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ASYMMETRIC PRICE ADJUSTMENT AND THE EFFECTS OF STRUCTURAL REFORMS IN A LOW INCOME ENVIRONMENT: THE CASE OF THE GASOLINE MARKET IN GREECE

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Abstract

The pricing mechanism in the gasoline market has often been the subject of public debate in Greece during the crisis years. Inefficient pricing could imply oligopolistic practices in the market and losses to consumers' welfare in a period characterised by a dramatic fall in consumers' income and standard of living. A way to test whether pricing is efficient in the market is by testing for asymmetries in the adjustment of domestic gasoline prices to world oil price changes. The present paper has two aims: (a) The first is to investigate the existence of asymmetric adjustment of gasoline prices to oil price variations in the Greek market, thus contributing to the relevant literature. (b) The second is to examine whether the structural reforms that took place in the gasoline market and the large fall in income, which characterise consumers' behaviour in the recent period, had any impact on the pricing dynamics in the market. To this end, the analysis: (i) applies the TAR-ECM threshold cointegration technique, which assumes asymmetric adjustment towards the long-run equilibrium; (ii) makes use of observations at the highest frequency available; and (iii) uses the most recent data. The results provide evidence in favour of symmetric behaviour just for the crisis period. This may reflect competitive behaviour by suppliers who had to interact in a low demand environment and under a new institutional framework following the reforms, along with a change in consumers' search behaviour who had to deal with a severe fall in their income.

Keywords: Price asymmetry, Gasoline prices, Crude oil, Threshold cointegration.

JEL classification: D43, Q41, Q43, Q48.

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1. Introduction

An issue that has attracted and continues to attract public 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 domestic retail gasoline prices adjust to both rises and decreases of crude oil prices at the same speed. The issue is commonly known in the literature as the “rockets and feathers” hypothesis, which implies that gasoline prices “shoot up like rockets” and “fall down slowly like feathers” (following Bacon’s seminal paper (Bacon 1991)). From a policy maker’s 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). 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 breaking of any 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 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.

However, 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 a 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 the fast adjustment of gasoline prices. Finally, in periods of low demand, service stations may decrease their prices faster in order to increase their market shares.

Systematic asymmetry in price adjustments could have negative consequences for the economy as a whole and a continuing deterioration of consumers' purchasing power to the benefit of producers/suppliers. Consequently, in cases where asymmetry is observed, it is crucial that the competition authorities monitor the market, to ensure competitive operation to the greatest possible extent (see also Balaguer and Ripolles (2012), Polemis and Fotis (2013) and Asane- Otoo and Schneider (2015) for similar policy implications). This becomes even more crucial in periods of recession when consumers have to deal with a general decline in their incomes and standard of living. The matter has additional implications in economies with a high concentration of suppliers, who have high market power and could thus abuse their dominant position.

The Greek gasoline market is characterised by high concentration: there exist two companies in the refining sector, four large companies in the wholesale market (which have a market share of more than 50%), each of them with a nationwide network of fuel stations.[1] Thus, as might be expected, during the recent years of crisis, the issue of the pricing of gasoline in the Greek market 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 accused of using crude oil price changes to unreasonably increase their margins, by increasing gasoline prices quickly when crude oil prices increase, and adjusting them downwards slowly when crude oil prices decrease.

The issue has been regularly presented in the Greek media during the crisis years (see, *inter alia*, Kathimerini 2012a, 2014, 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 Commission (HCC), which repetitively stated the need for further liberalisation of the market (see, *inter alia,* HCC, 2006, 2007, 2008, 2010, 2012, 2014). It has also been subject of policy recommendations by international organizations (see e.g. OECD, 2013, 2014, 2017) and by the Institutions –the IMF, the European Commission and the European Central Bank (see e.g. Memorandum of Understanding (MoU) 2010, 2012, 2015). Measures towards further liberalisation of the market have repeatedly been among the suggestions and prior actions to be completed for the disbursement of the loans directed to Greece in connection with the three structural adjustment programmes of 2010, 2012 and 2015

[1] See also the Hellenic Competition Commission Decisions, 2010, 2012.

(MoU, 2010, 2012, and 2015). Following these reports and recommendations, the Greek state started to monitor closely the conditions in all open retail sale markets, including the gasoline market, in 2010, and has taken a number of measures to liberalize the gasoline market since then. Major measures included the independence of the HCC, measures to facilitate entry into the wholesale market, (such as the reduction of the minimum capital and storage capacity required from the wholesale traders in order to obtain a trading license), measures which facilitated entry in the distribution of oil products, and the electronic tracking and monitoring of the fuel market (see Appendix).

On top of the measures and laws towards the gradual liberalisation of the market, the strict monitoring of the market, the publicity that the issue has taken and the decrease in domestic demand during the crisis years may have also affected the pricing strategies of market participants, and the issue is no longer in the media.

The present study tests for "rockets and feathers" in the gasoline market in Greece, during the period January 2005 – December 2017. The objective is to provide robust evidence in response to 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 sample, which also comprises observations from the market-reforming period of the Greek economy. (ii) The paper applies a threshold cointegration approach, which identifies two regimes of adjustment, the Asymmetric Threshold Auto Regressive (TAR) – Error Correction Model (ECM) technique developed by Enders and Siklos (2001). The TAR-ECM technique has been advocated by the relevant literature to be the most robust econometric method for identifying such kind of asymmetries. The 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. Arguments in favour of the threshold cointegration methodology can also be found in a number of recent papers in the relevant literature (see Birmigham and O'Brien (2011), Asane-Otoo and Schneider (2015), Chua *et al*. (2017)). (iii) The study uses observations of the highest frequency available for gasoline prices in Greece: weekly observations. Since the market prices of gasoline change very often – at least once per week – it is reasonable to assume that the use of weekly observations is more revealing of the practices of the market participants.

An additional issue of interest is whether the more cautious monitoring of the market, the structural reforms, which have taken place in the gasoline market, and the low-income conditions, which characterised consumers' behaviour after 2010, had any impact on the price-setting mechanism in the gasoline market. The signing of the 1st memorandum in May 2010 can be considered as a significant structural break 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. It also marks the start of the Greek crisis: the period following it, is 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 (a) the reforms and (b) the low demand (because of the fall in income) in the market, the present paper tests for the "rockets and feathers" hypothesis, for two separate periods, before and after May 2010.[2]

The rest of the paper is organised as follows: Section 2 offers a short survey of the "rockets and feathers" literature on Greece, while section 3 provides a brief description of the gasoline market in Greece. Section 4 presents the econometric methodology. The data and the empirical results are presented in Section 5. The final section summarises and concludes.

2. Literature review

The "rockets and feathers" hypothesis has been extensively addressed in the literature for a large number of economies over the last thirty years or so. The majority of the studies detect asymmetry in domestic retail price adjustments; see, for

[2] In this respect, the approach of the present paper is in line with the approach of Ogbuabor *et al* (2018) and Asane -Otoo and Schneider (2015). Ogbuabor *et al* (2018) test whether the oil-gasoline price relationship in the UK and the US markets changed after the global financial crisis, because of the increased regulation activities in the markets after the crisis. They provide evidence of asymmetric adjustment for both markets even after the crisis, and suggest eternal monitoring of the markets by policy makers and regulators. In a similar vein, Asane -Otoo and Schneider (2015), test for asymmetric adjustment in the German oil market in two separate periods before and after the crisis. According to their analysis, there is no evidence for asymmetric price transmission and consumer welfare losses in the post crisis period in Germany.

instance the summaries contained in, *inter alia*, Polemis (2012), Perdiguero-Garcia (2013), Kristoufeck and Lunackova (2015) and Ogbuabor *et al* (2018). 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, the econometric methodology used and the way asymmetry is defined. More recently, a number of studies on the rockets and feathers hypothesis have attempted to replicate results of previous studies, using more sophisticated econometric techniques (see, *inter alia*, Kristoufeck and Lunackova (2015), Cook and Fosten (2018) and Martin-Moreno *et al* (2018).

The evidence in the Greek gasoline market can also be characterised as inconclusive, even though most studies find asymmetric adjustment. Some evidence on the Greek market is reported in studies which cover country groups (Meyler, 2009; Cleridis, 2010; Polemis and Fotis (2013)): Of these, Meyler (2009) and Polemis and Fotis (2013) detect asymmetry in the response of retail fuel prices to cost increases and decreases in Greece, whereas Cleridis (2010) does not find any indications of asymmetric pricing. There exists one study, which tests for asymmetries exclusively in the Greek oil market: Polemis (2012), uses monthly observations for the period January 1988-June 2006 and applies the Asymmetric Error Correction Model (AECM) technique. He provides evidence of asymmetry in the retail gasoline price adjustments in both the long and the short term, evidence which implies poor competition in the oil market in Greece. In a different context, in a paper analysing the determinants of retail gasoline prices in Greece, Angelopoulou and Gibson (2010) examine pricing in the domestic fuel market, using weekly observations for the period November 2004-February 2009. They show that prices adjust symmetrically to world oil prices in the short run, but asymmetrically to tax changes and/or across various regions in Greece. These findings probably reflect the lack of competitive conditions in the Greek market.

Nevertheless, and despite their somewhat inconclusive results, the studies on asymmetric adjustments of gasoline prices in the Greek market share a number of similarities: First, all studies (with the exception of Polemis and Fotis (2013), who use panel cointegration) use the Asymmetric ECM 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 2011 and thus do not include the most recent period, which is also characterised by measures to liberalise the gasoline market in Greece[3]. Third, all studies, excluding Polemis and Fotis (2013), use monthly observations.

3. The Greek 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 two companies in the refining market, the Hellenic Petroleum (ELPE) and MOTOROIL, which own all four refineries operating in Greece.[4] ELPE, having a market share of more than 60%, clearly leads the refining market. Duopoly conditions prevail, with significant barriers to entry for 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.[5] Also, pricing differs across regions: it is not clear how companies set their prices across the different regions in Greece (see also Angelopoulou and Gibson, 2010). In addition, the transportation market (fuel is transported by public- and private-use tanker trucks) in which transport costs are determined, is not perfectly competitive. 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

[3] More specifically, Meyler (2009), Cleridis (2010), Angelopoulou & Gibson (2010) and Polemis (2012) and Polemis and Fotis (2013) analyse the periods 1994-2008, 2000-2010, 2004-2009, 1998-2006 and 2000-2011, respectively.
[4] ELPE is the leading industrial and commercial group in the energy sector. MOTOROIL is the largest privately held industrial complex in Greece.
[5] Wholesale companies can import oil from foreign refineries, as long as they keep buffer stocks that can meet consumption for 90 days.

stations per geographical area. Moreover, contracts between filling stations and wholesale companies may be restrictive, with 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 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.[6] Crude oil prices and the exchange rate are exogenous to the Greek fuel market. State duties and taxes raise the price by a specified rate, which is also exogenous to market forces.[7] 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.

4. The econometric methodology

The empirical work on the "rockets and feathers" hypothesis is based on the 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:

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

[6] 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*, 2012b).
[7] 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.

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 that accounts for 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. u_t denotes deviations from equilibrium level.

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 Ho: $\rho = 0$ against $\rho<0$ (the standard Dickey-Fuller tests, Dickey and Fuller, 1979), in an equation of the form:

$$\Delta\hat{u}_t = \rho\hat{u}_{t-1} + v_t \qquad (2)$$

where *Δ* denotes the first difference and ρ denotes the speed of adjustment of the deviations to their mean value. In the event 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:

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

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 $a\hat{u}_{t-1}$. The coefficient a is expected to take negative values: when in period *t-1* the variable r_t^g deviates from the long-run equilibrium (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 a denotes the speed of adjustment to the long-run equilibrium: higher a values in absolute terms imply faster adjustment to long-run equilibrium.

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 a, 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).

Assumption (c) of the dependent variable's symmetric adjustment to long-run equilibrium has been questioned in the literature. The Asymmetric ECM (AECM) divides errors into positive u_t^+ and negative u_t^- deviations of r_t^g from equilibrium. The error correction term $\hat{u}_{t-1}$ is defined as $\hat{u}_{t-1}^+ = I_t u_{t-1}$ where I_t depends on whether $\hat{u}_{t-1} \geq 0$ and $\hat{u}_{t-1}^- = I_t u_{t-1}$ where I_t hinges on whether $\hat{u}_{t-1} < 0$. The AECM is specified as follows:

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

where a_1 <0 and a_2 <0. Specification (4) assumes that the adjustment speed is a_1 for negative deviations and a_2 for positive ones. A first indication of asymmetric adjustment comes up when the estimated values of a_1 and a_2 are not equal. The AECM specification allows for a statistical test for the symmetry hypothesis (that the coefficients are equal) H_0: $a_1 = a_2$.

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 asymmetric TAR cointegration technique as the adequate and statistically robust technique to be used when testing for asymmetric adjustment. This is the methodology applied in the present paper. According to it, unit root tests should 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 $\hat{\tau}$, which does not necessarily equal zero.

The TAR model can be written as follows:

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

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

$$\mathbf{I}_t = \begin{cases} 1 \ \text{ if } \ \hat{u}_{t-1}^{up} \geq \hat{\tau} \\ 0 \ \text{ if } \ \hat{u}_{t-1}^{down} < \hat{\tau} \end{cases} \tag{6}$$

The TAR cointegration model assumes that the residuals adjust at a speed ρ_1 when their values are above the threshold value $\hat{\tau}$ and at a speed ρ_2 when their values are below $\hat{\tau}$. 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.

The threshold parameter does not need to be restricted to zero, as assumed in model (4). 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 $\hat{\tau}$, for which the asymmetric adjustment is statistically significant.[8] Enders and Siklos (2001) propose the "Chan's approach" (1993) for searching a consistent method to detect $\hat{\tau}$ 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 separated into those which take a value higher than $\hat{\tau}$ and those which take a value lower than $\hat{\tau}$. In such a case, an Asymmetric ECM can be estimated as follows:

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

[8] In its simplest version, the TAR model hypothesises that $\hat{\tau} = 0$. This means that positive and negative deviations from equilibrium are assumed to be corrected at different adjustment speeds.

where $\hat{u}_{t-1}^{up}$ = $I_t \hat{u}_{t-1}$ και $\hat{u}_{t-1}^{down}$ = $(1-I_t)\hat{u}_{t-1}^{down}$ and a_3 <0 and a_4 <0. In (7), the $\hat{u}_{t-1}$ deviation values are split into $\hat{u}_{t-1}^{up}$ and $\hat{u}_{t-1}^{down}$, which represent deviations above and below the threshold value $\hat{\tau}$, 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 empirical critical values t-max and Φ* for testing cointegration on these hypotheses since the tests do not follow a standard distribution, and propose a Wald-type statistical test to determine whether the residuals' adjustment is symmetric.

In addition, in order to test whether gasoline prices respond asymmetrically to short-run variations of world oil prices, first differences in the oil price changes can be decomposed into positive and negative values. Model (7) can be written as:

$$\Delta r_t^g = \mu_0 + \sum_{i=1}^{k_1} \beta_{1,i} \Delta r_{t-i}^g + \sum_{i=0}^{k_2} \beta_{2,i}^{+} \Delta r_{t-i}^{b^+} + \sum_{i=0}^{k_2} \beta_{2,i}^{-} \Delta r_{t-i}^{b^-} + a_3 \hat{u}_{t-1}^{up} + a_4 \hat{u}_{t-1}^{down} + e_t \qquad (8)$$

In the extended specification (8) of model (7), short-run asymmetry is captured by decomposing the first differences into $\Delta r_{t-i}^{b^+} \geq 0$ and $\Delta r_{t-i}^{b^-} < 0$, where i =0,…, k_2. In other words, $\beta_{2,i}^{+}$ and $\beta_{2,i}^{-}$ provide estimates of the different speeds of adjustment of the gasoline prices to increases and decreases in Brent oil prices. To test for short-run asymmetries, the total impact of the significant $\beta_{2,i}^{+}$ s should be compared with the total impact of the significant $\beta_{2,i}^{-}$ s.

Essentially, in the present paper asymmetric adjustment is examined by testing: (i) whether the residuals respond asymmetrically to deviations from their equilibrium value; (ii) whether the gasoline prices (the dependent variable) adjust symmetrically to the long-run equilibrium relationship between oil and gasoline prices; and (iii) whether gasoline prices respond with the same speed to positive or negative changes of the oil prices in the short run.

5. Empirical results

5.1 The dataset-unit root tests

The study uses weekly observations for the period January 2005 – December 2017. Data on retail gasoline prices R_t^g are taken from the European Commission *Oil*

Bulletin.[9] The analysis focuses on the pre-tax price series of the 95-octane unleaded gasoline.[10] 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. The graphs of the variables are presented in Figure 1.

[Figure 1 here]

Analysis is performed initially for the full sample period. Then, in order to investigate whether there exist changes in the functioning of the gasoline market in the most recent period, analysis is performed separately for the pre-crisis (and pre-reform) period Jan. 2005 – April 2010, period A, and the crisis (and reform) period May 2010-Dec. 2017, period B.[11]

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 for the series in levels, but is rejected for the series in their first differences.

[Table 1 here]

5.2 The standard cointegration analysis

Based on the results of the unit root tests, the next step is to investigate whether the two I(1) series are cointegrated in a long–run relationship, of the form of (1). The Engle-Granger methodology is then applied, essentially for indicative purposes, as it has been applied in most of the existing studies for Greece. 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.

[Table 2 here]

[9] 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.

[10] 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.

[11] Nevertheless the results do not differ when the sample is split in different time points around April 2010; the results can be provided upon request.

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

$$r_t^g = 0.1+0.6\, r_t^b + u_t \qquad (9)$$

According to (9), the long-run oil price elasticity of domestic gasoline prices, γ_1, is 0.6. This means that a 10% change (rise or fall) in crude oil prices, causes a 6% change (increase or decrease, respectively) in retail gasoline prices. For period A, the long–run relationship takes the form:

$$r_t^g = 0.1+0.7\, r_t^b + u_t\,, \qquad (10)$$

whereas, in period B the gasoline prices – oil prices relationship, becomes:

$$r_t^g = 0.1+0.6\, r_t^b + u_t. \qquad (11)$$

However, as already indicated in section 4, the 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 approach 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-ECM model with estimated threshold $\hat{\tau}$. The results are presented 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 presented for the three periods. The results of the Asymmetric TAR-ECM cointegration models are presented in Table 3.

[Table 3 here]

The results for the whole 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 $\hat{\tau}$ = -0.062. In addition, the hypothesis for the absence of threshold cointegration [H_0: $\rho_1 = \rho_2 = 0$] is rejected based on the Φ^* statistic value.

According to the estimated results, the coefficients ρ_1 and ρ_2 take different values (ρ_1 = -0.15 and ρ_2 = -0.28), 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 $\hat{\tau}$, adjustment to equilibrium takes place slowly (at a speed of ρ_1 = -0.15), whereas when the deviations take values lower than the threshold, adjustment to equilibrium is fast (at a speed of ρ_2 = -0.28). In addition, the hypothesis of equal adjustment coefficients $\rho_1 = \rho_2$ is rejected based on the Wald test statistic value [F (1,636) = 7.15, P-value = 0.007)]. 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 with a different speed, depending on whether they take values above or below a threshold value. They adjust slowly when they take values higher than this threshold value and fast when they obtain values lower than the threshold value of -0.062.

The analysis of the two sub-periods provides additional information on the functioning of the market before and after the crisis and reforms. The results for 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 $\hat{\tau}$ different from zero. 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. Thus, this result indicates that the TAR-ECM methodology is appropriate to test for asymmetries in periods A and B. The threshold value $\hat{\tau}$ is estimated to equal -0.061 for period A and -0.029 for period B; it is estimated to be lower in absolute terms in period B than in period A, which implies that adjustment costs are lower in period B. The results indicate that the market is more efficient in the post-reform and crisis period B.

The estimated adjustment coefficients ρ_1 and ρ_2 do not equal each other in the two periods (ρ_1 = -0.28 and ρ_2 = -0.53 for period A, and ρ_1= -0.20 and ρ_2 = -0.14 for period B). In addition, for period A the symmetry hypothesis (the hypothesis of equal adjustment coefficients $\rho_1 = \rho_2$) is rejected based on the Wald test statistic value [F (1,257) = 6.163, P-value = 0.013)].

However, symmetry is not rejected for the post-reforms period B [F (1,375) = 0.83, P-value = 0.36)]. The results indicate that the market has been functioning efficiently in the post reform and crisis period B but not before. They probably reflect competitive behaviour by suppliers who had to interact in a new institutional market framework following the reforms, and in an effort to keep their market shares, in an environment of weak demand. They may also indicate higher search efforts for low-priced stations by consumers. Still, in order to come to clear conclusions about the functioning of the market in period B, further empirical testing is needed to examine whether domestic prices adjust with the same speed to deviations above or below their equilibrium value as estimated by their long-run relationship of the form of (1).

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 (7). Analysis is applied for all three periods. The results are presented in Table 4. According to them, the hypothesis of symmetric adjustment of gasoline prices is rejected for the full period and the pre-crisis period A.

[Table 4 here]

For the crisis period B, symmetry is found for the adjustment process to deviations from the threshold value. According to the results, changes in gasoline prices in the current week are determined by: (a) gasoline price variations 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 adjustment speeds, $a_3 = -0.07$ and $a_4 = -0.09$. 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 (1,370) = 0.981, P-value = 0.322)]. The results provide strong support of symmetric adjustment of domestic prices to crude oil prices in the Greek market in the crisis period. In other words, they indicate that the "rockets and feathers" hypothesis does not hold in the most recent period in Greece.

The results of the tests, which examine asymmetries in the adjustment of gasoline prices to increases and decreases of world oil prices in the short run (based on the specification (8)), are presented in Table 5.

[Table 5 here]

They provide evidence in favour of symmetric adjustment in all cases. In the short run, the total adjustment of gasoline prices to positive changes of crude oil prices as estimated by $(\beta^{+}_{2,1} + \beta^{+}_{2,3})$ turns out to be equal to the adjustment to negative changes of crude oil prices, $(\beta^{-}_{2,1} + \beta^{-}_{2,4})$, for the three periods, as indicated by the respective F statistics. Nevertheless, the findings of asymmetric adjustment of the deviations of the gasoline prices from their long-run threshold values remain valid for the full period and period A. Symmetric adjustment is indicated just for period B.

6. Conclusions

The pricing mechanism in the gasoline market has often been the subject of public debate in Greece during the crisis years. The asymmetric response of the gasoline prices to variations in world oil prices could indicate market power abuse on the part of suppliers to the loss of consumers, in a non-competitive market. 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. It also examines whether the structural reforms that took place in the gasoline market, the more cautious monitoring of the market, and the fact that suppliers and consumers had to interact in a low income environment in the post-2010 period, had any impact on the functioning of the market.

To this end, the present study. (i) Applies an asymmetric Threshold Auto-Regressive cointegration technique, the TAR-ECM technique, which tests for asymmetric adjustment to the long-run equilibrium. The technique is advocated by the literature as the most robust econometric method for identifying such kind of asymmetries. (ii) Uses a long data sample which includes all available observations. It thus provides recent empirical evidence, given that the existing empirical literature predates 2011. (iii) Uses data observations at the highest 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 about the practices of the market participants.

From an econometric - technical point of view, asymmetric adjustment has been examined by testing: (i) whether deviations of the error correction terms above or below their equilibrium value adjusted symmetrically; (ii) whether gasoline prices (the dependent variable) adjusted symmetrically to the long-run equilibrium relationship between oil and gasoline prices; (iii) whether gasoline prices responded symmetrically (with the same speed) to oil price changes in the short run.

The econometric analysis tests for asymmetric evidence in three different periods: the full period, and the periods before and after the crisis, with the second period also being characterised by the implementation of structural reforms in the market. The pre-crisis period A is characterised by asymmetric adjustment, evidence that seems to dominate the results for the whole period. Prices tend to adjust faster when they are below their equilibrium value than when they are above it. The results are in line with most of the existing studies for Greece, which use data for this particular period- see Meyler, (2009), Angelopoulou and Gibson (2010), Polemis (2012) and Polemis and Fotis (2013).

Turning to the most recent crisis and post-reforms period, the results provide evidence in favour of symmetric behaviour, notwithstanding the high concentration of suppliers in the market. This could be due to a change in the behaviour of the market participants, as a result of the new institutional framework, following the structural measures that were legislated. Thus, the findings may indicate that the new regulatory framework and measures managed to control the oligopolistic practices of the past. The results may also reflect effects of the conditions of low income and low demand, which characterise the crisis years: on the one hand, the dramatic fall in income may have pushed consumers to search more thoroughly for oil stations with low prices; on the other hand, gasoline suppliers, either in the wholesale or the retail market, may have kept prices low and have reacted in a symmetric way, in an effort not to lose their market share. Additionally, the systematic investigation of the market conditions and regulations by the HCC and the publicity that the matter has taken may have played an important role for the change in the practices of the market participants.

The main conclusion from the analysis is that, in the crisis period the gasoline market shows no signs of asymmetric pricing and thus the market appears to be efficient, despite its oligopolistic structure. Consequently, the consumer welfare losses from a negative asymmetry are insignificant at present. The findings probably suggest that the new regulatory framework, the cautious monitoring of the market and the low-income conditions, which have affected the consumers' search behaviour have been capable of controlling oligopolistic practices that were present in the past. Nevertheless, the Hellenic Competition Commission should continuously monitor the market in an effort to ensure price transparency and prevent oligopolistic practices in the future.

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Appendix: Reforms in the Greek fuel market

In 2008 (November) the Hellenic Competition Commission (HCC) announced (Decision No 418/V/2008) a set of measures to enhance fuel price transparency and ensure healthy competitive conditions in the fuel market. More specifically:

- Domestic refineries are required to notify wholesale companies and large final customers of the cost of compulsory stockholding regarding the petroleum products traded in the domestic market (gasoline, diesel, heating oil) and in the international market (aviation and shipping fuel). Domestic refineries must release a breakdown of the costs included in the premium, which is charged to wholesale companies and large final customers, and notify the Ministry of Development and the Regulatory Authority for Energy.
- Wholesale companies that offer discounts must report these discounts in the invoices they issue, and in the agreements, they conclude with retailers, and they shall not grant any discounts other than those mentioned in the aforementioned invoices or the agreements with retailers. Wholesale companies are required to abolish the price support discount scheme that they apply to retailers and to clearly state the duration of the discounts offered in the invoices issued by them. Such discounts must be offered by wholesale companies in a non-discriminatory manner to retailers throughout the Greek territory. Such discounts must not be linked with the amortization of any investments made by wholesale companies in retailers.

The second MoU (2012) stresses that:

- "Legislation has also been passed to facilitate fuel distribution. This encompasses the liberalization of the opening hours of gas stations, easing the opening of petrol stations by supermarkets eliminating unjustified restrictions in the transportation of fuel by independent retailers, as well as to ease the import of oil and of oil products (in the context of the transposition of the Directive of Security of Oil Stocks). Additional measures will be adopted before year-end to remove regulatory restrictions hindering competition in the wholesale and retail fuel sector" (MoU, 2012, p. 46).
- "The Greek government must take measures: (i) To allow independent gas stations to own or rent tanker trucks of any capacity, provided that they meet the safety requirements on the transportation of fuel. (ii) To allow gas stations to hire public-used tanker trucks for fuel transportation. (iii) To allow any tanker truck, regardless of its capacity, to enter the refineries to transport fuels under their own trademark, provided that safety standards are respected" (MoU, 2012, p. 49).
- "Furthermore, the Greek government must issue technical specifications on the implementation of the input-output measurement system in all petrol stations, as well as a Ministerial Decision for the installation of GPS systems, as provided for in Article 320 of Law 4072/2012" (MoU, 2012, p. 68).

In 2014 (April), the Greek government, following the recommendations of the OECD toolkit (2014), enacted by Law 4254/2014 a series of measures to remove barriers and regulations in the retail sector of liquid fuel. The most important of them are:

- The distribution of oil products for heating is allowed if the retailer holds a gas station license and has signed an exclusive cooperation agreement with a wholesale trader which has privately owned tanker trucks. Heating oil retail traders without privately owned storage facilities may be supplied with fuel products for heating by other wholesale traders with type A license or directly from refineries. However, the distribution of petroleum products from a retailer to another retailer or to another heating oil retail trader is not allowed.

- Domestic refineries may only supply oil products to wholesale traders, large final consumers (hotels, etc.), the armed forces, supply cooperatives or consortia, and retail license holders.
- Retailers, who are supplied exclusively by a wholesale trader are obliged to display the trademark of the wholesale trader in a prominent place at their petrol stations. Retailers may also import oil products so long as they comply with the provisions of legislation on imports, the Customs Code and Article 12 regarding oil stockholding obligations and provided that their input-output measurement system is fully operational.

In line with the third MoU (2015) proactive measures (MoU, 2015, p.23), Law 4336/2015 (p. 1027) states that: "… by October 2015, the authorities will implement the remaining recommendations of the OECD Food Toolbox and OECD Toolbox II on Drinks and Petroleum Products …".

In 2016, Law 4447/2016 eased the minimum capital and storage capacity requirements for wholesale traders to obtain a trading license. It thus facilitated the entry of more oil traders into the fuel market chain, thereby stimulating competition in the market. More specifically:

- Law 4447/2016 determined new lower minimum capital requirements on fuel trading licensing, and new lower minimum storage capacity requirements for the fuel trading license of type A, compared with previews laws (Laws 4172/2013, 4123/2013 and 3054/2002).[12] Under Law 3054/2002, a minimum storage capacity of 13,000 cubic meters was required for type A license, regardless of the volume of fuel products sales. Law 4447/2016 introduced a more flexible scheme that provided for a much lower minimum storage capacity on the basis of the volume of fuel products sales over the previous year (see Table A1).[13]

Ministerial Decision No 182269/2016 simplified Ministerial Decision No 16570/2005 regarding the transparency of licensing procedures for oil retailers. Applications for an oil trading license in petroleum products are posted on the website of the Licensing Authority by the responsible service, within five business days after submission. The Licensing Authority shall ensure that any interested applicant is duly notified of the application process, the attached documents and any other relevant information. The decision on the granting of an oil trading license shall be published online and can be identified using the relevant Online Posting Number, while information is provided on the possibility, the procedure and the time limit for lodging an appeal against the licensing decision.

[12] The new minimum capital requirement is now set to EUR 200,000 for a type A license if the volume of fuel products sales in the previous year is up to 100,000 metric tonnes (M.T.).

[13] Law 4447/2016 lowers the level of minimum storage capacity at 1,500 cubic metres for a type A license if the volume of fuel products sales is up to 100,000 metric tonnes. The new minimum storage capacity requirement increases progressively on the basis of a more flexible scale, compared with past laws.

In 2016 (December), the Greek government went on with the adoption of the OECD Toolkit (2014) recommendations, by removing regulatory barriers to competition. Law 4441/2016 introduced the following changes:

- Retail license holders may be supplied with oil products by wholesale traders and refineries, and the transportation of petroleum products may be carried out by tanker trucks that are privately owned or leased by retailers. Retailers shall be responsible for the quality and the quantity of the products distributed and sold. Retailers may use the services of third parties (carriers) that are not licensed under this law.
- A joint decision by the Minister of Economy and Development, and the Minister of Maritime and Island Policy lays down the specifications, the procedure and the conditions for the installation of an electronic GPS system in specific types of tanker trucks and vessels, as well as a precise implementation timetable.

Table A1
Minimum capital and storage capacity requirements on fuel trading licensing

		Law 3054/2002	**Law 4172/2013 and Law 4223/2013**	**Law 4447/2016**
	Licence type	Minimum capital requirement	Minimum capital requirement	Minimum capital requirement
Based on sales volume of fuel products of the previous year, as follows:				
up to 100.000 M.T.				200.000 €
from 100.000 M.T to 300.000 M.T.				500.000 €
from 300.000 M.T to 600.000 M.T.	A	2.000.000 €		1.000.000 €
over 600.000 M.T.				1.500.000 €
up to 300.000 M.T			500.000 €	
from 300.000 M.T to 600.000 M.T.			1.000.000 €	
over 600.000 M.T.			1.500.000 €	
	B1	800.000 €	500.000 €	500.000 €
	B2	800.000 €	500.000 €	500.000 €
	C	800.000 €	500.000 €	500.000 €
	D	800.000 €	500.000 €	150.000 €
	Licence type	Minimum storage capacity requirement	Minimum storage capacity requirement	Minimum storage capacity requirement
Based on sales volume of fuel products of the previous year, as follows:				
up to 100.000 M.T.				1.500
from 100.000 M.T to 300.000 M.T.				4.000
from 300.000 M.T to 600.000 M.T.	A	13.000		7.000
over 600.000 M.T.				13.000
up to 300.000 M.T.			4.000	
from 300.000 M.T to 600.000 M.T.			7.000	
over 600.000 M.T.			13.000	
	B1	5.000	5.000	5.000
	B2	5.000	5.000	5.000
	C	500	500	500
	D	2.000	2.000	1.000

M.T. = Metric Tone
Sources: Laws 3054/2002, 4172/2013 and 4472/2016.

Figures & Tables

Figure 1

Weekly retail gasoline (R_t^g) and crude oil (R_t^b) prices (Euro/liter)

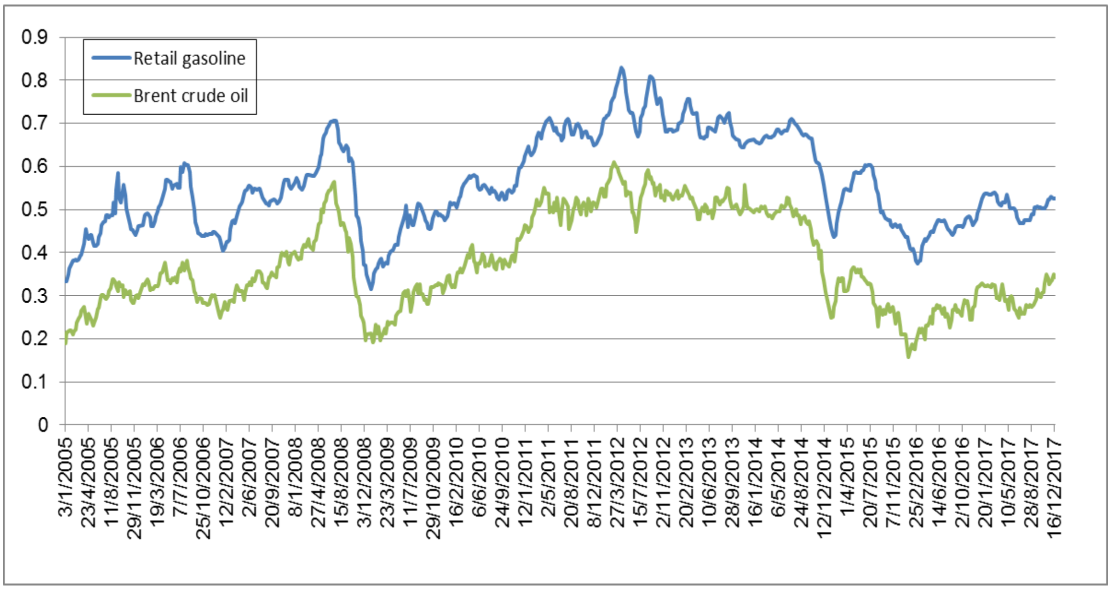

Table 1

Unit root tests ADF, PP and DF-GLS

Sample period	Full period				Pre-reforms period (A)				Post-reforms period (B)			
Variables	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			
Augmented Dickey-Fuller (ADF)												
Constant	-2.642	-21.858**	-3.181	-16.292**	-2.425	-16.536**	-3.027	-11.375**	-1.452	-19.846**	-1.835	-10.420**
Constant and Trend	-2.589	-25.864**	-3.040	-16.323**	-2.349	-16.507**	-3.014	-14.381**	-2.150	-19.823**	-2.651	-10.412**
No Constant, No Trend	-1.198	-25.872**	-1.431	-16.295**	-1.405	-16.525**	-1.383	-14.358**	-0.250	-19.872**	-0.448	-10.432**
Phillips-Perron (PP)												
Constant	-2.706	-25.848**	-3.201	-16.637**	-2.521	-16.536**	-2.906	-11.811**	-1.422	-19.846**	-1.609	-10.339**
Constant and Trend	-2.649	-25.855**	-3.063	-16.664**	-2.455	-16.509**	-2.844	-11.816**	-2.137	-19.833**	-2.404	-10.326**
No Constant, No Trend	-1.198	-25.861**	-1.422	-16.640**	-1.370	-16.526**	-1.342	-11.799**	-0.330	-19.872**	-0.370	-10.352**
Detrended Residuals (DF-GLS)												
Constant	-0.738	-0.967**	-0.783	-15.983**	-0.254	-1.108**	-0.877	-11.178**	-1.390	-1.230**	-1.843	-9.730**
Constant and Trend	-1.139	-2.772**	-1.606	-16.140**	-1.401	-2.248**	-2.038	-11.297**	-1.741	-2.670**	-1.998	-10.291**

Note 1: ** Denotes rejection of null hypothesis at significance level of 5%.

Note 2 : In the ADF tests, the Schwarz Information Criterion is used to determine the optimal lag length of each test equation.

Note 3: In the PP tests we control the bandwidth using the Newey-West bandwidth selection method and the Bartlett kernel.

Table 2
Engle and Granger (E-G) cointegration tests

Sample period	Full period	Pre-reforms period (A)	Post-reforms period (B)
Number of observatons (n)	640	262	378
Fully Modified Least Squares (FMOLS)			
γ_0	0.055	0.114**	0.013
	(1.823)	(2.666)	(0.503)
γ_1	0.638**	0.715**	0.574**
	(22.289)	(19.304)	(21.761)
R^2	0.899	0.883	0.917
Standard error of regression	0.061	0.054	0.052
Long-run variance	0.044	0.016	0.025
Engle-Granger tests			
t-statistic	-6.426**	-7.348**	-6.084**
z-statistic	-84.770**	-89.705**	-67.216**

Note 1: t-statistics values in parentheses.

Note 2: ** Denotes rejection of null hypothesis at significance level of 5%.

Table 3
Enders - Siklos (E-S) tests for TAR cointegration

TAR models								
Sample period			Full period		Pre-reforms period (A)		Post-reforms period (B)	
Consistent threshold value			-0.062		-0.061		-0.029	
		ρ_1	-0.154**		-0.281**		-0.204**	
		t-Max test	(-5.522)	[0.000]	(-5.086)	[0.000]	(-5.400)	[0.000]
		ρ_2	-0.286**		-0.528**		-0.148**	
		t-Max test	(-7.038)	[0.000]	(-6.191)	[0.000]	(-3.126)	[0.001]
Test for threshold cointegration	$\rho_1 = \rho_2 = 0$	Φ test	Φ (2,636) 40.014**	[0.000]	Φ (2,257) 32.348**	[0.000]	Φ (2,375) 19.469**	[0.000]
Test for symmetry	$\rho_1 = \rho_2$	Standard F test	F(1,636) 7.150**	[0.007]	F(1,257) 6.163**	[0.013]	F(1,375) 0.839	[0.360]

Note 1: t-statisstics values in parentheses.

Note 2: p-values in brackets.

Note 3: ** Denotes rejection of null hypothesis at significance level of 5%.

Note 4: Φ(κ,T-κ) empirical critical values for Enders and Siklos tests are taken from Enders-Siklos (2001) and Wayne (2004).

Note 5: The Akaike and the Schwarz Information Criterions are used to determine the optimal lag length of each test equation.

Table 4
Asymmetric ECM with TAR cointegration without short-run asymmetries

Sample period		Full period			Pre-reforms period (A)			Post-reforms period (B)		
HAC standard errors and covariance			t-statistic	p-value		t-statistic	p-value		t-statistic	p-value
Constant	μ_0	-0.001	(-0.1367)	[0.171]	-0.001	(-0.510)	[0.610]	-0.001	(-0.547)	[0.584]
$\Delta(r^g)_{t-1}$	$\beta_{1,1}$	0.237**	(4.036)	[0.000]	0.199**	(2.397)	[0.017]	0.362**	(9.199)	[0.000]
$\Delta(r^g)_{t-4}$	$\beta_{1,4}$	0.084**	(2.517)	[0.012]	0.118**	(2.572)	[0.010]	0.063*	(1.832)	[0.067]
$\Delta(r^b)_{t-1}$	$\beta_{2,1}$	0.184**	(8.273)	[0.000]	0.190**	(4.104)	[0.000]	0.142**	(8.750)	[0.000]
$\Delta(r^b)_{t-2}$	$\beta_{2,2}$	0.131**	(5.796)	[0.000]	0.161**	(3.936)	[0.000]	0.076**	(4.590)	[0.000]
$\hat{u}_{t-1}^{up}$	a_3	-0.058**	(-2.749)	[0.006]	-0.138**	(-2.958)	[0.003]	-0.070**	(-3.503)	[0.000]
$\hat{u}_{t-1}^{down}$	a_4	-0.152**	(-5.311)	[0.000]	-0.287**	(-4.994)	[0.000]	-0.099**	(-3.899)	[0.010]
Test for symmetry	$a_3 = a_4$	F(1,628) 8.471**		[0.003]	F(1,250) 5.883**		[0.016]	F(1,370) 0.981		[0.322]
Findings		Asymmetric adjustment			Asymmetric adjustment			Symmetric adjustment		

Note 1: t-statisstics values in parentheses.

Note 2: p-values in brackets.

Note 3:** Denotes rejection of null hypothesis at significance level of 10%.

Note 4:** Denotes rejection of null hypothesis at significance level of 5%.

Table 5
Asymmetric ECM with TAR cointegration with short-run asymmetries

Sample period		Full period			Pre-reforms period (A)			Post-reforms period (B)		
HAC standard errors and covariance			t-statistic	p-value		t-statistic	p-value		t-statistic	p-value
Constant	μ_0	0.001	0.0406	[0.684]	0.001	(-0.203)	[0.839]	0.001	(0.010)	[0.991]
$\Delta(r^g)_{t-1}$	$\beta_{1,1}$	0.230**	(3.887)	[0.000]	0.197**	(2.375)	[0.018]	0.358**	(8.915)	[0.000]
$\Delta(r^g)_{t-4}$	$\beta_{1,4}$	0.082**	(2.491)	[0.013]	0.122**	(2.579)	[0.010]	0.059*	(1.681)	[0.093]
$\Delta(r^b)^+_{t-1}$	$\beta^+_{2,1}$	0.182**	(6.252)	[0.000]	0.211**	(3.409)	[0.000]	0.128**	(4.632)	[0.000]
$\Delta(r^b)^-_{t-1}$	$\beta^-_{2,2}$	0.191**	(5.872)	[0.000]	0.172**	(3.145)	[0.001]	0.156**	(5.890)	[0.000]
$\Delta(r^b)^+_{t-2}$	$\beta^+_{2,3}$	0.090**	(3.823)	[0.000]	0.104*	(1.813)	[0.071]	0.073**	(2.827)	[0.004]
$\Delta(r^b)^-_{t-2}$	$\beta^-_{2,4}$	0.171**	(4.004)	[0.000]	0.213**	(2.887)	[0.004]	0.078**	(2.864)	[0.004]
$\hat{u}^{up}_{t-1}$	a_3	-0.053**	(-2.479)	[0.013]	-0.138**	(-2.934)	[0.003]	-0.067**	(-3.283)	[0.001]
$\hat{u}^{down}_{t-1}$	a_4	-0.156**	(-5.095)	[0.000]	-0.281**	(-4.756)	[0.000]	-0.102**	(-3.949)	[0.000]
Test for short-run asymmetry	$\beta^+_{2,1}+\beta^+_{2,3} = \beta^-_{2,2}+\beta^-_{2,4}$	F(1,626) 1.575**		[0.209]	F(1,248) 0.286**		[0.593]	F(1,368) 0.350**		[0.554]
Test for long-run asymmetry	$a_3 = a_4$	F(1,626) 7.911**		[0.005]	F(1,248) 4.837**		[0.028]	F(1,368) 1.059		[0.303]
Short-run findings		Symmetric adjustment			Symmetric adjustment			Symmetric adjustment		
Long-run findings		Asymmetric adjustment			Asymmetric adjustment			Symmetric adjustment		

Note 1: t-statisstics values in parentheses.

Note 2: p-values in brackets.

Note 3:* Denotes rejection of null hypothesis at significance level of 10%.

Note 4:** Denotes rejection of null hypothesis at significance level of 5%.

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