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Abstract
This paper explores whether asymmetric pricing can be identified in the eleven euro zone countries (Austria, Belgium, Finland, Greece, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain) by utilizing Error Correction Model on the weekly price changes in order to assess current and future potential. The sample spans from July 1996 to August 2011. We also try to analyze the effect of competition on the dynamic adjustment of gasoline price to which has been paid scant attention in the past. The results favor the common perception that retail gasoline prices respond asymmetrically to cost increases and decreases both in the long and the short-run. At the wholesale segment, there is a symmetric response of the spot prices of gasoline towards the adjustment to the short-run responses of the exchange rate.

JEL classification L11· C51 · C32

Keywords: asymmetric pricing; euro zone countries; dynamic ordinary least squares; error correction model; unit root; Cointegration techniques; gasoline prices; competition; oil industry

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I. Introduction

Market structure and market dynamics in oil industry across the globe are highly complicated and diversified in many aspects. To mention but a few, these are the existing differences in oil reserves, different levels of oil markets development, different political and regulatory environments, and different responses to growth challenges (Fafaliou and Polemis, 2011). Hence, to avoid generalization pitfalls and gain better policy insights, the existing oil literature often examines this industry's issues by distinguishing two broad sub-markets' categories. These are namely the upstream and the downstream oil market segment. The upstream segment comprises all the activities that have to be done to extract oil from earth whereas the downstream segment relates to activities necessary to get oil from producers to final consumers. In particular, the oil downstream includes the transportation of oil to refineries, the refinement of crude oil into final products, the transportation of these products to storage terminals, and the trading of the products produced by the wholesalers and retailers

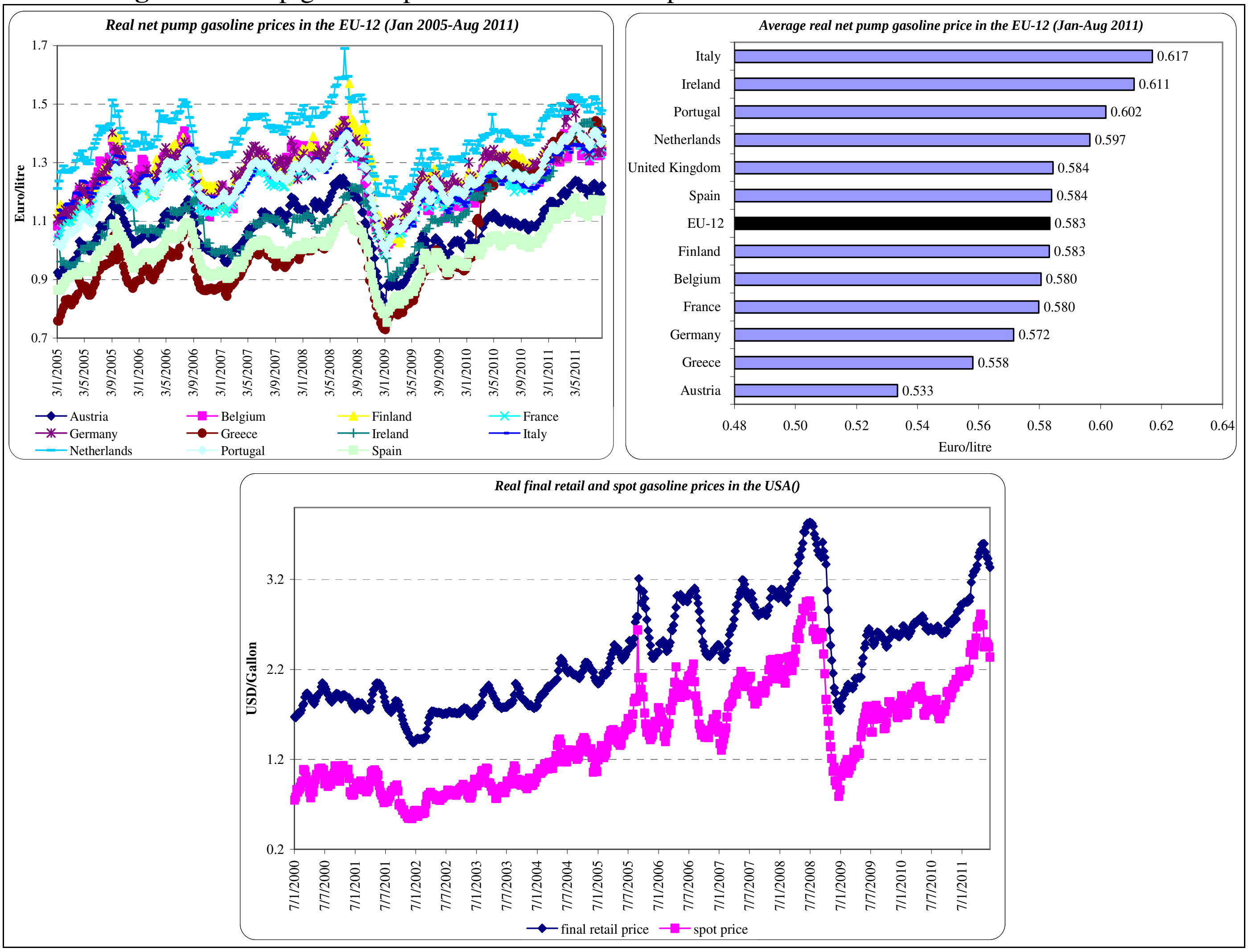
In most European countries oil industry is still heavily regulated due to fears of problems that may arise particularly in case of an oil crisis. Upstream activities (oil extraction) are assumed more concentrated compared to downstream segments (refining, transportation, wholesale and retail trading) wherein the level of competition and deregulation policies play a crucial role. Globalized oil markets are not homogenous and the characteristics and competition differ even among the various sub-markets of the same oil industry.

The oil industry in the EU continues to be dominated by large, integrated and often multinational companies that are active in all stages of oil production (extraction, processing/refinement and retail). They can be distinguished into multinational majors (ExxonMobil, Royal Dutch Shell, BP) and minimajors – multinational companies that limit their activities to few Member States (TexacoChevron or TotalFinaElf). Other competitors, predominantly active at the national level, include Eni (Italy), Statoil, Orlen or OMV (Austria). The average size of companies differs between the different stages of the production process. More specifically, extraction and refinement in particular are dominated by a small number of large firms, whereas a larger number of smaller firms are active in the retail of automotive fuels.

It is worth mentioning that in the EU retail market segment, there is a consolidation in the number of sites, leading to rising average throughput and reductions in the number of sites per capita (Pöyry, 2009). Furthermore, there is an increasing emergence of supermarkets / hypermarkets selling road fuel at their sites in some markets (most notably in the UK and France), while many petrol stations provide supplementary services (i.e car washing, dishes, toys, plates and glasses, music CD's, loyalty cards, etc).

Gasoline prices among the EU-11 (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain) were characterized by high volatility within the last years (Figure 1). The net retail gasoline prices in the EU-11 have shown a tremendous increase during the last two years (31.2%) reaching (in real terms) the level of 0.584 Euro / litre on average (August 2011). On the other hand, the pump gasoline price (taxes and duties included) in the EU-11 reached the level of 1.513 Euro / litre on average within the same period (August 2011). Due to this price volatility, consumers have become more reluctant to the oil companies' price setting behaviour.

Figure 1: Pump gasoline price evolution in Europe and the USA



Source: Oil Bulletin and USA Energy Information Administration.

A comparison of net pump prices for gasoline (euro-95) in the twelve member states (Figure 1) for the period January 2001-August 2011 shows a difference of around 8.4 cents/litre between the country with lowest price (Austria) and the country with the highest (Italy). More specifically, countries like Austria, Greece, Germany and France are well bellow the european average (0.583 euro / litre) while retail gasoline prices in other European countries (Italy, Ireland, Portugal and Netherlands) are significant higher. However, comparisons between prices and price trends in different countries shall be carefully made because of differences in product quality, in marketing practices, in market structures, and to the extent that standard categories are representative of the total sales of a given product.

On the other side of the globe (United States) spot prices and pump retail prices (with taxes and charges) are highly correlated and follow each other closely (Figure 1). More specifically, during the period running form January 2000 until June 2011 pump retail price of unleaded gasoline was strongly fluctuated (430 times). 293 adjustments were upward and 137 adjustments were downward covering the 68% and 32% of the total price fluctuations respectively. Examining the distribution of the size of the adjustments we see that they were quite small in the period 2000-2007 whereas became more volatile from 2008 onwards. The price of crude oil has followed a similar pattern. More specifically, within the same period, the price of crude oil has fluctuated 474 times; 296 (62%) adjustments were upward and 178 (38%) adjustments were downward.

Within the last years there is a plethora of studies on the existence of price asymmetry in the gasoline market with controversial results. The majority of these studies apply cointegration techniques and especially Engle-Granger methodology by utilizing an asymmetric error-correction model in order to discover the existence of price asymmetries. Table 1 reports the main empirical studies.

Table 1: Summary of main literature review

Study	Country / product	Frequency / Period	Stage of transmission	Model	Findings
Polemis, 2011	Greece / gasoline	Monthly / 1988 mid 2006	Wholesale and retail market	Error-correction model	Retail gasoline prices respond asymmetrically to cost increases and decreases both. At the wholesale segment, there is a symmetric response of the spot prices of gasoline towards the adjustment to the short-run responses of the exchange rate.
Bermingham and O' Brien. 2010	United Kingdom and Ireland / gasoline and diesel	Monthly / 1997-mid 2009	Retail market	Threshold autoregressive model	No
Clerides, S, 2010	Several European countries	Weekly 2000-2010	Retail market	Error-correction model	Mixed results
European Commission, 2009	Several European countries / gasoline, heating oil, diesel	Weekly time period varies	Retail market	Error-correction model	Mixed evidence for asymmetry in the markets for heating oil, diesel oil and gasoline.
Faber, 2009	Netherlands / gasoline	Daily 2006-2008	Wholesale / Retail market	Error-correction model	38% of stations respond asymmetrically. No evidence of asymmetry at the level of the oil companies.
Valadkhani, 2009	Australia / gasoline	Monthly / 1998-2009	Retail market	Error-correction model	Evidence of asymmetry in four out of seven Australian capital cities.
Kuper and Poghosyan, 2008	USA / gasoline	Weekly / 1986-2005	Retail market	Error-correction model	Pre 1999: International oil price adjusts linearly to deviations from the long-term equilibrium. Post 1999: Retail prices increased at a faster pace after an oil shock than during the pre-1999 period.
Kaufmann and Laskowski, 2005	United States / gasoline and home heating oil	Monthly / 1986-2002	Wholesale and retail market	Error-correction model	Mixed results
Bachmeir and Griffin, 2003	United States / gasoline	Daily / 1985-1998	Wholesale market	Error-correction model	Mixed results
Bettendorf, et al, 2003	Netherlands / gasoline	Weekly / 1996-2001	Retail market	Error-correction model	Mixed results
Galeotti, et al, 2003	Germany, France, UK, Italy and Spain / gasoline	Monthly / 1985-2000	Wholesale and retail market	Error-correction model	Mixed results
Johnson, 2002	United States / gasoline and diesel	Weekly / 1996-1998	Retail market	Error-correction model	Mixed results

Source: Authors' elaboration

More specifically, Kirchgässner and Kübler, (1992), used an error correction model to investigate possible price asymmetries in the wholesale and retail gasoline and heating oil markets in Germany for the period 1972-89. Their results differ according to the relevant time period. More specifically, for the 1980s the authors find rapid symmetric and full adjustment of the retail prices to the spot prices (Rotterdam prices), whereas there is considerable short-run asymmetry in the 1970s.

Clerides (2010) uses data from several European Union (EU) countries to investigate the response retail gasoline prices to changes in the world oil price. The findings indicate significant variation in the adjustment mechanism across countries. Fluctuations in the international price of oil are transported to local prices with some delay but evidence of asymmetric adjustment is fairly weak. Statistically significant evidence of asymmetric responses is only found in a small number of countries, while in some countries there is even (weak) evidence of asymmetry in the reverse direction: prices drop faster than they rise.

Bermingham and O' Brien (2010) empirically test whether Irish and United Kingdom (UK) petrol and diesel markets are characterised by asymmetric pricing behaviour. The econometric assessment uses threshold autoregressive models and a dataset of monthly refined oil and retail prices covering the period 1997 to mid-2009.Their study concluded that for both the Irish and UK liquid fuel markets at national levels, there is no evidence to support the hypothesis that retail prices rise faster than they fall in response to changes in oil prices (price asymmetry).

A different approach is followed in the pioneering study of Bacon (1991) who uses a quadratic quantity adjustment function to estimate the existence of price asymmetries in wholesale and retail gasoline market in the United Kingdom respectively. In this study, bi-weekly data are used for the period 1982-1989.

According to the main findings, the upward adjustment process is slightly faster than price reductions and the period of adjustment more concentrated than was the case when costs fell. Moreover, changes in the exchange rate necessitate two extra weeks relative to product prices before being incorporated in the retail gasoline prices

Most of the studies under scrutiny primarily focus on prices asymmetries and few of them allow for other asymmetries. The paper by Galeotti et al (2003) re-examines the issue of asymmetries in the retail market of gasoline by allowing possibly asymmetric role of the exchange rate. In their stimulating paper the issue of asymmetric pricing on specific European countries (Germany, France, UK, Italy, Spain) is examined by using an error-correction model and bootstrapping techniques in order to overcome the low-power problem of conventional testing procedures. Polemis (2011) by using the error-correction methodology in the Greek gasoline market reported that retail gasoline prices respond asymmetrically to cost increases and decreases both in the long and the short-run. However, at the wholesale segment, there is a symmetric response of the spot prices of gasoline towards the adjustment to the short-run responses of the exchange rate.

Furthermore, Polemis & Fotis (2011) elaborate the generalized method of moments (GMM) estimation to a panel data error correction model (ECM) in order to measure the asymmetries in the transmission of shocks to input prices and exchange rate onto the wholesale and retail gasoline price respectively. For this purpose, the authors use an updated data set of weekly observations covering the period from January 2000 to February 2011 for eleven euro zone countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain). The results favor the common perception that retail and wholesale gasoline prices respond asymmetrically to cost increases and decreases.

In contrast to several previous findings, the empirical results generally point to widespread differences in both adjustment speeds and short-run responses on prices and exchange rate when input prices are volatile. In order to assess the issue of asymmetric gasoline pricing, a small number of studies use daily data (Asplund, et al, 2000; Bachmeir and Griffin, 2003; Johnson, 2002) for a number of countries (Sweden, United Kingdom and United States).

This paper has two objectives. Firstly, we explore whether asymmetric pricing can be identified in the eleven euro zone countries (Austria, Belgium, Finland, Greece, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain) by utilizing ECM on the weekly price changes in order to assess current and future potential. Despite the crucial importance of the relevant topic due to the recent oil price hikes, no one –to the best of our knowledge- has performed formal econometric tests that would allow the testing of the various explanations for price asymmetry against the available data. For that purpose, we employ sophisticated econometric techniques such as GMM and cointegrated panel data analysis.

Secondly, an in-depth analysis of the oil industry aiming at qualitative aspects of competition in euro zone area is expected to help government officials formulate better policies (that is policies which promote in a more effective way the functioning of the wholesale and retail oil segments). This paper differs from other relevant work in the field in a sense that it is the first approach focused at a comparative examination of the two downstream sub-markets of eleven euro zone countries.

The remainder of this paper is organized as follows. Section II provides a detailed description of the empirical model and the methodology employed. Section III reports our results and Section IV concludes the article.

II. Methodology

Following the specification of Bettendorf, et al, (2003), Polemis, (2011), Kaufmann and Laskowski, (2005), and Reilly and Witt, (1998), various unrestricted error-correction models are used to link the relevant variables. In order to investigate the adjustment path in the different relevant gasoline markets, we estimate two distinct asymmetric error-correction models that account for the wholesale and retail segment respectively. By taking into account the previous considerations, the basic (long-run) relationships are the following:

$$SPG_{r,t} = \beta_0 + \beta_1 CR_{r,t} + \beta_2 EXR_{c,t} + \varepsilon_t \quad (1)^1$$

$$NRPG_{c,t} = \beta_0 + \beta_1 SPG_{r,t} + \varepsilon_t \quad (2)$$

The above equations represent the long-run relationships in the wholesale (eq.1) and retail market respectively (eq.2). In order to investigate the effect of taxation (VAT and excise tax) in the possible asymmetrical movements of price in the retail segment, we estimated two ECMs per market segment by using two different dependent variables (See Appendix, Table A_2)[2]. The aforementioned equations as well as the ECMs are estimated by using *Dynamic Ordinary Least Square* (DOLS). The main reason for using this method, is that although the OLS estimate of the cointegrating vector is superconsistent, it will contain a small-sample bias and the limiting distribution is non normal with a nonzero mean (Stock 1987). A bias in the estimate for the cointegrating vector will affect the cointegrating residual, which is an independent variable in the error correction model. This method gives an asymptotically efficient estimator which eliminates the feedback in the cointegrating

[1] The subscripts r and c denote the geographic region {i = Europe, USA} and the sample country respectively {n = Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain and United Kingdom}.
[2] For the explanation of the variables see Table A_1 of the Appendix.

system (Stock and Watson, 2003; 1993). It involves augmenting the cointegrating regression with lags and leads so that the resulting cointegrating equation error term is orthogonal. Moreover, DOLS increases the efficiency and reduces the small sample bias relative to the OLS estimator, while DOLS generates asymptotically efficient estimates of the regression coefficients for variables that cointegrate (Kaufmann and Laskowski 2005).

The interpretation of the relevant variables comes as follows: NRPG measured in Euro/litre for EU-11, pounds/litre for the UK and USD/gallon for the USA, denotes the net price of gasoline (excluding taxes and duties), SPG is the Rotterdam gasoline spot price measured in USD/gallon[3]. CR is the Brent spot price for Europe measured in USD/barrel[4] and EXR_t is the exchange rate between U.S dollar and national currencies (euro for EU-11 and pound for the UK respectively), while finally ε_t stands for the error term. The reason for using *EXR* in the wholesale model is related with the fact that exchange rate may be a relevant source of asymmetry in non-US countries. More specifically, as stated by Galeotti et al, (2003), since crude oil is paid for in dollars whereas gasoline sells for different sums of national currencies, the exchange rate plays a significant, possibly asymmetric role.

The asymmetry in the transmission of changes in input prices to output prices can be accommodated within a dynamic model. In order to allow for possible price and exchange rate asymmetries we construct the following ECM specifications in the wholesale (eq. 3) and retail market (eq. 4):

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[3] Due to lack of data we use from 4.4.2008 onwards, the New York spot prices of gasoline as a good proxy for the European spot gasoline prices (Rotterdam).
[4] However, for the USA, we used the weekly WTI spot price as traded on the New York Mercantile Exchange (NYMEX) for delivery at Cushing, Oklahoma.

$$\Delta SPG_{r,t} = a_0 + \sum_{i=0}^{k} a_i^{+} \Delta \mathrm{CRP}_{\mathrm{r,t-i}} + \sum_{i=0}^{l} a_i^{-} \Delta \mathrm{CRN}_{\mathrm{r,t-i}} + \sum_{i=0}^{m} b_i^{+} \Delta EXRP_{c,\mathrm{t-i}} + \sum_{i=0}^{n} b_i^{-} \Delta EXRN_{c,\mathrm{t-i}} +$$

$$\sum_{i=1}^{p} c_i \, \Delta SPG_{r,\mathrm{t-i}} + \lambda^{+} ECMP_{t-1} + \lambda^{-} ECMN_{t-1} + \varepsilon_t \qquad (3)$$

$$\Delta NRPG_{c,t} = a_0 + \sum_{i=0}^{k} a_i^{+} \Delta SPGP_{r,\mathrm{t-i}} + \sum_{i=0}^{l} a_i^{-} \Delta SPGN_{r,\mathrm{t-i}} + \sum_{i=1}^{p} b_i \, \Delta NRPG_{c,\mathrm{t-i}} + \lambda^{+} ECMP_{t-1} +$$

$$\lambda^{-} ECMN_{t-1} + \varepsilon_t \qquad (4)$$

The Greek letter Δ is the first difference operator. In the above asymmetric ECMs, changes in the input prices (crude oil and spot prices) and fluctuations in the exchange rate are split into positive and negative changes, respectively. In other words as suggested by Galeotti, et al (2003) short-run asymmetry is captured by similarly decomposing price and exchange rate changes into $\Delta x_t^{+} = x_t - x_{t-1} > 0$ and $\Delta x_t^{-} = x_t - x_{t-1} < 0$ for x = CR,SPG,EXR. Hence ΔCRP = ΔCR if ΔCR>0 and 0 otherwise. ΔSPGP = ΔSPG if ΔSPG>0 and 0 otherwise and ΔEXRP = ΔEXR if ΔEXR>0 and 0 otherwise. The opposite holds for ΔCRN, ΔSPGN and ΔEXRN. Finally ECMP and ECMN denote the one-period lagged deviation from the long-run equilibrium (eqs 1 and 2) and account for asymmetry in the adjustment process. Similarly ECMP = ε_t>0 and 0 otherwise and ECMN = ε_t<0 and 0 otherwise. The orders *k, l, m, n* represent the number of lagged terms for decreases and increases in the explanatory variables respectively and are chosen by using the Akaike information criterion so as to make ε_t white noise.

The sample spans the period from July 1996 to August 2011 using an updated weekly dataset of 792 observations to carry out a thorough investigation of gasoline market in certain European countries and the USA[5]. All variables are in their natural logarithms. Energy prices for crude oil and spot price of gasoline are taken from the USA Energy Information Administration and are deflated by the Harmonised Consumer Price Index (HCPI) provided by the Eurostat. However, retail pre-tax gasoline prices measured in real terms (deflated by the HCPI) are obtained directly from the European Oil Bulletin[6]. Finally, data on the exchange rate between the national currencies and the US dollar are obtained from the European Central Bank and the Federal USA Bank[7].

III. Empirical results

Stationarity and cointegration of the variables

Unit root inference is an important step in the analysis of data. If time series are integrated of order one (I-1), cointegration is necessary to establish that we are estimating structural and not spurious equations (Christopoulos and Tsionas, 2003). For the investigation of the order of integration we have applied a series of diagnostic tests both in levels and first differences of the variables (Augmented Dickey –Fuller, Phillips-Perron and Elliot-Rothenberg and Stock Point Optimal tests). The results of the above tests are presented in Table 2[8]. Applying the relevant tests, we observe that the null-hypothesis of a unit root cannot be rejected at 5% critical value for all the relevant variables. In other words all the series are non-stationary in levels and stationary in first differences (I-1).

[5] Due to lack of data, the sample for the USA spans the period from December 1997 to June 2011 (n = 709).

[6] The bulletin reports weekly the average Monday's pump price with and without taxes and duties in each member state of the European Union.

[7] Taking into account the fixed exchange rate for the EZ-11 countries and that of Euro/dollar provided by the European Central Bank we calculate the exchange rate national currency/dollar on each week for the period January 2002 onwards by using the following formulation: national currency / dollar = fixed exchange rate * euro/dollar

[8] The unit root results as well as the cointegration tests regarding the alternative specifications of the retail stage model are available from the authors' upon request.

Table 2: Results from unit root testing

	Augmented Dickey Fuller (ADF)				(Philips-Perron) P-P				Elliot-Rothenberg and Stock Point Optimal (ERS)			
Country	**EXR**	**NRPG**	**SPG**	**CR**	**EXR**	**NRPG**	**SPG**	**CR**	**EXR**	**NRPG**	**SPG**	**CR**
Austria	0.221 [1] (0.000)* [0]	0.145 [2] (0.000)* [1]	0.542 [3] (0.000)* [2]	0.746 [1] (0.000)* [0]	0.225 [6] (0.000)* [1]	0.156 [11] (0.000)* [8]	0.627 [8] (0.000)* [5]	0.797 [1] (0.000)* [6]	36.322* [1] 0.328 [0]	4.075* [2] (0.316) [1]	4.023* [3] (0.502) [2]	7.195* [1] (0.297) [0]
Belgium	0.191 [3] (0.000)* [2]	0.166 [0] (0.000)* [0]	0.542 [3] (0.000)* [2]	0.746 [1] (0.000)* [0]	0.229 [2] (0.000)* [8]	0.227 [5] (0.000)* [8]	0.627 [8] (0.000)* [5]	0.797 [1] (0.000)* [6]	32.155* [3] 0.376 [2]	3.068* [0] (0.231) [0]	4.023* [3] (0.502) [2]	7.195* [1] (0.297) [0]
Finland	0.229 [1] (0.000)* [0]	0.215 [0] (0.000)* [0]	0.542 [3] (0.000)* [2]	0.746 [1] (0.000)* [0]	0.262 [6] (0.000)* [1]	0.257 [9] (0.000)* [8]	0.627 [8] (0.000)* [5]	0.797 [1] (0.000)* [6]	36.206* [1] 0.314 [0]	3.418* [0] (0.232) [0]	4.023* [3] (0.502) [2]	7.195* [1] (0.297) [0]
France	0.250 [1] (0.000)* [0]	0.443 [1] (0.000)* [0]	0.542 [3] (0.000)* [2]	0.746 [1] (0.000)* [0]	0.240 [6] (0.000)* [1]	0.485 [11] (0.000)* [5]	0.627 [8] (0.000)* [5]	0.797 [1] (0.000)* [6]	34.739* [1] 0.357 [0]	4.023* [3] (0.502) [2]	4.023* [3] (0.502) [2]	7.195* [1] (0.297) [0]
Germany	0.221 [1] (0.000)* [0]	0.227 [0] (0.000)* [0]	0.542 [3] (0.000)* [2]	0.746 [1] (0.000)* [0]	0.223 [6] (0.000)* [1]	0.217 [5] (0.000)* [4]	0.627 [8] (0.000)* [5]	0.797 [1] (0.000)* [6]	36.763* [1] 0.326 [0]	4.023* [3] (0.502) [2]	4.023* [3] (0.502) [2]	7.195* [1] (0.297) [0]
Greece	0.273 [1] (0.000)* [0]	0.232 [1] (0.000)* [0]	0.542 [3] (0.000)* [2]	0.746 [1] (0.000)* [0]	0.269 [5] (0.000)* [1]	0.251 [9] (0.000)* [3]	0.627 [8] (0.000)* [5]	0.797 [1] (0.000)* [6]	44.899* [1] 0.329 [0]	4.023* [3] (0.502) [2]	4.023* [3] (0.502) [2]	7.195* [1] (0.297) [0]
Ireland	0.955 [0] (0.000)* [0]	0.510 [0] (0.000)* [0]	0.542 [3] (0.000)* [2]	0.746 [1] (0.000)* [0]	0.955 [0] (0.000)* [3]	0.255 [13] (0.000)* [13]	0.627 [8] (0.000)* [5]	0.797 [1] (0.000)* [6]	14.345* [0] 0.237 [0]	4.023* [3] (0.502) [2]	4.023* [3] (0.502) [2]	7.195* [1] (0.297) [0]
Italy	0.305 [1] (0.000)* [0]	0.380 [2] (0.000)* [1]	0.542 [3] (0.000)* [2]	0.746 [1] (0.000)* [0]	0.331 [6] (0.000)* [2]	0.437 [14] (0.000)* [12]	0.627 [8] (0.000)* [5]	0.797 [1] (0.000)* [6]	30.630* [1] 0.312 [0]	4.023* [3] (0.502) [2]	4.023* [3] (0.502) [2]	7.195* [1] (0.297) [0]
Netherlands	0.216 [1] (0.000)* [0]	0.240 [2] (0.000)* [0]	0.542 [3] (0.000)* [2]	0.746 [1] (0.000)* [0]	0.218 [6] (0.000)* [2]	0.273 [5] (0.000)* [2]	0.627 [8] (0.000)* [5]	0.797 [1] (0.000)* [6]	37.010* [1] 0.330 [0]	4.023* [3] (0.502) [2]	4.023* [3] (0.502) [2]	7.195* [1] (0.297) [0]
Portugal	0.257 [1] (0.000)* [0]	0.398 [1] (0.000)* [0]	0.542 [3] (0.000)* [2]	0.746 [1] (0.000)* [0]	0.264 [6] (0.000)* [2]	0.244 [14] (0.000)* [14]	0.627 [8] (0.000)* [5]	0.797 [1] (0.000)* [6]	35.743* [1] 0.323 [0]	4.023* [3] (0.502) [2]	4.023* [3] (0.502) [2]	7.195* [1] (0.297) [0]
Spain	0.234 [1] (0.000)* [0]	0.353 [2] (0.000)* [1]	0.542 [3] (0.000)* [2]	0.746 [1] (0.000)* [0]	0.247 [6] (0.000)* [1]	0.352 [14] (0.000)* [10]	0.627 [8] (0.000)* [5]	0.797 [1] (0.000)* [6]	35.948* [1] 0.316 [0]	4.023* [3] (0.502) [2]	4.023* [3] (0.502) [2]	7.195* [1] (0.297) [0]
United Kingdom	0.672 [3] (0.000)* [2]	0.689 [1] (0.000)* [0]	0.542 [3] (0.000)* [2]	0.746 [1] (0.000)* [0]	0.733 [5] (0.000)* [5]	0.619 [15] (0.000)* [12]	0.627 [8] (0.000)* [5]	0.797 [1] (0.000)* [6]	12.243* [3] 0.399 [2]	4.023* [3] (0.502) [2]	4.023* [3] (0.502) [2]	7.195* [1] (0.297) [0]
United States	-	0.347 [2] (0.000)* [1]	0.488 [1] (0.000)* [0]	0.151 [3] (0.000)* [2]	-	0.527 [14] (0.000)* [7]	0.544 [2] (0.000)* [3]	0.687 [0] (0.000)* [4]	-	4.023* [3] (0.502) [2]	4.530* [1] (0.335) [0]	5.727* [3] (0.402) [2]

Notes: The calculated statistics are those reported in Dickey and Fuller, (1981). The critical values at 5% and 1% for $N = 50$ are given in Dickey and Fuller (1981). The critical values for the Phillips Perron unit root tests are obtained from Dickey and Fuller, (1981). In the Elliot-Rothenberg and Stock Point Optimal (ERS) test the null hypothesis means that the variable is stationary whilst the alternative hypothesis denotes the existence of a unit root in the data generation process. Critical values fir the ERS test are computed by interpolating the simulation results provided by ERS (1996, Table 1, p.825) for T = {50, 100, 200, ∞ }. The number in square brackets denotes the lag length using the Schwarz Info Criterion, while the number in parenthesis refers to the first differences.* Indicates significance at the 1% level.

Source: Authors' elaboration

The next step is to examine if there is a cointegrated relationship between the non-stationary variables of the models. The reason for using cointegration techniques is that nonstationary time series result to spurious regressions and hence do not allow statistical interpretation of the estimations. In order to overcome this problem, we apply the Johansen (1992) technique. This method allows us to examine whether there is a long-run co-movement of the variables.

Table 3: Cointegration tests

Country	**Trace statistic**	**Maximum eigenvalues**
Wholesale segment: *SPG = f(CR, EXR)*		
Austria	53.8^{*} [r=0] 8.2 [r>=1]	45.6^{**} [r=0] 7.8 [r>=1]
Belgium	53.6^{*} [r=0] 8.2 [r>=1]	45.3^{*} [r=0] 7.8 [r>=1]
Finland	53.7^{*} [r=0] 8.0 [r>=1]	45.7^{*} [r=0] 7.6 [r>=1]
France	53.4^{*} [r=0] 7.8 [r>=1]	45.6^{*} [r=0] 7.4 [r>=1]
Germany	53.7^{*} [r=0] 8.2 [r>=1]	45.5^{*} [r=0] 7.7 [r>=1]
Greece	53.4^{*} [r=0] 7.9 [r>=1]	45.5^{*} [r=0] 7.5 [r>=1]
Ireland	48.3^{*} [r=0] 3.4 [r>=1]	44.8^{*} [r=0] 2.8 [r>=1]
Italy	53.2^{*} [r=0] 7.4 [r>=1]	45.8^{*} [r=0] 6.9 [r>=1]
Netherlands	53.7^{*} [r=0] 8.2 [r>=1]	45.5^{*} [r=0] 7.8 [r>=1]
Portugal	53.6^{*} [r=0] 7.9 [r>=1]	45.7^{*} [r=0] 7.5 [r>=1]
Spain	53.7^{*} [r=0] 8.2 [r>=1]	45.6^{*} [r=0] 7.9 [r>=1]
United Kingdom	51.8^{*} [r=0] 6.2 [r>=1]	45.6^{*} [r=0] 4.7 [r>=1]
United States^{+}	48.9^{*} [r=0] 7.5 [r>=1]	41.4^{*} [r=0] 4.4 [r>=1]
Retail segment: *NRPG = f(SPG)*		
Austria	30.8^{**} [r=0] 5.6 [r>=1]	21.2^{**} [r=0] 5.6 [r>=1]
Belgium	15.7^{**} [r=0] 1.5 [r>=1]	14.2 [r=0] 1.5 [r>=1]
Finland	20.9^{*} [r=0] 2.2 [r>=1]	18.7^{*} [r=0] 2.2 [r>=1]
France	20.5^{**} [r=0] 3.2 [r>=1]	13.9 [r=0] 3.2 [r>=1]
Germany	23.4^{*} [r=0] 1.2 [r>=1]	22.2^{*} [r=0] 1.2 [r>=1]
Greece	21.8^{*} [r=0] 2.8 [r>=1]	15.3 [r=0] 2.8 [r>=1]
Ireland	34.5^{*} [r=0] 2.8^{***} [r>=1]	31.7^{*} [r=0] 2.8^{***} [r>=1]
Italy	23.0^{*} [r=0] 3.2 [r>=1]	13.8 [r=0] 3.2 [r>=1]
Netherlands	23.2^{*} [r=0] 2.9 [r>=1]	13.9^{*} [r=0] 2.9 [r>=1]
Portugal	28.0^{**} [r=0] 8.7 [r>=1]	19.3^{***} [r=0] 8.7 [r>=1]
Spain	24.8^{***} [r=0] 10.7 [r>=1]	14.1 [r=0] 10.7^{***} [r>=1]
United Kingdom	18.4^{**} [r=0] 1.7 [r>=1]	16.7^{**} [r=0] 1.7 [r>=1]
United States	31.9^{*} [r=0] 2.9 [r>=1]	28.9^{*} [r=0] 2.9 [r>=1]

Notes: ($^{+}$) The variable EXR is not included in the cointegration testing. Null hypothesis implies absence of cointegration, while r denotes the number of cointegrating equations with no deterministic trend. Significant at *1%, **5% and ***10% respectively.
Source: Authors' elaboration

Table 3 presents the maximum-likelihood eigenvalue statistics[9]. It is evident that the null hypothesis (no cointegration) is rejected at 1% level for all the sample countries[10]. The estimated likelihood ratio tests and eigenvalues indicate that there is one cointegration vector for each model (gasoline and diesel).

Long - run estimations

In this subsection, we take up estimation of the long run coefficients given that we have established cointegration. That is, given that eqs. 1-2 represent structural and not spurious long-run relations; we proceed to estimate the parameters.

In the wholesale specification, the estimated coefficients on crude oil (CR) are significantly different from zero at the 1% significance level for all the countries involved. The magnitude of the relevant coefficient does not reveal a significant variation between the scrutinized countries indicating that the crude oil is an important cost marker. The magnitude of the estimated coefficients is significantly high exceeding 0.92. In other words in the long run, a change in the crude oil price is fully passed to the wholesale price of gasoline. On the other hand, fluctuations in the exchange rate do not play significant role in the wholesale price formation since the relevant coefficients for all of the sample countries are not statistical significant.

[9] The null hypothesis is that there is no cointegration relationship, so r = 0.
[10] However, in the retail segment according to maximum eigenvalues, the existence of a cointegration relationship does not hold for a number of countries (Belgium, France, Greece, Italy and Spain). Since the two statistics (i.e trace statistics and maximum eigenvalues) yield different results, one cannot reach a definite conclusion. However, we can accept the hypothesis of cointegration for the aforementioned countries as a working hypothesis.

Table 4: Long-run estimates

Variables	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Netherlands	Portugal	Spain	UK	USA
Wholesale segment: SPG = f(CR, EXR)													
c	-3.343*	-3.356*	-3.343*	-3.333*	-3.329*	-3.343*	-3.322*	-3.354*	-3.331*	-3.378*	-3.365*	-3.341*	-3.384*
CR	0.926*	0.927*	0.927*	0.926*	0.926*	0.928*	0.925*	0.926*	0.927*	0.927*	0.927*	0.918*	0.946*
EXR	0.006	0.008	0.009	0.004	0.006	0.001	0.008	0.004	0.007	0.009	0.007	-0.087	-
Diagnostics													
Adjusted R^2	0.978	0.978	0.978	0.978	0.978	0.978	0.978	0.978	0.978	0.978	0.978	0.978	0.975
Durbin-Watson	0.177	0.177	0.177	0.177	0.177	0.178	0.175	0.177	0.177	0.177	0.177	0.177	0.277
S.E of regression	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.077
Retail segment: NRPG = f(SPG)													
c	-0.982*	-1.028*	-1.039*	-1.142*	-1.103*	-0.980*	-0.952*	-0.937*	-0.915*	-0.935*	-1.000*	-1.424*	0.427*
SPG	0.344*	0.469*	0.496*	0.582*	0.515*	0.431*	0.328*	0.431*	0.422*	0.391*	0.431*	0.873*	0.707*
Diagnostics													
Adjusted R^2	0.811	0.904	0.854	0.911	0.928	0.849	0.702	0.918	0.884	0.602	0.911	0.950	0.985
Durbin-Watson	0.059	0.253	0.164	0.051	0.254	0.038	0.109	0.040	0.078	0.037	0.044	0.080	0.152
S.E of regression	0.089	0.082	0.110	0.097	0.076	0.097	0.115	0.069	0.082	0.171	0.072	0.106	0.042

C denotes the constant term. ***, ** and * denotes significance at 0.10, 0.05 and 0.01 respectively.

Source: Authors' elaboration

In the retail segment[11] it is evident that the spot price estimated coefficients (SPG) are statistically significant and have the anticipated signs. More specifically, the price effect on the net retail price of gasoline is positive and substantial in magnitude, with the relevant coefficients bellow unity. It is worth mentioning that the relevant magnitude of the spot price coefficients shows significant variation between the sample countries. More specifically, in countries such as Austria, Ireland, Portugal and Netherlands, Greece, Italy and Spain the estimated coefficient is bellow 0.5, indicating that a change in the gasoline spot price is not fully passed through to the net retail price. The relatively smaller pass-through price mechanism (compared to the wholesale segment) is due to the fact that as we are moving down the oil supply chain, the upstream oil price becomes a smaller portion of the cost of the price of oil in the next stage (Polemis, 2011). Therefore a change in the upstream oil price would generate a smaller price increase downstream. On the other hand, in countries like the United Kingdom and the United States, the long-run response of net gasoline price to spot price variations is bigger in its magnitude estimated to 0.873 and 0.707 respectively.

Results from the error correction models (short – run estimations)

Table 5 depicts the results from the estimation of the two ECM's (wholesale and retail level). Each coefficient of the explanatory variables denotes the short-run response to the output prices (spot and retail prices). In order to select the appropriate number of lags in the ECM's, we try to minimise the Akaike Information Criterion (AIC).

[11] Due to space limitation, the long-run estimates from the two alternative specifications per market segment are available from the authors' upon request.

Table 5: Estimation results of the ECMs

Variables	**Austria**	**Belgium**	**Finland**	**France**	**Germany**	**Greece**	**Ireland**	**Italy**	**Netherlands**	**Portugal**	**Spain**	**UK**	**USA**
c	-0.001 **(-0.000)**	-0.001 **(-0.002***)**	-0.001 **(-0.001)**	-0.001 **(-0.001)**	-0.001 **(-0.002)**	-0.001 **(0.001)**	-0.001 **(0.002)**	-0.001 **(-0.000)**	-0.000 **(0.002**)**	-0.001 **(0.001)**	-0.001 **(-0.000)**	-0.001 **(-0.000)**	-0.005 **(0.000)**
ΔSPG_{t-1}	1.202*	1.173*	1.120*	1.187*	1.123*	0.891*	1.245*	1.176*	1.181*	1.161*	1.201*	1.244*	-
ΔSPG_{t-2}	-0.052**	-0.050**	-0.052**	-0.051**	-0.048**	0.680*	-0.053**	-0.051**	-0.052**	-0.050**	-0.052**	-0.052**	-
$\Delta NRPG_{t-1}$	**(0.500*)**	**(0.411*)**	-	**(0.448*)**	**(0.384*)**	**(0.553*)**	**(0.088)**	**(0.512*)**	**(0.100*)**	**(0.298*)**	**(0.529*)**	**(0.467*)**	**(0.437*)**
$ECMP_{t-1}$	-1.087* **(-0.693*)**	-1.059* **(-0.601*)**	-1.059* **(-0.121*)**	-1.074* **(-0.406*)**	-1.012* **(-0.660*)**	-0.791* **(-0.648*)**	-1.137* **(-0.106***)**	-1.062* **(-0.356*)**	-1.067* **(-0.571*)**	-1.048* **(-0.165*)**	-1.088* **(-0.547*)**	-1.136* **(-0.213*)**	-0.244* **(-0.119**)**
$ECMN_{t-1}$	-0.974* **(-0.519*)**	-0.946* **(-0.781*)**	-0.946* **(-0.185*)**	-0.961* **(-0.208*)**	-0.896* **(-0.668*)**	-0.670* **(-0.602*)**	-1.018* **(-0.041)**	-0.949* **(-0.377*)**	-0.955* **(-0.256*)**	-0.934* **(-0.187*)**	-0.975* **(-0.357*)**	-1.017* **(-0.223*)**	-0.213* **(-0.064***)**
ΔCRP_t	0.651*	0.654*	0.650*	0.652*	0.657*	0.680*	0.662*	0.653*	0.650*	0.652*	0.651*	0.668*	0.745*
ΔCRP_{t-1}	-0.729* -	-0.711* -	-0.729* *[-0.055]*	-0.719* -	-0.672* -	-0.508* -	-0.761* -	-0.710* -	-0.712* -	-0.699* -	-0.728* -	-0.760* -	0.158*
ΔCRN_t	0.690*	0.695*	0.689*	0.691*	0.695*	0.704*	0.699*	0.691*	0.690*	0.691*	0.689*	0.707*	0.801*
ΔCRN_{t-1}	-0.930*	-0.907*	-0.933*	-0.920*	-0.873*	-0.705*	-0.967*	-0.912*	-0.916*	-0.900*	-0.931*	-0.969*	-
$\Delta SPGP_t$	**(0.424)***	**(0.452*)**	**(0.444*)**	**(0.410*)**	**(0.505*)**	**(0.315*)**	**(-0.011)**	**(0.226*)**	**(0.463*)**	**(0.059)**	**(0.296*)**	**(0.157*)**	**(0.370*)**
$\Delta SPGN_t$	**(0.334)***	**(0.471*)**	**(0.436*)**	**(0.233*)**	**(0.366*)**	**(0.363*)**	**(-0.025)**	**(0.218*)**	**(0.481*)**	**(0.099**)**	**(0.207*)**	**(0.066*)**	**(0.216*)**
$\Delta SPGP_{t-1}$	-	-	**(-0.103*)**	-	-	-	-	-	-	-	-	-	**(-0.083*)**
$\Delta SPGN_{t-1}$	-	-	-	-	-	-	-	-	-	-	-	-	**(0.083*)**
$\Delta EXRP_t$	-0.129	-0.081	-0.167	-0.129	-0.152	-0.139	0.030	-0.150	-0.191	-0.159	-0.155	0.063	-
$\Delta EXRN_t$	-0.105	-0.106	-0.099	-0.091	-0.086	-0.118	-0.031	-0.092	-0.026	-0.092	-0.088	-0.021	-
Diagnostics													
Adjusted R^2	0.545 **(0.423)**	0.550 **(0.277)**	0.550 **(0.190)**	0.550 **(0.633)**	0.550 **(0.303)**	0.541 **(0.489)**	0.543 **(0.005)**	0.544 **(0.524)**	0.545 **(0.525)**	0.544 **(0.588)**	0.545 **(0.506)**	0.544 **(0.256)**	0.466 **(0.700)**
Durbin-Watson	1.995 **(2.022)**	1.997 **(2.175)**	1.996 **(2.031)**	1.995 **(2.154)**	1.997 **(2.133)**	1.981 **(2.215)**	2.002 **(2.008)**	1.995 **(2.093)**	1.996 **(2.054)**	1.995 **(2.082)**	1.996 **(2.043)**	1.998 **(2.205)**	2.041 **(2.210)**

Notes: The bold numbers in parentheses refer to the retail segment. C denotes the constant term. ***, ** and * denotes significance at 0.10, 0.05 and 0.01 respectively.
Source: Authors' elaboration

In the wholesale segment, from the empirical results and the statistical tests (see subsequent section) it is obvious that negative coefficients are larger, in absolute value, than their positive counterparts for all the sample countries. This finding which is also evident in other empirical studies (Polemis, 2011; Grosso and Manera 2007; Contin et al. 2006) reflects the consumers' perception of the actual effects of oil price variations on gasoline price changes at least in the short-run. This means that the effects of upstream price decreases are larger than those of price increases. Moreover, on average over the estimation period, spot prices of gasoline do not register a significant response to increases (or devaluations) in the euro dollar exchange rate. In other words, in the wholesale level, positive and negative changes of the exchange rate appear to be insignificant. This evidence suggests that refineries are generally reluctant to transfer to consumers those price increases or reductions originated from movements in exchange rates.

The coefficients of the variables $ECMP_{t-1}$ and $ECMN_{t-1}$ indicate asymmetric adjustment speeds. In other words the positive and negative ECM coefficients are associated with adjustment to the long-run equilibrium level of price from above and from bellow. From the empirical results, we see that the positive coefficients are generally larger (in their absolute terms) than the negative ones for all the sample countries indicating a positive long-run asymmetry, which is not in alignment with the Wald test results (Table 6). However, the magnitude of the relevant error-correction terms varies significantly between the selected countries. In countries such as the UK, and Ireland, the negative error-correction term has estimated to slightly above unity, whereas appears to be significant smaller in the USA (-0.213) and Greece (-0.670). The same conclusion can be reached regarding the positive error-correction term. To sum up, the variation in the magnitude of the adjustment speeds primarily between the

USA and the European countries (e.g United Kingdom, Ireland, France and Austria) reveals important differences in the oil industry structure regarding the level of competition in the wholesale segment.

Finally, the estimated autoregressive coefficients, which enter the model when the lag-length is equal to one (ΔSPG_{t-1}) are statistically significant and have the anticipated positive signs for the sample countries. The opposite holds when the lag length is set to two (ΔSPG_{t-2}).

We now stress our attention into the examination of point estimates in the retail level specification. From the empirical results, we see that positive short-run spot price effect is larger than its negative counterpart in a number of countries (Austria, Finland, France, Germany, Italy, Spain, UK and USA), while the reverse holds for the rest of the sample countries (Belgium, Greece, Netherlands and Portugal)[12]. This means that retail gasoline prices seem to react more to price increases and to negative gaps to the equilibrium than to price decreases and positive disequilibrium. From the magnitude of the relevant estimates, we see that a 10% short-run increase in spot price of gasoline (wholesale price) will increase the net retail price of gasoline within the range from 1,57% (UK) to 5,05% (Germany) respectively. This outcome is intuitively valid, since crude oil, refining costs and profit account for roughly 30-40% of retail costs, while taxes (excise taxes and VAT) and wholesale margin account for another 70-60% on average.

Regarding the speed of adjustment to the long-run equilibrium, we see that in most cases the positive coefficients are generally larger (in their absolute terms) than the negative ones thus indicating a positive long-run asymmetry in the retail segment for selected countries (Austria, France, Greece, Ireland, Netherlands, Spain and USA).

[12] In the case of Ireland the relevant magnitude comes with a negative sign and is not statistical significant.

However, in countries such as the UK, and Ireland, the negative error-correction term is larger than the positive one. Finally, the estimated autoregressive coefficient when the lag-length is equal to one (ΔNRP_{t-1}) is statistically significant with the anticipated positive sign for all the sample countries but for Ireland.

If we try to compare the two-level analysis, some interesting remarks emerge. First, the magnitude of short-run coefficients is in the most sample countries larger in the wholesale than in the retail level. Second, the adjustment towards the equilibrium level is more gradual in the retail level revealing the structural differences between the wholesale and retail segment of the gasoline industry. Furthermore, the retailers tend to react more to price increases than price decreases compared to the wholesalers, indicating a different adjustment path to the long-run equilibrium level of price. Lastly, from the relevant magnitude of the price coefficients in the wholesale and the retail equations, we assume that retailers do not immediately transfer onto final prices (pump prices) all the adjustments in the wholesale prices. Instead changes time distributed.

Testing for asymmetric responses

The following table depicts the calculated Wald and F-statistics testing the asymmetry hypothesis in all of the two market segments. Rejection of the null hypothesis H_0: $\lambda^+ = \lambda^-$ implies asymmetric long-run adjustment, whereas short-run asymmetries (price and exchange rate) arise when at least one of the hypotheses H_0: $\alpha^+ = \alpha^-$ or $b^+ = b^-$, is rejected.

By using the relevant Wald tests, we see that the hypothesis of long-run symmetric adjustment speeds can not be rejected at the wholesale level for all the european countries except for the USA. We reach the same outcome when we test for short-run asymmetries (price and exchange rate) since the null hypothesis (H_o: $\alpha^+ = \alpha^-$ and H_o: $b^+ = b^-$ respectively) cannot be rejected for all the sample countries (and the USA as well) suggesting the existence of symmetric adjustment speeds in the short-run.

Table 6: Computed Wald and F-tests of asymmetric responses

Country	*$\lambda^+ = \lambda^-$ (Symmetric adjustment speeds)*	*$\alpha^+ = \alpha^-$ (price asymmetry)*	*$b^+ = b^-$ (exchange rate asymmetry)*	*$\alpha^+ = \alpha^- = \beta^+ = \beta^- = 0$ (short-run asymmetry)*
Wholesale segment: SPG = f(CR, EXR)				
Austria	-1,17 (0,24)	-0,52 (0,60)	-0,08 (0,93)	137,88* (0,00)
Belgium	-1,17 (0,24)	-0,55 (0,58)	0,11 (0,91)	141,07* (0,00)
Finland	-1,16 (0,24)	-0,52 (0,60)	-0,23 (0,81)	137,04* (0,00)
France	-1,17 (0,24)	-0,53 (0,60)	-0,13 (0,89)	138,46* (0,00)
Germany	-1,20 (0,23)	-0,52 (0,60)	-0,23 (0,81)	142,87* (0,00)
Greece	-1,29 (1,19)	-0,32 (0,75)	-0,08 (0,93)	167,37* (0,00)
Ireland	-1,23 (0,22)	-0,49 (0,63)	0,58 (0,56)	145,77* (0,00)
Italy	-1,17 (0,24)	-0,51 (0,61)	-0,20 (0,84)	138,85* (0,00)
Netherlands	-1,16 (0,25)	-0,54 (0,59)	-0,58 (0,56)	137,91* (0,00)
Portugal	-1,18 (0,24)	-0,53 (0,60)	-0,23 (0,82)	139,57* (0,00)
Spain	-1,17 (0,24)	-0,51 (0,61)	-0,24 (0,81)	137,08* (0,00)
United Kingdom	-1,22 (0,22)	-0,52 (0,60)	0,28 (0,78)	154,55* (0,00)
United States	-4,30*(0,00)	-0,45 (0,65)	-	-
Retail segment: NRPG = f(SPG)				
Austria	-1,95** (0,05)	2,14* (0,03)	-	-
Belgium	2,58* (0,01)	-0,30 (0,76)	-	-
Finland	0,84** (0,40)	0,10 (0,92)	-	-
France	3,05* (0,00)	5,52* (0,00)	-	-
Germany	-0,56 (0,58)	-1,29 (0,20)	-	-
Greece	-0,55 (0,57)	-1,29 (0,20)	-	-
Ireland	1,70*** (0,09)	-0,48 (0,63)	-	-
Italy	0,24 (0,81)	0,30 (0,77)	-	-
Netherlands	-3,70* (0,00)	-0,41 (0,68)	-	-
Portugal	0,27 (0,79)	-0,61 (0,54)	-	-
Spain	-1,96** (0,05)	2,76* (0,01)	-	-
United Kingdom	0,14 (0,88)	1,78*** (0,06)	-	-
United States	4,20* (0,00)	5,61* (0,00)	-	-

Notes: ***, ** and * denotes significance at 0.10, 0.05 and 0.01 respectively. The numbers in parenthesis are the asymptotic P-values.
Source: Authors' elaboration.

When we simultaneously test the equality of all short-run parameters of the same lags in the wholesale level by using the F-statistic, the null hypothesis (equality hypothesis) is rejected for all the sample countries. However, we must be very skepticism when we perform the equality test, since there is a tendency to over-reject the null hypothesis of symmetry due to the low power of standard F statistics (Galeotti et al. 2003).

From the combined results of the above-mentioned Wald-tests, we reach the conclusion that in European sample countries there is a symmetric response of the output prices of gasoline in the wholesale level both in the short and the long run respectively. This conclusion is in alignment with other empirical studies as well (Godby et al. 2000; Galeotti et al. 2003; Contin et al. 2006, Polemis, 2011) and runs contrary to the common perception regarding the price asymmetries that emerge in the gasoline market. Similar results can be found when testing for exchange rate asymmetry in the wholesale level. However, in the USA, the hypothesis of the symmetric adjustment speeds appears to be valid only in the short-run.

When we investigate the issue of asymmetry in the retail segment of the gasoline industry, some important remarks emerge. Firstly, there is a wide variation in the existence of asymmetric price responses within the sample european countries. It is worth mentioning that in countries characterized by a high degree of competition such as Germany and the United Kingdom[13], whose oil industry is consisted of vertically integrated companies and significant market players (hypermarkets, big groceries stores, etc) in the retail chain, the null hypothesis (symmetry) cannot be rejected in the long-run (P-value equals to 0,58 and 0,88 respectively). The absence of (long-run) asymmetry in the retail segment of the market is consisted with a previous study for the United Kingdom (OFT, 1998). On the other hand, the long-run symmetry hypothesis is rejected in a number of countries (Austria, Belgium, Finland, France, Ireland, Netherlands, Spain and the United States). From the short-run perspective, the existence of price asymmetry seems to hold only in Austria, France, Spain, UK and the USA[14].

[13] In the United Kingdom, the supermarkets and the hypermarkets have grown continuously and significantly over the last years, whereas their volumes have grown at the expense of the traditional road site filling stations (OFT, 1998).

[14] The results from the inclusion of the taxation are presented in the Appendix (see Table A_3).

IV. Conclusions and policy implications

The relevant empirical study uses an updated weekly dataset to carry out a thorough investigation of asymmetric gasoline price responses within the euro zone area (EZ-11), the UK and the USA. In the specific study, we used sophisticated econometric techniques (DOLS) in order to estimate asymmetric ECMs at each market segment (wholesale and retail segment). This technique allows us to distinguish between asymmetries arising from short-lived deviations in input prices and asymmetries concerning the speed at which the gasoline price reverts to its long-run (equilibrium) level.

The empirical results favor the common perception that wholesale and retail gasoline prices respond asymmetrically to cost increases and decreases. Except for the possible exercise of market power by the refineries operating in an oligopolistic way, asymmetries in the gasoline market are likely to be the outcome of other market parameters (i.e regulatory barriers, legal framework, etc).

In order to eliminate price asymmetries in the euro area, government officials should pursue policies to enhance the level of competition in the relevant markets. One suitable policy to protect consumers from welfare loses concerns the implementation of regulatory and behavioural measures as well. To be more specific, the strengthening of the role of the wholesalers and the elimination of certain barriers to entry in the oil market could provide a suitable mechanism to enhance the level of petroleum imports in the euro area.

Another suitable policy in order to prevent the market players from the imposition of exploitative practices (i.e price fixing, abuse of dominant position) that hinder the level of competition in all of the three market segments is linked with a thorough investigation of mergers by the competition authorities. Mergers in the oil sector that increase market concentration without creating economies of scale or scope may lead to anticompetitive effects and increase the market power of the incumbents. In such cases where competition is hampered, the government should develop a closely monitoring of the market in order to prevent the marketeers from concerted practices.

In less deregulated countries (i.e Greece, Portugal, Spain), the government could enhance the level of competition by a further opening of the market to new entrants such as hypermarkets or big stores and by removing certain legal or technical barriers for the establishment of new filling stations. The industry structure in other European countries (United Kingdom, France and Germany) consisted of vertically integrated companies and significant market players (hypermarkets) in the retail chain of the industry could constitute a useful paradigm to the government officials and policy makers.

APPENDIX

Table A_1: Representation of the variables

Variable	Explanation	Source	Availability
NRPG	Net final gasoline (pump) price without taxes and charges	European Oil Bulletin	July 1996-August 2011 (weekly basis)
FPR	Final gasoline (pump) price	European Oil Bulletin	July 1996-August 2011 (weekly basis)
FPRV	Final gasoline (pump) price without VAT	European Oil Bulletin	July 1996-August 2011 (weekly basis)
FPREX	Final gasoline (pump) price without excise tax	European Oil Bulletin	July 1996-August 2011 (weekly basis)
CR	Crude oil price	USA Energy Information Administration	July 1996-August 2011 (weekly basis)
SPG	Gasoline spot price	USA Energy Information Administration	July 1996-August 2011 (weekly basis)
EXR	Exchange rate	European Central Bank and the Federal USA Bank	July 1996-August 2011 (daily basis)
HCPI	Harmonised consumer price index	Eurostat	July 1996-August 2011 (monthly basis)
EXC	Excise tax	European Oil Bulletin	July 1996-August 2011 (weekly basis)
VAT	Value added tax	European Oil Bulletin	July 1996-August 2011 (weekly basis)

Table A$_2$: Alternative estimation results of the ECMs (Retail segment)

Variables	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Netherlands	Portugal	Spain	UK
$\Delta FPRV_{c,t} = a_0 + \sum_{i=1}^{p} b_i\ FPRV_{c,t-i} + \sum_{i=0}^{m} c_i^{+} \Delta SPGP_{r,t-i} + \sum_{i=0}^{n} c_i^{-} \Delta SPGN_{r,t-i} + \lambda^{+}\ ECMP_{t-1} + \lambda^{-}\ ECMN_{t-1} + \varepsilon_t$												
c	-0.000	-0.001^{***}	-0.000	-0.000^{**}	-0.000	0.001	0.002^{**}	-0.000	0.001^{***}	0.001	0.000	-0.002^{**}
$\Delta FPRV_{t-1}$	0.508^{*}	0.429^{*}	-0.089^{***}	0.473^{*}	0.295^{*}	0.584^{*}	0.031	0.540^{*}	0.114^{*}	0.527^{*}	0.863^{*}	0.200^{**}
$ECMP_{t-1}$	-0.639^{*}	-0.603^{*}	-0.125^{***}	-0.550^{*}	-0.606^{*}	-0.565^{*}	-0.125^{***}	-0.494^{*}	-0.605^{*}	-0.260^{*}	-0.804^{*}	0.147
$ECMN_{t-1}$	-0.639^{*}	-0.787^{*}	-0.136^{***}	-0.362^{*}	-0.510^{*}	-0.557^{*}	0.068	-0.424^{*}	-0.267^{*}	-0.149^{*}	-1.024^{*}	-0.245^{**}
$\Delta SPGP_t$	0.186^{*}	0.167^{*}	0.178^{*}	0.196^{*}	0.204^{*}	0.105^{*}	-0.021	0.126^{*}	0.170^{*}	0.010	0.065^{*}	0.072^{**}
$\Delta SPGN_t$	0.154^{*}	0.151^{*}	0.162^{*}	0.127^{*}	0.136^{*}	0.162^{*}	0.009	0.111^{*}	0.175^{*}	0.022^{**}	0.135^{*}	0.056^{***}
Adjusted R^2	0.452 [2.015]	0.252 [2.170]	0.216 [2.041]	0.598 [2.087]	0.326 [2.171]	0.433 [2.119]	0.598 [2.087]	0.462 [2.023]	0.477 [2.035]	0.229 [2.180]	0.330 [1.965]	0.072 [1.994]
$\Delta FPREX_{c,t} = a_0 + \sum_{i=1}^{p} b_i\ FPREX_{c,t-i} + \sum_{i=0}^{m} c_i^{+} \Delta SPGP_{r,t-i} + \sum_{i=0}^{n} c_i^{-} \Delta SPGN_{r,t-i} + \lambda^{+}\ ECMP_{t-1} + \lambda^{-}\ ECMN_{t-1} + \varepsilon_t$												
c	-0.000	-0.003^{**}	-0.000	-0.001^{**}	-0.003^{***}	-0.000	-0.004^{**}	-0.001	0.002^{***}	0.000	0.001	-0.005^{**}
$\Delta FPREX_{t-1}$	0.524^{*}	0.429^{*}	0.003	0.520^{*}	0.425^{*}	0.564^{*}	0.079	0.563^{*}	0.107^{**}	0.455^{*}	0.676^{*}	0.274^{*}
$ECMP_{t-1}$	-0.729^{*}	-0.569^{*}	-0.156^{***}	-0.702^{*}	-0.693^{*}	-0.527^{*}	-0.164^{**}	-0.478^{*}	-0.581^{*}	-0.282^{*}	-0.548^{*}	0.081
$ECMN_{t-1}$	-0.590^{*}	-0.842^{*}	-0.222^{**}	-0.314^{*}	-0.699^{*}	-0.878^{*}	0.059	-0.531^{*}	-0.257^{*}	-0.294^{*}	-0.688^{*}	-0.281^{*}
$\Delta SPGP_t$	0.390^{*}	0.386^{*}	0.407^{*}	0.451^{*}	0.429^{*}	0.312^{*}	-0.031	0.241^{*}	0.396^{*}	0.065^{***}	0.090^{*}	0.128^{**}
$\Delta SPGN_t$	0.303^{*}	0.406^{*}	-0.083	0.251^{*}	0.279^{*}	0.465^{*}	0.033	0.207^{*}	0.408^{*}	0.102^{*}	0.191^{*}	0.072^{***}
Adjusted R^2	0.445 [2.018]	0.269 [2.177]	0.221 [2.053]	0.650 [2.004]	0.366 [2.126]	0.391 [2.080]	0.005 [2.012]	0.500 [2.039]	0.509 [2.042]	0.129 [2.117]	0.354 [2.108]	0.091 [2.004]
$\Delta FPR_{c,t} = a_0 + \sum_{i=1}^{p} b_i\ FPR_{c,t-i} + \sum_{i=0}^{m} c_i^{+} \Delta SPGP_{r,t-i} + \sum_{i=0}^{n} c_i^{-} \Delta SPGN_{r,t-i} + \lambda^{+}\ ECMP_{t-1} + \lambda^{-}\ ECMN_{t-1} + \varepsilon_t$												
ΔFPR_{t-1}	0.511^{*}	0.429^{*}	-0.086	0.485^{*}	0.316^{*}	0.597^{*}	0.039	0.548^{*}	0.117^{*}	0.490^{*}	0.840^{*}	0.180^{**}
ΔFPR_{t-2}	-	-	-0.073^{**}	-	-	-	-	-	-	-	-	-
$\Delta SPGP_t$	0.208^{*}	0.190^{*}	0.200^{*}	0.221^{*}	0.223^{*}	0.157^{*}	-0.022	0.139^{*}	0.191^{*}	0.014	0.077^{*}	0.071^{**}
$\Delta SPGN_t$	0.169^{*}	0.177^{*}	0.188^{*}	0.138^{*}	0.149^{*}	0.215^{*}	0.012	0.120^{*}	0.195^{*}	0.027^{**}	0.136^{*}	0.058^{**}
$\Delta SPGN_{t-1}$	-	-	-	-	-	-	-	-	-	-	-	0.068^{*}
$ECMP_{t-1}$	-0.648^{*}	-0.594^{*}	-0.140^{***}	-0.598^{*}	-0.629^{*}	-0.587^{*}	-0.126^{***}	-0.504^{*}	-0.619^{*}	-0.260^{*}	-0.741^{*}	0.181^{**}
$ECMN_{t-1}$	-0.630^{*}	-0.805^{*}	-0.152^{**}	-0.353^{*}	-0.536^{*}	-0.733^{*}	0.060	-0.435^{*}	-0.276^{*}	-0.028	-0.924^{*}	-0.233^{*}
c	-0.001	-0.002	-0.000	-0.001^{**}	-0.001	0.001	0.002^{**}	0.000	0.001^{***}	0.001^{**}	0.000	-0.001
Adjusted R^2	0.459 [2.018]	0.258 [2.176]	0.220 [2.014]	0.614 [2.071]	0.332 [2.164]	0.421 [2.073]	0.001 [2.005]	0.480 [2.015]	0.487 [2.038]	0.204 [2.128]	0.387 [1.975]	0.102 [1.977]

Notes: The numbers in square brackets refer to the Durbin Watson statistic. ***, ** and * denotes significance at 0.10, 0.05 and 0.01 respectively. **Source**: Authors' elaboration

Table A$_3$: Computed Wald tests of asymmetric responses final price (retail segment)

Country	***$\lambda^+ = \lambda^-$ (Symmetric adjustment speeds)***	***$\alpha^+ = \alpha^-$ (price asymmetry)***
	FPR = f(SPG)	
Austria	-0,16 (0,87)	7,87** (0,00)
Belgium	2,34** (0,02)	0,40 (0,69)
Finland	0,13 (0,90)	0,28 (0,78)
France	-2,47* (0,01)	5,01** (0,00)
Germany	-1,00 (0,32)	2,61** (0,01)
Greece	1,22** (0,22)	-1,68*** (0,09)
Ireland	-1,98** (0,05)	-0,79 (0,43)
Italy	-0,65 (0,52)	1,05 (0,30)
Netherlands	-3,50* (0,00)	-0,19 (0,85)
Portugal	-2,47* (0,01)	-0,59 (0,55)
Spain	1,58 (0,11)	-2,60* (0,01)
United Kingdom	4,94* (0,00)	0,31 (0,76)
United States	-	-
	FPRV = f(SPG)	
Austria	0,00 (0,99)	1,54 (0,12)
Belgium	2,01** (0,05)	0,55 (0,58)
Finland	0,12 (0,90)	0,48 (0,63)
France	-1,92** (0,05)	4,58* (0,00)
Germany	-1,05 (0,29)	2,60* (0,01)
Greece	-0,08 (0,93)	-1,76 (0,08)
Ireland	-2,08** (0,04)	-0,77 (0,44)
Italy	-0,66 (0,51)	0,90 (0,37)
Netherlands	-3,43* (0,00)	-0,23 (0,82)
Portugal	-1,58 (0,12)	-0,63 (0,53)
Spain	-1,94** (0,05)	-2,99* (0,00)
United Kingdom	4,55* (0,00)	0,35 (0,73)
United States	-	-
	FPREX = f(SPG)	
Austria	-1,34 (0,18)	3,13* (0,00)
Belgium	3,15* (0,00)	-0,32 (0,75)
Finland	0,75 (0,46)	0,55 (0,58)
France	-3,53* (0,00)	5,80* (0,00)
Germany	0,07 (0,97)	2,44* (0,01)
Greece	3,36* (0,00)	-2,34** (0,02)
Ireland	-2,32** (0,02)	-0,84 (0,40)
Italy	0,50 (0,62)	1,10 (0,27)
Netherlands	-3,26* (0,00)	-0,28 (0,78)
Portugal	0,12 (0,90)	-0,66 (0,51)
Spain	1,22 (0,22)	-2,69* (0,01)
United Kingdom	4,58* (0,00)	0,68 (0,50)
United States	-	-

Notes: ***, ** and * denotes significance at 0.10, 0.05 and 0.01 respectively. The numbers in parenthesis are the asymptotic P- values.

Source: Authors' elaboration

References

Asplund, M. Erikson, R. Friberg, R. (2000). Price adjustments by a retail gasoline chain. *Scandinavian Journal of Economics*, Vol 102, pp. 101-121.

Bacon, RW. (1991). Rockets and Feathers: The asymmetric speed of adjustment of UK retail gasoline price to cost changes. *Energy Economics*, Vol. 13, pp. 211-218.

Balke, NS. Brown, SPA. Yücel, MK. (1998). Crude oil and gasoline prices: An asymmetric relationship. *Economic Review*, pp. 2-11.

Bermingham, C. and O' Brien, D. (2010). Testing for asymmetric pricing behaviour in Irish and UK petrol and diesel markets, *Research Technical Paper*, Central Bank and Financial Services Authority of Ireland.

Bettendorf, L. Van der Geest, A. Varkevisser, M. (2003). Price asymmetry in the Dutch retail gasoline market, *Energy Economics*, Vol. 25, pp. 669-689.

Borenstein, S. (1991). Selling costs and switching costs: explaining retail gasoline margins. *Rand Journal of Economics*, Vol. 22, pp. 354-369.

Borenstein, S. Cameron, CA. Gilbert, R. (1997). Do gasoline prices respond asymmetrically to crude oil price changes? *Quarterly Journal of Economics*, Vol. 12, pp. 305-339.

Brown, SPA. Yucel, MK. (2000). Gasoline and crude oil prices: Why the asymmetry? *Economics and Financial Review*, pp. 23-29.

Christopoulos, D K. and Tsionas, E G. (2003). A reassessment of balance of payments constrained growth: Results from panel unit root and panel cointegration tests, *International Economic Journal*, Vol. 17, pp. 39 – 54.

Clerides, S. (2010**).** Retail Fuel Price Response to Oil Price Shocks in EU Countries, *Cyprus Economic Policy Review*, Vol. 4, No. 1, pp. 25-45.

Dickey DA, Fuller WA (1981) The likelihood ratio statistics for autoregressive time series with a unit Root. *Econometrica* Vol. 49, pp. 1057– 1072.

Duffy-Deno, KT. (1996). Retail price asymmetries in local gasoline markets. *Energy Economics*, Vol. 18, pp. 81-92.

European Commission, Directorate General Economic and Financial Affairs (2009) Pass Through from Crude Oil Prices to Consumer Prices of Fuels.

Fafaliou, I. and Polemis, M. (2011). Market power in oil industry: the wholesale and retailing case'. *Economics and Finance Notes* Vol. 1, No. 1, pp.1-18.

Faber, R. (2009). Asymmetric price responses of gasoline stations: evidence for heterogeneity of retailers, *Tinbergen Institute Discussion Paper* 2009-106/1.

Frey, G. Manera, M. (2007). Econometric models of asymmetric price transmission. *Journal of Economics Survey*, Vol. 21, pp. 259-325.

Galeotti, M. Lanza, A. Manera, M. (2003). Rockets and feathers revisited: an international comparison on european gasoline markets. *Energy Economics*, Vol. 25, pp. 175-190.

Godby, R. Lintner, AM. Stengos, T. Wandschneider, B. (2000). Testing for asymmetric pricing in the canadian retail gasoline market. *Energy Economics*, Vol. 22, pp. 349-368.

Grosso, M. Manera, M. (2007). Asymmetric error correction models for the oil-gasoline price relationship. *Energy Policy*, Vol. 35, pp. 156-177.

Johansen, S. (1992). Cointegration in partial systems and the efficiency of single-equation analysis. *Journal of Econometrics,* Vol. 52, pp. 389– 402.

Kao, C. (1999). Spurious regression and residual-based tests for cointegration in panel data', *Journal of Econometrics*, Vol. 90, pp. 1–44.

Kaufmann, RK. Laskowski, C. (2005). Causes for an asymmetric relation between the price of crude oil and refined petroleum products. *Energy Policy*, Vol. 33, pp. 1587-1596.

Kirchgässner, G. Kübler, K. (1992). Symmetric or asymmetric price adjustment in the oil market. *Energy Economics*, Vol. 14, pp. 171-185.

Kuper, G. and Poghosyan, T. (2008). Non-Linear Price Transmission between Gasoline Prices and Crude Oil Prices, Working Paper, University of Groningen.

Manning, DN. (1991). Petrol prices, oil price rises and oil price falls: some evidence for the UK since 1972, *Applied Economics*, Vol. 23, pp. 1535-1541.

OFT (1998) Competition in the supply of petrol in the UK, A report by the Office of Fair Trading, OFT 230.

Polemis, M. (2011). Competition and price asymmetries in the Greek oil sector: An empirical analysis on gasoline market, Empirical Economics, published online: 10 September 2011, DOI 10.1007/s00181-011-0507-7.

Polemis, M. and Fotis, P. (2011). Gasoline Price Asymmetries in the Euro Zone, MPRA, Working Paper No. 32755.

PÖYRY (2009) Survey of the competitive aspects of oil and oil product markets in the EU. A report to Directorate-General Energy and Transport of the European Commission.

Radchenko, S. (2005). Oil price volatility and the asymmetric response of gasoline prices to oil price increases and decreases. *Energy Economics*, Vol. 27, pp. 708-730.

Reilly, B. Witt, R. (1998). Petrol price asymmetries revisited. *Energy Economics*, Vol. 20, pp. 297-303.

Stock, J.H, Watson M.W (2003) Introduction to econometrics Addison Wesley, Boston.

Stock, J.H (1987) Asymptotic properties of least squares estimators of co-integrating vectors. Econometrica 55, pp. 1035–1056.

Valadkhani, A. (2009) Do retail petrol prices rise more rapidly than they fall in Australia's capital cities? *University of Wollongong Economics Working Paper* 09-08.