Asymmetric price adjustment and the effect of structural reforms in the gasoline market in Greece

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Abstract

Efficient pricing in the gasoline market has often been the subject of public debate in Greece during the recent years. The present paper: (a) Investigates the possible existence of asymmetric adjustment of gasoline prices to oil price variations in the Greek market in the recent years, thus contributing to the relevant literature. (b) Examines whether the structural reforms that took place in the gasoline market in the post-2010 period had any impact on the pricing dynamics of the market. To this end, the analysis applies the TAR-ECM cointegration technique, which is considered to be the most robust econometric method for identifying such kind of asymmetries, and makes use of observations at the lowest frequency available. The results provide evidence in favour of symmetric behaviour for the period following the structural reforms in the market, but not for the period before the reforms. This could be due to the change of the behaviour of the market participants as a result of the new institutional framework.

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1 Introduction

An issue that has attracted and continues to attract public interest [attention] in a large number of economies is whether retail gasoline prices in the domestic market respond symmetrically to changes in world oil prices, or, in other words, whether retail gasoline prices adjust to both rises and decreases of crude oil prices at the same speed. The issue is commonly known as the "rockets and feathers" hypothesis, which implies that gasoline prices "shoot up like rockets" and "fall down slowly like feathers" (after Bacon's seminal paper (Bacon 1991)). From a policy maker point of view, the question is particularly interesting as asymmetry could indicate distortions and lack of competition in the domestic gasoline market. (see *inter alia* Borenstein *et al.*, 1997).[1] Systematic asymmetry in price adjustments could imply negative consequences for the economy as a whole and a continuing deterioration of consumers' purchasing power to the benefit of producers/suppliers.[2] In such cases, it is crucial that competition authorities monitor the market, so as to ensure competitive operation to the greatest possible extent. This becomes even more crucial in periods of recession when consumers have to deal with a general decline of their incomes and standard of living; the matter takes additional implications in economies with high concentration of suppliers, who could influence gasoline prices.

Reasonably, [not without a reason], during the recent years of crisis, the issue of the pricing mechanism of gasoline in the Greek market, which is characterised by high concentration of suppliers, has become a major public issue, and has often been the focus of public debate. Refiners, wholesalers and retailers– essentially the whole oil industry - have been frequently said [accused] to use crude oil price changes to unreasonably increase their margins, by increasing fast gasoline prices when crude oil prices increase, and by adjusting them downwards slowly, when crude oil prices decrease.

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[1] Consider a market with a few producers: then, the producers have the incentive to collude in order to maximise their profits. In such an event, during a period of decreasing oil prices, a gasoline price reduction by one producer may be perceived by the others as an aggressive move, which signals the break of the cartel agreement. As a result, companies tend to keep prices rigid. In contrast, during periods of increasing prices, as a price increase cannot be misunderstood as breaking the cartel agreement, companies tend to increase their prices immediately. Consumer search costs could also lead to temporary market power of gasoline stations. Search costs (related to the comparison of retail prices by customers) are particularly high, since prices vary very often. In addition, consumers tend to regard some stations as cheap, without verifying their belief prior to every purchase. Service stations could exploit this consumer loyalty by reacting asymmetrically to changes in oil prices.

[2] Nevertheless, asymmetries can arise even in competitive markets: During periods of increasing prices, consumers tend to buy more gasoline, for precautionary reasons, assuming that this upward trend will continue; during periods of decreasing prices, demand does not fall at the same speed, causing asymmetries on the demand side. On the other hand, if the fall in prices leads to high increase in demand, companies will be reluctant to reduce prices further unless they have sufficiently high levels of stocks to meet the rise in demand. Refineries are also constrained by production costs and production capacity in the short run which may be another obstacle to fast adjustment of gasoline prices. Finally, in periods of low demand, service stations may decrease faster their prices in order to increase their market shares.

The issue [topic] has been regularly presented in the Greek mass media during the crisis years (see *inter alia* Kathimerini, 2012, 2015, Vima 2014). The structure of the oil market in Greece has also been the topic of monitoring and research in a number of reports of the Hellenic Competition Committee, which repetitively stated the need for further liberalisation of the market (2006, 2007, 2008, 2012, 2015). It has also been subject of policy recommendations by international organizations (see e.g. OECD, 2013) and by the Institutions (see e.g. IMF, 2013) and its further liberalisation has repeatedly been among the prior actions to be completed for the disbursement of the financial aid directed to Greece based in the three economic programmes of 2010, 2012 and 2015 (IMF, 2010, 2012, 2015). Following these reports and recommendations, the Greek State started to monitor the market closely in 2010 and has taken a number of measures to liberalize the oil market since then. [Measures started to be legislated in 2010 in an effort to meet [fulfil] the requirements of the economic programs for Greece in 2010, 2012 and 2015]. On top of the effects of the gradual liberalisation of the market, the decrease in domestic demand during the crisis years and the publicity that the issue has taken, may have also affected the pricing strategy of the sellers, and the issue is not anymore in the mass media.

The "rockets and feathers" hypothesis has been extensively addressed in the economic literature for a large number of economies over the last twenty seven years or so (see, *inter alia*, Bacon (1991), Manning (1991), Duffy-Deno (1996), Balaguer and Ripolles (2012), Asane-Otoo and Schneider (2015)). Most of the studies detect asymmetry in domestic retail price adjustments. However, not all studies provide the same results. Essentially their findings vary depending on the economy and the period analysed, the size of the sample, the time frequency of the observations, and the econometric methodology used [and the way asymmetry is defined].

The evidence in the Greek gasoline market is also inconclusive. Meyler (2009) and Polemis (2011) detect asymmetry in the adjustment of retail fuel prices in Greece, whereas Cleridis (2010), and Angelopoulou and Gibson (2010) do not find any[3]. Nevertheless, and despite their inconclusive results, the studies share a number of similarities: First, all studies use the Asymmetric Error Correction Model (AECM) methodology: they first estimate an equilibrium relationship between gasoline and oil prices and then test for asymmetries in the speed of adjustment of the domestically determined gasoline prices towards this equilibrium. Second, the sample periods examined in the studies extend up to 2010 and thus do not include

[3] Angelopoulou and Gibson (2010) however, show that prices adjust asymmetrically to tax changes and across various regions in Greece, which they interpret as evidence of lack of competition in the market.

the most recent period, which is also characterised by measures to liberalise the gasoline market in Greece [4].

The present study tests for “rockets and feathers” in the retail gasoline market in Greece, during the period January 2005 – September 2015. The objective is to provide robust evidence in response to the public concern and the mixed results provided by the earlier studies. To this end: (i) the study uses all available observations for the variables under consideration. The Greek oil market is analysed using observations of a large statistical sample, which also comprises observations from the market reforming period of the Greek economy. Thus, it provides more recent empirical evidence, given that the existing empirical literature predates 2010. (ii) The paper applies the TAR-ECM cointegration technique, which is advocated by the relevant literature to be the most robust econometric method for identifying such kind of asymmetries. The TAR-ECM technique rather than fixing the threshold value, above or below which the residuals tend to return to equilibrium, to zero, permits the value of the threshold to be purely determined by the data. (iii) The study uses observations of the lowest frequency available for gasoline prices in Greece: weekly observations. Since the market prices of gasoline are changed very often –at least once per week- it is reasonable to assume that the use of weekly observations is more revealing for the practices of market participants.

An additional issue of interest is whether the more cautious monitoring of the market (as testimonied also by the high frequency of the reports published by the Hellenic Competition Committee), and the structural reforms which have taken place in the gasoline market after 2010, had any impact on the price setting mechanism in the gasoline market in Greece. The signing of the 1st memorandum in May 2010 can be considered as a significant structural change point, as it signals the commitment from the side of the authorities to proceed with structural reforms in the gasoline market, and may have affected the behaviour of the gasoline market participants. The period following it, is also characterised by a severe fall in domestic demand, which may have contributed to a more competitive functioning of the market, as consumers may have started to search for lower prices and firms may have kept low prices in an effort to keep their market shares. Thus, in order to analyse the effects of the reforms in the market (and of the low demand), the present paper tests for asymmetries (i.e. the rockets and feathers hypothesis), for the two periods, before and after May 2010.

[4] More specifically, Meyler (2009), Cleridis (2010), Angelopoulou & Gibson (2010) and Polemis (2011), analyse the periods 1994-2008, 2000-2010, 2004-2009 and 1998-2006, respectively.

The rest of the paper is organised as follows: Section 2 offers a brief description of the gasoline market in Greece. Section 3 presents the econometric methodology. The data and the empirical results are presented in Section 4. The final section summarises and concludes.

2. The Greek market

The structure of the market

The Greek oil market consists of three submarkets: a) the refining market, in which refineries purchase crude oil and sell petroleum products to wholesale vendors; (b) the wholesale market, in which companies sell fuel to service stations; and (c) the retail market, in which service stations sell fuel to consumers. There are just two companies in the refining market, the Hellenic Petroleum (ELPE) and MOTOROIL, which own all four refineries operating in Greece.[5] ELPE, having a market share of more than 60%, clearly leads the refining market. Duopoly conditions prevail, with significant barriers to entry of new firms in the market due to the high level of sunk costs. Around twenty companies are active in the wholesale market, some of which are subsidiaries of the refineries. The four larger companies (ELPE and MOTOROIL subsidiaries plus the multinationals BP and SHELL) have a market share of more than 50%. Although there are no formal barriers to market entry, constraints existed due to regulations on oil stocks. [6] However, pricing differs across regions: it is not clear how companies set their prices across the different regions in Greece. In addition, the transportation market in which transport costs are determined is not perfectly competitive (fuel is transported by public- and private-use tanker trucks). There are roughly 7,000 filling stations in Greece, of which just about 600 are independent retailers. The rest are owned by, affiliated to, or subsidiaries of the petroleum companies. The number of filling stations is high compared to other countries. In Greece there is one station for every 1,400 inhabitants compared to one for every 3,800 in the EU. However, the Greek market is geographically segmented, and competition is determined by the number of stations per geographical area. Moreover, contracts between filling stations and wholesale companies may be restrictive, causing an adverse impact on retail prices.

Crude oil prices in the Greek market are derived from the international market, where prices are driven by supply and demand conditions (reserves, extraction costs, transport costs, etc.), as well as by derivatives trading. Refineries purchase crude oil as raw material to produce (final) fuel products, which are then sold initially to wholesale companies, then to service stations, and finally to consumers. Consequently, retail fuel prices in the Greek market are

[5] ELPE is the leading industrial and commercial group in the energy sector. MOTOROIL is the largest privately held industrial complex in Greece.

[6] Wholesale companies can import oil from foreign refineries, as long as they keep buffer stocks that can meet consumption for 90 days.

determined by the output price at refineries, the profit margins of wholesalers and service stations, and the duties and taxes imposed by the state. In detail, the price of gasoline can be decomposed as follows: 65% of it is taxes, 29.4% is the cost of crude oil, and 5.6% is the gross profit rate of marketing companies and service stations.

Refineries set their prices according to crude oil prices, the exchange rate of the euro vis-à-vis the US dollar, and a mark-up.[7] Crude oil prices and the exchange rate are exogenous to the functioning of the Greek fuel market. State duties and taxes raise the price by a specified rate, which is also exogenous to the Greek market forces.[8] Only the mark-up charged by refineries and the profit margins of wholesalers and retailers depend on factors related to domestic market characteristics, such as the market structure, the vertical integration, the geographical distance of regional markets from the refineries and short-term demand fluctuations.

Domestic factors also account for any pre-tax price differences between Greece and other EU economies which buy crude oil in the same market. Crude oil prices applicable in Greece are the MED prices quoted in the Mediterranean market (of Genoa). Consequently, retail fuel prices in Greece are comparable with those in Cyprus, Spain, Italy and Portugal.[9] Chart 1 shows the evolution of gasoline prices in South European countries in 2005:H1- 2015:H1. It is evident that in the period 2005-2010 i.e. before the debt crisis, Greek gasoline prices were among the highest in the European south. From the onset of the crisis to the end of the sample, gasoline prices in Greece became the lowest in the group. The evidence probably suggests differential mark-ups applied by refineries, wholesalers and service stations relative to the pre-crisis period.

3. The econometric methodology

The empirical studies on the "rockets and feathers" phenomenon apply the error correction model (ECM) methodology (Engle and Granger, 1987). The first step in the methodology is to test for the existence of a long-run equilibrium relationship between international oil prices, R_t^b and the retail gasoline prices in the domestic (Greek) economy, R_t^g, of the form:

$$r_t^g = \gamma_0 + \gamma_1 r_t^b + u_t \qquad (1)$$

[7] Market participants argue that prices are based on the Mediterranean market quotes and an additional mark-up of 3% (see, inter alia, press release by ELPE in *Kathimerini*, 18 September 2012).
[8] According to the applicable tax regime, VAT is calculated on the sum of the oil price and the excise duties, thereby duplicating the tax burden for consumers.
[9] However, as methodologies for measuring product price and quality differ across countries (see European Commission, *Oil Bulletin*, 2011), prices are not fully comparable; thus caution is warranted in drawing any conclusions.

where r_t^b and r_t^g denote the logarithms of R_t^b and R_t^g respectively. γ_0 is a measure which accounts for [the constant mark-up and] the fixed cost which comprises all refining, marketing and distribution costs, and γ_1 is a measure for the degree of pass-through in the long run. Then, for $\gamma_1 = 1$, the long-run adjustment (pass-through) is complete; for $\gamma_1 < 1$, the pass-through is incomplete, implying that markets are not fully competitive and that there exist high switching and menu costs and/or asymmetric information. u_t denotes deviations from equilibrium.

If both series r_t^b and r_t^g are I(1), Engle and Granger propose to test whether they are cointegrated by testing whether the errors u_t are stationary or not. This can be done by testing the hypothesis $H_0 : \rho = 0$ against $\rho<0$ (the standard Dickey-Fuller tests), on an equation of the form: $\Delta u_t = \rho u_{t-1} + v_t$ (2)

where Δ denotes the first difference and ρ denotes the speed of adjustment of the errors to their mean value. In case that the errors are stationary, they can be used as error correction terms in the short-run dynamic relationship for gasoline prices of the form:

$$\Delta r_t^g = \mu_0 + \sum_{i=1}^{k_1} \beta_{1,i} \Delta r_{t-i}^g + \sum_{i=0}^{k_2} \beta_{2,i} \Delta r_{t-i}^b + \alpha u_{t-1} + e_t \qquad \text{where } \alpha < 0 \qquad (3)$$

where k_1, k_2 denote time lags. According to (3), in the short run gasoline price changes Δr_t^g are determined by gasoline price changes in previous periods, $\Sigma \Delta r_{t-i}^g$, oil price changes in previous periods $\Sigma \Delta r_{t-i}^b$, and the tendency of gasoline prices to return to their long-run equilibrium, as expressed by αu_{t-1}.The coefficient α is expected to take negative values: when in period t-1 the variable r_t^g deviates from the long-run equilibrium (1), (resulting to a non-zero error u_{t-1}), there is a tendency to return to the long-run equilibrium in period t. In other words, when the errors exceed their mean value in period t-1, they tend to move downwards to reach the long–run equilibrium value in period t, whereas when errors are below their mean, they tend to move upwards, to reach the long-run equilibrium value in period t. The coefficient α denotes the speed of adjustment to the long-run equilibrium: higher α values in absolute terms mean faster adjustment to long-run equilibrium. (3) is the general form of the symmetric error correction model ECM and the term.

Engle and Granger's ECM in its original symmetric form (3) is based on the following assumptions: (a) Residuals have zero mean. (b) Residual values (either higher or lower than their mean) revert to their mean symmetrically, i.e. at the same speed ρ. (c) The dependent variable responds symmetrically to any deviation from equilibrium. This implies that α, the dependent variable's speed of adjustment to equilibrium, is the same (identical), irrespective of whether residual values are negative (below their mean) or positive (above their mean).

The hypothesis (c) of the dependent variable's symmetric adjustment to long-run equilibrium has been questioned in the literature. The asymmetric ECM model (AECM) divides errors into positive u_t^+ and negative u_t^- (in other words, positive and negative deviations of r_t^g from equilibrium) and estimates the following relationship:

$$\Delta r_t^g = \mu_0 + \sum_{i=1}^{k_1} \beta_{1,i} \Delta r_{t-i}^g + \sum_{i=0}^{k_2} \beta_{2,i} \Delta r_{t-i}^b + a_1 \overset{-}{u}_{t-1} + a_2 \overset{+}{u}_{t-1} + e_t \qquad (4)$$

where $\alpha_1<0$ and $\alpha_2<0$. Specification (4) assumes that the adjustment speed is α_1 for negative deviations and α_2 for positive ones. A first indication of asymmetric adjustment comes up when the estimated values of α_1 and α_2 are not equal. The AECM specification allows for a statistical test for the symmetry hypothesis (that the coefficients are equal) H_0: $\alpha_{1=}$ α_2.

Yet, [Nevertheless] the AECM has been shown to be statistically invalid, in cases for which asymmetric adjustment is detected. Balke and Fomby (1997) and Enders and Granger (1998) indicate that if the residuals' adjustment to their mean value (the long-run equilibrium) is not symmetric, (i.e. the assumption (b) does not hold) the auxiliary equation (2) for cointegration tests is miss-specified and could lead to misleading results. To tackle this problem, Enders and Granger (1998) and Enders and Siklos (2001) propose the threshold autoregressive (TAR) cointegration technique as the adequate and statistically robust technique to be used when testing for asymmetric adjustments. This is the methodology applied in the present paper. According to it, unit root tests also take into account the possibility that the residuals (deviations) return to the long-run equilibrium value with different speed, depending on whether their value is higher or lower than a threshold value τ , which does not necessarily equal zero. The TAR model can be written as follows:

$$\Delta \hat{u}_t = I_t \rho_1^+ \hat{u}_{t-1} + (1 - I_t) \rho_2^- \hat{u}_{t-1} + v_t \qquad (5)$$

where $\hat{u}_t$ are the residuals of the long-run equation (1). The function I_t depends on the lagged values of the residuals, according to the following scheme:

$$\mathrm{I}_t = \begin{cases} 1 \ \text{ if } \ \hat{\mathrm{u}}_{t-1} \geq \hat{\tau} \\ 0 \ \text{ if } \ \hat{\mathrm{u}}_{t-1} < \hat{\tau} \end{cases} \qquad (6)$$

The TAR cointegration model assumes that the residuals adjust at a speed ρ_1 when their values are above the threshold value τ and at a speed ρ_2 when their values are below τ. The TAR model is designed to capture potential asymmetric "deep" movements in the residuals. Negative "deepness" (i.e. $|\rho_1| < |\rho_2|$) of $\hat{u}_t$ implies that increases tend to persist, whereas decreases tend to revert quickly towards equilibrium.

In addition, the threshold parameter does not need to be restricted to zero, [as instead is assumed in model (4) - hypothesis (a)]. If the threshold enters the model unrestrictedly, the problem of how to consistently estimate the threshold, or attractor, emerges. The crucial point in the TAR methodology is to identify correctly the threshold value τ , for which the asymmetric adjustment is statistically significant.[10] Enders and Siklos (2001) propose a consistent method to detect τ among all residual values resulting from the cointegration relationship. According to this method, a search procedure over all possible values of the attractor in order to minimize the sum of squared residuals yields a super-consistent estimator of the threshold.

When the existence of a threshold autoregressive cointegration is identified, errors can be discerned into those which take a value higher than τ and those which take a value lower than τ. In such a case, an asymmetric ECM can be estimated as follows:

$$\Delta r_t^g = \mu_0 + \sum_{i=1}^{k_1} \beta_{1,i} \Delta r_{t-i}^g + \sum_{i=0}^{k_2} \beta_{2,i} \Delta r_{t-i}^b + a_3 u_{t-1}^{down} + a_4 u_{t-1}^{up} + e_t \tag{7}$$

where a_3 <0 and a_4<0. In (5), the u_{t-1} deviation values are split into u_{t-1}^{up} and u_{t-1}^{down}, which represent deviations over and below the threshold value τ, respectively. Thus, (7) provides the basis to test the hypothesis $a_3 = a_4$, which expresses the dependent variable's symmetric adjustment to equilibrium. Enders and Siklos (2001) provide the critical values for testing cointegration on these hypotheses and propose a Wald-type statistical test to determine whether the residuals' adjustment is symmetric.

Once the asymmetric properties of the models are correctly specified and tested, the mean lags associated with upward and downward adjustment of gasoline prices to equilibrium can be calculated based on the estimated parameters of model (7). The asymmetric mean adjustment lags of a complete pass-through can be measured as follows:

$$MAL^+ = (\sum_i^{k_2} \beta_{2i} - 1) / \alpha_1^+ \tag{8}$$

$$MAL^- = (\sum_i^{k_2} \beta_{2i} - 1) / \alpha_2^- \tag{9}$$

[10] In its simplest version, the TAR model hypothesises that τ = 0. This means that positive and negative deviations from equilibrium are assumed to be corrected at different adjustment speeds.

where MAL+ represents the mean adjustment lag when the retail prices are above their equilibrium level and MAL− represents the mean adjustment lag when the administered prices are below their equilibrium level.

5. Empirical results

5.1 The dataset-Unit root tests

The study uses weekly observations for the period January 2005 – March 2015. Data on retail gasoline prices R_t^g are taken from the European Commission *Oil Bulletin*.[11] The analysis focuses on the pre-tax price series of the 95-octane unleaded gasoline. [12] The crude oil prices series, R_t^b, refers to Brent crude oil spot prices series (considered to be the pricing benchmark in Europe) published in the US Energy Information Administration database. For comparability with retail prices, dollars per barrel are expressed in euro per litre, on the basis of a 158.987 litres/barrel rate. Analysis is initially performed for the whole period. Then, in order to investigate any possible effects coming from the liberalisation of the Greek gasoline market, analysis is also performed for the pre-reform period Jan 2005– April 2010, (period A) and the post-reform period May 2010-March 2015 (period B).

The first step in the empirical work is to test the series r_t^b and r_t^g for unit roots in the three periods. The D-F (Dickey-Fuller, 1979) and DF-GLS (Elliot et al., 1996) tests are applied. The results are presented in Table 1. The findings show that both series are *I(1)* for all three periods: the hypothesis of the existence of a unit root cannot be rejected at the level of the series, but the series turn out to be stationary at their first differences.

5.2 The standard cointegration analysis

Based on the results of the unit root tests, the next step of the analysis is to investigate whether the two I(1) series cointegrate in a long –run relationship, of the form of equation (1), using the Engle and Granger methodology. The analysis is performed for the three different periods. The results of the Engle-Granger cointegration tests (t-statistic and z-statistic), are presented in Table 2.

For the full sample period the results indicate that there exists a cointegrating relationship between the series, of the form:

[11] Weekly prices of various fuel types are published in the Oil Bulletin since 2005. For transparency and information purposes, all EU Member States are required to report such prices both before and after tax in their respective retail markets.

[12] Indirect taxes comprise custom duties, fuel excise duties and VAT. As already mentioned, VAT is calculated on the sum of the final product price and the excise duties, thereby further increasing the final consumer price.

$$r_t^g = 0.1 + 0.7 r_t^b + u_t \quad (6)$$

According to (6), the long-run oil price elasticity of domestic gasoline prices, γ_1, is 0.7. This means that a 10% change (rise or fall) in crude oil prices causes a 7% change (increase or decrease, respectively) in retail gasoline prices. The estimated value is less than one, evidence which probably implies the existence of market imperfections, menu costs and asymmetric information in the Greek market.

Nevertheless, cointegration analysis in the two subperiods sheds further light on the relationship between world oil prices and domestic gasoline prices, and –consequently- the functioning of the market before and after the reforms. For the pre-reforms period A, the long –run relationship takes the form

r_t^g = 0.11+0.71 r_t^b + u_t (7)

whereas, in period A, which is characterised by the implementation of reforms, the gasoline prices – oil prices relationship, becomes:

r_t^g = 0.12+0.74 r_t^b + u_t (8)

The estimated adjustment coefficients in (7) and (8) indicate that the degree of adjustment has increased from 71% in period A to 74% in period B. The results provide evidence in favour of the assumption that the gradual application of the reforms, exerted a positive impact on the market, and that prices are set in a more competitive environment in the post-reforms period.

However, as already indicated in section 4, the traditional Engle and Granger approach assumes: (i) symmetric adjustment of the error term to its mean value, (ii), the mean value of the error terms to equal to zero and (iii) a symmetric ECM. Thus, the Engle-Granger methodology has been shown to be statistically invalid in cases for which asymmetric adjustment is detected. The three assumptions have to be tested applying the asymmetric TAR model with estimated threshold τ. The tests are performed in the following subsection.

5.3 TAR cointegration (with τ threshold estimation)

The Enders and Siklos methodology which tests for cointegration with a consistent estimation of the threshold, is pursued for the three periods. The results of the TAR cointegration models are presented in Table 3.

The results on the full [whole available] period provide evidence in favour of the existence of a long-run relationship between oil prices and retail gasoline prices. They also indicate that the speed of adjustment changes when the residuals are above or below a threshold, which is consistently estimated to equal $\hat{\tau}$ = -0.053. In addition, the hypothesis for the absence of threshold cointegration [H_0: $\rho_1^{up} = \rho_2^{down} = 0$] is rejected based on the Φ*statistic value. According to the estimated results, the coefficients ρ_1^{up} and ρ_2^{down} take different values (ρ_1^{up} = -0.26 and ρ_2^{down} = -0.44), which also turn out to be statistically significant. In other words, the TAR results indicate that when the system deviations from the long-run equilibrium take values higher than the threshold $\hat{\tau}$ =-0.053, adjustment to equilibrium takes place slowly (at a speed of ρ_1^{up} = -0.26), whereas when the deviations take values lower than the threshold, adjustment to equilibrium is fast (at a speed of ρ_2^{down} = -0.44).

In addition, the hypothesis of equal adjustment coefficients $\rho_1^{up} = \rho_2^{down}$ is rejected based on the Wald test statistic value (F(1,495) = 5.68, P-value = 0.017)). Thus, based on the outcomes, the "feathers and rockets" phenomenon characterises the Greek market during the whole period analysed: There is evidence that deviations from the equilibrium relationship adjust asymmetrically [with a different speed] depending on whether they take values above or below a threshold value. They adjust slower when they obtain values higher than [above] their equilibrium values than when they obtain values lower than their equilibrium values.

The analysis of the two sub-periods provides additional information on the functioning of the market before and after the reforms. The results on periods A and B, provide evidence in favour of the existence of a long-run relationship between oil prices and retail gasoline prices, for consistently estimated threshold values of $\hat{\tau}$ ($\hat{\tau}$ is estimated to equal 0.059 for period A and 0.032 for period B). In addition, the hypothesis for the absence of threshold cointegration [H_0: $\rho_1^{up} = \rho_2^{down} =0$] is rejected for the two periods, based on the Φ*statistic value. The estimated adjustment coefficients ρ_1^{up} and ρ_2^{down} do not equal each other in the two periods (ρ_1^{up} = -0.29 and ρ_2^{down} = -0.54 for period A and ρ_1^{up} = -0.21 and ρ_2^{down} = -0.29 for period B). Thus, the TAR-ECM methodology which advocates for a consistent estimate of τ different to zero, turns out to be the adequate methodology to test for asymmetries in periods A and B.

However, whereas the symmetry hypothesis [the hypothesis of equal adjustment coefficients $\rho_1^{up} = \rho_2^{down}$] is rejected for period A based on the Wald test statistic value (F(1,258) = 5.73, P-value = 0.018)), it is not rejected for the post-reforms period B (F(1,234) = 0.99, P-value = 0.000)). Thus, the results indicate that the market has been functioning more efficiently in the post reform period than before. They probably reflect the impact of the reforms and of a more competitive behaviour from the part of the suppliers, in an effort to keep their market shares, in an environment of weak demand. Still, in order to come to clear conclusions for the functioning of the market in period B, further examination of whether domestic prices adjust with the same speed to deviations from equilibrium, is needed.

5.4 The Asymmetric ECM with TAR cointegration (with τ threshold estimation)

The existence of TAR cointegration allows for the estimation of an asymmetric ECM of the form of (5). Analysis is applied for the post reforms period B, for which symmetry is evidenced for the adjustment process of the deviations from the consistent threshold value. Results are presented in Table 4. According to the results, changes in gasoline prices at the current period (week) are determined by: (a) gasoline price changes one and four weeks ago; (b) oil prices changes one and two weeks ago; and (c) the long-run equilibrium relationship. The error correction terms are statistically significant, with different (unequal) adjustment speeds, a_3 = -0.14 and a_4 = -0.05. Nevertheless, the symmetry hypothesis cannot be rejected based on the relevant Wald test statistic. The null hypothesis on the equality of adjustment coefficients is not rejected at a 5% level of significance (F(1,229) = 3.66, P-value = 0.057)).] The results indicate that adjustment to the equilibrium is symmetric, or in other words, that the *rockets and feathers* hypothesis does not hold in the most recent period in Greece.

Based on (8) and (9), the mean lags associated with the adjustment of gasoline prices to equilibrium can be calculated using the estimated parameters of model (7). The results based on the ECM with TAR indicate that the mean lag is 4.7 weeks irrespectively of whether gasoline retail prices adjust downwards or upwards. The results provide strong evidence of symmetric adjustment of domestic prices to crude oil prices in the Greek market in the post-reforms period.

6. Conclusions

The pricing behaviour of the participants in the gasoline market has often been the subject of public debate in Greece during the crisis years. The present paper investigates the possible existence of asymmetries in the adjustment of gasoline prices to oil price variations, in the Greek gasoline market, thus contributing to the relevant literature which provides contradictionary results. It also examines whether the structural reforms that took place in the gasoline market in the post-2010 period had any impact on the functioning of the market.

To this end, the present study: (1) Applies the TAR-ECM cointegration technique, which is advocated by the relevant literature to be the most robust econometric method for identifying such kind of asymmetries. (2) Uses a long data sample which includes all available observations. The long data sample, which, in addition covers observations of two different economic policy regimes, ensures the reliability of the results in terms of economic significance and statistical inference. (3) Uses data observations at the lowest frequency available: weekly. Since the market prices of gasoline are changed very often –at least once per week- it is reasonable to assume that the use of weekly observations is more revealing for the practices of market participants

The econometric analysis tests for asymmetric evidence in three different periods: the whole period, and the periods before and after the implementation of structural reforms in the Greek gasoline market. The results provide evidence in favour of symmetric behaviour only for the period following the structural reforms in the market. This could be due to the change of the behaviour of the market participants, as a result of the new institutional framework. Nevertheless, the recent period is also characterised by weak demand. Thus, we cannot exclude the possibility that the pricing behaviour of gasoline suppliers has also been influenced by the demand conditions, i.e. that the effects of the structural reforms have been enforced by the low demand environment..

Table 1: Unit root tests ADF, PP και DF-GLS.

Sample period	Full period				Period A				Period B			
Augmented Dickey-Fuller (ADF)	r^b	$\Delta(r^b)$	r^g	$\Delta(r^g)$	r^b	$\Delta(r^b)$	r^g	$\Delta(r^g)$	r^b	$\Delta(r^b)$	r^g	$\Delta(r^g)$
	t-Statistic				**t-Statistic**				**t-Statistic**			
constant	-2.638	-21.575**	-3.012	-14.510**	-2.425	-16.536**	-3.027	-11.375**	-1.554	-13.156**	-2.355	-8.007**
time lags	0	0	1	0	0	0	3	0	1	0	1	1
constant and trend	-2.168	-21.623**	-3.374	-14.570**	-2.349	-16.507**	-3.014	-14.381**	-1.470	-13.242**	-2.204	-8.137**
time lags	0	0	3	0	0	0	3	0	1	0	1	1
no constant, no trend	-1.316	-21.588**	-1.478	-14.513**	-1.405	-16.525**	-1.383	-14.358**	-0.024	-13.178**	-0.309	-8.023**
time lags	0	0	1	0	0	0	1	0	1	0	2	1
Phillips-Perron (PP) (Newey-West using Bartlett kernel)	r^b	$\Delta(r^b)$	r^g	$\Delta(r^g)$	r^b	$\Delta(r^b)$	r^g	$\Delta(r^g)$	r^b	$\Delta(r^b)$	r^g	$\Delta(r^g)$
	t-Statistic				**t-Statistic**				**t-Statistic**			
constant	-2.690	-21.575**	-2.986	-14.848**	-2.521	-16.536**	-2.906	-11.811**	-1.477	-13.171**	-1.518	-7.368**
	3	0	11	7	5	5	9	7	4	2	6	9
constant and trend	-2.370	-21.622**	-2.908	-14.885**	-2.455	-16.509**	-2.844	-11.816**	-1.329	-13.242**	-1.203	-7.215**
	4	1	11	7	5	5	9	7	2	0	5	10
no constant, no trend	-1.303	-21.588**	-1.437	-14.850**	-1.370	-16.526**	-1.342	-11.799**	0.011	-13.193**	-0.158	-7.389**
	2	0	11	7	5	5	9	7	3	2	6	9
DF-GLS Detrended Residuals	r^b	$\Delta(r^b)$	r^g	$\Delta(r^g)$	r^b	$\Delta(r^b)$	r^g	$\Delta(r^g)$	r^b	$\Delta(r^b)$	r^g	$\Delta(r^g)$
	t-Statistic				**t-Statistic**				**t-Statistic**			
constant	-0.503	-0.989**	-0.693	-14.304**	-0.254	-1.108**	-0.877	-11.178**	-1.259	-5.136**	-0.1.392	-6.599**
time lags	0	7	1	0	0	5	3	0	1	6	2	0
constant and trend	-1.241	-1.984**	-1.785	-14.204**	-1.401	-2.248**	-2.038	-11.297**	-1.247	-4.781**	-2.013	-7.539**
time lags	0	7	1	0	0	5	3	0	1	6	1	0

**Rejection of mull hypothesis at significance level of 5%.

Table 2: Engle and Granger cointegration tests

Sample period	1/10/2005 2/23/2015	1/17/2005 - 4/26/2010	5/03/2010 2/23/2015
FMOLS			
α	0,106** (5,412)	0,114** (2,663)	0,121** (3.437)
β	**0,708** (35,511)**	**0,714** (19.328)**	**0,731** (15.604)**
R^2	0.941	0.883	0.882
SE	0.048	0.054	0.040
Engle - Granger tests			
Engle-Granger t-statistic	-9,485** [0,00(	-7.346** [0,000]	-5.512** [0,000]
Engle-Granger z-statistic	-152,508** [0,000]	-89.670** [0,000]	-53.632** [0,000]

Table 3: Enders-Siklos tests for consistent TAR cointegration

Consistent TAR models					
		Sample period	1/17/2005 - 2/23/2015	1/17/2005 - 4/26/2010	5/10/2010 - 2/23/2015
		T	497	260	236
			$\hat{\tau} = -0.053483 \rightarrow \min(RSS)$	$\hat{\tau} = -0.058965 \rightarrow \min(RSS)$	$\hat{\tau} = -0.032068 \rightarrow \min(RSS)$
		AIC SBC RSS	-3,884 -3,867 0.593	-3,543 -3,515 0.433	-4,425 -4,396 0.162
ρ^{+}_{1}	ρ^{+}_{1}	E-S t-MAX	-0,264** (0,000)	-0,289** (0,000)	-0,205** (-3,903)
ρ^{-}_{1}	ρ^{-}_{2}	E-S t-MAX	-0,435** (0.000)	-0,543** (-5,941)	-0,292** (-4,191)
Hypothesis testing					
Tests for TAR cointegration	Ho: $\rho^{+}_{1} = \rho^{-}_{2} = 0$	E-S Φ test	Φ* (2,495)= 50,104** (0,00)	Φ* (2,258)=30,100** (0,000)	Φ* (2,234) = 16,401** (0,000)
Symmetry tests	Ho: $\rho^{+}_{1} = \rho^{-}_{2}$	E-S F test	F (1,495)= 5,685* (0,017)	F (1,258)= 5,734* (0,017)	F (1,234)= 0,991 (0,320)
			reject symmetry	reject symmetry	accept symmetry

Note 1 :P-values in parentheses.

Note 2: * denotes rejection at the 0.05 level, ** denote rejection at the 0.01 level.

Enders and Siklos (E-S) critical values for Φ*are taken from Enders and Siclos (2001) and Wayne (2004).

Table 4: Asymmetric ECM with consistent TAR cointegration

Post-reforms period			
constant	μ_0	0,001 (1,286)	[0,199]
$\Delta(r^g)_{t-1}$	$\beta_{1,1}$	0,303** (5,515)	[0,000]
$\Delta(r^g)_{t-4}$	$\beta_{1,4}$	0,016 (0,265)	[0,790]
$\Delta(r^b)_{t-1}$	$\beta_{2,1}$	0,215** (7,161)	[0,000]
$\Delta(r^b)_{t-2}$	$\beta_{2,2}$	0,092** (3,562)	[0,000]
	α_3	-0,135** (-4,350)	[0,000]
	α_4	-0,047 (-1,261)	[0,208]
T		236	
R^2		0,650	
SSR		0,030	
SE		0,011	
DW		2,072	
F-statistic		73,944	
HAC se, covariance, Prewhitening with lags		0 from SIC	
maxlags		6	
Bartlett kernel, Newey-West fixed bandwidth		5,000	
Hypothesis testing			
Wald-type test	Ho: symmetry	F-stat.(1,229)=3,656	[0,057]

Note1: t-stats in (), p-values in [].

Note 2: *, ** denote rejection at the 0.05 and the 0.01 level, respectively.

Note 3: Max lag based on AIC and SBC

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