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THE DETERMINANTS OF GREECE'S EXPORT SUPPLY OF OIL

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ABSTRACT

In the last fifteen years or so Greece has emerged as an important exporter of refined oil products, which led to an increase of its share in total world exports as well as to the improvement of the country's oil balance and overall current account. This paper presents an empirical investigation of the factors that determine Greece's oil export supply contributing to the improvement of the country's export performance. The analysis focuses on the supply side considering the traditional specification of the imperfect substitute model by Goldstein and Khan, which is augmented by introducing the role of investment in the sector. The empirical estimation involves the cointegration methodology, distinguishing between long-run and short-run effects. The findings show that there exist significant stable cointegrating relationships across the traditional and the augmented specifications as well as short-run effects. Investment activity by the oil companies has been an enhancing factor of the sector's exports, revealing itself in linear and non-linear form. Furthermore, significant long-run and short-run effects stem from domestic demand and the refining margin. In particular, the negative effect of domestic demand reflects primarily the impact of the recession on oil exports. That is, falling domestic demand necessitates the channelling of excess supply to external markets, thereby mitigating the adverse effects of the recession.

Keywords: refined oil, export supply, export performance, investment in the oil sector, cointegration, recursive estimation, VECM

JEL classification: F4, C51

ΟΙ ΠΡΟΣΔΙΟΡΙΣΤΙΚΟΙ ΠΑΡΑΓΟΝΤΕΣ ΤΗΣ ΠΡΟΣΦΟΡΑΣ ΕΞΑΓΩΓΗΣ ΠΕΤΡΕΛΑΙΟΥ ΤΗΣ ΕΛΛΑΔΟΣ

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ΠΕΡΙΛΗΨΗ

Τα τελευταία 15 περίπου χρόνια η Ελλάδα έχει εξελιχθεί σε σημαντικό παραγωγό προϊόντων διυλισμένου πετρελαίου και έχει αυξήσει το μερίδιό της στις παγκόσμιες εξαγωγές διυλισμένου πετρελαίου, γεγονός που οδήγησε στη βελτίωση του πετρελαϊκού ισοζυγίου της χώρας και του συνολικού ισοζυγίου τρεχουσών συναλλαγών. Το παρόν άρθρο παρουσιάζει μια εμπειρική διερεύνηση των παραγόντων που καθορίζουν την προσφορά εξαγωγής πετρελαίου στην Ελλάδα συμβάλλοντας στη βελτίωση των εξαγωγικών επιδόσεων της χώρας. Η ανάλυση επικεντρώνεται στην πλευρά της προσφοράς, υιοθετώντας την παραδοσιακή προσέγγιση του υποδείγματος ατελούς υποκατάστασης Goldstein-Khan, το οποίο διευρύνεται με την εισαγωγή του ρόλου των επενδύσεων στον κλάδο. Η εμπειρική εκτίμηση περιλαμβάνει τη μεθοδολογία συνολοκλήρωσης που διακρίνει μεταξύ μακροχρόνιων και βραχυχρόνιων επιδράσεων. Τα ευρήματα δείχνουν ότι υπάρχουν σημαντικές μακροχρόνιες σταθερές σχέσεις μεταξύ των μεταβλητών της παραδοσιακής και της επαυξημένης εξειδίκευσης, καθώς και βραχυχρόνιες επιδράσεις. Από τα αποτελέσματα της εμπειρικής ανάλυσης αναδεικνύεται η σημασία των επενδύσεων ως κινητήριου μοχλού της ανταγωνιστικότητας του κλάδου, εξηγώντας σε σημαντικό βαθμό τα υψηλότερα επίπεδα εξαγωγών. Επιπρόσθετα, σημαντικό ρόλο στη διαμόρφωση της προσφοράς διυλισμένου πετρελαίου στη διεθνή αγορά διαδραματίζουν το ύψος της εγχώριας ζήτησης και το περιθώριο διύλισης. Η αρνητική επίδραση της εγχώριας ζήτησης που διαπιστώνεται αποτελεί πρωτίστως επίπτωση της ύφεσης και οδηγεί στη διοχέτευση της πλεονάζουσας προσφοράς στις αγορές του εξωτερικού. Αυτό έχει αποτέλεσμα τη βελτίωση του εμπορικού ισοζυγίου και συντελεί στο μετριασμό των αρνητικών επιπτώσεων από την κάμψη της εγχώριας ζήτησης.

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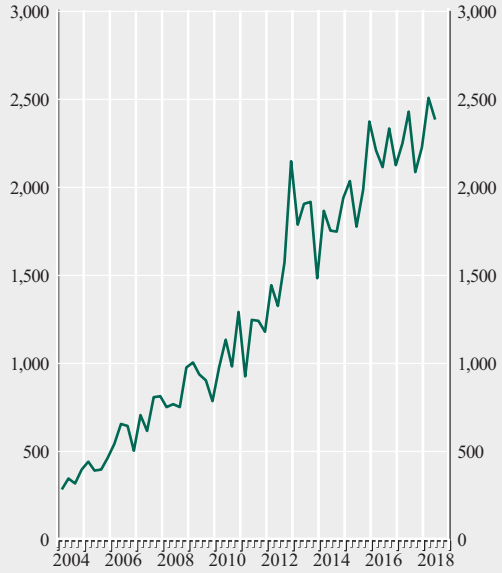
I INTRODUCTION

Greece is not a major oil or energy producing country, at least not as yet. But in the last fifteen years or so the country has emerged as an important exporter of refined oil products. That is, the Greek oil sector imports crude oil and through proper processing produces refined petroleum products, which it then makes available to domestic and foreign markets. By 2018, Greece more than doubled its share in total world exports of refined oil to 1.5% (corresponding to a value of about €11 billion), from 0.67%, or about €1 billion, in 2001.[1] This led to an improvement of the country's ranking among the world's top exporters of distilled oil by 18 places, to 19th from 37th in 2001 out of a total of 232 countries. The improvement in oil export performance had started taking place even before the outbreak of the Greek economic crisis but accelerated further during the economic downturn, as the decline in domestic demand made more urgent the need for expansion into international markets.

Chart 1 Real exports of distilled oil (2004:Q1-2018:Q2)

(EUR millions, 2010=100, seasonally adjusted data)



Sources: ELSTAT and Eurostat, SITC code 33.
Note: The series is deflated by the producer price index for exports of distilled oil, NACE code 19 from Eurostat.

The upward trend of the country's oil exports is clearly shown in Chart 1. Furthermore, according to Chart 2, exports of oil as a percentage of oil imports rose gradually from about 15% at the beginning of the past decade to almost 66% at the end of 2018. This had a favourable impact on the country's oil balance, as the corresponding deficit has been following a downward trend, thereby contributing to an overall improvement in the country's current account balance. Chart 3 depicts this decline in Greece's oil deficit, observed especially during the years of the economic crisis. Greece exports distilled oil primarily to countries outside the European Union (EU). The most important destinations during 2014-2018, on average, include Turkey, Egypt and Lebanon, while Italy and Cyprus represent the main destinations within the EU (see Chart 4).

This major shift of the refined oil industry towards foreign markets, although necessitated by the economic crisis, has undoubtedly been the result of a conscious strategic decision. This is confirmed by the substantial increase in investment planned in the industry[2] and which,

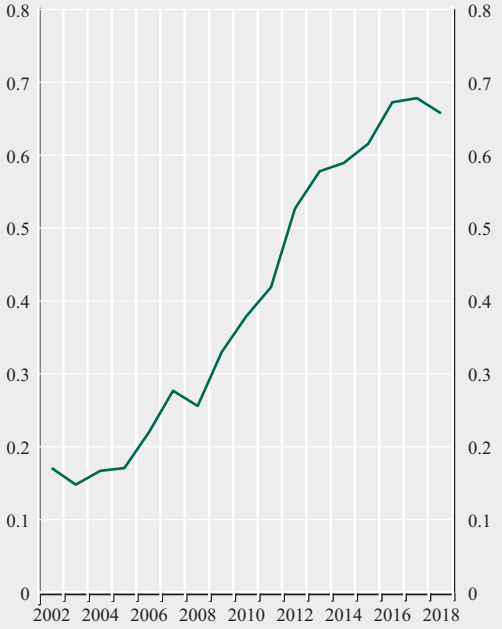
* The views expressed in this article are those of the authors and do not necessarily reflect those of the Bank of Greece. Any errors or omissions are the authors' responsibility.

1 Own calculations using data from the International Trade Center, Trade Map database (accessed in March 2019).

2 In this regard, see the Hellenic Petroleum's CEO announcement that the company's capital expenditure was expected to reach €2 billion for the 2006-2010 period (interview to Bloomberg, December 2005).

Chart 2 Oil exports (as a percentage of oil imports) (2002-2018)

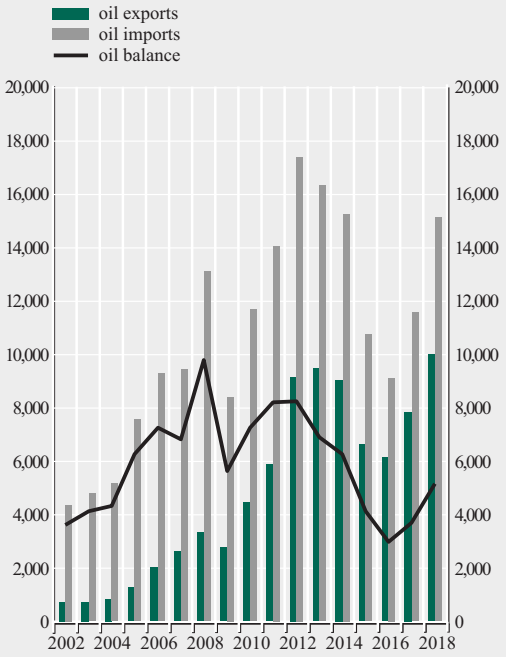
(%)



Source: Bank of Greece, Balance of Payments Statistics.

Chart 3 Oil exports, oil imports and oil balance (2002-2018)

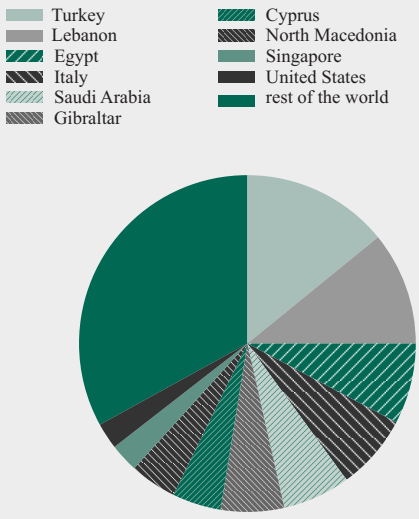
(EUR millions)



Source: Bank of Greece, Balance of Payments Statistics.

Chart 4 Destinations of Greece's exports of distilled oil (2014-2018)

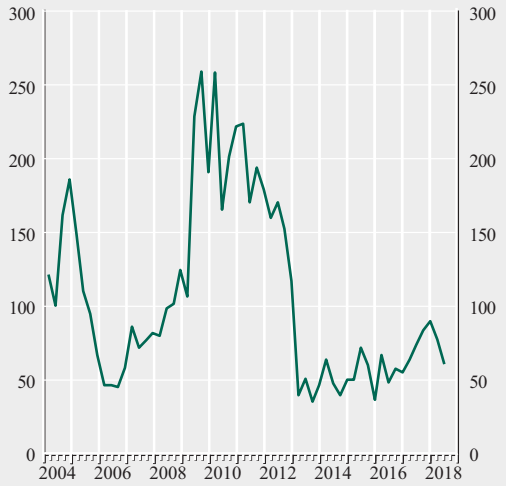
(period averages)



Source: Eurostat, SITC series 33.

Chart 5 Real investment in the Greek oil industry (2004:Q1-2018:Q2)

(EUR millions, at constant 2010 prices, seasonally adjusted)



Sources: Reuters (sum of capital expenditure of ELPE and MOTOR OIL from cash flows) and ELSTAT, National Accounts.
Note: Nominal values have been converted to real using the business expenditure deflator excluding housing and public investment.

as shown in Chart 5, did materialise primarily during the 2008-2012 period. This led to considerable technological upgrading and renewal of the industry's infrastructure and constituted the main driving force that made the shift possible and successful.

The present study attempts to estimate an export supply function for the Greek oil sector, aiming to identify the factors that determine and contribute to export activity. As pointed out and shown in Chart 2, the domestic market initially was the primary target of the oil sector, while exports represented only a small part of the overall supply. Gradually, however, exports became a strategic priority and this policy switch was accelerated further as a result of the economic crisis, while it was facilitated by higher investment. It is therefore important to independently assess and estimate the supply of Greece's refined oil exports. The empirical approach adopted is time series analysis which suggests the estimation of a long-run equation, as well as the dynamics of export supply where the short-term adjustment is compared with the longer-term adjustment, which is important from a policy perspective.

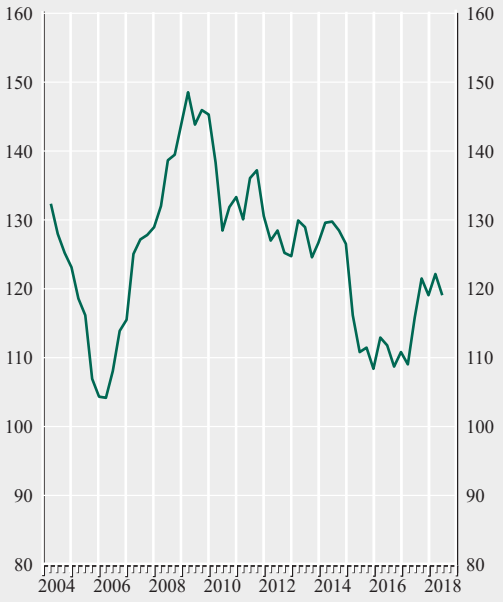
The paper is structured as follows: Section 2 discusses issues concerning the structure of the Greek oil sector, while Section 3 provides a review of the relevant literature. In Section 4 the theoretical and empirical models are specified. Section 5 presents and discusses the estimation results. Finally, Section 6 provides the conclusions and policy recommendations.

2 THE STRUCTURE OF THE REFINING SECTOR IN GREECE

Two refining companies are active in the oil refining sector in Greece, forming an oligopoly (duopoly). These are Hellenic Petroleum S.A. (ELPE), which is the largest, accounting for 57% of the country's refining capacity, and Motor Oil Hellas S.A., accounting for the remaining 43%, while, taken together, the two companies own four refineries. The companies buy raw materials (different types of crude oil and feedstock) from Saudi Arabia, Iraq, Libya, Iran and Russia and after proper processing they supply refined products (gasoline, diesel oil, fuel oil, jet fuel, etc.).

Chart 6 Refining margin in the oil industry (2004:Q1-2018:Q2)

(index, 2010=100, seasonally adjusted)



Sources: Eurostat, ELSTAT, US Energy Information Administration and Bank of Greece.
Note: Ratio of producer price index regarding exports of distilled oil, NACE code 19, to real crude oil spot price index (UK Brent spot price index converted to euro with the euro-dollar exchange rate and divided by the Greek implicit GDP deflator).

During the past decade, the oil industry experienced a sharp decline in both domestic and foreign (particularly European) demand, as well as low refining margins resulting from increasing input prices (crude oil prices were rising in the mid-2000s) and financing costs (see Chart 6). This necessitated a reorientation of oil exports towards new markets, mostly outside the EU, with the favourable results described above. As already mentioned, the main export destinations of Greek oil exports are reported in Chart 4.

In order to achieve this successful reorientation of exports, the oil sector undertook significant investment to modernise and upgrade its facilities. According to quarterly cash-flow data reported by Reuters, investment activity, approximated by capital expenditure, reached about €1 billion on a yearly average in the 2008-2012 period, while it averaged close to half a billion during the 2004-2017 period. Note that this was observed in contrast to the drastic reduction of total investment spending in Greece during the years of the economic crisis.[3]

The resulting remarkable improvement in the sector's export performance and its favourable impact on the country's trade deficit justify the importance of studying the export supply-side factors affecting the oil sector.

3 REVIEW OF THE LITERATURE

Empirical trade literature has traditionally exploited aggregate data and has less dealt with detailed data on a single sector. Despite the crucial relevance of sound trade elasticity estimates regarding the oil sector, which are useful for policy advice, scholarly research is scarce, even more so on the supply side of exports. A number of empirical studies dealing with Greece's aggregate exports exist and usually estimate aggregate demand through gravity models (see Papazoglou 2006) to examine export performance. At the moment, trade literature tells us little about the influence of factors on the exports of Greece's specific sectors, including the oil sector.

Aggregate export supply has been considered by Goldstein and Khan (1985), who review the international literature on, and estimate a supply function of, aggregate exports simultaneously with demand for eight large countries using the "imperfect substitutes" assumption. According to them, imports or exports are not complete substitutes for a country's domestic production. Export supply, based on this assumption, is determined by productive capacity, relative prices and input costs.

A relevant body of literature uses and augments this theoretical background in different aspects to estimate aggregate export supply functions for specific developing countries. In Utkulu et al. (2004), technological progress is a key determinant of Turkey's export supply, while relative prices are not important. Sajjad and Mahmood (2014) estimate an "augmented" export supply for South Asian economies and find significant effects from less traditional factors such as corruption and energy. Finally, Moniruzzaman et al. (2011) find a significant long-run relationship for aggregate export supply for Bangladesh, introducing real gross capital formation along with "traditional" variables such as relative prices and real GDP and a dummy variable for trade liberalisation in that country. They show that relative prices do not have a significant effect and that Bangladesh, given its small size, is a "price taker" in the international markets. The most significant variable is gross capital formation, indicating the importance of investment.

4 METHODOLOGY – THEORETICAL AND ECONOMETRIC SPECIFICATION

With regard to the theoretical specification of the link between exports of oil and supply-side factors, we draw evidence from Goldstein and Khan's approach and augment it by adding supply-side variables from the literature of aggregate export supply estimation. Oil firms export an (x^s) amount of their product based on price signals expressed by relative prices or else profitability or refining margins formed in this market (p_x/p_c). The refining margin is derived as the ratio of export prices received in foreign markets to the price or cost of the input, in which case crude oil. A supply-side variable that has attracted interest in previous

3 Investment in domestic manufacturing fell by about 12% between 2004 and 2017.

aggregate export supply estimations refers to real investment (i) in the sector and is introduced to augment the Goldstein and Khan's approach. Given the abovementioned observed growth in investment by the Greek oil refining firms, we expect that particular variable to exert a significant impact. Finally, real GDP at constant prices is introduced as a proxy to capture the effect of domestic demand pressures on the market. The equation to be estimated is specified in log-linear form as follows:

$$x_t^s=\beta_1+\beta_2 (p_x/p_c)+\beta_3 y+\beta_4 i, \quad (1)$$

where p_x is the export price of refined oil and p_c the UK Brent crude oil price, i is the level of real investment in the oil sector and y captures the level of real GDP.

In addition, a quadratic –with respect to investment– functional form of (1) was estimated alternatively to capture non-linearities in the effect of investment on export growth:

$$x_t^s=\beta_1+\beta_2 (p_x/p_c)+\beta_3 y+\beta_4 i+\beta_5 i^2 \quad (2)$$

The econometric specifications given by equations (1) and (2) are estimated as the long-run relationships. The Error Correction Model (ECM) representation conditional on (1) or (2) is the following:

$$\Delta x_t^s=\beta_1+\beta_2 \ \Delta x_{t-1}^s+\beta_3 \ \Delta z_{t-1}\ldots+\beta_{2k} \ \Delta x_{t-k+1}^s+ \beta_{3k}\Delta z_{t-k+1}+ \alpha_x(x_{t-k}^s-\beta_x' \ z_{t-k})+u_t \quad (3)$$

where β_x is a nxr matrix of the coefficients of the variables in the long-run relationship (cointegration vectors) and α_x is a nxr matrix of the loadings of the cointegrating vectors representing the error correcting speed of adjustment towards long-run equilibrium, r is the number of cointegrating vectors, n is the number of variables, k is the lag length of the VECM, and z_t is a vector consisting of the explanatory supply-side variables of the long-run relationship.

Data sources are described in the Appendix.

Table 1 Unit root tests

Variable	Levels	First differences
x^s	-2.503 (-2.917)	-6.607* (-2.917)
p_x/p_c	-1.505 (-2.914)	-5.765* (-2.915)
i	-1.990 (-2.914)	-8.621* (-2.915)
y	-0.356 (-2.914)	-1.948** (-1.613)

Source: Authors' own estimations.
Notes: One (two) asterisk(s) indicate(s) rejection of the null at 5% (10%) level of significance. The critical values for the ADF tests are those tabulated by MacKinnon (1991). The appropriate lag length of 10 maximum was selected in each case on the basis of the modified Swarz Criterion.

5 ESTIMATION RESULTS

5.1 TIME SERIES CHARACTERISTICS AND UNIT ROOT TEST

The time series used in this paper are at a quarterly frequency covering the period 2004:Q1-2018:Q2. Real exports of oil are increasing throughout the period, while real GDP is decreasing. The refining margin in the oil sector increases until 2009 and falls thereafter. Finally, real investment has a non-linear trend, increasing after 2008, reaching a peak in 2010 and then decreasing while remaining elevated between 2008 and 2012. This indicates the possibility of the existence of a non-linear export supply function.

In order to apply cointegration tests on the specified model, the unit root properties of the series have to be examined. The Augmented Dickey-Fuller test, which is the most widely used method, is adopted. Based on the results presented in Table 1, we fail to reject the null hypothesis of a unit root for the series in equation (1) version at 5% level of significance. Conversely, the above hypothesis is rejected when the variables are in first differences. Thus, the series are integrated of order one I(1).

Table 2 Johansen's ML test for the number of long-run relationships

		Linear	Non-linear	5% critical values
		Statistics		
		Trace		
r=0	r≥1	60.43*	78.17*	54.64
r≤1	r≥2	33.04	50.86*	34.55
r≤2	r≥3	14.22	28.24	18.17
		Maximal eigenvalue		
r=0	r=1	27.39	27.31	30.33
r≤1	r=2	18.82	22.62	23.78
r≤2	r=3	9.58	17.26	16.87

Source: Authors' own estimations.
Note: Tests are corrected for small sample bias.
* 5% significance.

5.2 COINTEGRATION ANALYSIS

In the analysis suggested by the Johansen multivariate cointegration procedure which is adopted (Johansen 1988, Johansen and Juselius 1990), the order of the VAR (the lag length) has to be determined. The Akaike Information Criterion and the Final Prediction Error (FPE) were applied to models (1) and (2) choosing the lag length where the criterion is minimised. The results are mixed for both the linear and the non-linear specifications. According to the former criterion, a VAR(1) is best and, based on the latter, a VAR(4) should be chosen. However, an inspection of the diagnostic statistics for both specifications shows that autocorrelation and heteroscedasticity are violated for lags lower than four.[4] A VAR(4) is thus chosen to be estimated for both specifications, which also seems reasonable given the quarterly frequency of the data.

The analysis continues with the determination of the number of the long-run relationships. Table 2 presents the results of the cointegration tests based on the trace and maximum eigenvalue statistics, first for the linear specification (the traditional and the augmented versions) and then for the non-linear quadratic equation. Proceeding sequentially, the hypothesis of no long-run relationship is tested. If rejected, the hypothesis of the existence of one or more long-run relationships is tested until there is no longer rejection. The likelihood ratio test statistics are corrected for sample size by multiplying the test statistic by (T-number of estimated parameters)/T, as discussed in Ahn and Reinsel (1992). Also, a deterministic logarithmic trend is incorporated in the estimation, which is included in the long-run vector under the linear model and in the short-run dynamics under the non-linear one. According to the trace statistic, there is one significant long-run relationship among the variables in equation (1) regarding both linear and non-linear specifications at 5% level of significance. The maximum eigenvalue statistic fails to reject the null hypothesis of non-existence of a long-run vector. Since the results are inconclusive, we consider other tests to validate the existence of one long-run relationship. The smaller size of the second eigenvalue, which is significantly smaller than the first in the case of the linear model, supports this argument. Moreover, since it has been shown that the trace test's power is superior to that of the

4 Non-normality is only present at VAR(4), which becomes insignificant at 1%.

Table 3 Cointegrating vectors

	Linear		Non-linear
x^s	1	1	1
p_x/p_c	0.612 (2.623)	1.401 (2.812)	0.687 (2.375)
i	-	0.360 (3.579)	2.261 (2.903)
i^2	-	-	-0.227 (-2.671)
y	-1.314 (-5.916)	-2.575 (-5.368)	-2.104 (-8.060)
log (trend)	-	0.587 (6.991)	-
		Alpha (short-run dynamics)	
Δx^s	-0.950 (3.848)	-0.726 (4.347)	-0.591 (-3.294)
$\Delta(p_x/p_c)$	0.081 (1.145)	0.091 (1.961)	0.116 (2.265)
Δi	-	0.658 (1.718)	1.133 (2.828)
Δi^2	-	-	10.06 (2.834)
Δy	0.065 (2.009)	0.031 (1.433)	0.009 (0.373)

Source: Authors' own estimations.
Note: t-statistics are in parentheses, logarithmic trend is included in the short-run dynamics in the linear equation without investment and in the non-linear equation.

maximum eigenvalue tests,[5] it is reasonable to conclude that one cointegrating relationship exists also in the non-linear specification. Thus, the rank is one in all specifications.

Table 3 reports the estimated Johansen long-run elasticities and their t-statistics after normalising on real exports. The first column gives the estimates based on the traditional specification, while the second and the third columns use equations (1) and (2), respectively. The equation-specific adjustment coefficients along with their corresponding t-statistics are also reported in the table. Overall, all the variables in the three specifications have the expected signs and are statistically significantly different from zero at the 5% level. This suggests that in terms of sign and magnitude we have attained estimates that reasonably express the true long-run equilibrium relationships. In all three long-run equations of real exports, the coefficients of the refining margin have a positive sign, indicating that favourable profit opportunities lead to higher supply of oil exports. The sign of real GDP is always negative, suggesting that downturns favour, but upturns discourage, export supply. Finally, there is a positive linear effect from real investment, an increase of which can lead to growing oil exports, and the estimates show that a non-linear effect could also be picked up. The square of real investment is significant with a negative sign, indicating a parabola which means that the rate of change in the effect is declining. This could mean that the effect of infrastructure expenditure may die out and new investment may be soon needed.

The adjustment coefficients in Table 3, which are significant in all three specifications, indicate that exports adjust negatively to a deviation from long-run equilibrium. Near complete adjustment, of 95% within a quarter, occurs in the traditional model, it is lower (73%) in the augmented linear model and it appears even lower (59%) in the augmented quadratic specification. Relative prices and investment absorb part of exports' long-run adjustment (being positive) to errors from equilibrium in the quadratic model, demonstrating endogeneity for these variables. Economic activity's

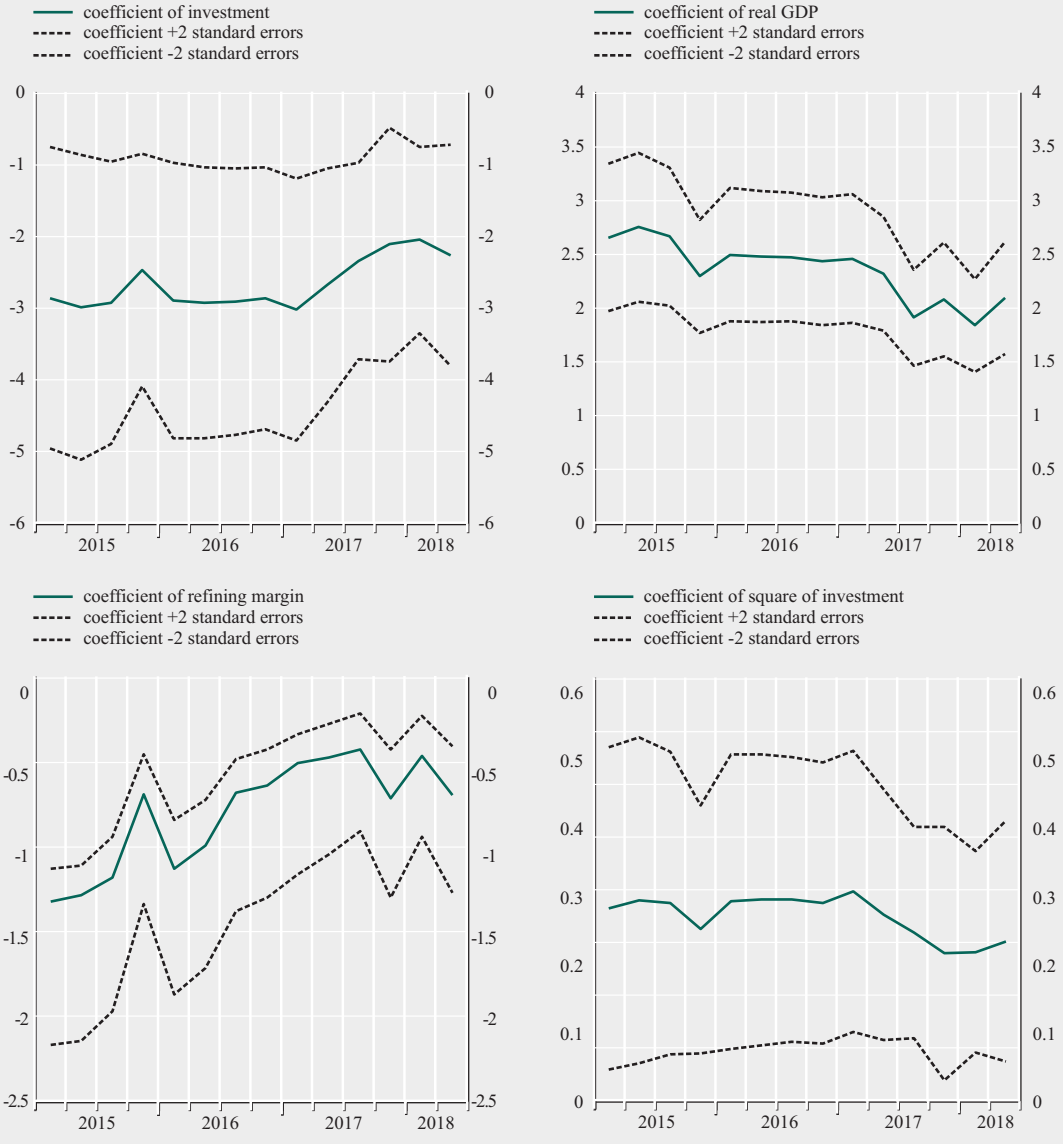
5 See Lütkepohl et al. (2004), where it is stated that it is sufficient to apply exclusively the trace statistic in cointegration analysis.

adjustment is significant and positive, but low in the traditional model.

5.3 CONSTANCY OF THE COINTEGRATION SPACE

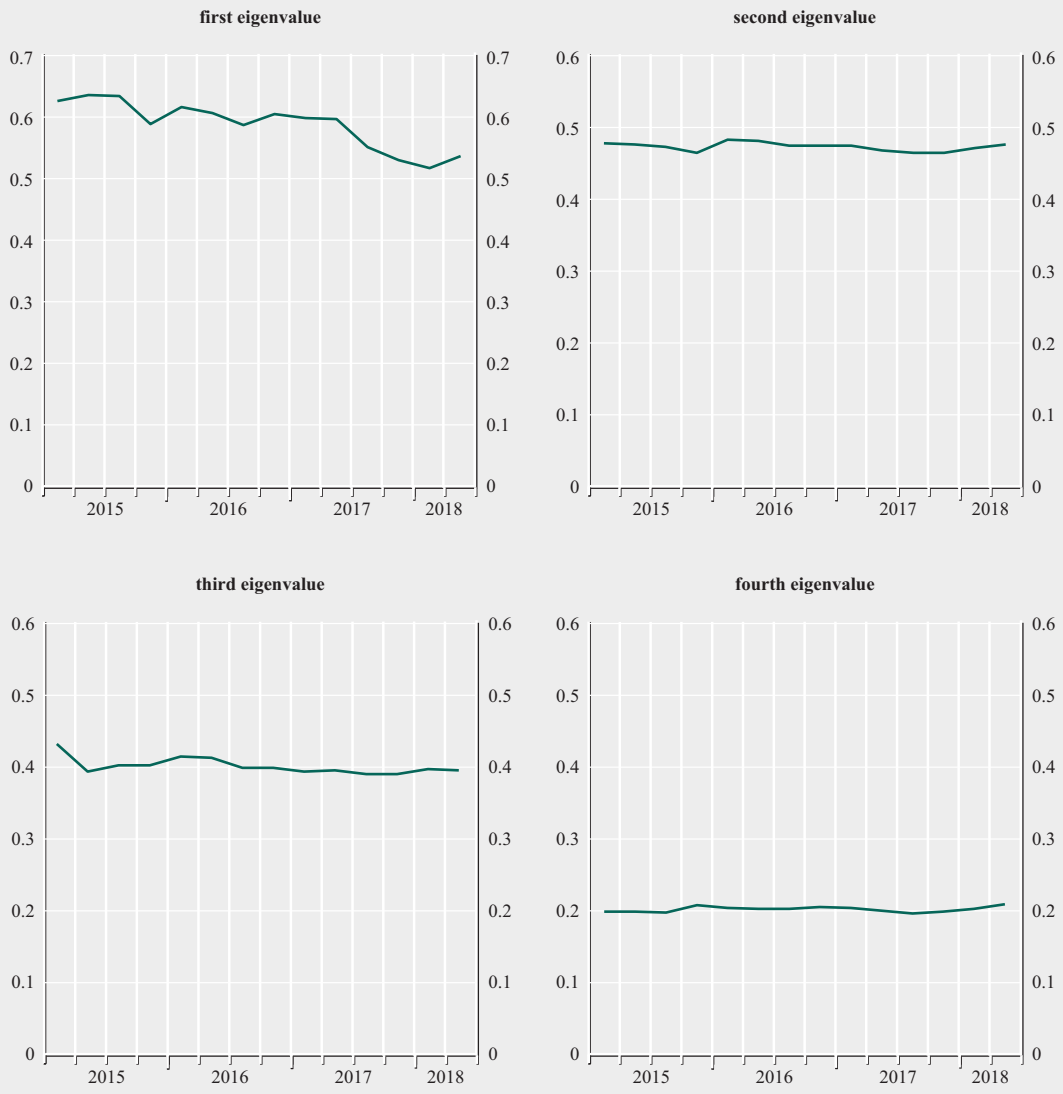
The finding that long-run relationships exist across the three alternative specifications ensures robustness concerning supply-side effects on oil exports. To further strengthen these results, we explore the stability properties of the non-linear augmented equation. The Johansen procedure is applied for the first 48 observations, which is considered as the base period 2004:Q1-2016:Q4 and then is updated recursively, adding one quarter each time. Table 4 shows the recursive trace sta-

Chart 7 Recursive estimation of the long-run coefficients of equation (2) with +/-2 standard error bands (2015:Q1-2018:Q2)



Source: Authors' own estimations.

Chart 8 Recursive eigenvalues of equation (2)
(2015:Q1-2018:Q2)



Source: Authors' own estimations.

tistic and eigenvalues, the recursive long-run elasticities of equation (2) and the resulting number of cointegrating vectors which always remains one. Eigenvalues over the subsamples and the values of the trace statistic are very close. The long-run elasticities of investment, income and relative prices over the subsamples do not present significant dissimilarities from those of the whole sample. Constancy of equation (2) can also be viewed in Charts 7, 8 and 9 that depict recursive tests using the first 40 observations as a base period. The recursive beta coefficients are presented in Chart 7 and exhibit reasonable stability, with the coefficients of investment showing the greatest stability. In Chart 8 the recursive eigenvalues are stable. Finally, the "Max likelihood function" test, which is a test for the overall constancy of the equation, is presented in Chart 9 along with the 95% quantile hori-

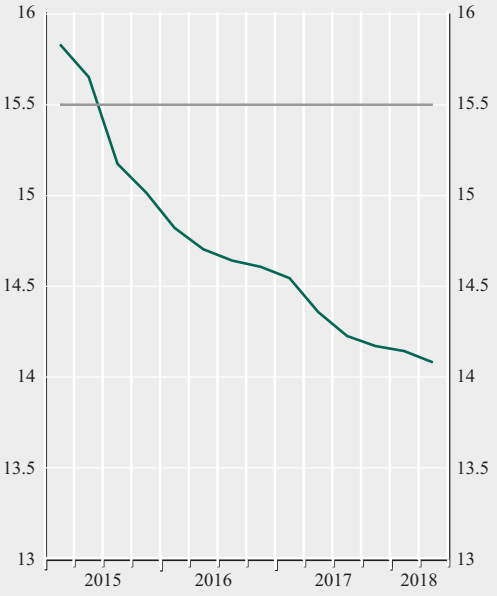
Table 4 Temporal stability tests for the non-linear cointegrating regression

		Trace				Long-run elasticities				
	Size	r=0	r≤1	r≤2	Eigen-values	*i*	i^2	*y*	p_x/p_c	# of vector
2016:Q4	48	76.07	43.95	25.96	0.61	5.22	0.50	-3.26	0.44	1
2017:Q1	49	76.45	42.69	24.05	0.60	5.02	0.49	-3.20	0.47	1
2017:Q2	50	75.29	44.50	25.73	0.60	3.42	0.34	-2.57	0.32	1
2017:Q3	51	69.98	44.51	25.20	0.55	2.42	0.25	-1.91	0.37	1
2017:Q4	52	69.77	45.83	25.87	0.53	2.05	0.20	-2.09	0.72	1
2018:Q1	53	72.85	49.00	28.06	0.52	2.00	0.21	-1.79	0.40	1
2018:Q2	54	76.30	50.16	28.15	0.54	2.26	0.22	-2.10	0.69	1

Source: Authors' own estimations.

zontal line. Since the test statistic is below the line for the whole subsample, constancy is not rejected at 5% level of significance. Thus, these results suggest that there is no significant change in the structure of the long-run parameters and there is constancy in the cointegration space.

Chart 9 Recursive loglikelihood for equation (2) (2015:Q1-2018:Q2)



Source: Authors' own estimations.

5.4 SHORT-RUN DYNAMIC ADJUSTMENT ESTIMATES OF EXPORT SUPPLY

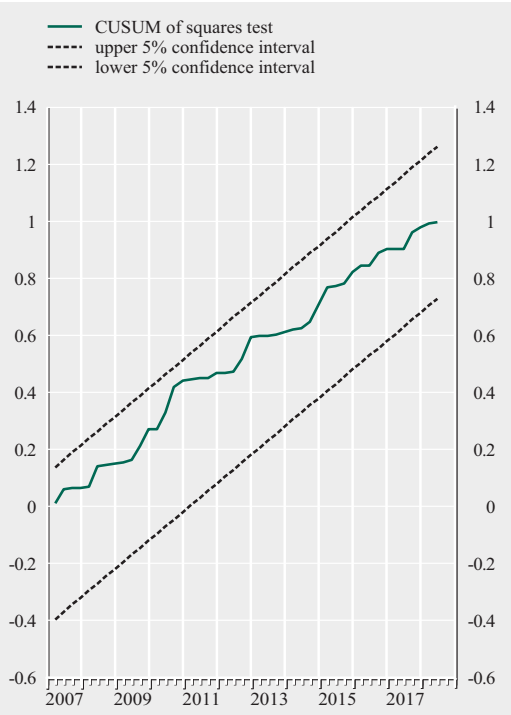
Given the long-run relationships, the conditional short-run error-correction mechanism (ECM) is estimated as expressed in (3) for each of the three models in Section 4.1. The ECMs use the residuals from the long-run relationships lagged once as error-correction terms. The coefficients of the differenced variables are the impact multipliers (short-run effects), and the coefficient of the error-correction term is the short-run adjustment effect showing how any disequilibrium in previous periods affects the adjustment in exports. Since every variable in this equation is stationary, it can be estimated with OLS. Using the general-to-specific methodology by David Hendry, the parsimonious statistically significant short-run estimates are presented in Table 5. The performance of the equations is good and the diagnostic tests find no non-normality, non-autocorrelation or heteroscedasticity. All variables have the correct sign. The size of the investment effect is smaller than that in the long run, but significant. Export growth responds to relative price changes with elasticities close to one and to real income changes with elasticities above one. The effect of the economic cycle is thus important, and an economic downturn may enhance the export supply of oil. Short-run adjustment is negative (stable) and significant.

Table 5 The short-run error correction model

Variable	Linear		Non-linear
		Coefficient	
Constant	0.040 (2.578)	0.051 (3.151)	0.040 (2.532)
Δx^s_{t-4}	-0.405 (-4.284)	-0.377 (-3.767)	-0.363 (-3.678)
$\Delta(p_x/p_c)$	0.779 (1.805)	1.104 (2.398)	0.896 (2.027)
Δi_{t-3}	-	0.101 (1.970)	0.105 (2.070)
Δy_{t-4}	-1.861 (-2.162)	-1.941 (-2.202)	-1.990 (-2.291)
ECT_{t-1}	-0.887 (-6.258)	-0.854 (-5.649)	-0.914 (-5.856)
		Statistics	
Adjusted R^2	0.56	0.55	0.57
Jarque-Bera	1.002 [0.605]	1.195 [0.550]	2.229 [0.328]
LM(4)	1.416 [0.841]	1.228 [0.874]	0.865 [0.929]
ARCH	2.045 [0.727]	1.961 [0.743]	0.977 [0.913]
Ramsey RESET	1.075 [0.305]	0.907 [0.346]	0.580 [0.450]

Source: Authors' own estimations.
Note: t statistics are in parentheses and p-values in brackets.

Chart 10 CUSUM of squares test for stability of the coefficients of the short-run error correction model (2007:Q1-2018:Q2)



Source: Authors' own calculations.

It indicates fast adjustment, which is almost complete within a quarter in all three equations. The highest significance based on t-statistics and the highest adjusted R-square appear in the quadratic equation chosen as the best specified. Chart 10, showing the CUSUM of squares test, verifies stability of the equation assuming quadratic investment effects (the chart is within the 5% error bands).

6 CONCLUSIONS

In this paper we attempted to empirically estimate supply elasticities in the long run and in the short run for the exports of the Greek oil industry. According to the study's estimates, supply-side factors affect export growth in the Greek oil sector both in the long run and in the short run across alternative specifications. The aim is to empirically test for the determinants of the oil sector's exports and derive useful policy conclusions regarding their contribution to rising export performance.

It was successfully shown that there exist significant stable cointegrating relationships

across three alternative specifications, namely one traditional and two augmented ones, exploring the role of investment. With respect to the latter, it was found that real investment activity by the oil companies has been an enhancing factor of the sector's exports during the last fifteen years, revealing itself in linear and non-linear form. That is, from the analysis it became apparent that the shift to foreign markets might not have been as successful without the increased investment activity, which contributed greatly to the improvement and modernisation of the industry's productive capacity.

Furthermore, significant long-run and short-run effects stem from domestic demand and the refining margin. The negative effect of domestic demand reflects primarily the impact of the recession on oil exports. That is, weakening domestic demand necessitated the channelling of excess supply to external markets. This, in turn, contributed to the improvement of the trade balance and provided a way to mitigate the adverse effects of the recession. In addition, the supply of exports responds positively to the refining margin. Greek oil companies act as price takers in the international oil market and simply react positively to changes in the refining margin. According to the non-linear equation, however, the impact of the refining margin appears to be rather weak. As a matter of fact, it appears that the relatively recent decline in the refining margin, which mostly occurred in the 2008-2013 period as a result of the rise in the price of crude oil, did not prevent oil exports from rising. Apparently, the significant improvement in productivity, resulting from increased investment activity, offset the adverse impact stemming from the drop in the refining margin.

From a policy standpoint, the paper reveals primarily the importance of investment in improving the export capacity of the Greek oil industry. More specifically, the expansion to foreign markets was made possible through the improvement of the existing infrastructure of the companies and the introduction of new technologies, which led to an upgrading in the quality of the product. Furthermore, the expansion of existing units and the resulting reduction of production costs, coupled with the achieved compliance with EU legislation, enhanced the industry's capacity to compete internationally by counterweighing any possible negative effects from several adverse exogenous factors such as increases in the international price of crude oil or narrower profit margins. Overall, it could be argued that, although the decline in domestic demand may have necessitated the turn to international markets by the Greek oil industry, it was largely the rise in investment and the subsequent upgrading of the facilities that made such turn feasible.

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APPENDIX

Data description

Variable	Notation	Approximation	Statistical sources
Exports of distilled oil	x^s	Value of exports of distilled oil in EUR millions	ELSTAT and Eurostat, SITC Series 33
Export prices of distilled oil	p_x	Producer price index regarding exports of distilled oil, code 19 NACE Rev. 2	ELSTAT
Real crude oil price	p_c	A real crude oil prices index (the UK Brent index, expressed in US dollars per barrel, chosen as an approximation of crude oil spot prices in Europe, is converted to euro with the euro-dollar exchange rate and divided by the Greek implicit GDP deflator)	US Energy Information Administration (EIA) and ELSTAT
Investment in the oil sector	I	Capital expenditure (in EUR millions) by ELPE and MOTOR OIL, the two Greek oil companies in the sector	Reuters
Investment deflator in the oil sector	p_{inv}	Business investment deflator (available at annual frequency and transformed to quarterly with the Denton interpolation method)	ELSTAT National Accounts
Real investment in the oil sector	i	I is converted to real using the business investment deflator	Own calculations
Greece's real Gross Domestic Product (GDP) at 2010 prices	y	In EUR millions	ELSTAT National Accounts