ENERGY CONSUMPTION BY ENERGY TYPE AND EXPORTS OF GOODS IN GREECE: A COMPARATIVE ANALYSIS IN RELATION TO THE EURO AREA

Ioanna C. Bardakas
Bank of Greece, Economic Analysis and Research Department

ABSTRACT

The rapid expansion of non-oil goods exports in Greece during the last decade contributed to raising net exports, despite the severe economic crisis the country was undergoing. Nevertheless, the EU's overall energy consumption exhibited a downward trend that was even stronger in Greece. This study examines the dynamic relationship between exports of non-energy goods and final consumption of energy in Greece and the euro area (EA) over the last two decades, considering five separate energy types. Single equation and panel estimations are employed, making it possible to compare the results of the two approaches. It is shown that exports of goods in Greece are dependent on final consumption of oil, electricity and renewable energy (RE), while the final consumption of natural gas, oil and electricity has an effect on goods exports in the EA. The largest effect on exports of goods in Greece comes from the consumption of electricity, part of which has been produced from RE in recent years. Greece's goods exports are found to have a higher dependence on RE consumption than the EA's, which is related to the recent higher growth of RE consumption. Statistically significant causal relationships are found between goods exports and the traditional energy types (i.e. oil and natural gas) both in Greece and the EA. The prospects for accelerating the energy transition are not as favourable, following the emergence of the energy crisis. This negative outlook may have consequences on Greece's improved openness and on the rising trajectory of goods exports.

Keywords: energy consumption; exports of goods; vector error correction model; panel estimation

JEL classification: F10; C01; C51

DOI link: https://doi.org/10.52903/econbull20225603

ΚΑΤΑΝΑΛΩΣΗ ΕΝΕΡΓΕΙΑΣ ΑΝΑ ΕΙΔΟΣ ΕΝΕΡΓΕΙΑΣ ΚΑΙ ΕΞΑΓΩΓΕΣ ΑΓΑΘΩΝ ΣΤΗΝ ΕΛΛΑΔΑ: ΣΥΓΚΡΙΤΙΚΗ ΑΝΑΛΥΣΗ ΣΕ ΣΧΕΣΗ ΜΕ ΤΗ ΖΩΝΗ ΤΟΥ ΕΥΡΩ

Ιωάννα Μπαρδάκα
Τράπεζα της Ελλάδος, Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

ΠΕΡΙΛΗΨΗ

Η σημαντική αύξηση των εξαγωγών μη πετρελαϊκών αγαθών στην Ελλάδα την τελευταία δεκαετία συνέβαλε στην αύξηση των καθαρών εξαγωγών, παρά τη σοβαρή οικονομική κρίση που αντιμετώπιζε η χώρα. Ωστόσο, η συνολική κατανάλωση ενέργειας στην Ευρωπαϊκή Ένωση παρουσίασε πτωτική τάση, που ήταν ακόμη εντονότερη στην Ελλάδα. Η παρούσα μελέτη εξετάζει τη δυναμική σχέση μεταξύ των εξαγωγών μη ενεργειακών αγαθών και της τελικής κατανάλωσης ενέργειας για την Ελλάδα και τη ζώνη του ευρώ κατά την περίοδο των δύο τελευταίων δεκαετιών, λαμβάνοντας υπόψη πέντε διαφορετικούς τύπους ενέργειας. Χρησιμοποιούνται δύο εμπειρικές προσεγγίσεις, η απλή εξίσωση και η εκτίμηση με πάνελ, καθιστώντας δυνατή τη σύγκριση των αποτελεσμάτων. Διαπιστώνεται ότι οι εξαγωγές αγαθών στην Ελλάδα εξαρτώνται από την τελική κατανάλωση πετρελαίου, ηλεκτρικής ενέργειας και ανανεώσιμων πηγών ενέργειας (ΑΠΕ), ενώ η τελική κατανάλωση φυσικού αερίου, πετρελαίου και ηλεκτρικής ενέργειας έχουν σημαντική επίδραση στις εξαγωγές αγαθών στη ζώνη του ευρώ. Τον μεγαλύτερο αντίκτυπο στις εξαγωγές αγαθών στην Ελλάδα έχει η κατανάλωση ηλεκτρικής ενέργειας, μέρος της οποίας τα τελευταία χρόνια παράγεται από ΑΠΕ. Επίσης, διαπιστώθηκε ότι οι εξαγωγές αγαθών της Ελλάδος έχουν μεγαλύτερη εξάρτηση από την κατανάλωση ΑΠΕ σε σχέση με εκείνες της ζώνης του ευρώ, γεγονός που σχετίζεται με τους πρόσφατους υψηλότερους ρυθμούς αύξησης της κατανάλωσης ΑΠΕ. Βρέθηκαν σημαντικές αιτιώδεις σχέσεις μεταξύ των εξαγωγών αγαθών και των παραδοσιακών τύπων ενέργειας (δηλαδή πετρέλαιο και φυσικό αέριο) τόσο στην Ελλάδα όσο και στη ζώνη του ευρώ. Ωστόσο, οι προοπτικές για επιτάχυνση της ενεργειακής μετάβασης είναι λιγότερο ευνοϊκές με την εμφάνιση της ενεργειακής κρίσης. Επιπρόσθετα, αυτή η εξέλιξη είναι πιθανόν να επηρεάσει αρνητικά τη βελτίωση της εξωστρέφειας της Ελλάδος που παρατηρείται τα τελευταία χρόνια και την ανοδική πορεία των εξαγωγών αγαθών.

ENERGY CONSUMPTION BY ENERGY TYPE AND EXPORTS OF GOODS IN GREECE: A COMPARATIVE ANALYSIS IN RELATION TO THE EURO AREA*

Ioanna C. Bardakas
Bank of Greece, Economic Analysis and Research Department

1 INTRODUCTION

During the last decade, net exports in Greece were on the rise, contributing to economic growth, despite the severe economic crisis the country was undergoing. This development was partly driven by the notable increase in goods exports, excluding oil, which had an average annual growth rate in real terms of approximately 7% during 2015-19 (higher than that of the euro area average, which was less than 2%). During the same period, a downward trend was identified in the EU's overall energy consumption, with a decrease of more than 10% between 2005 and 2015 (see, for example, European Environment Agency 2021a), which has been attributed to the global crises, i.e. the 2007-08 financial crisis and the 2020 COVID-19 pandemic. In addition, it has been found that the above decrease is related to increases in energy efficiency (Altdorfer 2017).[1] The downward trend in energy consumption was stronger in Greece,[2] where total final energy consumption decreased by 27%.[3] Thus, attention should be drawn to the impact of this decline on the growth of goods exports in Greece, which up to now has had a stimulating effect on the country's economy, since energy consumption is central to the production of goods.

This study examines the dynamic relationship between exports of non-energy goods and final consumption of energy in Greece and the euro area (EA) over the period of the last two decades, considering five separate energy types. It is shown that exports of goods in Greece are dependent on final consumption of oil, electricity and renewable energy (RE), while final consumption of natural gas, oil and electricity have an effect on goods exports in the EA. A larger effect on exports of goods in Greece comes from the consumption of electricity, part of which has been produced from RE in recent years. Significant causal relationships are found between goods exports and the traditional energy types (i.e. oil and natural gas) both in Greece and the EA. Another finding that refers to Greece concerns the shift towards clean energy, as the final consumption of RE is increasing, while the consumption of fossil fuels and oil is declining, which affects export growth. However, Russia's invasion of Ukraine and the emerging shock in energy markets related to Europe's dependence on traditional energy types have put strains on supplies, leading to high prices. This development, along with the resulting recession, inflation and economic uncertainty, increases the possibility of a setback in the shift towards clean and cheap energy, causing problems in all sectors of the economy, including exports of goods, which are highly dependent on the consumption of energy.[4]

The remainder of this paper is structured as follows. The next section identifies historical trends in final energy consumption from the 1990s to 2020 in Greece and the EA. Section 3 reviews the existing literature on the exports-energy relationship. The following section describes the data and the methodology and defines the empirical specification. Section 5 presents the estimation results and provides a discussion. Finally, Section 6 offers some conclusions and policy recommendations.

2 STYLISED FACTS

2.1 ENERGY CONSUMPTION PATTERNS

Greece's energy endowment comprises fossil fuels and hydroelectric energy. During the last

* The views expressed in this article are of the author and do not necessarily reflect those of the Bank of Greece. The author is responsible for any errors or omissions.

1 In 2020, energy consumption in the EU reached the lowest levels recorded since 1990, which is largely explained by the effects of the COVID-19 pandemic, and showed a recovery in 2021 (European Environment Agency 2021b).

2 Three times higher than that of the euro area (EA) average, which decreased by 9% (own calculations based on Eurostat data).

3 Greece surpassed its target for the first Kyoto Protocol commitment period of limiting the increase of greenhouse gas emissions, achieving a 17% rise over 2008-12 from 1990 levels (OECD 2020).

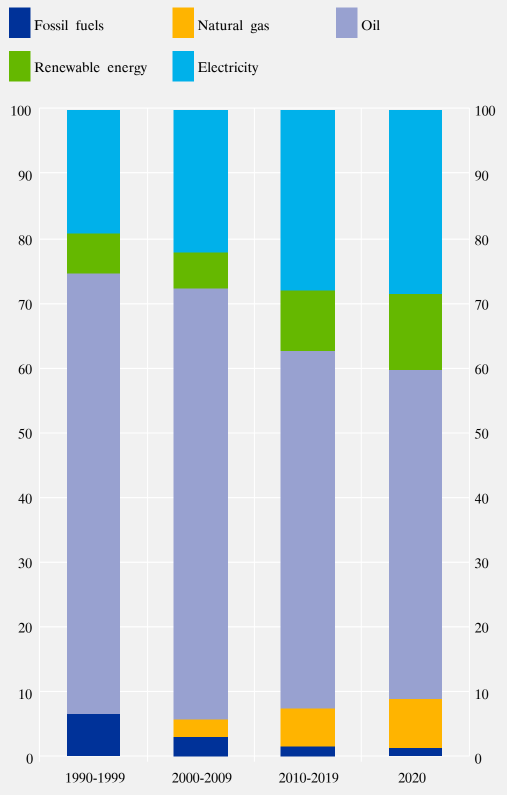
4 See Yergin (2022).

decade, the country began to exploit the plentiful resources of renewable energy it possesses, such as wind and solar energy. This was the result of a reform programme in the energy market launched in 2010. Greece's government has set climate change mitigation targets in line with EU targets and legislation, which have resulted in changing the energy mix.[5] The initial steps in reforming the Greek energy market focused on lignite. The government has set a goal to decommission all its lignite-based electricity by 2028. Following the outbreak of the COVID-19 pandemic, the EU required 37% of the financial support to Member States to be climate-related. As with other Member States, Greece's National Energy and Climate Plan (NECP) outlines the overall decarbonisation process, an important driver of which was the RE Special Account. This account ensured financial support providing incentives for producers to generate RE (Ioannidis 2022).

In the following we show the changes in the energy mix based on our dataset. Final consumption of fossil fuels (mainly in the form of lignite) has dropped by 25% since 2015 (same as the average EA decrease)[6] and now accounts for a small share in total consumption (about 1% in 2020, see Charts 1 and 2). Natural gas entered the Greek market in the early 2000s, its final consumption increased, but in 2020 it still covered a low proportion of total final energy consumption (8%, see Chart 1). Oil has the highest share in total final consumption in Greece as well as in the EA. It should be noted that the share of oil in total consumption in Greece was around 50%, significantly higher than the EA average (36%, see Chart 2). Nevertheless, oil consumption has decreased by 15% in the last five years due to EU legislation (-12% decrease in the EA), the COVID-19 crisis and price increases. Electricity is second in importance in Greece and in the EA regarding its share in final consumption.[7] The final consumption of electricity grew by 10% between 2013 and 2017 in Greece (1% in the EA) and its share in total final consumption in 2020 was 28%, above the respective EA average (24%). Moreover, as mentioned above, favourable

Chart 1 Shares of five energy types in total final energy consumption: Greece

(thousand tons of oil equivalent)



Source: Eurostat.

weather conditions in Greece allowed increases in renewable energy (RE) production. Solar and wind power generation capacity has grown significantly. Specifically, the share of RE in gross final energy consumption rose from 6.9% to 15.5% in 2017 (European Environment Agency Report 2021a and 2021b) and its share in gross final electricity consumption was projected to increase by 14% between 2018 and 2020 (OECD

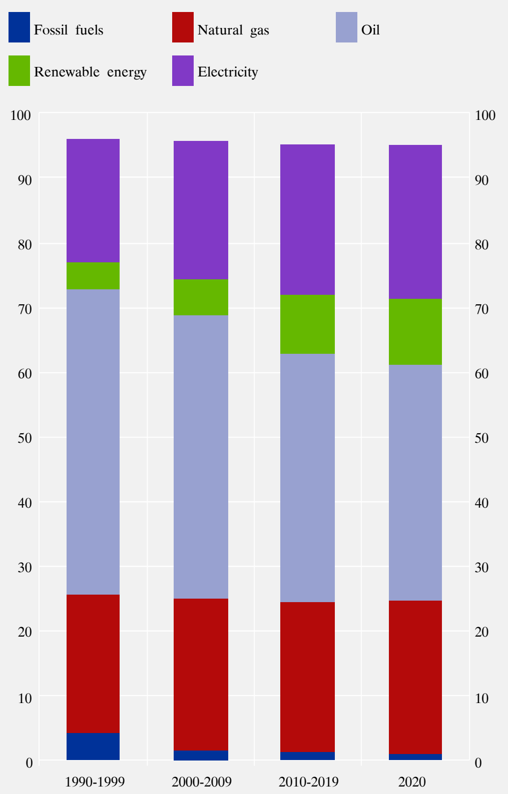
5 The steps taken by the Greek government that have led to a change in the energy mix are also described in OECD (2020) and include the ratification of the Kyoto Protocol in 2002 and the Paris Agreement in 2016. A Second National Climate Change Programme was adopted in 2002 regarding 2000-10 (amended in 2007) to achieve the target of Kyoto's first commitment period (2008-12).

6 The future course of the use of this type of energy is dictated by the 2020 Green Deal legislation of the European Commission, which introduced a commitment to reduce net greenhouse gas emissions by at least 55% by 2030. However, as mentioned above, the outbreak of the energy crisis in 2022 may undermine efforts in this direction.

7 In the EA, natural gas held a share (23%) in total energy consumption similar to electricity during 2015-20.

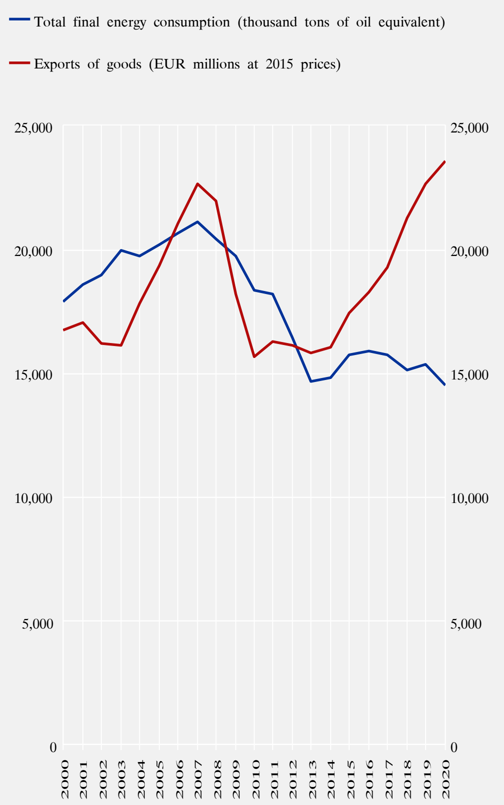
Chart 2 Shares of five energy types in total final energy consumption: euro area

(thousand tons of oil equivalent)



Source: Eurostat.

Chart 3 Energy consumption and exports of goods in Greece



Sources: Eurostat and own calculations.

2020). According to our Eurostat dataset, the final consumption of RE increased by 15% during the last five years (and by a total of 36% over the last decade). As a result, in 2020 the share of RE in total energy consumption was close to 12% (above the respective EA share, which was 11%). Finally, total final energy consumption has been decreasing over the last ten years in Greece, at an average annual rate close to -2.3% and a total decrease of -16% up to 2019, which exceed the corresponding EA rates (annual rate of -0.5%, total decrease close to -6%).[8]

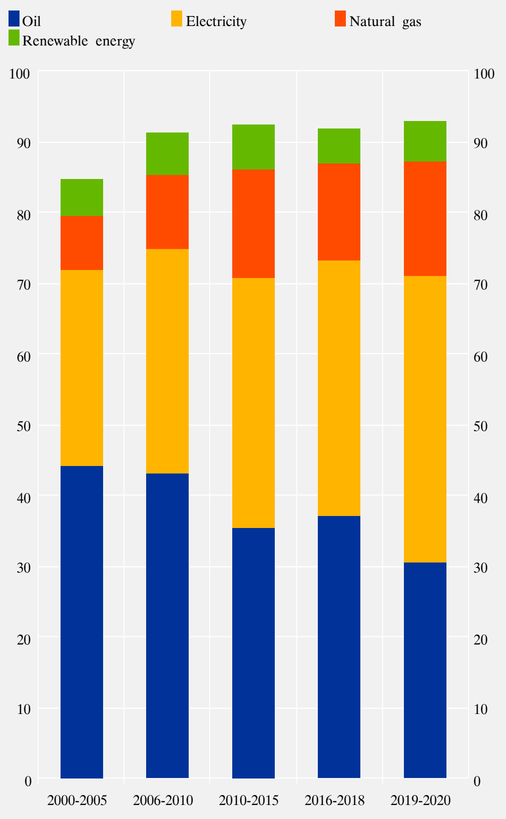
2.2 ENERGY CONSUMPTION IN THE INDUSTRIAL SECTOR AND EXPORTS OF NON-ENERGY GOODS IN GREECE

The relative paths of total final energy consumption and real exports of non-energy goods are shown in Chart 3 for the period 2000-2020. During 2000-12, total final energy consumption and real exports of goods moved in the same direction. From 2012 onwards, the two series diverge and the positive co-movement is interrupted. This is due to the decrease in final energy consumption, which is attributed mainly to the financial crisis (2009-17) and the COVID-19 crisis, but is also related to the implementation of the energy sector reforms. An analysis of the change in the energy mix by decomposing the evolution of each type of energy could help gain insight into the issue of the continued goods exports growth.

8 It should be noted that in 2020, the year when the COVID-19 crisis emerged, all types of energy consumption recorded a significant decrease in the EA. In Greece the consumption of natural gas and RE continued to rise.

Chart 4 Shares of energy consumption in industry by type of energy in Greece

(thousand tons of oil equivalent)



Sources: Eurostat and own calculations.
Note: Fossil fuels are not included in the chart since they account for a small share in total energy consumption over the sample period.

The evolution of the shares of the four most important types of energy (oil, natural gas, electricity and RE) in total final consumption in the industrial sector during the sample period in Greece is shown in Chart 4. The examination of changes in growth patterns in the industrial sector is relevant, since the energy consumed in industry is used in the production process of goods in manufacturing, part of which is exported. A general observation that is also verified visually is that the sum of the electricity, natural gas and RE shares has recorded an increase of 13 percentage points during the last two decades. The highest increase over this time was recorded in the shares of electricity and natural gas (almost equal, by 14 percentage points). The share of RE in total energy consumption in the industrial sector has increased modestly during the last four years, from 5% to 6%, which is lower than the corresponding share when total consumption in all sectors is considered (12%, as mentioned above).

However, during the five years following the financial crisis and subsequent recession of the period 2009-17, the growth rate of RE consumption has been increasing, reaching a 7% in industry, higher than that referring to the whole economy (4%). During the same time, electricity consumption in industry grew by 5%. A shift in the energy mix away from oil and fossil fuels[9] towards electricity, natural gas and RE – indicating a substitution of consumption – occurred in industry after 2016, and exports of goods exhibited a concomitant growth during this time.[10,11,12] Finally, the share of oil in total final consumption remained high in industry (above 30%, lower, however, than that seen when the whole economy is considered), even though it has dropped by 17%, which makes it second in importance, since the consumption of electricity has a prevalent role in industry.

3 LITERATURE REVIEW

The study of factors that affect export performance and export promotion has gained importance in recent decades since producing and exporting competitive products is a necessary prerequisite for a country to grow and prosper. The economic literature has focused on the estimation of export demand equations and real exports responsiveness to the changes in the real world income and a relative price ratio of a country's export prices over the world price, often approximated by the real effective exchange rates. Various econometric

9 Their share fell from 19% in 2000 to 6% in 2020.
10 The decrease in the share of oil is gradual throughout the sample and more intense in 2020 during the COVID-19 crisis.
11 In 2020, oil and electricity consumption covered more than two thirds of total energy consumption in industry.
12 During 2019-2020, RE consumption in industry increased by 12%, indicating a shift to consuming this type of energy during the COVID-19 crisis.

techniques have been used to estimate equations of exports at the aggregate, country, sectoral and firm levels. The recent trade literature has expanded the traditional approach to export demand estimation by relating export activity to additional factors other than the conventional ones (i.e. R&D in Benfratello 2022, non-price factors in Athanasoglou and Bardaka 2010) and attempts have been made to explore the links between exports and energy, drawing on recent concerns on environmental quality issues and the outbreak of the energy crisis.

There is, however, limited exploration of the relationship between final energy consumption and exports, while there is extensive work on the effects of energy consumption on growth since the pioneering study by Kraft and Kraft (1978). Energy economics is largely populated with research that explores the temporal relationship between energy and GDP and a branch deals extensively with its causal nature without reaching a definite conclusion yet. Various procedures have been used to estimate this relationship, initially in bivariate and then in multivariate models that have included energy and exports among other variables (see Ozturk and Acaravci (2011) for a review of the different hypotheses tested). Kahrl and Roland-Holst (2008), for example, claim that exports have been a primary driver of China's economic growth over the last decade. China has increased its relative energy usage in the exports of all technological categories of goods. Amador (2012) in a similar context compares the energy content in manufacturing exports of 30 advanced and emerging economies from 1995 to 2005, using input-output matrices of trade data for 17 sectors. He concludes that Brazil, India and, mostly, China present a high-energy content in manufacturing exports. Dedeoglu and Kaya (2013) investigate the relationships between energy use and GDP, energy use, exports and trade, and energy use and imports at the aggregate level in the OECD countries. By employing panel cointegration, they find the presence of a long-run relationship and two-way causality between energy use and GDP, energy use and exports, as well as energy use and imports.

Further, there is a literature strand on the electricity consumption-growth relationship and Payne (2010) offers a review. A related work by Bosupeng (2017) finds that among 40 economies, twenty-one exhibited statistically significant long-run relationships between exports, income and electricity consumption using the Johansen cointegration procedure. In addition, it is shown that exports and electricity consumption are statistically cointegrated in the long run for all economies based on the Saikkonen and Lutkepohl test. The existence of bidirectional causal relationships between exports and electricity consumption is confirmed.

Erkan, Mucuk and Uysal (2010) aim to determine the impact of domestic energy consumption on exports in Turkey. Using cointegration and Granger causality tests, they find a significant relationship between domestic energy consumption and exports in the long term. A Granger causality test shows that there is a unidirectional causality running from energy consumption to exports and the authors conclude that energy is an important factor for economic growth in the Turkish economy.

4 DATA, EMPIRICAL SPECIFICATION AND METHODOLOGY

The data on energy consumption and exports of non-energy goods comes from the Eurostat database. Final energy consumption – energy use – has been used, excluding consumption by the energy sector. Energy use considers the sum of consumption by all end-use sectors (e.g. transport, industry, residential, etc.).[13] EA real exports (chain-linked volumes, 2015) of oil and

13 Energy use is defined as the energy which reaches the final consumer's door and excludes that which is used by the energy sector itself. Final energy consumption excludes energy used by the energy sector, including for deliveries, and transformation. It also excludes fuel transformed in the electrical power stations of industrial autoproducers and coke transformed into blast-furnace gas, where this is not part of overall industrial consumption but of the transformation sector.

petroleum products[14] were subtracted from real exports of goods (chain-linked volumes, 2015). Greece's oil exports at current prices (Eurostat SITC 33 series) were subtracted from exports of goods at current prices and the resulting series was converted to real terms using the goods producer price index (external economy, excluding energy, ELSTAT). External demand, proxied by world demand, and real effective exchange rate values were obtained from the ECB SDW database. The data is annual and covers the last two decades, i.e. the period 2000-2020.

Final energy consumption is total, broken down by type of energy and measured in thousand tons of oil equivalent. Five individual energy types are considered, which comprise the most demanded sources of energy:

- Fossil fuels (FCFOSS)
- Natural gas (FCNGAS)
- Oil (FCOIL)
- Renewable energy (FCREN)
- Electricity (FCELEC)

The equation to estimate is an export demand equation augmented with energy consumption:

$$\log\,(REXPGOODS)_t = \alpha_1 + \beta_1{*}\log\,(WD)_t + \beta_2{*}\log\,(REER)_t + \beta_3{*}\log\,(Z)_t + e_t \qquad (1)$$

We define $REXPGOODS_t$ as the dependent variable (real exports of goods excluding oil products) with independent energy variables denoted with Z_t, including the various types of energy consumption respectively: FCTOT (total consumption), FCFOSS, FCNGAS, FCOIL, FCREN, FCELEC. Finally, control variables include the conventional variables of an exports demand equation, such as foreign demand (WD_t) and the real effective exchange rates ($REER_t$).

Two approaches were adopted in order to estimate the long-run relationship between the variables of equation (1). First, the Johansen (1988) VECM cointegration procedure was used to estimate six separate equations, the first considering total energy consumption as an independent variable and another five equations using the consumption of each energy type, both for Greece and the EA. The second approach uses various panel estimators for the set of 19 EA countries to estimate equation (1). Individual effects for Greece are captured by a country dummy, which allows the comparison to the time-series approach in order to check the robustness of our results. The panel estimation has the advantage that it does not suffer from the degrees of freedom problem, which burdens the estimation for each country separately, and thus it produces more efficient and consistent estimates.

For the panel estimation three methods were used: 1) the fixed effects method, which provides pooled panel estimates of the coefficients and improves efficiency by considering separate effects for each cross section; 2) the DOLS (dynamic ordinary least squares) method; and 3) the PMG (pooled mean group) method, of which the last two are panel cointegration, error-correction methods. The fixed effects methodology allows for cross section effects, but does not correct for possible non-stationarity in the series. The inclusion of an autoregressive coefficient in each equation improves efficiency, but this approach is inferior to the other two in terms of bias. The DOLS and PMG methods estimate a long-run cointegrating relationship. DOLS was originally developed by Phillips and Loretan (1991), Saikkonen (1991) and Stock and Watson (1993) for a single equation, and extended by Kao and Chiang (2000) for panel data. The method takes into account the dynamic nature of variables (i.e. integration of order 1) and pools the panel data to generate the estimated coefficients, allowing the constant and the trend to differ and to account for cross-section

14 Converted to real terms by dividing by real oil prices. Nominal prices in USD from the World Bank: Commodity Price Data are converted to euros by dividing by the USD/EUR exchange rate. Real oil prices are obtained by dividing by the EA implicit GDP price deflator.

heterogeneity. The PMG procedure calculates the pooled mean group (PMG) estimator for dynamic panel data according to Pesaran, Shin and Smith (1999). This estimator allows the intercepts, short-run coefficient and error variances to differ freely across groups, but restricts the long-run coefficients to being equal across cross sections. A long-run relationship is derived along with the short-run error correction equation.[15]

5 EMPIRICAL RESULTS: GREECE COMPARED TO THE EURO AREA

Table 1 summarises the descriptive statistics for each of the variables in the sample used for the single equation estimation.

Prior to the estimation of the long-run equations, unit root tests were carried out to find out the order of integration for each of the series included in equation (1) for both Greece and the EA. For the single equation, the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller 1981) results are presented in Table 2. It is verified that all the series are integrated of order one, I (1). For the panel data, the Levin, Lin & Chu (2002, LLC) and Breitung (2000) panel unit root tests have been used, which are based on cross-sectional independence. The results are presented in Table 3.[16] The null hypothesis of non-stationarity fails to

15 DOLS and PMG do not take into account cross-sectional dependence that may be present in a panel dataset.

16 The tests assume that there is a common unit root process across the panel members (e.g. cross sections are homogeneous).

Table 1 Descriptive statistics

	a. Euro area								
	REALEXPEA	FCTOTEA	FCFOSSEA	FCNGASEA	FCOILEA	FCELECEA	FCRENEA	WDEA	REERULCT
Mean	2861764.60	757566.37	10787.37	175605.45	310691.97	170157.85	55518.27	3.32	94.58
Median	2879561.99	748656.69	10326.63	175540.78	308085.41	172114.23	58171.95	3.34	96.49
Maximum	3746069.88	799427.79	15175.86	189000.05	352359.39	177568.54	73505.77	4.55	108.48
Minimum	1976067.50	690156.71	7030.32	158588.55	249261.79	153912.82	33002.65	1.96	84.47
Std. Dev.	552193.80	29851.55	2296.89	8419.55	31976.57	6323.72	13407.62	0.84	7.30
Skewness	-0.05	-0.29	0.35	-0.19	-0.05	-1.12	-0.41	-0.26	0.14
Kurtosis	1.89	2.49	2.18	2.14	1.66	3.48	1.83	1.82	1.70
Jarque-Bera	1.08	0.53	1.02	0.78	1.58	4.61	1.79	1.45	1.54
Probability	0.58	0.77	0.60	0.68	0.45	0.10	0.41	0.48	0.46
Sum	60097056.50	15908893.67	226534.85	3687714.39	6524531.33	3573314.94	1165883.68	69.79	1986.13
Observations	21	21	21	21	21	21	21	21	21

	b. Greece							
	REALEXPGR	FCTOTGR	FCFOSSGR	FCNGASGR	FCOILGR	FCELECGR	FCRENGR	WDGR
Mean	18548.14	17717.66	382.40	744.59	10842.15	4353.15	1345.37	3.46
Median	17828.02	18185.33	281.63	811.55	11427.57	4366.90	1340.43	3.52
Maximum	23552.54	21120.90	892.65	1097.87	13840.67	4870.68	1726.92	4.59
Minimum	15638.18	14482.86	167.42	257.25	7351.32	3710.32	1081.42	2.30
Std. Dev.	2622.38	2269.64	229.08	258.00	2427.47	294.93	223.24	0.73
Skewness	0.62	-0.04	1.04	-0.55	-0.11	-0.37	0.43	-0.18
Kurtosis	1.94	1.48	2.91	2.15	1.30	2.71	1.80	1.93
Jarque-Bera	2.32	2.02	3.83	1.69	2.58	0.55	1.90	1.12
Probability	0.31	0.36	0.15	0.43	0.27	0.76	0.39	0.57
Sum	389511.0	372070.90	8030.48	15636.45	227685.16	91416.10	28252.79	72.68
Observations	21	21	21	21	21	21	21	21

Table 2 ADF unit root tests – Variables in levels

	Greece	Euro area
REALEXP	-2.438 (0.145)	-1.200 (0.653)
FCTOT	-0.123 (0.934)	-0.130 (0.932)
FCFOSS	-3.589* (0.017)	-0.603 (0.864)
FCNGAS	-1.504 (0.511)	-2.320 (0.175)
FCOIL	0.167 (0.963)	0.558 (0.984)
FCELEC	-2.312 (0.178)	-2.925* (0.060)
FCREN	-0.753 (0.810)	-1.189 (0.657)
WD	-1.367 (0.577)	-1.425 (0.549)
REERULCT	-1.546 (0.490)	

Notes: The standard ADF test statistics are reported for the null hypothesis of the existence of a unit root of the variables included in the single equation model. Numbers in parentheses are p-values. The 1% and 5% asymptotic critical values are -3.808 and -3.020 and are from Mackinnon (1996).

Table 3 Panel unit root tests

	LLC	Breitung
REALEXP	2.375 (0.991)	-0.572 (0.284)
FCFOSS	-0.878 (0.189)	1.406 (0.920)
FCNGAS	0.472 (0.682)	-0.524 (0.300)
FCOIL	-0.476 (0.317)	2.296* (0.989)
FCELEC	-0.851 (0.197)	2.991 (0.998)
FCREN	-1.897* (0.029)	-0.331 (0.370)
WD	0.604 (0.727)	3.804* (0.999)
REERULCT	0.088 (0.535)	0.238 (0.594)

Notes: LLC and Breitung are the Levin, Lin & Chu (2002) and Breitung (2000) tests, respectively. The reported tests use a constant and a trend. All the test statistics follow the normal distribution. Variables are in logarithms. The * mark denotes the rejection of the null hypothesis of non-stationarity at the 5% level of significance. Numbers in parentheses are p-values.

Table 4 Panel cointegration tests

Pedroni tests	eq. 2	eq. 3	eq. 4	eq. 5	eq. 6
H_0: There is no cointegration					
H_1: Common AR coefficients					
Panel v	1.366* (0.086)	-2.177 (0.985)	2.813* (0.002)	0.073 (0.471)	1.963* (0.025)
Panel ϱ	-0.069 (0.472)	-1.526* (0.063)	1.779* (0.962)	0.292* (0.615)	0.117* (0.547)
Panel PP	-1.417* (0.078)	-4.438* (0.000)	0.266 (0.605)	-1.977* (0.024)	-1.301* (0.096)
Panel ADF	-2.062* (0.019)	-4.398* (0.000)	-1.270* (0.102)	-3.151* (0.000)	-1.598* (0.055)
H_1: Individual AR coefficients					
Group ϱ	1.685 (0.954)	0.558 (0.711)	3.663 (0.999)	2.350 (0.991)	1.484 (0.931)
Group PP	-0.409 (0.341)	-4.209* (0.000)	-2.526* (0.006)	-3.890* (0.000)	-0.919 (0.179)
Group ADF	-1.719* (0.043)	-4.661* (0.000)	-0.934 (0.175)	-4.087* (0.000)	-1.465* (0.071)

Notes: The * mark indicates rejection of the null hypothesis of no cointegration at the 10% level of significance. Numbers in parentheses are p-values. The Pedroni tests follow the normal distribution. PP and ADF stand for Phillips-Perron and Augmented Dickey Fuller, respectively. The critical values from Pedroni (1999) have been used. The notation eq. 2 to eq. 4 represents equation (1) using each of the five energy types.

Table 5 VECM long-run elasticities of exports of goods 2000-2020: Greece and euro area

(dependent variable: real exports of non-oil goods)

Equation	Independent variables	Greece	Euro area	Greece H_0: There is no cointegration H_1: There is at most one cointegration vector		Euro area H_0: There is no cointegration H_1: There is at most one cointegration vector	
				Trace	λmax	Trace	λmax
1	FCTOT	1.327** (17.5)	1.209** (52.3)	71.42*** 40.50	30.94 22.22	57.68** 24.45*	33.23* 16.46
2	FCFOSS	0.841** (9.212)	0.499* (2.055)	95.79*** 46.65***	49.14*** 25.66	82.17*** 44.86***	37.31† 18.01
3	FCNGAS	0.761** (5.660)	1.392** (21.55)	90.49*** 45.68***	44.81** 28.16	62.27** 32.71	29.56* 22.54*
4	FCOIL	1.829** (25.2)	1.466** (16.97)	92.62*** 30.24***	62.37*** 21.69	56.60* 30.02	26.60 17.90
5	FCELEC	1.830** (5.125)	1.367** (35.99)	80.85*** 35.39	45.46*** 18.99	56.60** 29.10	27.50 18.46
6	FCREN	1.712** (9.679)	0.455** (8.738)	67.79*** 35.71	32.01* 16.03	73.15* 37.52*	35.63* 19.34
1	WD	0.877** (7.027)	0.809** (45.2)				
2		2.010** (5.124)	0.829** (4.461)				
3		0.482* (1.817)	0.987** (11.38)				
4		1.257** (19.38)	0.933** (18.95)				
5		1.553** (5.034)	0.445** (10.14)				
6		0.700** (3.057)	0.347** (7.498)				
1	REER	-0.906** (5.101)	-0.540** (7.857)				
2		-0.148* (-1.945)	-0.112* (-1.492)				
3		-4.299** (-14.188)	-0.665** (-3.597)				
4		-1.885** (-11.667)	-1.046** (-4.241)				
5		-1.491** (-2.387)	-0.470** (-4.474)				
6		-0.639* (-2.095)	-0.266** (-4.355)				

Notes: t statistics are in parentheses and the *, **, *** and † marks indicate statistical significance at the 10%, 5%, 1% and 2.5% levels of statistical significance, respectively. For the trace and max eigenvalue tests the critical values from Osterwald-Lenum (1992) have been used. Equation 1 to 6 represents the estimated equation including each energy type separately due to the small size of the sample. The real effective exchange rate is calculated using unit labour costs for the whole economy and a group of 19 trading partners of the EA. Dummies were used for the years of the financial and the COVID-19 crises.

be rejected in each case and the panel series are non-stationary.

Testing for the existence of cointegration among the variables of equation (1) is necessary in order to determine if the variables share a common trend, which will then be estimated.

Table 4 reports the panel cointegration tests of Pedroni (1999). The null hypothesis of no cointegration is tested against alternative hypotheses that allow for heterogeneity among the 19 countries of the panel. The first four of the Pedroni tests pool the autoregressive coefficients across countries assuming homogeneity

Table 6 Granger causality tests

Equation	H_0	Test statistic	
		Greece	Euro area
1	Δ(FCTOT) does not cause Δ(REXPGOODS)	0.684 (0.408)	2.882* (0.090)
1	Δ(REXPGOODS) does not cause Δ(FCTOT)	0.702 (0.401)	0.002 (0.962)
2	Δ(FCFOSS) does not cause Δ(REXPGOODS)	3.044* (0.081)	0.001 (0.976)
2	Δ(REXPGOODS) does not cause Δ(FCFOSS)	3.455* (0.006)	0.119 (0.729)
3	Δ(FCNGAS) does not cause Δ(REXPGOODS)	0.473 (0.491)	3.215* (0.073)
3	Δ(REXPGOODS) does not cause Δ(FCNGAS)	1.893 (0.168)	2.004 (0.157)
4	Δ(FCOIL) does not cause Δ(REXPGOODS)	3.586* (0.058)	2.012 (0.156)
4	Δ(REXPGOODS) does not cause Δ(FCOIL)	2.315 (0.128)	1.030 (0.310)
5	Δ(FCREN) does not cause Δ(REXPGOODS)	0.002 (0.962)	0.401 (0.526)
5	Δ(REXPGOODS) does not cause Δ(FCREN)	0.875 (0.349)	1.593 (0.206)
6	Δ(FCELEC) does not cause Δ(REXPGOODS)	0.277 (0.598)	0.602 (0.647)
6	Δ(REXPGOODS) does not cause Δ(FCELEC)	4.461* (0.035)	0.004 (0.949)

Notes: The test statistic is χ^2 with 1 degree of freedom. The * mark denotes significance (i.e. Granger causality) at the 10% level of significance. Numbers in parentheses are p-values. Equation 1 to 6 represents the estimated equation including each energy type separately due to the small size of the sample.

of panel members, in our case the 19 EA countries. The next three tests allow the first-order autoregressive term to vary across countries. The null hypothesis of no cointegration is rejected, according to all panel and group tests with the exception of the group ϱ test. The consistence in rejecting the null hypothesis suggests that the series in the panel can be grouped and exhibit some homogeneity, which is in line with the adoption of the PMG and DOLS estimators.[17] Table 5 presents the cointegration tests of the single series VECM estimation of the goods exports demand equation for the final consumption of each of the five types of energy considered here for Greece and the EA. The reported trace and maximum eigenvalue test statistics in all cases indicate the existence of a long-run relationship and one long-run cointegration vector. Thus, exports of goods depend on total final energy consumption and on the consumption of each of the five energy types considered here.

Table 6 presents the estimated long-run elasticities with respect to the energy variables and the control variables WD_t and $REER_t$ that capture the effects of external demand and real effective exchange rates. All variables are found to be statistically significant and their signs are in accordance with theory. The elasticities with respect to total consumption do not differ significantly when comparing Greece to the EA. In both cases they are close to unity, indicating that a 10% increase in energy consumption is associated with a

17 However, as has been pointed out, these tests are based on the assumption of independent panel members. Because of common shocks, this condition is hardly fulfilled in applied work. It is known that panel unit root tests and cointegration tests have been developed to control for the panel member dependencies, but they lie beyond the scope of this study.

broadly equal percentage increase in the exports of goods.

Concerning the individual effect of the consumption of each type of energy on exports of goods, presented in the same table, a general observation is that the respective elasticities are statistically significant and all above unity, except for the effect of the consumption of renewable energy in the EA, natural gas in Greece and fossil fuels both in Greece and the EA, where exports have an inelastic response. The elasticities for Greece concerning the effect of the final consumption of oil, electricity and RE are above the EA average estimates. Specifically, in Greece exports increase by 18.3% and 17.2% in response to a 10% increase in final consumption of electricity and RE, respectively (VECM estimates). Thus, the increases in the final consumption of electricity and RE observed in our sample contribute to increased goods exports and partly explain their above-mentioned growth.[18] A response of goods exports to electricity consumption of almost unit elasticity is also found in the panel estimation in Table 7, considering Greece separately[19] (based on DOLS).

In addition, referring to the VECM estimates, the export demand elasticities with respect to oil, electricity and RE final consumption in Greece are similar in size. An increase in the consumption of each of these energy types has a broadly equal impact on exports of goods. The coefficient of electricity consumption is slightly higher compared to the other two coefficients, possibly reflecting the shift away from the consumption of oil and towards consuming electricity. Finally, the coefficient of the consumption of natural gas is lower, suggesting that an exogenous reduction in the consumption of natural gas could have a more muted impact on exports.

Regarding the EA average, final consumption of natural gas, oil and electricity have the highest and similar in size coefficients, according to both VECM and panel estimates (see Table 5). According to the panel estimation results based on the PMG and DOLS methods, the final consumption of gas and electricity have the highest effect on goods exports. The coefficients resulting from both approaches show a proportional or slightly above proportional effect (coefficients are unity in the PMG and DOLS methods and 1.4 in the VECM estimation). These findings are consistent with the high shares of electricity and natural gas in total final energy consumption (both close to 24%) reported in Section 2.1. The effect of fossil fuel consumption on exports of goods is small in both Greece and the EA, according to both methodologies, which is consistent with the significant reduction in the share of fossil fuels in total consumption in the EA and in the EU in general.

Furthermore, based on both VECM and panel estimation, the elasticity of the impact of consumption of RE is significantly higher in Greece than in the EA (1.712 and 0.455, respectively in the VECM, while in the panel estimation it ranges from 0.2 to 0.4 for Greece and from 0.03 to 0.06 for the EA). This finding indicates the increasingly important role of RE consumption in the evolution of exports of goods. It is also related to the shift of the energy mix towards RE during recent years in Greece, described in Section 2, which highlights the positive contribution of "green" forms of energy to the production of exported goods. According to these results, Greece already enjoys the advantages of this shift. A comparative advantage —also associated with climate conditions— can be obtained through significant investments, e.g. in wind turbines or solar energy through photovoltaic systems, which have acquired a significant market share. If maintained, these efforts should increase the country's autonomy in times when energy has become more expensive.

A question often asked by researchers concerns the existence of a causal relationship

18 The coefficient of natural gas consumption for Greece is lower (below unity) than that for the EA.

19 These correspond to the respective independent energy variable after multiplying with a dummy variable, which is unitary for Greece and zero elsewhere.

Table 7 Panel estimation of 19 euro area countries: 2000-2020

(dependent variable: real exports of non-oil goods)

Equation	Independent variables	Fixed effects	DOLS	PMG	ECM_{t-1}
2	FCFOSS	0.024** (1.846)	0.066* (1.627)	0.473*** (3.873)	-0.074** (-2.007)
3	FCNGAS	0.173*** (3.592)	0.932*** (11.748)	1.133*** (5.880)	-0.178*** (-3.365)
4	FCOIL	0.145** (2.451)	0.497*** (3.904)	0.844*** (6.458)	-0.143*** (-2.853)
5	FCELEC	0.899*** (5.561)	0.989*** (2.693)	1.092*** (4.107)	-0.191*** (-5.502)
6	FCREN	0.050*** (3.093)	0.029*** (2.595)	0.059* (1.562)	-0.138*** (-5.704)
2	WD	1.178*** (16.308)	1.277*** (5.660)	1.464*** (8.499)	-
3		1.012*** (14.929)	1.046*** (16.60)	0.355** (2.197)	-
4		0.925*** (12.90)	0.933*** (12.87)	0.821*** (16.49)	-
5		0.707*** (12.19)	0.467*** (2.979)	0.557*** (8.983)	-
6		1.054*** (15.47)	0.917*** (15.29)	0.814*** (14.20)	-
2	REER	-0.141** (-1.795)	-0.358** (-2.299)	-1.227*** (-3.454)	-
3		-0.153** (-1.939)	-	-0.929*** (-5.812)	-
4		-0.171** (-2.360)	-0.469** (-2.261)	-0.549*** (-5.313)	-
5		-0.375** (-2.105)	-0.708** (-2.453)	-1.566*** (-8.415)	-
6		-0.124* (-1.605)	-0.175*** (-2.896)	-0.570*** (-11.69)	-
2	Coefficient for Greece	0.061 (0.733)	0.204** (1.997)	-	-
3		0.175** (1.736)	0.359** (1.944)	0.676*** (4.785)	-0.229*** (-3.839)
4		0.437*** (3.699)	0.595** (2.043)	1.101*** (52.9)	-0.083** (-2.322)
5		0.663** (2.349)	0.860** (1.864)	-	-
6		0.315** (1.695)	0.419** (1.712)	0.194*** (6.403)	-0.287*** (-4.261)
2	RMS	0.056	0.078	0.057	-
3		0.061	0.570	0.046	0.045 [0.052]
4		0.070	0.143	0.041	0.041 [0.061]
5		0.174	0.119	0.049	0.049 [0.056]
6		0.095	0.051	0.058	0.057 [0.051]

Note: t statistics in parentheses. The ***, **, and * marks indicate statistical significance at the 1%, 5% and 10% levels of statistical significance, respectively. The last column reports RMS for the EA average error correction equation and numbers in brackets are the corresponding RMS for the error correction equation considering Greece separately. Dummies were used for the years of the financial and the COVID-19 crises.

between the variables involved in the estimation. Finding a statistically significant long-run relationship between goods exports and the independent variables in equation (1) does not provide information about the direction of causality between exports and energy. Table 6 presents the relevant Granger causality tests performed for Greece and the EA. Total consumption Granger causes exports of goods in the EA, since the χ^2 statistic referring to eq. 1 in Table 6 is statistically significant. The consumption of oil and natural gas Granger causes exports of goods in Greece and the EA, respectively (eq. 4 and eq. 3 in Table 6). These findings lead to the conclusion that oil and natural gas consumption are important drivers of exports of goods in both Greece and the EA.

Regarding Greece, unidirectional reverse causality is found to run from real exports of goods to electricity consumption. This implies that exports of goods determine the amount of electricity needed for these goods to be produced. In other words, there are satisfactory amounts of electricity available for the production of exported goods. This result is probably related to the country's efforts to change the energy mix in electricity production by shifting away from imported natural gas (National Energy and Climate Plan, NECP, 2019). A study commissioned by the Hellenic Wind Energy Association (2021) shows that in periods of high penetration of RE (wind and photovoltaic energy) in the electrical grid, prices in the wholesale electricity market decrease significantly. Thus, the increases in electricity consumption observed in recent years are related, among other things, to falling electricity prices.[20]

Furthermore, there is a feedback relationship in the case of fossil fuels. This bidirectional causal relationship between goods exports and the consumption of fossils fuels may have a dual implication. First, the availability of consumption of this energy type is important for the production of exported goods. Second, the feedback, implying adequate available quantities, which is found between fossil fuels consumption and goods exports, may be due to the lower consumption levels and the shift away from the use of this type of energy.

Table 7 also reports the error-correction term derived from PMG. The error correction coefficient that corresponds to natural gas, oil and electricity consumption is relatively low, ranging from -0.1 to -0.2, indicating adjustment in 5 years for Greece as well as the EA. The error correction coefficient in the equation that uses RE is higher for Greece than for the EA, showing a faster adjustment towards the long-run equilibrium. For Greece the adjustment takes about 3 years, while for the EA equilibrium is reached in 5 years. This is another indication of the increased importance of RE consumption in explaining goods exports in Greece compared to the other countries of the EA.

6 CONCLUSIONS

Greece is typically an energy importer, although its resources allow the production of electricity and RE. Total final energy consumption decreased in the last decade, reflecting the financial and the COVID-19 pandemic crises and, to a smaller extent, the contraction of fossil fuel and oil consumption due to comprehensive energy sector reforms. Electricity and RE consumption, on the other hand, have grown during the last decade and gas entered the energy market in the beginning of the last decade of the sample period. Oil consumption still has a high share in total energy consumption, but the share of fossil fuels has become small.

The estimated elasticities of the exports of goods with respect to total energy consumption and the consumption of each energy type reflect these developments. A positive relationship is detected between exports of goods and final energy consumption and it is shown

20 In 2021, Greece ranked 7th in the world in the use of RE to produce electricity. According to the World Economic Forum (2022), "all of the increased electricity demand during the first half of 2022 was met by renewable energy" at the global level.

that in Greece goods exports depend on oil, electricity and RE consumption, while the respective elasticities are higher than those corresponding to the EA. The electricity consumption effect is relatively larger. This result is also verified by the panel estimation regarding Greece. Reverse causality is detected for this energy type, possibly associated with its high growth rates in recent years. Causality tests show a causal link between exports of goods and final oil consumption in Greece and exports of goods and final natural gas consumption in the EA. Finally, Greece's goods exports are found to have a higher dependence on RE consumption than the EA's, which is related to the recent higher growth of RE consumption. Accelerating the energy transition has become even more important in the EU and Greece with the emergence of the energy crisis. However, prospects are not as favourable, since RE projects may be difficult to finance in the current high inflation and rising interest rate environment. The RE sector is affected by underinvestment, driven by the general uncertainty about future demand, social and political factors. This negative outlook may have consequences on the upward course of goods exports.

REFERENCES

Altdorfer, F. (2017), "Impact of the economic crisis on the EU's industrial energy consumption", Odyssee-Mure Policy Brief, April.

Amador, J. (2012), "Energy content in manufacturing exports: A cross-country analysis", *Energy Economics*, 34 (4), 1074-1081.

Apergis, N. and J.E. Payne (2010), "Renewable energy consumption and economic growth: Evidence from a panel of OECD countries", *Energy Policy*, 38 (1), 656-660.

Athanasoglou, P.P. and I.C. Bardaka (2010), "New trade theory, non-price competitiveness and export performance", *Economic Modelling*, 27 (1), 217-228.

Benfratello, L., A. Bottasso and C. Piccardo (2022), "R&D and export performance: exploring heterogeneity along the export intensity distribution", *Journal of Industrial and Business Economics*, 49, 189-232.

Bosupeng, M. (2017), "Electricity consumption and exports growth: Revisiting the feedback hypothesis", MPRA paper No. 81756.

Breitung, J. (2000), "The local power of some unit root tests for panel data", in B.H. Baltagi (ed.) (2000), *Nonstationary panels, panel cointegration and dynamic panels*, *Advances in Econometrics*, 15, Amsterdam, JAI Press, 161-178.

Chaviaropoulos, P.K. (2022), *RES penetration and electricity market prices in Greece 2021*, iWind Renewables.

Costantini, V. and M. Mazzanti (2012), "On the green and innovative side of trade competitiveness? The impact of environmental policies and innovation on EU exports", *Research Policy*, 41 (1), 132-153.

Dedeoglu, D. and H. Kaya (2013), "Energy use, exports, imports and GDP: New evidence from the OECD countries", *Energy Policy*, 57, 469-476.

Dickey, D.A. and W.A. Fuller (1981), "Likelihood ratio statistics for autoregressive time series with a unit root", *Econometrica*, 49 (4), 1057-1072.

Erkan, C., M. Mucuk and D. Uysal (2010), "The Impact of Energy Consumption on Exports: The Turkish Case", *Asian Journal of Business Management*, 2 (1), 17-23.

Erol, U. and E.S.H. Yu (1987), "On the causal relationship between energy and income for industrialized countries", *Journal of Energy and Development*, 13 (1), 113-122.

European Environment Agency (2021a), *Energy in Europe – State of play*, available at https://www.eea.europa.eu/signals/signals-2017/articles/energy-in-europe-2014-state-1.

European Environment Agency (2021b), *Trends and projections in Europe*, available at https://www.eea.europa.eu/publications/trends-and-projections-in-europe-2021.

Granger, C.W.J. (1988), "Some recent developments in a concept of causality", *Journal of Econometrics*, 39 (1-2), 199-211.

Halkos, G.E. and N.G. Tzeremes (2009), "Electricity generation and economic efficiency: Panel data evidence from world and East Asian countries", *Global Economic Review*, 38 (3), 251-263.

Ioannidis, A. (2022), "Energy reforms in Greece during the Economic Adjustment Programmes", European Commission, European Economy, Discussion Paper 166, July.

Johansen, S. (1988) "Statistical analysis of cointegration vectors", *Journal of Economic Dynamics and Control*, 12 (2-3), 231-254.

Johansen, S. and K. Juselius (1990), "Maximum likelihood estimation and inferences on cointegration with applications to the demand for money", *Oxford Bulletin of Economics and Statistics*, 52 (2), 169-210.

Kahrl, F. and D. Roland-Holst (2008), "Energy and exports in China", *China Economic Review*, 19, 649-658.

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

Kao, C. and M.-H. Chiang (2000), "On the estimation and inference of a cointegrated regression in panel data", in Baltagi, B. (ed.) (2000), *Nonstationary Panels, Panel Cointegration, and Dynamic Panels, Advances in Econometrics*, 15, Amsterdam, JAI Press, 161-178.

Kraft, J. and A. Kraft (1978), "On the relationship between energy and GNP", *The Journal of Energy Development*, 3 (2), 401-403.

Lee, C.C. (2006), "The causality relationship between energy consumption and GDP in G-11 countries revisited", *Energy Policy*, 34 (9), 1086 -1093.

Levin A., C.-F. Lin and C.-S. J. Chu (2002), "Unit root tests in panel data: asymptotic and finite-sample properties", *Journal of Econometrics*, 108 (1), 1-24.

MacKinnon, J. G. (1996), "Numerical distribution functions for unit root and cointegration tests", *Journal of Applied Econometrics*, 11 (6), 601-618.

Nachane, D.M., R.M. Nadkarni and A.V. Karnik (1988), "Co-integration and causality testing of the energy-GDP relationship: A cross-country study", *Applied Economics*, 20 (11), 1511-1531.

OECD (2020), *OECD Environmental performance reviews: Greece 2020*.

Ozturk, I. and A. Acaravci (2011), "Electricity consumption and real GDP causality nexus: Evidence from ARDL bounds testing approach for 11 MENA countries", *Applied Energy*, 88 (8), 2885-2892.

Ozturk, I. (2010), "A literature survey on energy-growth nexus", *Energy Policy*, 38 (1), 340-349.

Payne, J.E. (2010), "A survey of the electricity consumption-growth literature", *Applied Energy*, 87 (3), 723-731.

Pedroni, P. (1999), "Critical values for cointegration tests in heterogeneous panels with multiple regressors", *Oxford Bulletin of Economics and Statistics*, 61 (S1), 653-670.

Pesaran, M.H., Y. Shin and R. Smith (1999) "Pooled mean group estimation of dynamic heterogenous panels", *Journal of the American Statistical Association*, 94 (446), 621-634.

Phillips, P.C.B. and M. Loretan (1991), "Estimating long-run economic equilibria", *The Review of Economic Studies*, 58 (3), 407-436.

Saikkonen, P. (1991), "Asymptotically efficient estimation of cointegration regressions" *Econometric Theory*, 7 (1), 1-21.

Saqib, N. (2021), "Energy consumption and economic growth: Empirical evidence from MENA region, *International Journal of Energy Economics and Policy*, 11 (6), 191-197.

Stock, J.H. and M.W. Watson (1993), "A simple estimator of cointegrating vectors in higher order integrated system", *Economometrica*, 61 (4), 783-820.

Yergin, D. (2022), "Bumps in the energy transition", IMF, Finance and Development.

Yuan, J.H., J.G. Kang, C.H. Zhao and Z.G. Hu (2008), "Energy consumption and economic growth: Evidence from China at both aggregated and disaggregated levels", *Energy Economics*, 30 (6), 3077-3094.

Zamani, M. (2007), "Energy consumption and economic activities in Iran", *Energy Economics*, 29 (6), 1135-1140.

Zhang, X.P. and X.M. Cheng (2009), "Energy consumption, carbon emissions, and economic growth in China", *Ecological Economics*, 68 (10), 2706-2712.