Does Capacity or Price affect competition in Liner Shipping? An empirical investigation in passenger markets.

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ABSTRACT

In liner and especially in short sea shipping, ship owners decide which kind of ships they will employ in terms of their carrying capacity speed and qualitative characteristics. Clearly this decision is subject to the requirements of the specific characteristics of their market and the prevailing competitive conditions. Then, at a second stage, they bring these "quantities" to market and they engage in Bertrand-likeprice competition, while they have full and intertemporal access to information relating to other operators' market shares per category of passengers and vehicles. This competition theoretically should end up in a Bertrand-likeoutcome with prices equal to marginal cost, generating the competitive solution with the proviso that none of the ship owners can satisfy more demand than they are producing for in the first stage. However, as Kreps and Scheinkman (1983) have shown, this Bertrand-likecompetition may end up in Cournot outcomes due to the form of the game they are engaged in. In this paper we suggest a new test that applies the New Empirical Industrial Organization method (NEIO) and more specifically Conjectural Variation (CV) model in order to identify whether a duopoly game ends up in a Cournot or Bertrand outcome. At the same time we investigate Stackelberg related alternatives or collusive behaviour. We apply our model in short sea passenger shipping. Our findings suggest that rivals compete over both prices and quantities with one of the two firms leading the market. Additionally, the leader presents the highest deviations from marginal cost as suggested by the comparison of the Lerner indices, while he has undertaken the heaviest investment in the market. Thus, there is evidence that the prices charged to passengers are Cournot prices, validating the Kreps and Scheinkman argument. However, in the case of vehicles transportation there is strong evidence of collusion.

Keywords: Passenger Shipping, Games, New Empirical Industrial Organization

1. INTRODUCTION

Passenger coastal shipping markets are defined by lines connecting different ports and islands, where a limited number of competitors are engaged. Within this framework ship owners decide which kind of ships they will employ in terms of their carrying capacity speed and qualitative characteristics (itineraries, number of calls and comfort conditions). Clearly, this decision is subject to their expectations on the requirements of the specific market in which they operate and the prevailing competitive conditions. Then, at some second stage, they bring these "quantities" (i.e. carrying capacity, speed and qualitative characteristics) to this liner market and they engage in Bertrand-like price competition, while they have full and intertemporal access to information relating to other limited operators' market shares per category of passengers and vehicles. This competition theoretically should end up in a Bertrand-like outcome with prices equal to marginal cost generating the competitive solution with the proviso that neither ship owner can satisfy more demand than they are producing for in the first stage (indivisibility of supply) (Agarwal and Ergun 2007).

However, as Kreps and Scheinkman (1983) have shown this Bertrand-like competition may end up with Cournot outcomes due to the form of the game they are engaged in. Since capacities are set in the first stage, demand is then determined by Bertrand-like price competition that will not always set prices that exhaust capacity. Following the restriction set by the predetermined capacities and given that these capacities correspond to Cournot output levels, in the second stage each firm will name the Cournot price. These Cournot prices will be fixed for the entire game generating Cournot output levels as a unique equilibrium outcome. Thus prices charged will not represent competitive outcomes and they will reflect the market power of players generating subsequent welfare losses. In addition Davidson and Deneckere (1988) argue that in markets in which firms make capacity decisions before they make pricing decisions, the equilibrium tends to be more competitive than the Cournot outcome while they suggest that the cheaper the capacity the more the tendency towards asymmetric firm sizes and price dispersion.

The overall goal of this paper is to examine deviations of price and quantities from pure competition solution in the case of passenger coastal shipping and whether the form of these deviations is related to the investment undertaken by the rivals. More specifically, we examine whether an oligopolistic market structure in coastal shipping follows the Kreps and Scheinkman model ending up in Cournot outcomes or if it is simply a Bertrand-like game, while we investigate Stackelberg leadership alternatives. Our empirical application is based on a Greek coastal shipping market for sample period in which two rival firms compete. The method that we adopt is analysed as follows: first we compare adjusted Lerner indices constructed for the specific case to establish deviations from pure competition of the two companies. Then, we apply New Industrial Organization Approach (NEIO) (Bresnahan, 1989) and more specifically, the Conjectural Variation (CV) models that presuppose each firm believes its choice of a strategic variable will affect the strategic variable selected by its rival. This reaction is captured by a single parameter (Iwata 1974, Appelbaum 1982) the effect of which we isolate through the innovative use of reduced forms of simultaneous equations. In these equations, the impact of conjectural variation will be linearly identifiable with the use of the Generalized Method of Moments (GMM). If the Kreps and Scheinkman (1983) argument is valid, the CV parameter should be statistically significant. Combining our findings, that is, Lerner indices deviations from pure competitive outcome, CV parameters statistical significance and the investment undertaken by the rivals, we infer on the type of game that they are engaged in. Thus the main contribution of this paper is the introduction of a game structure in coastal passenger shipping that takes into account the heavy investment in the sector with an applied game model being tested. In addition we introduce a new empirical test of the CV hypothesis that avoids non-linearity and is easy to implement. However the test loses the identification of the extent of the CV impact.

The paper is organized as follows. In section 2 we discuss the game theory literature and especially cases that involve large fixed investment as it is the case in coastal shipping market. In section 3 we present the Greek market of coastal shipping along with the specific case study and the two rival firms' performance. Section 4 entails the adopted methodological approach, the theoretical model and its empirical counterpart. Section 5 presents the data and our findings while section 6 presents conclusions and policy suggestions.

2. GAME STRUCTURES AND THE EFFECT OF LARGE FIXED INVESTMENT.

Dynamic games are very appealing in economic modeling in many different fields of the discipline. In a competitive game, each player's actions take into account – among others - his rivals' response while the final outcome depends upon their relative market power. A critical issue that determines the end result of a game is the type of the game being considered. In a Nash type game, the decisions of rivals are instantaneously subject to the same information set. In contrast, in a Stackelberg type game the players move independently from each other and one player's strategy is unknown to the other prior to the move. Another critical issue for the determination of the outcome of a game is the strategic variable used by the players. If the strategic variable is quantity (the Cournot case) competition yields an equilibrium price that is above marginal cost, while if the strategic variable is price (the Bertrand case) the perfect competition outcome is generated with prices equal to marginal cost. The Cournot case is associated with producers who simultaneously and independently decide upon the produced quantities they bring to the market, with the market price being the price that equates total supply with demand.

In the Bertrand case, producers simultaneously and independently name prices. Demand is allocated to the low-price producers who serve up to the demand that they are allocated. Unsatisfied demand goes to the second lowest producer and so on. However as it has been shown by Kreps and Scheinkman (1982), even in the Bertrand case and given that at a first stage capacity creation and production takes place, the final outcome will be the Cournot outcome. This is so, since at the second stage competitors engaging themselves in Bertrand-like price competition, set prices, but cannot satisfy more demand than was produced in the first stage. As Kreps and Scheinkman argue that in a two-stage game, it is easy to produce equilibrium. Let each firm choose the Cournot quantity. If each firm does so, they subsequently set the Cournot price. If on the other hand, either firm chooses some quantity other than the Cournot quantity, its rival names price zero in the second stage. Since any defection in the first stage will result in one firm facing the demand residual from the Cournot quantity, and since the Cournot quantity is the best response to this residual demand function, this is clearly equilibrium.

In other words Kreps and Scheinkman's finding suggests that when production is associated with heavy investment and high fixed costs the final outcome will be the Cournot outcome. This is determined by their capacities despite the Bertrand-like competition that the competitors may be engaged in. And this is so since agents will choose Cournot price corresponding to Cournot quantities induced by the capacities that their investments will enable. Davidson and Deneckere (1988), further investigate the nature of equilibrium in markets in which firms make capacity decisions before making pricing decisions concluding that the equilibrium tends to be more competitive than the Cournot outcome. In addition, they suggest that the cheaper the capacity the more the tendency towards asymmetric firm sizes and price dispersion. This price dispersion may come as the result of periodic sales (Varian, 1980), or as the result of incomplete information games in which very small privately observed random shocks affect firms' payoffs (Harsanyi, 1973).

Within this symmetric game framework where each firm responds to the actions of its rival using the same strategic variables - conduct parameters, it is important to identify whether we have a leader – follower (Stackelberg) and dominant-fringe interaction. If the game is Bertrand then the follower will have the advantage, while if the game is Cournot then the advantage lies with the leader. Another important issue that has to be resolved is whether we have an open or a closed loop game. In an open-loop strategy a firm chooses a path of actions based on the initial condition and commits for the entire game. Firms do not respond and revise their decisions in the subsequent periods although unexpected shocks may occur (i.e. sub game is not perfect, as pointed out by Fershtman and Kamien, 1987). In contrast, in a closed-loop strategy, firms do not commit themselves to a particular path and they revise their decisions in each period choosing optimal strategies. Thus the Nash equilibrium is reached each time (sub game) and the game is sub game perfect. Clearly in the Cournot case, which is associated with high fixed costs the game has to be open. However within investment periods the game may be closed-loop if firms choose a Bertrand strategy and compete over prices.

2.1 Games modeling and testing

Applications of games in oligopoly structures are related to the testing of the market power index that allows a firm to set prices at some level different from marginal cost where profits are zero and the pure competition outcome emerges. The Lerner Index (Lerner, 1934) is the best well known index of such kind which has the forms

$$\lambda=(p-mc)/p \qquad (1)$$

Where p is price and mc is the marginal cost. A higher Lerner Index indicates higher market power. However, the Lerner Index is not easy to compute due to the difficulties associated with estimating marginal cost. Other models that have been developed to measure market power used the Structure-Conduct Performance (SCP) and the New Industrial Organization (NEIO) approaches. The SCP (Mason, 1949) relates oligopoly structure and market power from the positive relationship between structure variables – such as market concentration, product differentiation, vertical integration or barriers to entry – to market performance variables e.g. price – cost margin, capitalization relative to book value. However this method may lead to inaccurate estimators of market power due to the interdependence of variables or measurement difficulties as discussed in Caves and Porter, (1977), Bresnahan (1989) and Delorme et al. (2002). The NEIO approach proceeds to a direct estimation of market power by the deviation of prices from competitive price taking behavior (Perloff et al., 2007). The NEIO models are classified as static and dynamic. Static methods in their turn are distinguished between the comparative static models and the conjectural variation models.

Static methods use long run equilibrium conditions to compute market power indices that count the distance from competitive market solutions (Hall, 1988, Panzar and Rosse, 1987). In conjectural variation models the market power parameter is derived from the first order conditions of a profit maximizing firm that reacts to its rival's profit maximizing behavior (Iwata, 1974, Appelbaum, 1982). They assume game structures that involve a set of players I = {1,…n}, a vector of control variables for each player and a vector of state variables. The motion of the system is described by the state equations, while each player has a payoff function which describes his reaction to the action taken by the rivals. For instance, in a case of price competition between firms i and j the conjectural variation parameters are $\varphi_{ij} = \partial p_j / \partial p_i$ and $\varphi_{ji} = \partial p_i / \partial p_j$. If $\varphi_{ij} = \varphi_{ij} = 0$ we infer Nash competitive structure. If not, we may infer that one of the firms is the leader. For example if $\varphi_{ij}=0$ and φ_{ji} is non zero then we have price leadership by j firm (and vice versa). If $\varphi_{ij} = \varphi_{ij} = 1$, then there is evidence of collusion. Similar inferences can made for quantity CV models. Finally, dynamic NEIO models refer to dynamic or differential games that consist of a set of players that cooperatively or non-cooperatively want to maximize a payoff functional form subject to some vector of state variables, state of control variables and a state equation that describes the motion of the system (see Jorgensen and Zaccour, 2007).

In dynamic game structures intertemporal linkages are introduced connecting subsequent games and giving the opportunity to rivals to adjust. For a player i the objective is to maximize (2) with respect to the control variable $u_{it.}$

$$J_i (q_{t-1}, \nu) = \max [(p_t - c_i (t))q_{it} – (\gamma_{it} + (1/2)\theta_i u_{it}) + \delta J_i (q_t;\nu)] \quad (2)$$

$$\pi_{it} (q_t, u_t) = (p_t - c_i (t))q_{it} – (\gamma_{it} + (1/2)\theta_i u_{it}) \text{ uit} \quad (3)$$

(3) is the profit from the current period (which is the profit in static model including adjustment costs),while:
$J_i (q_t;\nu)$ is the future profits
δ is the discount factor
ν is an index of market power
$(\gamma_{it} + (1/2)\theta_i u_{it})$ (4)
(4) is the adjustment cost function with intercept γ_{it} and slope θ_i
$q_t = q_{t-1} + u_t$ (5)
(5) is the equation of motion with state variable q_{t-1}.

Empirical testing uses classical (Slade, 1995) or Bayesian techniques (Karp and Perloff, 1993). The quadratic form of the adjustment cost function that is evenly distributed over time and depends positively on the speed and size of adjustment has been criticized (e.g. Nilsen and Sciantarelli, 2003). Alternatives to the basic model are produced by using different typologies of the equation of motion (Jorgensen and Zaccour, 2007.

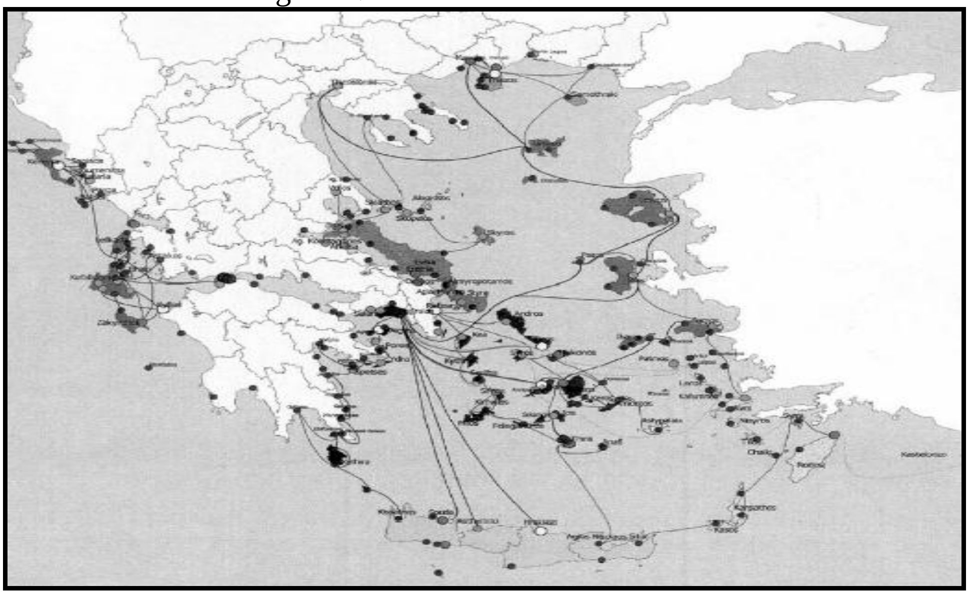
3. THE COASTAL PASSENGER SHIPPING MARKET IN GREECE

The Greek coastal passenger market is among the two biggest in Europe. Greece and Italy showed the highest maritime transport of passengers with 90.4 and 85.98 million passengers in 2006. Over the 2001-2006 period, Greece marked a considerable 80% growth. As far as passengers per thousand inhabitants are concerned, Denmark maintained the first place with 8.871. Greece ranked second with 8.126 and a 77% rise compared to 2001 (Eurostat, 2008).

For many years (1827- 2002) coastal shipping market remained a state regulated industry since its main aspects (Kahn, 1991), namely control of “entry and exit” of companies, “setting of prices”, and “intervention in the quality aspects of the services provided” were controlled by the state (Lekakou, 2007). This process finally resulted in a regulated oligopoly with heavy State intervention.

It is significant to notice that the «public» character of the coastal shipping services has mainly yielded State intervention. However, at the same time, this has raised also social awareness and mobilization due to ineffective policy provision. At figure 1 we can see that the network of Greek coastal passenger services is a complex one, consisting of a large number of mainland-to-island, island-to-island and mainland-to-mainland connections. The Aegean coastal passenger shipping network is the densest one and constitutes over two-thirds of daily departures from the port of Piraeus, excluding short ferry links

Figure 1: Coastal Network in Greece



Source: Tzannatos, 2005.

The structural characteristics of coastal market are the outcome of economic and geographical restraints. These restraints have largely determined both market prospects and the structural characteristics of the prevailing competition and include the following:.

Small number of providers: there is a high concentration levels with small number of usually interdependent enterprises in the main lines. A number of companies specialised in particular routes, often reflecting their historical roots on particular islands. (Lekakou and Vitsounis 2008).

A large number of users: a large number of independent users (50 million passengers, transport enterprises, tourist offices) with a changeable, intensely seasonal coastal demand that increases over time. In addition, transport flows are not balanced in the majority of coastal routes.

Low level of knowledge and information: knowledge deficit, especially from the consumers' side and asymmetry of information on behalf of involved actors (producers, users, port authorities, local authorities, central administration) with conflicting aims. Asymmetric information has further been held to clarify why industries during the regulatory process, may be able to reverse regulatory policies to their advantage and capture a regulatory agency (Hagg- Goran, 1997).

Differentiated service: differentiation in terms of space and quality with every pair of geographical points defining a different transport service and a special local market.

Institutional and economical barriers to entry: high institutional and economical entry barriers (investment cost, annual operation obligations, long preparation period, extended networking, fees).

Low mobility: limited mobility mainly due to a pre-existing institutional framework (license) and service differentiation per sub-market and the related prerequisites (ship type, port advertisement-agency expenses, etc.

Indivisibility of supply: Ships with a given and "rigid" capacity, compared to the seasonal and volatile demand, which leads to high rates of excess capacity during off peak periods.

*High fixed cost, low incremental and almost constant and low marginal cost (*fixed to variable: 3:1, and recently 3:2, due to dramatic increases in fuel prices or 4:1 for newcomers with newbuildings). There are differences among carriers and their cost structures. Differences in the size, types, and age of the vessels they own and differences in terms of the administrative and managerial capabilities are among the many factors that will contribute to differences in costs across different firms as in liner shipping (OECD 2002), i.e. bunkers cost seriously differs between conventional ships and high speed vessels (38% and 52% of the operational costs respectively) (UCS, 2005). Serious differences in cost patterns exist between the established companies and the newcomers due to capital expenses, networking cost, high administration cost and the long period of preparation.

Distance-based fares. Pricing of services are based on distance, and strongly related with the old state – tariff: fare based on the distance and the operational cost of service production and not on the demand or competition per city-pair. First Class passenger fares were partly deregulated in 1980's. However, during our sample period, fares are purely competitive.

3.1 Case study: a coastal line in North East Aegean Sea

The North East (NE) Aegean line is one of the busiest in Greek costal network. The route distance is 208 miles. (153 m. is the Piraeus – Chios link and 55 miles further to Mytilini). The Ports of Chios and Mitilini are state owned and belong to the 18 busiest ports of Greece showing high levels of passenger transportation. The area has a population of about 120,000. The two major population centres are Chios and Mytilini (Chlomoudis et al, 2007). There are scheduled air services to and from both islands, which are provided by more than one carrier.

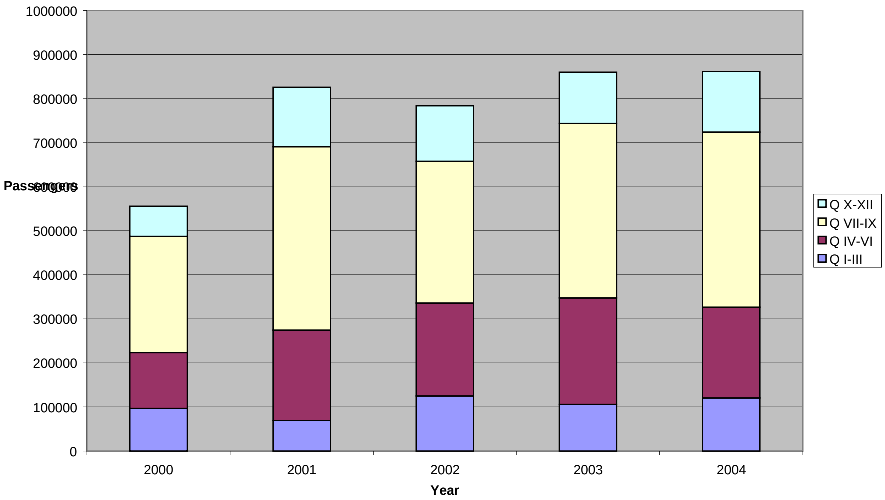
TABLE 1: QUARTERLY TRAFFIC TO CHIOS AND MYTILINI

PASSENGER TRAFFIC TO CHIOS				
Yearly Quarters	**2005**	**2006**	**2007**	**2008**
I- III	58.286	69.636	76.073	76.266
IV- VI	108.252	132.202	127.400	127.877
VII- IX	188.936	209.638	209.284	205.797
X- XII	83.918	90.964	82.629	79.442
TOTAL	**439.392**	**502.440**	**495.386**	**489.382**
PASSENGER TRAFFIC TO MYTILINI				
	2005	**2006**	**2007**	**2008**
I- III	56.576	64.167	66.923	64.360
IV- VI	118.800	137.354	131.883	134.183
VII- XII	244.927	264.126	267.059	265.138
X- XII	85.705	82.938	80.310	82.626
TOTAL	**506.008**	**548.585**	**546.175**	**546.307**

Source: Processed results based upon data obtained from Port Authorities

Table 1 shows that demand for passenger-ferry services in the NE Aegean has a high degree of seasonality. This variation is is a standard feature of Greek coastal shipping. This is largely due to seasonal tourism. Pronounced seasonality affects passenger satisfaction and financial viability of the lines concerned with important consequences for both users and service providers (Lagoudis *et al*, 2006). In the case of the NE Aegean, as everywhere in the islands, seasonality is blatantly present in the passenger and car demand peaking during the summer period. The Piraeus - Chios Mytilini line was traditionally (for almost 30 years) served by one operator ((J) LINES) had strong relations with local interests, which prevented the entry of any other firm. This monopoly was maintained by pressing the Minister of Mercantile Marine not to issue other licences. In 2002, a severe licensing system was put in force, which created a high barrier to entry. Folloiwng the abolishment of cabotage and the liberalization of the coastal market in 2002, (I) LINES entered the trade in 2005.

GRAPH 1: SEASONAL DISTRIBUTION OF PASSENGER TRAFFIC IN NORTH-EASTERN AEGEAN



Source: Lagoudis *et al*, 2006

3.2 (J) LINES

(J) Lines (founded in 1972) is an island-based company (multi-stakeholder firm on a cooperative base) as an outcome of intense social mobilization at both local and national level. It used to be a "user firm" with very strong relations with the island interests. With its subsequent listing in the Athens Stock Exchange, it was transformed from a stakeholders' to a shareholders' firm. In 2005 the company was controlled by a strategic investor and its stock exchange trading was put on hold. Currently, it operates a fleet of seven vessels, with an average age of 23.6 years. A restructuring program, which began four years ago, is still under way with the most recent development being geographic diversification in its operations in the Red Sea area. The main areas of (J) operation are the Cyclades, the N.E. Aegean and the Red Sea.

3.3 (I) LINES

(I) LINES (founded in 1999) is a major player in coastal shipping. Under the old legal system with a different ownership and brand name, it had controlled the majority of the coastal lines by controlling specific ships, since exclusive licenses were attached to ships. The end result of this near-monopoly led to better service for some islands but also to serious monopoly pricing for others. Yet, some claim that this reduced quality was part of a strategy on the part of the monopolist to force the government into providing the company with new licenses to improve service. Following a serious maritime accident in September 2000 with a loss of 80 lives, the system could not absorb the consequences. There was public outcry against both the monopolist and the state itself. This led to a conflict between the monopoly and the regulatory state and the existing institutional framework collapsed and the monopoly reached the brink of bankruptcy (Lekakou *et al*, 2002).

Currently, its successor, (I) controls the biggest fleet among the Greek ferry operators. Today the company operates 33 vessels of different types operating in the Aegean Sea. The fleet is the most diversified both in terms of type and in terms of areas of operation within the Aegean Sea area. The company operates in the areas of Cyclades, Saronic, Sporades, Crete, N.E. Aegean and Adriatic Sea with four Ro/Ro vessels focusing on the demand of trucks and cars. Tables 2 and 3 present information about the two firms and the ships active in the case study route.

3.4 THE COST OF INVESTMENT IN THE SHIPS SERVICING THE LINE

One of the main issues of our study is the cost of investment in the ships that are engaged in serving a specific line. As we have mentioned above, this initial investment decision creates the capacity that ship owners introduce to the market. It is this capacity that affects the competitors' strategy thereafter. Examining the investment performance of the two rival firms we find that company (I) invested in a new built ship ((I)1), constructed in 2006 with a 2010 estimated market value of about €50 million. On the other hand, the second hand ships of company (J), - (J)1 and (J)2 - have a 2010 market value of €5 and €4 million respectively. (These estimates are based on market experts' opinion). The transport capacity of (J)1, (J)2 and (I)1 along with maximum operational speed and year of built are reported in table 2, while table 3 outlines the qualitative characteristics of the provided services. Clearly, company (I) has undertaken heavier investment with respect to capacity and quality of services.

TABLE 2. THE PIRAEUS –MYTILINI FLEET

COMPANY	VESSEL NAME	CAPACITY (pax)	SPEED	YEAR OF BUILT
(J)	(J)1	1730	20 kn	1973
(J)	(J)2	1660	18 kn	1975
(I)	(I)1	1715	28 kn	2006

TABLE 3. THE COASTAL SERVICES CHARACTERISTICS

LINE	FREQUENCY (weekly)	DEPARTURE TIME	TRIP DURATION (hours)	VESSELS TYPE
PIRAEUS MYTILINI	7 8	EVENING NOON	8,5 12.5	((I)1) ((J)1, (J)2)
PIRAEUS CHIOS	7 6	EVENING NOON	6 8,5	((I)1) ((J)1, (J)2)

4. THE ALTERNATIVE MODELS AND THEIR EMPIRICAL COUNTERPARTS

4.1 The method

In this section a theoretical model is developed to capture the game structure employed under the alternative competitive strategies of prices or quantities. Two companies I and J coexisted as the sole competitors in the Pireaus-Chios-Mytilini route from January 2004 to April 2009, when a third company entered the market. The game between companies (J) and (I) is supposed to be closed loop with intertemporal access to information from all rivals. In order to formalize the game the Conjectural Variation model (CV) is adopted. As discussed above, in the CV models market power is derived from the maximization conditions of a firm's profit function (Iwata 1974, Appelbaum 1982). This not only provides evidence of market power but allow us to measure the degree of such market power (Panzar and Rosse, 1987). However, in order to avoid associated nonlinearity problems (Roy et al, 2006, p.373), we extent our model to a linear specification. This linear specification allows for its empirical implementation by using simple econometric methods. Thus we can easily deduce the kind of game that the companies are engaged in with the cost of losing on the estimation of the extent of the CV parameter. Clearly during our sample period the companies had competed each other in terms of prices or quantities basing their decisions on the ships that they have invested upon to serve the route. If the Kreps and Scheinkman (1983) argument is correct then the game should end up being Cournot. In addition, we will test the presumed oligopoly structure of the market and its association with deviations from pure competition outcomes and pricing behavior that distances itself from marginal cost behavior. For such a test we will compare simple Lerner indices of the two companies.

4.2 The model

Cournot

With quantities as the strategic variable the inverse demand function takes the form,

$$f_i = \alpha_i - \beta_i q_i - \gamma_i q_j \qquad (6)$$

Assuming that cost is constant and independent of passengers carried, the profit function is,

$$\Pi_i\,(q_i)=f_i q_i - c_i q_i \qquad (7)$$

Optimum output level is set at the point where,

$$\partial\Pi_i/\partial q_i = 0 \qquad (8)$$

From (8) we get,

$$q_i= B_i - \Gamma_i\, q_j - \Delta_i\, c_i \qquad (9)$$

where,

$$B_i = \alpha_i \,/\, (2\beta_i + \gamma_i\, \theta_{ij}) \qquad (10)$$

$$\Gamma_i = \gamma_i \,/\, (2\beta_i + \gamma_i\, \theta_{ij}) \qquad (11)$$

$$\Delta_i = 1/\, (2\beta_i + \gamma_i\, \theta_{ij}) \qquad (12)$$

θ_{ij} is the conjectural variation parameter which is,

$$\theta_{ij} = \partial q_j \,/\partial q_i \qquad (13)$$

From (11) we get that,

$$\theta_{ij} = 1/\Gamma_{ij} - 2\beta_i /\gamma_i \qquad (14)$$

i. if $\theta_{ji} = \theta_{ij} = 0$ then there is no conjectural variation effect and the case reduces to a simple Cournot-Nash,

$$B_i = \alpha_i / 2\beta_i \qquad (15)$$
$$\Gamma_i = \gamma_i / 2\beta_i \qquad (16)$$

ii. If $\theta_{ji} = \theta_{ij} = 1$ we have evidence of collusion, while
iii. if θ_{ji} is non zero and $\theta_{ij} = 0$ then we have evidence of price leadership where j firm leads and i follows (and vice versa).

<u>Bertrand</u>
In the case where the strategic variable is price then the demand function has the form,
$$q_i= \rho_i - \sigma_i f_i +\tau_i f_j \qquad (17)$$

profits are again as in (7). Optimum pricing decision is set at the point where,

$$\partial\Pi_i/\partial f_i = 0 \qquad (18)$$

From (26) we get,
$$f_i= E_i - Z_i f_j \qquad (19)$$

where,
$$E_i = \rho_i / 2\sigma_i - \tau_i \varphi_{ij} \qquad (20)$$
$$Z_i = \tau_i / 2\sigma_i - \tau_i \varphi_{ij} \qquad (21)$$
$$\varphi_{ij} =\partial f_j /\partial f_i \qquad (22)$$

φ_{ij} is the conjectural variation parameter.

From (21) we get that,
$$\varphi_{ij} = 1/Z_i - 2\sigma_i /\tau_i \qquad (23)$$

i. if there is no conjectural variation effect $\varphi_{ij}= 0$ and we get the simple Nash-Bertrand case where,
$$E_i = \rho_i / 2\sigma_i \qquad (24)$$
$$Z_i = \tau_i / 2\sigma_i \qquad (25)$$
ii. If $\varphi_{ij} =\varphi_{ij}=1$, then there is evidence of collusion.
iii. if $\varphi_{ij}=0$ and φ_{ji} is non zero then we have price leadership by j firm (and vice versa).

An empirical implementation of our theoretical models with the goal of identifying conjectural variation parameters involves the estimation of the set of equations (6) and (9) with the restrictions (10), (11) and (12) for the Cournot case and of the set of equations (17) and (19) with restrictions (20) and (21) for the Bertrand case. Testing for Nash or Stackelberg solutions leads to adjustments of the restrictions (Roy et al. 2006).

However, as discussed in Roy et al (2006, p.373), the implementation of such an empirical investigation strategy is associated with econometric problems due to the non-linearity of the imposed restrictions necessary to identify the conjectural variation parameter. This leads to using bootstrap techniques (Effron 1979) and 3 Stage Least Squares estimating method Freedman and Peters (1984). In addition, such a method does not allow to test whether the restricted version performs better than the reduced structural unrestricted relation that stems from the theoretical model and consequently there is no statistical validation of the imposed restriction that is used to identify conjectural variation. In order to avoid these problems we tried to expand further our theoretical model aiming at the construction of reduced forms of equations where the impact of conjectural variation will be linearly identifiable. More precisely using a computational device we assume that conjectural variation parameter φ and θ are analyzed to:

$$\varphi=1+\lambda \tag{26}$$
$$\theta=1+\mu \tag{27}$$

With λ, μ being any real numbers. After some straightforward computations we end up with the following relations.

In the Bertrand case

$$f_i= \Theta_i - K_i (f_j - f_i) + K_i [f_j\varphi_{ij}] \tag{28}$$

where

$$\Theta_i = \rho_i /2\sigma_i + \tau_i \tag{29}$$
$$K_i=\tau_i /2\sigma_\iota + \tau_i \tag{30}$$

In the above relationship we have isolated the effect of conjectural variation in the last term of the right hand side while coefficient K captures the effect of price differentiation of the two rivals. If φ_{ij} has no effect on f_i then we have the Nash solution and the one firm sets its price as a function of the price difference from the price of the other. If f_j affects f_i then firm i is affected by changes of firm j and we have evidence of probable price leading firm j and vice versa. If $\varphi_{ij} = \varphi_{ji} = 1$ we have collusion and a constant relationship between prices. The empirical part of (28) is

$$f_i= M0_i - M1_i (f_j - f_i) + M2_i [f_i(\partial f_j /\partial f_i)] \tag{31}$$

(31) along with (17) form our set of simultaneous equations system. If $M2_i = M2_j = 0$ we have evidence of Nash solution. If $M1_i = M2_i$ and $M1_j = M2_j$ we have evidence of collusion since it indicates that $(\partial f_j /\partial f_i) = (\partial f_i /\partial f_j)=1$. Econometrically, this will produce singularity of the estimation matrix since there will be a constant relationship between f_i and f_j. If both $M1_j$ and $M2_j$ are statistically significant and do not follow the above alternatives we have evidence of simple conjectural variation which turns to leadership of i if $M2_i \neq 0$, $M2_j=0$ (and vice versa). In the case of Cournot and after manipulating (9) along with (27) we get

$$q_i= N_i - Z_i (q_j + q_i) - Z_i (\theta_{ij} q_i) - \Phi_i c_i \tag{32}$$

Where

$$N_i = \alpha_i / (2\beta_i - \gamma_i) \tag{33}$$

$Z_i = \gamma_i / (2\beta_i - \gamma_i)$ (34)

$\Phi_i = 1/ (2\beta_i - \gamma_i)$ (35)

Equation (32) gives the optimum choice of output produced of a rival as a function of total demand in the sector ($q_j + q_j$) and the elasticity of substitution between the products. If conjectural variation θ_{ij} has no effect on q_i we end up to the Nash outcome. If θ_{ij} affects q_i we have evidence of probable leadership of firm j as long as θ_{ji} has no effect on q_j. If $\theta_{ij} = \theta_{ij} = 1$ we have collusion. The empirical counterpart of (32) is:

$$q_i = \Lambda 0_i - \Lambda 1_i (q_j + q_j) - \Lambda 2_i ((\partial q_j / \partial q_i) q_i) - \Lambda 3_i c_i \quad (36)$$

(36) along with (6) form the set of reduced form of unrestricted simultaneous equations. If $\Lambda 2_i = \Lambda 2_j = 0$ we have Nash outcome. If $\Lambda 1_i = \Lambda 2_i$ and $\Lambda 1_j = \Lambda 2_j$ we have evidence of collusion and singularity of the estimation matrix. If both $\Lambda 1_j$ and $\Lambda 2_j$ are statistically significant and do not follow the above alternatives we have evidence of conjectural variation which turns to leadership of i if $\Lambda 2_j = 0$, $\Lambda 2_i \neq 0$ (and vice versa).

With the method described above we can identify the different cases but we are not able to infer on the extent of conjectural variation in between cases. However it is easier to implement and estimate with simple econometric methods.

Table 4. Conjectural Variation Restrictions and Game Structure

	Cournot	Bertrand
Nash	$\Lambda 2_i = \Lambda 2_j = 0$	$M2_i = M2_j = 0$
Collusion	$\Lambda 1_j = \Lambda 2_j$ and $\Lambda 1_i = \Lambda 2_i$ (singular matrix)	$M1_i = M2_i$ and $M1_j = M2_j$ (singular matrix)
Stackelberg leader j	$\Lambda 2_j \neq 0$, $\Lambda 2_i = 0$	$M2_j \neq 0$, $M2_i = 0$
Stackelberg leader i	$\Lambda 2_i \neq 0$, $\Lambda 2_j = 0$	$M2_i \neq 0$, $M2_j = 0$
Conjectural Variation	$\Lambda 2_i \neq 0$, $\Lambda 2_j \neq 0$	$M2_i \neq 0$, $M2_j \neq 0$

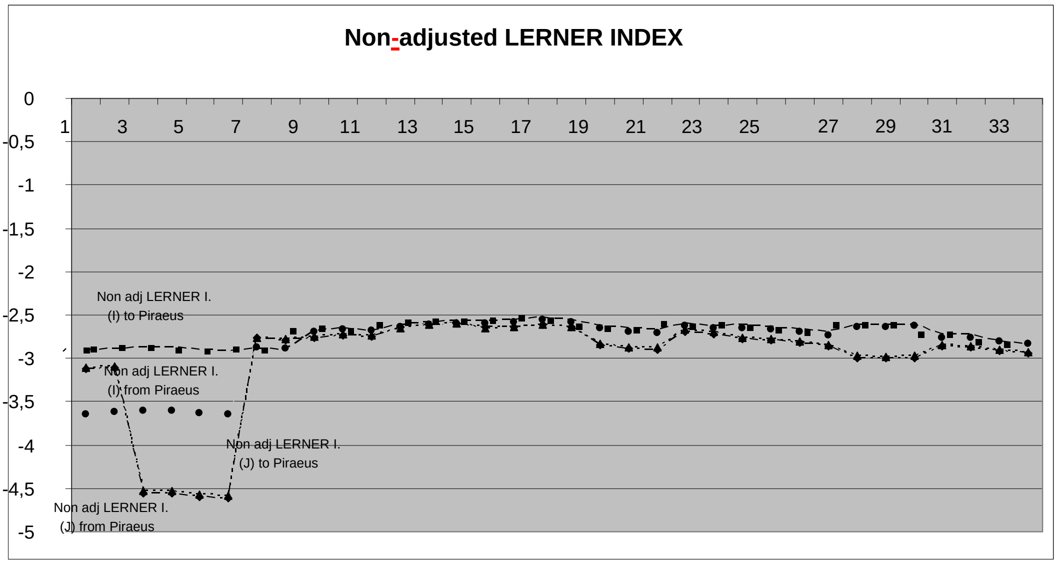
5. EMPIRICAL TESTING

In order to endure the restricted efficiency of price competition and thus of the Bertrand prototype we proceed to the estimation of a non-adjusted Lerner Index for the two companies. As we have seen, the index traditionally has the form L= (p-c)/p where p is the output price and c is the marginal cost. To compute Lerner indices for the two companies an implicit price and marginal cost estimate were constructed under the assumption that ships travel at full capacity in terms of passengers and vehicles and speed. In our case, the output price is taken as the freight rate of the third class passenger and marginal cost is the bunker fuel cost. Given the fact that manning in Greek passenger ships is regulated, marginal cost is mainly affected by bunker price. Clearly, under these assumptions the Lerner index is loosing seasonal variation and precision. However, in general terms, it allows the comparison of pricing relative to marginal cost as decided by ship owners and thus of their market power.

The period of interest is January 1 2004 to April 30 2009 when the two companies (J) and (I), coexisted in servicing the specific route in this case study. Data on freight rates were collected from local port authorities and agencies. To capture bunker prices we have used monthly data 380cst bunker prices ($/Tonne) from Rotterdam Database (Clarksons. Period: 01/1985 – 04/2009).

A higher Lerner Index is interpreted as a higher degree of market power and the "distance" from the Bertrand outcome (for the computational details see the data appendix). From the results presented in Graph 2, (I) presents higher Lerner indices. The volatility of freight rates in the early period after the entry of (I) is also interesting and is related to special offers to the passengers and probable testing of the market. Moreover it is clear that mark-up over marginal cost presents slight decrease over the period, despite the competition between the rivals.

GRAPH 2 – NON-ADJUSTED LERNER INDEX



Note: The non adjustment of the Lerner Index is related to the fact that there is no normalization of the prices involved. The index is in logs. The Marginal Cost is proxied by the bunkering cost. Horizontal scale is time quarters within the period January 1 2004 to April 30 2009.

Next, we proceed to the testing of conjectural variation by trying to identify whether we have Bertand or Cournot competition strategies and further establishing whether competing firms offer Nash solutions, collusion or Stackelberg leadership. For that we estimated the simultaneous set of equations (36) and (6) for the Cournot case and (31) and (17) for the Bertrand case and we tested the alternatives of Nash outcome, collusion and the statistical significance of conjectural variation. The structural equations have been extended with dummy variables to capture seasonality effects and the occasional utilization of three ships by (J) in the servicing of the line. We study each destination separately for all passengers and vehicles and then we distinguished further to the different categories per destination (cabins and seats, trucks and cars). For the estimation, we use the Generalized Method of Moments (GMM) which improves over ordinary least squares or two stage least squares in the presence of heteroskedasticity of unknown form (Gragg, 1983) or neglected serial correlation (Wooldridge, 2001). As it is known in application of time series models in maritime economics, serial correlation and heteroskedasticity in the errors are the most important departure from common textbook assumptions. This raises the possibility of allowing the GMM weighting matrix to account for serial correlation of unknown form as well as for heteroskedasticity, as discussed in Hansen (1982), White (1984) and Newy and West (1987). In addition GMM is widely used in cases where variables are linear in the models but subject to non-linear restrictions on the parameters (Hansen and West, 2002). Instruments comprise lagged values of the dependent and the independent variables (analytical results from the estimated equations are presented in Appendix 2). The significance of the parameters of interest namely, Λ1, Λ2, M1 and M2 is tested through t-statistics as presented in the unrestricted structural model. The collusion hypothesis Λ1=Λ2 and M1=M2 if true, will yield near singularity of the estimation matrix due to linear inter-dependence of the exogenous variables. Results are reported in tables 5 and 6 for the Bertrand and the Cournot case respectively.

TABLE 5 - STATISTICAL SIGNIFICANCE OF CONJECTURAL VARIATION PARAMETER (T-TEST). SUMMARY FINDINGS. BERTRAND

	Hypothesis	(I) lines	(J) lines	
Piraeus –Chios (cabin)	M1 M2	72.7 10.2	296.6 2.1	Conjectural Variation
Piraeus –Chios (seat)	M1 M2	25.3 2.69	52.2 0.63	I, Stackelberg leader
Piraeus–Mytilini (cabin)	M1 M2	26,6 8.98	170.2 2.24	Conjectural Variation
Piraeus –Mytilini (seat)	M1 M2	34.9 2.14	93.5 1.8	I,Stackelberg leader*
Chios –Piraeus (cabin)	M1 M2	59.55 7.59	353 2.11	Conjectural Variation
Chios –Piraeus (seat)	M1 M2	22.7 2.65	89.2 0.77	I, Stackelberg leader
Mytilini–Piraeus (cabin)	M1 M2	59.5 7.59	159.8 3.00	Conjectural Variation
Mytilini –Piraeus (seat)	M1 M2	22.1 1.93	88.43 0.69	Nash**

Notes: All estimates are from a GMM estimation. Absolute t statistics are reported. For values of t smaller than the critical value 2, we cannot reject the hypothesis that the coefficient is zero at the 5% level. No of observations is 32.

- *Stackelberg is rejected at the 10% and the outcome turns to simple conjectural variation.
- ** Nash is rejected at the 10% level and the outcome turns to (I) Stackelberg leadership.

In the case of price competition as shown in table 5, we have strong evidence of (I)'s leadership in the seats while in the pricing of cabins, the shipping companies compete taking into account each others' pricing strategies. The Nash solution appears only for the seat tickets in the direction Mytilini to Piraeus, which serves the greatest number of passengers (see table 1). However, the Cournot results, shown in table 6 for this direction suggest that the non-cooperative Nash pricing solution turns to cooperative collusion.

If we loosen up the confidence interval from 5% to 10%, the Cournot results in table 6 are not affected. However the Bertrnad results in table 5 change from Nash to (I) leadership and from Stackelberg leadership of (I) to simple conjectural variation in the line Piraeus to Mytilini (seat). However, these changes do not drastically affect the picture of competition since they do not question the distinctive role of (I) in the market.

TABLE 6 – STATISTICAL SIGNIFICANCE OF CONJECTURAL VARIATION PARAMETER (T-TEST). SUMMARY FINDINGS. COURNOT

		(I)	(J)	
Piraeus –Chios (cabin)	Λ1 Λ2	175 4.68	75.9 5.63	Conjectural Variation
Piraeus –Chios (seat)	Λ1 Λ2	52.3 5.84	40.0 3.01	Conjectural Variation
Piraeus–Mytilini (cabin)	Λ1 Λ2	56.2 2.58	78.0 4.78	Conjectural Variation
Piraeus –Mytilini (seat)	Λ1 Λ2	79.4 3.89	54.8 1.73	(I) Stackelberg leader
Chios –Piraeus (cabin)	Λ1 Λ2	71.8 2.87	58.9 0.60	(I) Stackelberg leader
Chios –Piraeus (seat)	Λ1 Λ2	32.3 3.49	40.6 1.17	(I) Stackelberg leader
Mytilini–Piraeus (cabin)	Λ1 Λ2	44.1 4.29	64.0 1.36	(I) Stackelberg leader
Mytilini –Piraeus (seat)	Λ1 Λ2	Singular matrix	Singular matrix	Collusion

Notes: All estimates are from a GMM estimation. Absolute t statistics are reported. For values of t smaller than the critical value 2 we cannot reject the hypothesis that the coefficient is zero at the 5% level. Number of observations is 32.

When we examine the conjectural variation for the case of vehicles (trucks and cars) we get singularity of the matrix indicating the presence of collusion in both Bertrand and Cournot type models. This may be related to the structure of the market of trucks serving the islands. This market is controlled by a small number of transport companies. Thus, collusive behaviour of the two shipping companies may be the result of some agreement with the truck companies which is extended to the automobile segment of the vehicles market.

The above results accept the hypothesis of competition in both prices and passengers with strong (I) firm Stackelberg leadership. However, if we re-examine the Lerner index we get firm (I) setting the higher mark up over marginal cost steadily throughout our sample period and despite small decline at the end. Therefore, the data support the existence of a market leader that follows a high price strategy and not a low price strategy that converges towards marginal cost. Thus we are inclined to accept that this price is the Cournot price. Deviations from such a price constitute adjustments of conjectural variation within the Cournot price setting framework. These results support Kreps and Scheinkman (1983) arguments where Bertrand-like competition may end up in Cournot outcomes due to the form of the game the players are engaged in and the heavy investment that they undertake in the first place. This is especially true for company (I), since the associated investment for the construction of it's a new built ship is much higher than its rival's (see tables 2 and 3).

6. CONCLUSIONS AND POLICY SUGGESTIONS

In this paper we examine whether in a recently liberalized passenger coastal shipping market we have Bertrand or Cournot type competition with Stackelberg leadership. In order to detect the existence of the market power of rivals and the kind of game strategy that they adapt, a New Empirical Iindustrial Organization type structural model was constructed that ends up in linear tests, which are based on robust estimation results. In order to enforce robustness the GMM was employed as the estimation method. The empirical investigation was based on a case of a Greek coastal shipping market. Our findings provide evidence of both Cournot and Bertrand competition in passenger service with strong evidence of Stackelberg leader-follower relation. For the case of vehicles, the data indicate extensive collusion. However, the detected leader is proved to be following a high price strategy which does not converge towards marginal cost levels during our sample period. At the same time our leader has undertaken the highest investment in the market. Thus we are inclined to support the Kreps and Scheinkman (1983) arguments where Bertrand-like competition may end up in Cournot outcomes due to the form of the game the players are engaged in and the heavy investment in ships set in at some first stage. Following the restriction set by the predetermined capacities and given that these capacities correspond to Cournot output levels, in the second stage each firm will name the Cournot price.

Such a conclusion is important for the design and implementation of regulatory policies in the sector. In an oligopoly that involves heavy investment by the rivals the end result will be one that distance from pure competition. Thus, prices will be higher than the minimum affordable by market conditions. Clearly, in such an environment there is room for competition in terms of the qualitative characteristics of the provided services. However, if the rivals do not proceed competing in terms of the qualitative characteristics of their services, the market will result in bad services along with high prices. Consumer surplus transfer to oligopolies will be totally wasted. Such an outcome is more probable in the case of collusion – as is the case of vehicles. Thus, regulative authorities that try to control terms and conditions of competition should direct their policies both in restricting prices at low possible levels and securing high quality standards of the provided services. As long as there is one player that provides better quality services within this Cournot-type competition, collusion will be avoided and there will be some return to consumers for the consumer transfer to oligopolies.

Our findings emphasize the need for further research on this type of oligopoly models and more precisely on the competition that arises in terms of the qualitative characteristics of the provided services when rivals name Cournot prices due to heavy investment.

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