	6.238	0.000

Table 10: Error Correction Model Unleaded95, Period 2, "Stage 2"

Dependent Variable: Unleaded 95 ΔP_t^{retail}
Sample: 10/09/2014 11/09/2018 "Period 2" Model:MTAR

Variable	Coefficient	t-Statistic
c_2	0.0002 *	1.797
E_{t-1}^{+}	−0.007	−0.815
E_{t-1}^{-}	-0.015 ***	−2.927
ΔP_{t-1}^{ref+}	0.129 ***	8.837
ΔP_{t-2}^{ref+}	0.071 ***	4.870
ΔP_{t-3}^{ref+}	−0.009	−0.637
ΔP_{t-4}^{ref+}	-0.056 ***	−4.027
$\Delta P_{t-5}^{ref=}$	0.053 ***	3.765
ΔP_{t-1}^{ref-}	0.128 ***	9.646
ΔP_{t-2}^{ref-}	0.075 ***	5.921
ΔP_{t-3}^{ref-}	0.027 **	2.055
ΔP_{t-4}^{ref-}	−0.020	−1.537
ΔP_{t-5}^{ref-}	0.061 ***	4.929
$\Delta P_{t-1}^{retail+}$	0.284 ***	5.974
$\Delta P_{t-2}^{retail+}$	0.070	1.425
$\Delta P_{t-3}^{retail+}$	0.007	0.137
$\Delta P_{t-4}^{retail+}$	0.024	0.492
$\Delta P_{t-5}^{retail+}$	0.136 ***	3.179
$\Delta P_{t-1}^{retail-}$	0.017	0.344
$\Delta P_{t-2}^{retail-}$	0.204 ***	4.096
$\Delta P_{t-3}^{retail-}$	0.039	0.772
$\Delta P_{t-4}^{retail-}$	−0.037	−0.776
$\Delta P_{t-5}^{retail-}$	0.275 ***	6.226
Adjusted R-squared	0.735	
Akaike info criterion	−9.365	
Schwarz criterion	−9.257	
H01 Null Hypothesis:	**Value**	**Probability**
$\gamma^+ = \gamma^- = 0$		
F-statistic	0.744	0.389
H02 Null Hypothesis:	**Value**	**Probability**
$\sum_{i=1}^{5} g_i^+ = \sum_{i=1}^{5} g_i^-$		
F-statistic	32.917	0.000
H03 Null Hypothesis:	**Value**	**Probability**
$\sum_{i=1}^{5} d_i^+ = \sum_{i=1}^{5} d_i^-$		
F-statistic	30.523	0.000

Study	Bacon, R. W. (1991). Rockets and feathers: the asymmetric speed of adjustment of UK retail gasoline prices to cost changes. Energy economics, 13(3), 211-218.	Galeotti, M., Lanza, A., & Manera, M. (2003). Rockets and feathers revisited: an international comparison on European gasoline markets. Energy economics, 25(2), 175-190.	Grasso, M., & Manera, M. (2007). Asymmetric error correction models for the oil–gasoline price relationship. Energy Policy, 35(1), 156-177.
Methodology	• Quadratic quantity adjustment model (limited to the stage of the distribution)	• Asymmetric Error Correction model (two stage process, refinery and distribution stage)	• Asymmetric ECM • Autoregressive threshold ECM • ECM with threshold cointegration (Both single and two-stage process)
Sample (countries, data frequency, sample size)	• United Kingdom • Fortnightly data 6/1982 – 1/1990	• Germany, France, United Kingdom, Italy • Weekly data 1985-2000	• France, Germany, Italy, Spain and UK • Monthly data 1/1985 – 3/2003
Main results	The upward adjustment process is slightly faster and the period of adjustment more concentrated than in case of cost decrease.	Widespread differences both in adjustment speeds and short-run elasticities when input prices rise or fall. Results are in favor of widespread price asymmetries in the data have been examined. "Rockets and feathers" appear to dominate the price adjustment mechanism of gasoline markets in many European countries.	The asymmetric ECM yields some evidence of asymmetry for all countries, mainly at the distribution stage. The threshold ECM strongly rejects the null hypothesis of symmetric price behavior, particularly in the case of France and Germany. Finally, the ECM with threshold cointegration finds long-run asymmetry for each country in the reaction of retail prices to oil price changes.

Al-Gudhea, S., Kenc, T., & Dibooglu, S. (2007). Do retail gasoline prices rise more readily than they fall? : A threshold cointegration approach. Journal of Economics and Business, 59(6), 560-574.	Asane-Otoo, E., & Schneider, J. (2015). Retail fuel price adjustment in Germany: A threshold cointegration approach. Energy Policy, 78, 1-10.	Angelopoulou, E., & Gibson, H. D. (2010). The determinants of retail petrol prices in Greece. Economic Modelling, 27(6), 1537-1542.	Apergis, N., & Vouzavalis, G. (2018). Asymmetric pass through of oil prices to gasoline prices: Evidence from a new country sample. Energy Policy, 114, 519-528.
• United States • Daily data 12/1998 – 1/2004	• Germany • Weekly(national) & daily(city-specific) data 2003-2013 & 12/2013-9/2014 respectively	• Greece • Weekly data 11/2004-2/2009	• US, UK, Spain, Italy and Greece • Weekly data 01/2009 - 07/2016
• ECM with threshold cointegration (TAR & MTAR) (two stage process)	• ECM with threshold cointegration (TAR & MTAR) (single stage process)	• Panel regressions (single stage process)	Non-linear autoregressive distributed lags (NARDL) model (single stage process)
Empirical evidence show that adjustments toward long-run equilibria are asymmetric for all pairwise relationships when the downstream prices exhibit more momentum in response to above threshold deviations from long run equilibrium than below threshold deviations.	At the national level with weekly prices, the authors mainly find positive asymmetries for both gasoline and diesel within the period 2003–2007 while in the case of 2009–2013, they observe symmetric adjustment and negative asymmetry for retail diesel and gasoline prices, respectively.	Results provide little evidence for asymmetric behavior. The degree to which prices overreact to tax changes and the significance of market power across the different regions suggests that the market for petrol/diesel is not very competitive.	Oil and gasoline prices provide mixed evidence of an asymmetric behavior. Short-run asymmetry is found in the Italian market, while in the Spanish market there is evidence of both short- and long-run asymmetry. The cases of Greece, U.K. and U.S. illustrate a symmetric pass-through scheme of oil to retail gasoline prices.

Polemis, M. L. (2012). Competition and price asymmetries in the Greek oil sector: an empirical analysis on gasoline market. Empirical Economics, 43(2), 789-817.	• Greece • 01/1988 – 06/2006 • Monthly data	• Asymmetric ECM (two stage process, wholesale and distribution stage)	Results indicate that retail gasoline prices respond asymmetrically to cost increases and decreases both in the long and the short-run.

ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΥΠΟΥΡΓΕΙΟ
ΟΙΚΟΝΟΜΙΑΣ & ΑΝΑΠΤΥΞΗΣ

ΓΕΝΙΚΗ ΓΡΑΜΜΑΤΕΙΑ ΕΜΠΟΡΙΟΥ ΚΑΙ ΠΡΟΣΤΑΣΙΑΣ ΚΑΤΑΝΑΛΩΤΗ

Αθήνα, **22/11/2018**

Αριθ. Πρωτ. : **125305 - 22/11/2018**

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Δ/ΝΣΗ ΕΛΕΓΧΩΝ ΚΑΙ ΠΑΡΑΤΗΡΗΤΗΡΙΩΝ
ΤΜΗΜΑ ΠΑΡΑΤΗΡΗΤΗΡΙΩΝ ΤΙΜΩΝ

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ΘΕΜΑ: ΧΟΡΗΓΗΣΗ ΤΙΜΩΝ ΠΩΛΗΣΗΣ ΚΑΥΣΙΜΩΝ.

Σχετ.: Το από 01-11-2018 αίτημα σας που εστάλη με το ηλεκτρονικό ταχυδρομείο.

Σε ανταπόκριση του ανωτέρω σχετικού αιτήματός σας , σας γνωρίζουμε ότι στα επισυναπτόμενα ηλεκτρονικά φύλλα δεδομένων, θα βρείτε σε επεξεργάσιμη μορφή χρονοσειρές με στοιχεία τιμών καυσίμων.

Στη διάθεσή σας για τυχόν πρόσθετες πληροφορίες ή διευκρινήσεις.

ΑΚΡΙΒΕΣ ΑΝΤΙΓΡΑΦΟ
Ο προϊστάμενος του τμήματος Διοικητικής Υποστήριξης, Οργάνωσης & Τεχνικών Υπηρεσιών Τομέα Ανάπτυξης

Κ.Α.Α.
ΜΑΛΟΥΝΗ ΒΑΣΙΛΙΚΗ

Ο ΠΡΟΪΣΤΑΜΕΝΟΣ ΔΙΕΥΘΥΝΣΗΣ
Α/Α

ΓΑΛΗ ΑΛΙΚΗ

Συνημμένα: 1) ΤΙΜΕΣ ΑΝΤΛΙΑΣ ΑΝΑ ΝΟΜΟ 2012-2018
2) ΤΙΜΕΣ ΔΙΥΛΙΣΤΗΡΙΟΥ
3) ΑΝΑΛΥΣΗ ΤΙΜΩΝ ΛΙΑΝΙΚΗΣ