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Business cycles in Greek maritime transport: an econometric exploration (1998–2015)

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Business Cycles in Greek Maritime Transport: An Econometric Exploration (1998-2015)

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Abstract: Maritime transport has been a crucial input for the growth of the Greek economy given that the Greek fleet is one of largest merchant fleets in the world. However, the impact of the local and international business cycle on Greek maritime transport is inadequately researched, so far, in the literature. In this context, the present paper investigates the key determinants of maritime transport fluctuations in the three major ports of the Greek hinterland, taking into account a number of variables for the 1998-2015 time-span, capturing, at least partly, the global financial crisis and the local crisis, as well. To this end, various relevant quantitative techniques have been used, such as Granger causality, Dufour and Renault multistep causality and SURE system estimation. Our main finding is that Greek maritime transport traffic, as expressed through the cargo volumes of the three major ports of Piraeus, Volos and Thessaloniki, has not been influenced by the Greek business cycle, implying that the country's maritime sector is practically independent of the macroeconomic conditions of the total economy. Clearly, future and more extended research would be relevant in the direction of applying the aforementioned approach to other EU countries of the Mediterranean.

Keywords: maritime transport, greek crisis, global crisis, business cycles, SURE, causality

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An Econometric Exploration (1998-2015)[1]

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1. Introduction

Following the vast literature of maritime transportation, the maritime cycle[2] is clearly linked to the business cycle (Tomassian 2011). Shipping short-term cycles reflect fluctuations in the shipping market's supply and demand (Stopford 1997). In general, the shipping market is extremely volatile, as it is a global business, subject to an ever-changing geopolitical scene and to economic ups and downs, where the cyclical fluctuations of the world economy have profound consequences on the shipping market and on the economy, as a whole (Scarsi 2007).

The relation between fluctuations in output, i.e. business cycles fluctuations and the fluctuations in maritime transportation is conventionally considered through a rather simple schema: On the demand side, fluctuations of aggregate output due to global and/or local crisis influence the price and volumes of commodities that are traded (business crisis) mainly through maritime transport which, in turn, influence the number of transport freights and, thus, the maritime revenues, leading to maritime cycles. On the other hand, on the supply side, maritime cycles influences maritime revenues which, in turn, influence the maritime policy decisions on both the number of new freight orders as well as the type of new freights which influences the composition of merchant fleet, directly influencing maritime productivity. The above scheme, which is well described in Stopford (2000, 2009), summarizes both the supply and demand side of the maritime economy and its fluctuations.

Nevertheless, so far, the direction of causality between maritime transport and aggregate output fluctuations is not perfectly clear. In addition, trade openness determines the magnitude of business cycle fluctuations, albeit, its impact remains ambiguous (see Rodrik 1998; Easterly et al. 2001; Kose et al. 2003; Bejan 2006; Bekaert et al. 2006 and Cavallo 2008, Konstantakis et al. 2015). Therefore, major fluctuations in the value of exports have been primarily linked with cycles even though, phases of readjustment and growth in maritime fluctuations have greatly exacerbated compared to output cycles because of the increasingly important role of finance in maritime shipping (De Monie et al. 2011).

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[2] "The maritime cycle can be defined as a certain temporal sequence of balances and imbalances in supply and demand for the services of maritime markets, which is assimilated in economic theory to a spider's web in which prices and products behave cyclically" (Tomassian 2011).

Shipping demand also draws upon efficiency of shipping and ports; ocean highways are getting more efficient, having shorter handling time at terminals and higher quality transport which, in turn, decreases capacity bottlenecks in the ports, increasing thus containerization. Demand is also heavily dependent on oil prices, both in terms of shipping operation and on industrial production – also dependent on the pricing of oil. Finally, politics seem to be an important driver on shipping demand; the ban on Russian grain exports and imports alters the demand coming from Middle East and North Africa. The same is in force regarding the export ban on Chinese raw materials, which resulted in the decision of many bulkers to ballast to non-Chinese ports, after having exported to China to find the cargo to be charged. Therefore, demand is taken not to be affected from freight rates (Koopmans 1939, Hawdon 1978). The following table (Table I) summarizes the main determinants of shipping demand.

Table I: Demand determinants for shipping

Demand Determinants for shipping
Port efficiency
Oil Price
Bans in Commerce
Geographic location of ports

Furthermore, what is notable for the recession that began in 2008[3] is the extreme rapidity at which the sequence unfolded, implying that future indexes first collapsed, so did container volumes and global trade immediately afterwards, confirming the inevitability of the collapse of the material economy (De Monie et al. 2011). According to Schinas and Psaraftis (2004), the inexistence of regional data casts doubts on the analyses of macroeconomic parameters and aggregate data. A typical cyclical pattern, in the short period, followed by the bulk shipping market is mainly a result of the

[3] After the crisis of 2008 and especially after 2009, there were signs of over-tonnage, where most expansion projects were cancelled or reconsidered, freight rates fell significantly and idle and laid-up ships increased, both nominally and as percentage of the total ships used.

continuous freight adjustments that balance demand and supply, despite a strong linkage with the macroeconomic course (Scarsi 2007).

Since the begging of 2010, as a result of international and local factors, the Greek economy faced a severe economic crisis: it experienced the second highest budget deficit and the second highest debt to Gross Domestic Product (GDP) ratio in the EU, which in combination with the high borrowing costs, resulted in a deep crisis (Charter, 2010). Since then a number of austerity measures have been implemented by the so-called "Troika", i.e. ECB/EU/IMF.

Actually, Greece constitutes the first European Monetary Union (EMU) country where a sovereign debt crisis made its appearance, after the introduction of the common currency. In view of this tremendous change, it is evident that the Greek GDP has fallen dramatically by approximately 20% (BoG, 2013), whereas unemployment rate has reached 27%, and youth unemployment 56% (EL.STAT, 2013). In this context, and given the fact that the Greek maritime transport is one of the dominant pillars of the Greek economy, an investigation of the effects of the Greek business cycle as well as of the global financial crisis on the Greek Maritime transport business cycle is of outmost importance. Meanwhile, exported goods have steadily increased from 1 trillion US$ in 1977, up to more than 16 trillion in 2008, due to the steady growth of containerized trade of high value merchandise.

The present paper contributes to the literature in the following ways: (a) It analyzes the impact of the local and global crises on Greek maritime transport, captured through the cargo volumes of the ports of Piraeus, Volos and Thessaloniki, based on data availability; (b) It employs an advanced quantitative framework based on time series analysis in order to unveil the determinants of Greek maritime traffic using a set of key variables such as (i) the Greek GDP cycle which, captures the volatility of the Greek total economy because of the ongoing recession, (ii) the Greek unemployment rate, which captures, in a nutshell, the labour conditions of the Greek economy, and (iii) the Greek interest rate, which captures the cost of investment in the Greek economy; and (c) it utilizes a relevant statistical framework which is capable of analyzing the both the direction of causality and its timing pattern.

The paper is structured as follows: Section 2 analyzes maritime transport. Section 3 provides a short review of the literature; section 4 sketches the methodological framework; section 5 describes the data and the variables; section 6 discusses the results and finally section 7 concludes.

2. Greek and International Maritime Transport: A Brief Overview

Maritime transport accounts for a 90% share in the world transport, and an annual income of $ 380 billion in freight, which stands for the 5% of the world economy (UNCTAD, 2011). The European Commission (E.C.) (2001) has adopted, as main policy goal, the shifting of cargo traffic from road to sea, making the prospects of the industry, especially in Europe, even better. Also, the abolition of non-tariff trade barriers and the decrease in the customs duties are acting towards a steady increase of global trade. Therefore, in the first decade of the 21st century, container traffic has grown by 9% per year on average, compared to an increase of 4% for seaborne trade (UNCTAD, 2011). Thus, global container traffic was 7 times higher in 2011 than in 1990 (reaching 600 million TEUs). This increase is mainly attributed to the increased exports of Asian markets[4] in developed European and American economies. Mediterranean ports having increased capacity and efficiency, have improved their relative position, handling a steady 9% of world container traffic, whereas the ports of Northern Europe have lost more than 10% of their market share. In 2015, world container traffic comprised 687,309 thousand TEUs (Mariner Finance p. l.c. 2016). The compound average growth rate ("CAGR") of world container traffic from 2005 to 2015 is estimated at 6% compared with a global real GDP CAGR of 2.4% for the same period, according to the World Bank (Mariner Finance p. l.c. 2016). Key drivers that contributed to the growth in global container throughput this period were: growth in global trade, increased global sourcing and manufacturing, a shift from transporting cargo in bulk to transporting cargo in containers and growth in transhipment volumes. In 2015, world container traffic growth was lower than its historical average, equal to approximately 1.1%, because of the slowdown in the global economy (see also Global Ports 2016).

[4] During the period 1995-2011, container trade has increased almost 5 times between Asia and Europe, and about 3 times between Asia and North America.

Despite the steady position of the Mediterranean ports in the world container traffic, World trade's trajectory during the last 20 years has not been steady, because of its increasing dependence on technology, financing, logistics and politics, and partly because of increasing world-wide competition. In that sense, it should be incorporated with the provision of the "sophisticated global network of maritime services" (Branch 1986). For most of the last 30 years trade elasticity has been positive, averaging 1.4 and sea trade grew 40% faster than world economy (Stopford 2004). Possible reasons for this result could be the inferiority of domestically produced goods; the exhaustion of raw materials in a well established manufacturing economy; or even the transformation of developed economies to service oriented economies. Thus, the demand for shipping services seems much more volatile than its supply. As Lorange (2009) put it, "demand rarely exceeds supply for long; rather, there tend to be relatively short peaks of prosperity in the freight markets, followed by longer slumps". However, the volatility of the demand for shipping services in not equal for all commodities.

Greece, partly due to its multi-island geography and its resulting significant number of ports (Karachalis and Kyriazopoulos 2006), has a strong tradition in the shipping business. According to Reuters (2015), the fleet owned by Greeks is the largest both in terms of number of ships and in value, while by flag, the Greek flag is the 8th more popular in terms of value; they operate almost 20% of the global fleet of merchant ships (WSJ 2015). In this country, shipping companies are mainly family companies and, moreover, family connections link the different companies. In this context, affective dynamics seem to strongly influence management behavior. Some years ago, emulation was at the origin of a rush to order the biggest ship, and enormous investments were made with the sole aim of outclassing the relatives/competitors (Scarsi 2007). The port sector of Greece also gains from its special geographical location, i.e. in the crossroads of three continents (Europe, Asia and Africa), creating a large part of the Greek GDP and one of the largest in Eastern Mediterranean countries. Calculated on the basis of ship ownership, shipping is said to contribute around $9 billion - or 4 % - of the country's Gross Domestic Product (GDP) (Reuters, 2015). According to a recent survey (BCG 2013), the estimated indirect contribution of the shipping sector to the economy sums to 2,3 billion euro, while the total contribution of Greek shipping is estimated at about 3,4 billion euro. Also, the Greek cargo ship companies contribute with 6,5 billion euro, summing up to 13,4 billion euro or 6% of Greek GDP (BCG, 2013).

All ports of Greece, except for the port of Piraeus, are state owned[5]. Meanwhile, due to the signing of the third memorandum between the Greek state and the so-called Troika, other ports, such as the port of Thessaloniki, entered a process of privatization, to facilitate the repayment of the Greek debt. Governments' overlook on the functioning is performed through a collaboration of the Ministry of Mercantile Marine, Ministry of Economy and Finance and Ministry of Environment, Physical Planning and Public Works. The fact that the ports that are privatized or are under privatization, are those of Piraeus and Thessaloniki is not accidental. The two ports are the ones with the greater movement of bulk cargo in Greece, and were the only two 'large trans-European ports', according to the classification of the Ministry of Mercantile Marine. The second group in the classification are the ones called 'national ports', including the ports of Volos, Elefsina, Patras, Igoumenitsa, Kavala, Herakleion, Alexandroupoli and Kerkyra. The third group bears the name of 'municipality portuary fund' and the fourth of 'peripheral ports'[6].

The fact that the vast majority of the Greek GDP is produced in the area of Attica, is one of the reasons that Piraeus is by far the larger ports in terms of containership movement (1,6 million TEU vs. 0,27 million TEU the port of Thessaloniki in 2003). Concerning the rest of the ports, Volos used to be a container alternative to both Piraeus

[5] Until 1999, and for almost 70 years, the port authorities of Piraeus and Thessaloniki (OLP and OLTh respectively) were 'public law undertakings', a common scheme for public ownership of the core state. After 1999, the port authorities were transformed into public enterprises though functioning outside the core of the state, an entrepreneurial function quite common in Greece, called DEKO, facilitating the listing in the Stock Exchange Market of Athens (ASE), which was finally succeeded in 2001 for the one of Thessaloniki and in 2003 for the one of Piraeus. This evolution has increased competition between ports, since profit seekers and shareholders were pushing for increase in containership and magnitudes of cargo, as well as decrease of the wages and greater flexibility for the port workers, even though the majority of shares remained under state ownership and the executives were decided by government and ministerial decisions. (see also Psaraftis 2007).

[6] The geographical location of each port may be a factor for the placement, according to the magnitude of cargo, in each one of the tiers, along with the proximity with other markets and countries, for example Patras and Igoumenitsa are the main gateways to Italy, whereas the ports of Thessaloniki, Kavala and Alexandroupoli are gateways for goods' import to Balkans and main gateways for Turkey and the countries of the Black sea and especially Russia. Finally, Volos serves mainly the province of Thessaly and its industrial production and Piraeus and Elefsina are the main cargo ports for the Attica hinterland; Elefsina serves as a complementary to Piraeus cargo port.

and Thessaloniki in terms of cargoes to be transmitted from/to the hinterland of central Greece, and Igoumenitsa, Kavala and Alexandroupoli were reinforced due to the construction of the 'Egnatia' east-west motorway axis.

Transshipmen[7] traffic in the port of Piraeus has increased, mainly due to investments that increased the capacity by 60%, leaving way to increase transit traffic. At the same time, the positive performance of domestic cargo continued in 2014 with an increase equal to 35.9% which followed the increase by 12.8% that was recorded in 2013 (OLP 2015). In Greece, container handling covers around 20% of port revenue for trade activities, whereas containers constitute about 13% of freight volume. The ports of Piraeus and Thessaloniki make the 75% of their profits from container handling. The Mediterranean container market counts for around 54 million TEUs (2011), half of which has to do with transshipment.

Greek share in the Mediterranean market reaches its long term average of 6% (2012), with Piraeus handling more than 5% and Thessaloniki around 0.7%. Taking into account the latest data (SEP balance sheets 2015), the market share of Piraeus has grown up over 6.5%, while the port of Thessaloniki does not have significant fluctuations. In the former, 76% is transshipped, whereas in the latter the percentage of transshipment is negligible. Piraeus' port has a level of available capacity, infrastructure and equipment greater than the average mean of the ports of equivalent size, whereas Thessaloniki has significant potential[8] for future development, given that its infrastructure is almost half than that of the competitor ports in the Mediterranean (Mylonas, 2013). Finally, the completion of railway and road network Sofia-Thessaloniki will strengthen the competition of the port of Thessaloniki. According to Mylonas (2013), there is a significant untapped potential in

[7] The maritime traffic where ports act as intermediate destinations, where cargo is diversified into more than one destination, thus containers are reloaded to other, usually smaller, ships and then are shipped to other or final destinations.

[8] Thessaloniki's port potential is mainly in transit and not in transshipment, being relatively far from the Suez-Gibraltar shipping route. On the market of transits, Greeks controls only 45.000 TEUs (2012) of the market of 2.5 million TEUs, mainly reaching port of Thessaloniki, partly because until then the train operation in Thriasio had not begun. However, the main reason for the limited use of Greek ports as transit ports is the low competitiveness of Greek and Southern Europe transport Europe (road and rail). Greek container transit market has reached about 1.2 million (estimation for 2015), mainly due to the amelioration of rail infrastructure in Greece, as well as the completion of the road axis of Egnatia. The competitiveness of the ports of Northern Greece is about ti improve further, making them ideal for ships whose cargoes move to overland Balkans and countries of the Black sea region (Polyzos et al. 2008).

the Greek ports as gateways for transit traffic, if the appropriate investment in land transport is completed (around 3 billion Euro); this potential would significantly increase revenues for the Greek economy since the value added in the transit traffic is about 4.5 times per TEU more than the one in transshipment traffic.

3. Review of the Literature

Maritime traffic has not been inadequately explored so far in the relevant literature (see, among others, Willingale 1984, and Murphy et al. 1992). In an early study, Pearson (1980) noted that the path to improve competitiveness for ports passes through confidence in port schedules, frequency of calling vessels, variety of shipping routes and accessibility of ports. According to Tongzon (2002), port efficiency is the most important factor in port choice and performance. Also, according to the same study, port choice and performance is determined by high port efficiency, shipping frequency, infrastructure, location, charges, rapidity of responses to users' needs and safety reputation. Determinants for port choice can be classified into three broad categories, route factors, cost factors and service factors (D'Este and Meyrick 1992). According to Mylonas (2013), port choice depends mostly on geographic location and a satisfactory combination of cost and quality and service. Malchow and Kanafani (2001, 2004) conclude than port selection depends upon distance, frequency of sailings, average size of vessel and loading/unloading time in the port. Geographical location is mentioned also by Guy and Urli (2006) as being a primary factor for port choice, along with port infrastructure, cost of port transit and level of port administration. Wiegmans et al. (2008) tested the determinants of port selection and found the following ones: port efficiency and infrastructure, geographical location, interconnectivity of the port, reliability, quality and costs, availability of value-added services and their costs and finally, security/safety and reputation of the port.

Furthermore, according to Wilmsmeier et al. (2006), higher prices are not necessarily related to ports' lower efficiency; on the contrary, ship to shop gantries, or less time in the ports may be crucial determinants of ports' efficiency and, thus, of traffic volumes. Also, port investments and improvements, along with increases in port infrastructure and private sector participation, lead to reduced maritime transport costs (Wilmsmeier et al.

2006). According to Cho (2014), cost per volume of cargo is the key index that determines container port volumes for individual container ports. When port facilities are specialized or non-standard, total costs tend to be higher (Williamson 1996). Increased traffic volumes have been related to port freight, hinterland access, port productivity, sufficient capability, container port development, container port competition, port depth and transshipment, according to Peters (1990) and Medda and Carborano (2007). See also Cho (2014). The low efficiency of ports should not necessarily be attributed to a weak performance of the economy, since many of the least performing ports are located in Europe and in the USA, surprisingly enough the worst performing terminals are found in Italy, UK, Spain and Australia (Merk and Dang 2012). However, port efficiency is mentioned as a relevant determinant of a country's competitiveness (Cho 2014).

4. Methodology

An overview of procedures and methods to be implemented in this study is hereby presented in order to investigate the impact of the local and global crises on the Greek maritime transport business cycle, expressed through the cargo volumes of the three major ports of the hinterland, namely Piraeus, Volos and Thessaloniki.

We briefly present the econometric properties of the original series and their derived components, their causality with respect to other variables of interest, the existence of multi-step causality, possible long-run relationships and, of course, the incorporation of this information into a full-blown SURE model.

- *Definition of Business Cycles*

In this work, we regard business cycles as fluctuations around a trend, i.e. the so-called "deviation cycles", in the spirit of the seminal contributions by Lucas (1977), Kydland, and Prescott (1990), Alesina et *al.* (2008), Battaglini and Coate (2008), Ales et al. (2014). Hence, every time series can be decomposed into a cyclical component and a trend component:

$$c_t = y_t - g_t \quad \textbf{[1]}$$

where: c_t is the cyclical component of time series,y_t is the actual time series and g_t is the respective trend that the time series exhibits.

- *Filtering*

In order to extract the cyclical component we use the Hodrick - Prescott (HP) filter, due to its widespread acceptance in the literature. The robustness of the HP de-trending method is confirmed, among others, by Artis and Zhang (1997) and Dickerson et al. (1998). The parameter used for quarterly data is equal to λ =129,600 (Baum, 2006). The trend is obtained by minimizing the fluctuations of the actual data around it, i.e. by minimizing the following function:

$$\sum_{t=1}^{T}(y_t - y_t^*)^2 - \lambda\sum_{t=2}^{T-1}[(y_{t+1}^* - y_t^*) - (y_t^* - y_{t-1}^*)] \quad \textbf{[2]}$$

where y* is the long-term trend of the variable y and the coefficient λ>0 determines the smoothness of the long-term trend.

- *White Noise*

In order to test whether the cycles extracted by our filtering technique are not mere random walk processes we test for white noise using the Ljung and Box (1978) test (Q-Stat) which tests the null hypothesis of white noise for a maximum lag length k:

$$Q = n(n+2)\sum_{j=1}^{k}\frac{\widehat{p_j}^2}{n-1} \quad \textbf{[3]}$$

where n is the sample size, $\widehat{p_j}^2$ the sample AC at lag j, and h the number of lags being tested; for significance level a, the critical region for rejection of the hypothesis of randomness is $Q > x^2{}_{1-a,h}$ is the a-quantile of the chi-squared distribution with h degrees of freedom.

- *Stationarity*

Now, we have to investigate the stationarity characteristics of the data series employed in our analysis so as to avoid potential spurious regression effects between the variables. In case the time series employed are not stationary, we induce stationarity by taking first differences.

As we know, there are several ways to test for the existence of a unit root. In this paper, we use the popular Augmented Dickey-Fuller (ADF) methodology (Dickey and Fuller. 1979). The ADF test is based on the following regression:

$\Delta y_t = a + bt + \rho y_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta y_{t-i} + \varepsilon_t$ **[4]**

where Δ is the first difference operator, *t* the time and ε is the error term:

(a) if b≠0 and -1<ρ<0 implies a trend stationary model;

(b) if b=0 and -1<ρ<0 implies an ARMA Box/Jenkins class of models;

(c) if b=0 and ρ=0 implies a difference stationary model where Y variable is integrated of degree one I(1).

- *Cointegration*

Next, in the presence of I(1) variables, i.e. first differenced stationary variables, we have to check for the existence of potential cointegration among these variables, since if cointegrating relationships are present, then the Error Correction Model (ECM) has to be employed. In this context, we employ the popular Johansen (1988) methodology which allows for more than one cointegrating relationship, in contrast to other tests. The methodology is based on the following equation:

$$\Delta y_t = m + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + e_p \quad \textbf{[5]}$$

$$\text{where: } \Pi = \sum_{i=1}^{p} A_i - I \; and \Gamma_i = -\sum_{j=i+1}^{p} A_p \quad \textbf{[6]}$$

The existence of cointegration depends upon the rank of the coefficient matrix Π, which is tested through the likelihood ratio, namely the trace test described by the following formulas:

$$J_{trace} = -T \sum_{i=r+1}^{k} \log(1 - \lambda_i) \quad \textbf{[7]}$$

where: T is the sample size and λ_i is the largest canonical correlation.

The trace test tests the null hypothesis of $r<n$ cointegrating vectors and the critical values are found in Johansen and Juselius (1990). Also, having stationary variables in the system is not an issue according to Johansen (1995), as long as all the time series are integrated of the same order.

- *Model Specification*

In order to unravel the effect of the Greek business cycle as well as the impact of local and global crises on the Greek maritime transport cycle, as expressed through the volume cargo cycles of the three major ports of Greece i.e. Piraeus, Volos and Thessaloniki, we employ the following system estimation:

$$Y_{i,t} = X_t b_{i,t} + \varepsilon_{i,t} \textbf{ [8]}$$

where: $i = \{Pireuas, Volos, Thessaloniki\}$ denotes the three major Greek ports investigated; $Y_{i,t}$ is the cyclical component of traffic volume of each port $i = \{Pireuas, Volos, Thessaloniki\}$; while X_t is a 13x1 vector of independent variables, while $\varepsilon_{i,t}$ is the error term for each equation (port) $i = \{Pireuas, Volos, Thessaloniki\}$.

Please note that since the vector of independent variables is common for all ports, then it is very natural to assume that $Cov(\varepsilon_{i,t}\varepsilon_{j,t}) \neq 0$. In this context, in order to consistently estimate the aforementioned system of equations we need to employ Seemingly Unrelated Regression Estimation (SURE).

The main assumption behind the use of SURE estimation is that for each equation i, $i = 1,..N$, the set of regressors $X_{i,t} = [X_{1,t}, \dots, X_{K,t}]$ is of full rank K, and that conditional the regressors, the error terms, U_t, are *iid* over time with zero mean, i.e. $E(U_t/X_t) = 0$ and positive semi-definite homoscedasticity variance $\Sigma = E\left(\frac{U_t U'_t}{X_t}\right)$. See Zelner (1962). In this context, the covariance matrix of the entire vector of disturbances $U_t' = [U_{1,t}, \dots, U_{N,t}]$ is given by $E(vec(U_t)vec(U_t)') = \Sigma \otimes I_t$.

In this work, in order to consistently estimate the SURE system, we employ the so-called Minimum Distance (MD) estimator of the unrestricted coefficients $A(b)$, which is relevant, where: $A(b) = diag(b_1, \dots, b_N)$ is the block diagonal coefficient matrix of a SURE system of the form:

$$Y_t = A(b)'X_t + U_t \textbf{ [9]}$$

where the coefficient $A(b)$ satisfies the condition:

$$vec(A(b)) = Gb \textbf{ [10]}$$

for some full rank matrix G.

The main idea of the MD estimator is to obtain an estimator of the unrestricted coefficient A in (9), and then obtain an estimator of b by minimizing the distance between $\hat{A}$ and b in (10). Thus, when $\hat{A}$ is the OLS estimator of $A(b)$ i.e. $\hat{A} = \left(\sum_{t=1}^{T} X_t X_t{'}\right)^{-1} \sum_{t=1}^{T} X_t Y_t{'}$, the optimal MD estimator $\widehat{b_{MD}}$ minimizes the optimal MD objective function of the form:

$$Q_{MD}(b) = \left(vec(\hat{A}) - Gb\right)'\left(\Sigma^{-1} \otimes \sum_{t=1}^{T} X_t X_t{'}\right)\left(vec(\hat{A}) - Gb\right) \quad \textbf{[11]}$$

Therefore, the optimal MD estimator is of the form:

$$\widehat{b_{MD}} = \left(G'\left(\Sigma^{-1} \otimes \sum_{t=1}^{T} X_t X_t{'}\right) G\right)^{-1}\left(G'\left(\Sigma^{-1} \otimes \sum_{t=1}^{T} X_t X_t{'}\right) vec(\hat{A})\right) \quad \textbf{[12]}$$

- *Granger Causality*

Next, we assess the long-term causality properties of the variables using Granger causality testing. In general, the empirical investigation of (Granger) causality is based on the following general autoregressive model (Engle and Granger 1987):

$$\Delta Y_t = a_0 + \sum_{i=1}^{m} a_{1i} \Delta Y_{t-i} + \sum_{i=0}^{n} a_{2i} \Delta X_{t-i} + \lambda \mu_{t-1} + \varepsilon_t \quad \textbf{[13]}$$

where Δ is the first difference operator, ΔY and ΔX are stationary time series; ε_t is the white noise error term with zero mean and constant variance; μ_{t-1} is the lagged value of the error term of the co-integration regression:

$$Y_t = c_1 + c_2 X_t + \mu_t$$

through which causality could emerge. This model is appropriate only when co-integration is detected**.** If the variables are co-integrated, then the null hypothesis that X does not Granger-cause Y implies that all the coefficients α_{2i} and λ are equal to zero.

- *Multistep Causality*

Short-run and long-run causality measures between the Greek business cycle and the cyclical part of maritime Traffic as expressed through the cargo traffic cycles in the Ports of Piraeus, Thessaloniki and Volos are investigated following Dufour and Renault (1998) and Dufour et al. (2006). Consider the following Vector Autoregressive (VAR) model of order p>0, augmented by exogenous dummy and/or quantitative variables:

$$Y_t = a + \sum_{k=1}^{p} \pi_\kappa Y_{t-k} + \sum_{q=0}^{Q} \beta_q D_{t-q} + u_t \quad \textbf{[14]}$$

where: Y_t is an (1xm) vector of variables; a is a (1xm) vector of constant terms; D_t is a vector of (Lx1) qualitative (dummy) or quantitative variables and u_t is a (1xm) vector of error terms such that $E(u_t u_s) = \sigma_{ii} I$ if $t = s$ and $E(u_t u_s) = \sigma_{ij} I$ if$t \neq s$, where I is the identity matrix.

Following Dufour et al. (2006), the model described in (14) corresponds to horizon h=1. In order to test for the existence of non-causality in horizon *h>0*, a model of the following form is considered:

$$Y_{t+h} = a^{(h)} + \pi^{(h)} Y_{t,p} + \beta^{(h)} D_{t,q} + u_{t+h}{}^{(h)} \quad \textbf{[15]}$$

where: $Y_{t,p} = (Y_t, Y_{t-1}, \dots, Y_{t-p+1})$, $\pi^{(h)} = (\pi_1{}^{(h)}, \dots, \pi_p{}^{(h)})$, $\beta^{(h)} = (\beta_0{}^{(h)}, \beta_1{}^{(h)}, \dots, \beta_q{}^{(h)})$ and $u_{t+h}{}^{(h)} = (u_{1,t+h}{}^{(h)}, \dots, u_{m,t+h}{}^{(h)})$ for t=1,…,T-h and h<T.

Equation (15) can be written in matrix form as:

$$Y_{t+h} = \Gamma X + u \quad \textbf{[16]}$$

where $Y_{t+h} = [Y_{1,t+h}, \dots, Y_{m,t+h}]$ is a (1xm) vector which denotes the m-quantitative variables that enter the model; $X = \left[I_T; Y_{1,t-1}, \dots, Y_{1,t-p}; \dots; Y_{m,t-1}, \dots, Y_{m,t-p}; D_{1,t-1}, \dots, D_{1,t-q}; \dots; D_{l,t-1}, \dots, D_{l,t-q}\right]$ is an (2m+l) x max{t-p+1, t-q+1} matrix that includes both quantitative and qualitatitive variables; $\Gamma = [a_1, \dots, a_m; \pi_{1,1}, \dots, \pi_{1,p}; \dots; \pi_{m,1}, \dots, \pi_{m,p}; \beta_0, \dots, \beta_{0,q}; \dots; \beta_l, \dots, \beta_{l,q}]$ is the inverse of a (2m+l)x[max{p, q+1}] matrix of coefficients and $u = [u_{1,t+h}, \dots, u_{m,t+h}]$ is a (1xm) vector of idiosyncratic shocks such that $u \sim N(0, \Sigma)$ so that the variance covariance matrix is of the form: $\Omega = \Sigma \otimes I$ where $\Sigma = (\sigma_{ij})$ and I the identity matrix, with det $(\Omega) \neq 0$.

Therefore, in order to test for non-causality of the quantitative variables in the augmented VAR (p) model, at a given horizon *h>0*, we use the following algorithm which builds on Dufour et al. (2006).

Step 1: An augmented VAR model as in equation (14) is fitted for using GLS estimation and the Newey-West heteroskedasticity and autocorrelation consistent covariance (HAC) for horizon h=1 and we obtain the estimates $\widehat{\pi_{\kappa}}$, $\widehat{\beta_m}$and $\hat{\Omega}$.

Step 2: A restricted augmented VAR model using GLS estimation as described in equation (15) is fitted and we obtain the estimates $\widehat{\pi^{(h)}}$ and $\widehat{\beta^{(h)}}$.

Step 3: We compute the test statistic $\mathcal{D}$ for testing non-causality at horizon *h>0,* i.e. we test the hypothesis ${H_{0,X_i \nrightarrow Y_{jt}/I(X_i)}}^{(h)}: \beta_{im} = 0, m = 0,1, \ldots, M, i\epsilon\{1, \ldots, l\}, j\epsilon\{1, \ldots, m)$. We denote $\mathcal{D}_0^{(h)}$ the test statistic based on actual data.

Step 4: We draw *N* simulated samples from equation (4), using Monte Carlo, with $\pi^{(h)} = \widehat{\pi^{(h)}}$,$\beta^{(h)} = \widehat{\beta^{(h)}}$ and $\Omega = \hat{\Omega}$. We impose the constrains of non-causality at horizon h i.e. $\beta_{im} = 0, m = 0,1, \ldots, M, i\epsilon\{1, \ldots, l\}, j\epsilon\{1, \ldots, m)$ and we compute the test statistic for non-causality at horizon h, i.e. $\mathcal{D}_n^{(h)}, n\epsilon\{1, \ldots, N\}$.

Step 5: We compute the simulated *p*-values based on the following formula:

$$\hat{p}_N[x] = \{1 + \sum_{n=1}^{N} I[\mathcal{D}_n^{(h)} - x]\}/(N + 1)$$

Step 6: We reject the null hypothesis of non-causality at horizon h i.e.${H_{0,X_i \nrightarrow Y_{jt}/I(X_i)}}^{(h)}$, at level a if $\hat{p}_N[\mathcal{D}_0^{(h)}] \leq a$.

- *Optimum Lag Length*

In order to identify the optimal lag length in all the aforementioned procedures, several criteria can be used. See, among others, Thornton and Batten (1985), Gutiérrez et al. (2007), Hsiao (1981), Ahking and Miller (1985), Khim and Liew (2004), and Hacker and Hatemi (2008).

We make use of the Schwartz-Bayes Information criterion (SBIC) (Schwartz 1978), where the optimum lag length is given by the following objective function:

$$\hat{k} = argmin_{k \leq n}\{-2\frac{\ln(LL(k))}{n} + k\frac{\ln(n)}{n}\} \quad \textbf{[17]}$$

where LL(k) is the log-likelihood function of a VAR(k) model, n is the number of observations, k is the number of lags, and $\hat{k}$ is the optimum lag length selected. As the works of Breiman and Freedman (1983) and Speed and Yu (1992) have shown, SBIC is an optimal selection criterion when used in finite samples.[9]

5. Empirical Results

All data are monthly, come from IMF's databases and cover the period 1998 (M1) - 2015 (M12) except for the data regarding the cargo volume in containers for the ports of Piraeus, Thessaloniki and Volos, which come from the Statistical Service of Piraeus Port Authority, Thessaloniki Port Authority and Volos Port authority, respectively. The use of these specific ports was made based on data availability.

The variables under investigation are: TV_{cy}, i.e. the cyclical component of traffic volume of the ports of Piraeus, Thessaloniki and Volos ($TVP_{cycle}, TVT_{cycle}, TVV_{cycle}$ accordingly), CR_{cycle}, i.e. the cyclical component of world credit in billions of dollars in 2000 prices, TR_{cycle}, i.e. the cyclical component of world trade in billions of dollars in 2000 prices, GDP_{cycle}, i.e. the cyclical component of the Greek Gross Domestic Product in billions of dollars in 2000 prices, $unemployment$ i.e. unemployment of the Greek economy as percentage, $libor$ i.e. the libor interest rate as percentage, $oilprice$ i.e. the price of oil in 2000 prices, $exch$ i.e. the exchange rate between euro and dollar, Ir i.e. the Greek real interest rate, $fleet$, i.e. the number of the Greek ships in thousands, $Crisis_{gr,t}$ i.e. the dummy variable that expresses the Greek crisis and takes the value of 1 in the time period 2010 (M1) – 2015 (M12) and 0 elsewhere; $Crisis_{global,t}$ i.e. the dummy variable that express the Global Crisis and takes the value of 1 in the time period 2008 (M1) – 2015 (M1) and 0 elsewhere; and $DoubleHull_t$ i.e. the dummy variable that expresses the regulation regarding the mandatory double hall in most ships that takes the value of 1 in the time span 2004 (M1) – 2015 (M12).

[9] For the sake of brevity, the empirical results regarding the SBIC criterion for the various procedures are available upon request by the authors.

To begin with, we used the HP-filter to decompose the time series into trend and cyclical component for the following variables: credit, trade, Greek GDP, maritime traffic volume for Piraeus, Thessaloniki and Volos. Having extracted the cyclical components, we proceed by testing if the extracted time series are white noise. The results of the Ljung and Box test – which are available upon request by the authors – indicate a rejection of the null hypothesis of white noise for all the cyclical variables under investigation. In other words, the existence of cyclical regularities is a valid hypothesis from a statistical viewpoint, for all the countries.

Next, we proceed by investigating the stationarity properties of the macroeconomic variables and the results of the ADF test indicate that all macroeconomic variables in levels are non-stationary (Table IIa) but are stationary (Table IIb) in first differences.

Table IIa: ADF test Original Variables

Variable	p-value	Stationarity
Unemployment	0.88	No
Libor	0.12	No
Exchange rate	0.13	No
Fleet	0.44	No
Greek GDP	0.36	No
InterestRate	0.44	No

Table IIb: ADF Test First Differenced Variables

Variable	p-value	Stationarity
Unemployment	0.03	Yes
Libor	0	Yes
Exchange rate	0	Yes
Fleet	0.01	Yes
Greek GDP	0.01	Yes
InterestRate	0	Yes

In the presence of I(1) variables we checked for the existence of potential long-run relationships, based on Johansen's cointegration test. These results, which are available upon request by the authors, show that no long-run relationships are present among the various I(1) variables.

Next, we estimated, by means of SURE, the system of equations for the ports of Piraeus, Thessaloniki and Volos (Table III).

Table III: SURE results

Independent Variables	Piraeus	Thessaloniki	Volos
Credit cycle	0.001 (0.42)	0.0007 (0.10)	-0.0003 (-0.44)
Trade cycle	-0.0004 (-0.42)	-0.0002 (-0.10)	0.0001 (0.44)

Unemployment	982.29 (0.26)	-23.6 (-0.03)	-82.81 (-0.86)
Libor	-147.3 (-0.05)	-329.83 (-0.52)	-54.67 (-0.72)
Greek fleet	-16.93 (-0.15)	38.36 (1.60)	2.32 (0.81)
Oil price	-33.00 (-0.49)	0.98 (0.07)	-1.51 (-0.88)
Exchange rate	-8873.78 (-0.80)	-5042.23 (-0.68)	-1420.33 (-1.59)
Greek Interest rate	-202.5 (-0.23)	-145.97 (-0.78)	-34.47 (-1.53)
Greek GDP cycle	0.65 (1.23)	0.65 (1.23)	0.006 (0.48)
Greek GDP	-0.20 (-0.30)	0.17 (1.25)	-0.003 (-0.23)
Greek Crisis	6708.66 (1.69)*	815.82 (0.96)	-60.08 (-0.59)
World Crisis	-8840.97 (-2.31)*	-505.96 (-0.62)	162.67 (1.66)*
DoubleHull	9357.68 (2.75)*	140.03 (0.19)	75.34 (0.86)
Constant Term	-2587.29	-118.00	-32.19

*denotes statistical significance

Furthermore, we conducted Granger causality analysis in order to study the causalities between the variables under investigation (Table IV).

Table IV: Granger Causality Results

Hypothesis	Lags	Chi-square	Probability
Trade cycle does not Granger cause the Traffic Volume of Piraeus	2	0.36	0.84
Trade cycle does not Granger cause the Traffic Volume of Thessaloniki	2	0.47	0.79
Trade cycle does not Granger cause the Traffic Volume of Volos	2	1.04	0.59
Credit cycle does not Granger cause the Traffic Volume of Piraeus	2	0.39	0.82
Credit cycle does not Granger cause the Traffic Volume of Thessaloniki	2	0.78	0.68
Credit cycle does not Granger cause the Traffic	2	3.59	0.17

Volume of Volos			
Unemployment does not Granger cause the Traffic Volume of Piraeus	2	2.64	0.27
Unemployment does not Granger cause the Traffic Volume of Thessaloniki	1	2.50	0.11
Unemployment does not Granger cause the Traffic Volume of Volos	1	0.04	0.85
Greek fleet does not Granger cause the Traffic Volume of Piraeus	2	0.19	0.91
Greek fleet does not Granger cause the Traffic Volume of Thessaloniki	2	2.65	0.27
Greek fleet does not Granger cause the Traffic Volume of Volos	2	0.51	0.78
Libor does not Granger cause the Traffic Volume of Piraeus	2	1.77	0.41
Libor does not Granger cause the Traffic Volume of Thessaloniki	1	1.08	0.30
Libor does not Granger cause the Traffic Volume of Volos	1	0.07	0.79
Oil price does not Granger cause the Traffic Volume of Piraeus	2	7.05	0.03
Oil price does not Granger cause the Traffic Volume of Thessaloniki	2	1.09	0.58
Oil price does not Granger cause the Traffic Volume of Volos	2	0.43	0.80
Exchange Rate Euro/Dollar price does not Granger cause the Traffic Volume of Piraeus	1	1.42	0.22
Exchange Rate Euro/Dollar does not Granger cause the Traffic Volume of Thessaloniki	1	2.97	0.08
Exchange Rate Euro/Dollar does not Granger cause the Traffic Volume of Volos	1	1.44	0.23
Greek interest rate does not Granger cause the Traffic Volume of Piraeus	1	0.11	0.74
Greek interest rate does not Granger cause the Traffic Volume of Thessaloniki	1	0.28	0.60
Greek interest rate does not Granger cause the Traffic Volume of Volos	1	0.37	0.55
Greek GDP cycle price does not Granger cause the Traffic Volume of Piraeus	1	0.02	0.89
Greek GDP cycle does not Granger cause the Traffic Volume of Thessaloniki	1	1.06	0.29
Greek GDP cycle does not Granger cause the Traffic Volume of Volos	1	0.88	0.35

Finally, we also estimated the timing pattern of causality between the Greek business cycle and the cargo volumes of the ports of Piraeus, Thessaloniki and Volos, based on the concept of multistep causality a la Dufour and Renault (Table V).

Table V: Durfour-Renault Timing Pattern of Causality

Lags (months)	p-values>chi square		
	Greek Business Cycle *does not cause* Piraeus traffic cycle	**Greek Business Cycle *does not cause* Thessaloniki traffic cycle**	**Greek Business Cycle *does not cause* Volos traffic cycle**
1	0.00	0.00	0.14
2	0.00	0.00	0.16
3	0.12	0.01	0.07
4	0.65	0.04	0.56
5	0.38	0.12	0.27
6	0.77	0.23	0.33
7	0.82	0.89	0.45
8	0.69	0.95	0.36
9	0.79	0.90	0.16
10	0.46	0.11	0.14
11	0.55	0.12	0.50
12	0.97	0.59	0.09

6. Result Analysis and Discussion

According to the results of the system estimated (SURE), the Greek crisis is statistically significant for maritime traffic in Piraeus. Also, the dummy variable of the world crisis seems crucial for the ports of Piraeus and Volos. However, after the full operation of the port of Piraeus in COSCO's hands, mainly after 2012, the fluctuations should have decreased, given the ability of COSCO to be vertically organized and act as port owner and as a transporter. Finally, maritime traffic in Piraeus is influenced by the double-hull regulation, which changed the total cost of production for new ship orders. What is quite striking is the fact the Greek maritime traffic is uninfluenced by the Greek business cycle, which in turn implies that the Greek maritime sector is independent of the total macroeconomic conditions of the Greek economy. This, in turn, could be attributed to the fact that Greece acts as an intermediate station for a large volume of cargos that are headed to the Balkans and Eastern Europe. As a result, the percentage cargo volume of products directly headed to the Greek economy account only for a small proportion of the overall cargo volume arriving at the various Greek ports.

Regarding causality, we note that most relations do not show evidence of causality except for the relation between the prices of oil and the cyclical component of the maritime traffic in the port of Piraeus, and the exchange rate between dollar and euro and the port of Thessaloniki (Table II). This finding is in line with Psaraftis (2005, p. 372) who stated that the uncontested assumption that demand for local traffic in Piraeus is quasi-inelastic is not true, but the issue of exactly what characterizes the (in)elasticity is still open. The bulk of maritime traffic, mainly coming from Asian countries has, at least theoretically, strong elasticity towards oil pricing. The increase of oil price has driven ship-owners to operate larger vessels, more efficient, and trying to find, bigger transit, instead of transshipment ports to make use of more independent from oil means of transport such as railway. Also, a number of structural changes take place in liner shipping, such as a trend towards larger vessels, mergers and alliances and increased transshipment (Hoffmann 2001). In that sense, and taking for granted that, at least until 2012, railway network was not functioning in Piraeus, maritime traffic was significantly lower.

The exchange rate between euro and dollar seems to Granger cause maritime traffic in the port of Thessaloniki. This should not be surprising as, by September 2009 when the financial crisis was in its peak point, the crisis was also transmitted from the US to the EU, having severe effects on the exchange rates. At that period, also container line operators re-assessed the market situation and, thus, reduced capacity, delayed deliveries of vessels and canceled when possible (De Monie et al. 2011), probably having effects in the demand of European Countries and especially of Balkans, Central European and Eastern European that are serviced through the port of Thessaloniki. In other words, in contrast to the ports of Piraeus and Volos, the port of Thessaloniki acts as an intermediate station for cargo volumes that are headed to the Balkans, and this fact seems to be behind the statistically significant impact of the exchange rate, since most of the Balkan economies do not use euro as their main currency.

Finally, we investigated the short-run causalities between the Greek Business cycle and the maritime traffic in the ports of Piraeus, Thessaloniki and Volos, through the Dufour and Renault multistep causality (Table V). Based on our findings, Greek business cycle causes the traffic volume of Piraeus, for the first two months, the traffic volume of Thessaloniki for the first four months, while Volos traffic is unaffected. The time difference in causality for the ports could be attributed to the fact that the port of Piraeus, which is the largest port in Greece and one of the larger ports in Mediterranean, acts as an intermediate station for cargos, since a large volume of them is then transferred to other regions/economies, via other routes and means. In this context, it is quite natural that the timing pattern of causality for the port of Piraeus differs from the rest of the ports that operate at a more "local" scale.

The finding that short run causalities exist in most ports is in accordance with our previous findings and with the literature, since the lag between the order and the delivery of the ship is crucial (Scarsi 2007). Finally, the fact that changes in maritime traffic occasionally take place with a lag after changes in the business cycle is further confirmed. In the phase of the upturn of the business cycle, the bulk of products increase placing a need for more exports, ship-owners place orders for new boats, which are delivered usually when the business cycle has turned into its slump pushing prices even lower, contrarily to would be the case if new buildings had not been placed.

7. Conclusion

Greece has traditionally had a glorious history in the shipping business and currently possesses one of the largest merchant fleets in the world. Nevertheless, thus far, no adequate attention has been paid to the impact of the Greek business cycle and of both the Greek and the global crises, on the Greek maritime traffic cycle.

The present paper contributed to the literature in the following ways: (a) It analyzed the impact of the Greek and global crises on Greek maritime transport; (b) It employed an advanced quantitative framework based on time series analysis in order to unveil the determinants of Greek maritime traffic using a set of key variables; and (c) it utilized a relevant statistical framework which is capable of analyzing the both the direction of causality and, more importantly, its timing pattern.

In this context, our research contributed to the better understanding of the Greek business cycle, in general, and of the macroeconomic and sector-specific conditions. In detail, the Greek maritime activity seems to be unaffected by the volatility of the Greek business cycle since there is no statistically significant relationship between them. In general, the overall macroeconomic conditions in Greece do not seem to affect the country's maritime transport sector.

Clearly, future and more extended research on the subject would be of great interest. A good example for further investigation would be to apply the aforementioned approach to other EU countries of the Mediterranean to examine whether and the extent to which their maritime transport has been hit by the recent recession.

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