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Modal Split Analysis in Greek Shortsea Passenger/Car Transport.

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ABSTRACT

The purpose of this paper is to investigate the problem of modal split for passengers and vehicles in a specific context, that of the Greek coastal shipping system. The transport modes considered are conventional passenger/car ferries (P/C vessels), fast (30-50 knot) vessels, and air transport. For a variety of reasons, monumental changes are about to take place within this system over the next decade. These center primarily on the deregulation of the market that is a result of the European Union integration, and on the introduction of vessels capable of carrying passengers and cars at high speeds. By EU directive, the Greek coastal market shall be fully deregulated by the year 2004. This means that owners would be able to set up routes with minimal governmental interference. The question is of course how passenger demand will evolve within such a new environment, and how the various competing modes of transport will fare. This paper is an attempt to systematically analyze scenarios that might be the possible outcomes of these changes.

1. INTRODUCTION

The purpose of this paper is to investigate the problem of modal split for passengers and vehicles in a specific context, that of the Greek coastal shipping system. The transport modes considered are conventional passenger/car ferries (P/C vessels), fast (30-50 knot) vessels, and air transport. For a variety of reasons, monumental changes are about to take place within this system over the next decade. These center primarily on the deregulation of the market that is a result of the European Union integration, and on the introduction of vessels capable of carrying passengers and cars at high speeds. This paper is an attempt to systematically analyze scenarios that will be the possible outcomes of these changes.

By EU directive, the Greek coastal market shall be fully deregulated by the year 2004. This means that owners would be able to set up routes with minimal governmental interference. In addition, air transport will also become increasingly deregulated in the years ahead. The question is of course how passenger demand will evolve within such a new environment, and how the various competing modes of transport will fare.

This paper attempts to answer this question by examining various scenarios for the following modes of transport: conventional ferries (passenger/car), hydrofoils, other fast vessels (passenger only), other fast vessels (passenger/car), and air transport. The methodology used is applied to an illustrative subset of the entire network and is based on the "logit" model and the "generalized cost" concept. The cost components used are the fares and the time value of the trip. The time values have been derived from a "revealed preference" dataset. The paper describes the various assumptions made in data collection and model formulation, and discusses the results of the analysis and the additional research needed in this field. Policy recommendations are finally offered for an improved operation of the system in view of the monumental changes that are about to occur.

This paper is one of the products of a large project on Greek Coastal shipping, carried out by NTUA on behalf of the Hellenic Industrial Development Bank (ETBA) during 1993, and in the context of the SPA programme of the EU (Regional Development Plan). The project, heretofore referred to as the ETBA project, carried out a comprehensive investigation of all major aspects of the system, including the topic covered here. Complete details can be found in Psaraftis (1993).

This paper is structured as follows. Section 2 gives an update on the status quo of the system, vis-a-vis the description in a paper that was presented at the previous Roundtable Conference. Section 3 performs the modal split analysis. Section 4 provides some information on the economic viability of fast ships. Finally Section 5 makes some concluding remarks and offers some policy recommendations.

2. STATUS QUO UPDATE.

The basic characteristics of the Greek coastal shipping system were presented in the previous Roundtable Conference in Delft (November 1992), and were published in the Proceedings of that conference (paper by Psaraftis and Papanikolaou (1992)). However, as that paper was written both before the ETBA project had started, and, before the passing of the EU Regulation on maritime cabotage (7 December 1992), some of the data and hypotheses presented in that paper are now obsolete. Thus, before we proceed with our analysis, we deem necessary to give a brief update on the status of the system, with a focus on these elements that are more relevant for our analysis. The basic reference for this material is the ETBA final report (Psaraftis, 1993), which describes all this in more detail.

1) Lines and routes. The Ministry of Merchant Marine (MMM) classifies the 102 official lines of the network in 5 classes: (a) 16 main passenger/car ferry (P/C) lines, (b) 30 secondary P/C lines, (c) 11 local P/C lines of the Argosaronikos bay, (d) 39 other local P/C lines, and (e) 3 main and 3 secondary freight (ro-ro) lines. Within this "line" system, the number of individual routes and schedules that are traveled is on the order of several hundreds.

Some of these lines extend to ports in Italy (Brindisi, Bari, Ancona, and Trieste), although from a legal standpoint the services to Italy are not subject to internal cabotage legislation (e.g., ships can fly foreign flags, even if Greek-owned).

2) Fares. With the exception of First Class fares, which are in principle free (with a theoretical maximum of 4 times but in practice 2.8 - 3 times the level of the corresponding Third Class fare), all other fares are uniform for all ships and established every year by the MMM for all pairs of ports. Fares include Second Class, Third Class, Tourist Class, and fares for vehicles (cars, buses, trucks, and motorcycles). Hydrofoils and catamarans have special fares for the routes on which they operate, all (still) regulated by the MMM. There are services in which the official fare with or without a cabin is exactly the same, cabins being allotted to passengers on a first-come first-served basis, many times onboard the ship (in which case the tip to the steward plays the role of the fare supplement).

At first glance, the fare structure seems reasonable in terms of levels. A more careful examination however reveals that fare levels are largely arbitrary, depending more on what they were the year before, and less on the result of a transparent cost analysis. As an example, the fare to distant Kastellorizo is 8,639 GRD (2nd class), while that to Sitia (Crete) is 8,750

GRD, even though the latter destination is much closer to Piraeus. Such a difference could be explained by socieconomic criteria, but such criteria are not explicitly defined.

In other examples, the direct 2nd class fare to Hydra is 2,665 GRD, less than the 2,499 GRD fare if one goes to Hydra via Aegina (999 GRD from Piraeus to Aegina and 1,500 GRD from Aegina to Hydra). The fare from Sifnos to Paros is 1,469 GRD if one travels on a small wooden boat, and only 748 GRD if one travels on ferry (2nd class). The catamaran fare to Mykonos is 6,709 GRD, higher than the 2nd class conventional fare (4,470 GRD), but lower than the equivalent 1st class fare (7,988 GRD),and much lower than the airfare to Mykonos, which is 15,900 GRD for an economy class ticket.

The rule of thumb that the triangle inequality (Fare (A-B) ≤ Fare (A-C) + Fare (C-B)) holds for most of the network seems to be true, but in general there seems to be no consistent logic in the fare structure, nor there exists a well-defined algorithm or procedure for fare determination.

3) Fleet. The Psaraftis and Papanikolaou (1992) paper referred to 1988 fleet data. Having now fleet data that go at least to 1992, we can make some brief observations. The first is that the mean age of large (1,000 GRT or more) P/C vessels increased by 4 years (to 25) in the 4 years from 1988 to 1992. The second is that the situation is worse for the smaller conventional P/C vessels (between 100 and 999 GRT), with a mean age of 28 years, and even worse for the small (100 to 500 GRT) general cargo (feeder) ships, with a mean age of 35 years (in 1992). There is a mandatory withdrawal age of 35 years for P/C ships (which, interestingly enough, does not apply to ships on the Italian service routes). Thus, at 2004, many ships that operate today within the system will have been withdrawn from service.

In 1992, hydrofoils had a mean age of about 15 years, while the three catamarans in the system (one of which was seriously damaged in 1993 and may never again engage in service) were virtually new. Although hydrofoils have been traditionally restricted to protected waters, 1993 saw the deployment of hydrofoils to several new lines, including many of the Central Aegean islands where the sea is sometimes rough during the summer.

4) Passenger and vehicle traffic. With about 12 million passenger movements in 1990 (see Section 3 for estimates in subsequent years), Greek coastal shipping is one of the biggest in Europe. With few exceptions (short periods of temporary decline), passenger traffic has steadily grown every year over the last 30 years, from approximately 3 million movements in 1964, to about 5 million in 1970, 8 million in 1980, and 8.5 million in 1985. There was a period of decline from 1981 to 1983, with a local minimum of 7.5 million.

The heaviest traffic is generated within the short-distance routes of the Argosaronikos system, with traffic that is more than double in passenger movements than that of the long-haul Piraeus- Crete lines. The biggest growth in recent years has been experienced in the Volos-Euvoia-North Sporades lines, mainly due to the massive influx of hydrofoils in that area, and in spite of the decline in conventional vessel passenger traffic that resulted because of this entry.

Vehicle traffic has also grown, in many cases more steeply than passenger traffic. The Piraeus - Crete line is the leader for both cars and trucks, with car movements experiencing a 48% growth between 1981 and 1990, more than double the equivalent passenger growth rate. The introduction of large P/C vessels has been the main reason for the generation of such a demand.

Competing with sea transport of passengers in many mainland and island destinations is air transport, provided by Olympic Airways and its "commuter" subsidiary, Olympic Aviation. Growth between 1980 and 1992 has been mixed, with the peak of about 5.3 million annual trips in 1985, and a lowest level of about 3.2 million trips in 1991 (the year of the Gulf war). A few of these destinations are also served directly by foreign airlines (charter or regular flights).

5) Legal regime. The most significant recent development in the legal arena has been the passing by the Council of the EU of Regulation No. 3577/92 (7 December 1992), regarding the freedom of service in maritime cabotage trades. Such regulation (heretofore referred to as "the Regulation") stipulates, among other things, that Greece's coastal shipping market becomes fully deregulated and open to other EU-flag ships by Jan. 1, 2004. The 11 year waiting period (already reduced to less than 10 years) was intended to provide Greece with the necessary time to prepare for the opening of the market to competition.

Describing the Regulation vis-a-vis the national legal regime, or the probable impacts of the removal of cabotage privileges, or finally what should be done to prepare for 2004, is beyond the scope of this paper. The ETBA final report (Psaraftis, 1993, section 3.6) and a companion paper to the present paper (Sturmey et al, 1994) deal with these issues in more detail. However, as the adoption of the Regulation is the actual reason behind the analyses reported in our paper, we shall be referring to it and to some of its provisions whenever this is necessary during the course of this paper.

With these preliminary considerations, we now proceed with our analyses.

3. MODAL SPLIT ANALYSIS

In the summer of 1993, the Italian company Tirrenia Navigazione introduced the fast monohull GUIZZO in the line between Civitavecchia (mainland Italy) and Olbia (island of Sardinia). The GUIZZO, built by Rodriquez Aquastrada, is a state-of-the-art fast ship, capable of carrying 450 passengers and 126 cars at speeds up to 43 knots. The trip (124 nautical miles) is traveled in 3.5 hours, of which 3 hours are at the maximum speed. Two daily trips were planned for the summer high season, dropping to one at lower traffic seasons. The GUIZZO was scheduled to operate only 11 weeks per year (July- October), and charged for cars a fare only 15% over the equivalent conventional fare.

Such a low high-speed supplement is also charged by the wave-piercer catamarans (such as the HOVERSPEED GREAT BRITAIN) that cross the Channel. Both cases, although completely different in terms of vessel design, enjoy remarkable capacity utilization rates, being generally preferred by the public over the conventional, slower ferries.

In view of the EU Regulation, the appearance of such ships in Greece is considered only a matter of time. Note that as today in Greece there are no fast vessels that can also carry vehicles, conventional P/C ships have a real monopoly on those passengers who travel with their cars (captive demand). The rest of the fast ships operating today are hydrofoils and catamarans, neither of which can carry cars. And although hydrofoils have carved their own special niche in the market, catamarans have been less successful. Technical factors such as sea worthiness have probably little to do with this state of affairs (other than a catamaran collision with a pier in 1993). Their meager presence is mostly attributed to the existing system of route licensing, which, in one case, granted a license to a catamaran on the condition that it serve a 10- port route. It is obvious that such a condition anihilates any speed advantage of these ships over conventional ships and makes their operation uneconomic.

Since the EU Regulation presumably will make route licensing more rational, a natural question to ask is what portion of passenger demand will shift to fast ships (including fast ferries), when these, in fact, are permitted to operate within the system. Given that the passengers would be able to choose among several competing modes, what will be the modal split? It is the purpose of this section to try to answer this question. Note that by "mode" here we mean not only the general distinction between sea and air, but also the finer grain distinction among the various types of vessels (more on this later).

Another (albeit related) question is what is the economic viability of these fast vessels. This question is addressed in Section 4.

Performing the modal split analysis is by no means an easy task, for a number of reasons. First, the coastal shipping network in Greece is huge (138 ports, 34 airports, thousands of inter-port links). Second, one has little or no idea of what will actually happen during the 10 years to 2004 in terms of the fleet, introduction of new technologies, port expansion, and development of legislation, to mention just a few of the crucial factors. Third, it is not immediately clear how the Greek traveler values his or her time, which is perhaps the most critical parameter that one needs to know in order to assess how much more the traveler is willing to pay in order to travel faster.

Some additional difficulties exist (for instance, lack of origin-destination (O-D) flow data). These difficulties will be described in the course of the exposition that follows. Last, but not least, we are aware of no similar analyses in other coastal shipping problems that involve such difficulties. Most of the analyses involve freight (for which the issue of fast transport is different), and/or much simpler network configurations (for instance, the analysis for the Channel Tunnel).

In the face of this complex situation, the approach that we adopted consists of the following steps:

STEP 1: Choose a workable (but hopefully relevant) subset of the entire network for the analysis.

STEP 2: Make aggregate demand projections on this network up to 2004.

STEP 3: Make some assumptions on what kinds of transport modes provide service on this network, and for each evaluate the transit times for the relevant links of the network.

STEP 4: Make some assumptions on the fares charged by each mode.

STEP 5: Calculate the monetary value of the time of the passengers.

STEP 6: Run the logit model to determine the modal split on each branch of the network.

STEP 7: Interpret results and perform sensitivity analysis.

The main advantage of such an approach is that it bypasses the problem of trying to predict inherently unpredictable scenarios, and produces a flexible tool, by which "what if" assessment of scenarios can be performed. Such a tool can readily be applied to larger networks and alternative scenarios (not only for Greece) once the appropriate data have been assembled.

We now describe the work involved in each of these steps, bearing in mind that the complete detailed analysis is reported in Psaraftis (1993).

STEP 1: Choose a workable (but hopefully relevant) subset of the entire network for the analysis.

In making such a choice, the following conditions must be satisfied:

a) There should be a correspondence between ports and airports, so that a comparison between sea and air transport is meaningful.

b) The range of distances between network nodes should be relatively broad.

c) The selected sub-network should represent a non-trivial part of the entire network in terms of traffic volume.

In this vein, we have decided to examine a 9-port, 6-airport network, distributed in 6 geographical "zones" as follows:

Zone	Region	Ports	Airports
11	Attiki	Piraeus, Rafina	Elliniko
21	Mykonos	Mykonos	Mykonos
31	Santorini	Thira	Thira
41	West Crete	Souda, Rethymno	Hania
42	Iraklio	Iraklio	Iraklio
43	Lasithi	Ag. Nikolaos, Sitia	Sitia

Notice first that each zone has at least one port (and sometimes two), and one airport. So condition (a) above is satisfied. Also, inter-zone distances for this network range from 69 nautical miles (nm) (between zones 31-42) to 221 nm (between zones 11-43). So the range of distances is indeed broad.

In terms of size, and even though 9 ports is only a small fraction of the 138 ports in the system, in 1990 total passenger traffic among the 9 selected ports was 19.2% of total Greek coastal traffic. Also in 1990, total traffic among the 6 selected airports was 27.3% of total Greek domestic air traffic. So from this perspective the selected sub-network is certainly non-trivial.

STEP 2: Make aggregate demand projections on this network up to 2004.

By "aggregate demand" we mean that at this stage we shall not break down demand by mode, ie how many passengers will go by fast ships, how many by air, etc. This will be done later (Step 6). On the other hand, we want to take full advantage of existing data regarding flows of passengers in the network, including the choice of mode made by these passengers.

Before we proceed, and as an aside to our analysis, we state that in Psaraftis (1993), a projection of total passenger demand for sea transport on the entire network and up to year 2010 was made. After several regression analyses, it was determined that the best fit to historical data (1964-1989) is the one described by the following equation:

TOTAL_PAX = exp(1.271 + 0.0414*(Y-1963)),

where TOTAL_PAX is the total passenger trips by sea in year Y. The R**2 of this equation is 0.95, and the t-statistic on the coefficient of 0.0414 is 21.06, both acceptable.

The above equation projects about 16.5 million trips in year 2000, about 19.5 million trips in 2004, and about 25.5 million trips in 2010.

Returning now to Step 2, this step involves two sub-steps. First, create origin-destination (O-D) tables for this network for a number of years in the past, and second, use these to forecast origin-to-destination demand on the network up to 2004.

Creating the O-D tables for the sub-network was a rather tricky task. The first difficulty was that no such data was directly available in the databases of MMM's Statistical Service or anywhere else (as much as a lot of other data was available). To circumvent this problem, the direct assistance of this service was requested, and after a series of estimates on how flows at each port split among different routes, an "expert estimate" of the O-D table of passenger trips by sea in the sub-network for 1990 was finally made (see Table 1). Psaraftis (1993) provides more details on how this table was produced.

Table 1: O-D table for passengers traveling by ship, 1990.

From/To	11	21	31	41	42	43	Total
11		145,879	201,373	357,060	372,855	9,538	1,086,705
21	140,459		28,603				169,062
31	203,281	27,757			14,712		245,750

41	349,526						349,526
42	387,970		11,332				399,302
43	10,890						10,890
Total	1,092,126	173,636	241,308	357,060	387,567	9,538	2,261,235

Doing the same for passenger trips by air in 1990 was far easier, for this data was directly available from Olympic Airways (see Table 2).

Table 2: O-D table for passengers traveling by air, 1990.

From/To	11	21	31	41	42	43	Total
11				148,572	260,554	830	537,119
21	66,231		4,592		1,664		72,847
31	65,466	4,358			2,067		71,891
41	140,226						140,226
42	249,578	1,784	1,940				253,302
43	816						816
Total	522,317	70,000	70,197	148,572	264,285	830	1,076,201

In addition to passengers, O-D tables for vehicles are necessary, for a portion of the total passengers (those who travel with a vehicle) do not have the choice between sea and air transport (captive demand), and these passengers must be identified. Here we assume that a person traveling with a vehicle has already made the decision to do so and thus does not have the choice of taking the airplane (this assumption is true for a truck driver, but may not necessarily be true for a motorcycle driver, a car driver, or a bus passenger, all of whom conceivably can take the plane and use another vehicle at their destination).

Using a similar methodology to the one described for passengers, O-D tables were produced for trucks, buses, cars, and motorcycles traveling in the sub-network in 1990 (these tables are not reproduced here but are available in Psaraftis (1993)).

To estimate now the passengers traveling with these vehicles, an estimate of how many passengers are carried by each vehicle is necessary. We used the estimate made by Martedec S.A. of Piraeus (in the context of a NATO project on Greek coastal shipping) that each truck carries one passenger, each bus 40 passengers, each car 2.5 passengers, and each motorcycle one passenger. On this basis, Table 3 shows the O-D table of passengers traveling with a vehicle in the sub-network in 1990.

Table 3: O-D table for passengers traveling with a vehicle, 1990.

From/To	11	21	31	41	42	43	Total
11		37,685	35,173	159,265	206,644	4,703	443,470
21	33,892		876				34,768
31	35,116	735			561		36,412
41	145,806						145,806
42	200,804		541				201,345
43	3,989						3,989
Total	419,607	38,420	36,590	159,265	207,205	4,703	865,790

On the basis of Tables 1, 2, and 3, the O-D table of total passengers traveling without a vehicle in the sub-network in 1990 can be constructed. This is Table 4, and consists of all passengers traveling by air, plus those sea passengers who travel without a vehicle. It is clear that if a(i) is a specific inter-zone entry in Table i (i = 1 to 4), then a(4) = a(1) + a(2) - a(3).

Table 4: O-D table for passengers traveling without a vehicle, 1990.

From/To	11	21	31	41	42	43	Total
11		172,052	229,505	346,367	426,765	5,665	1,180,354
21	172,798		32,679		1,664		207,141
31	233,631	31,380			16,218		281,229
41	343,946						343,946
42	436,744	1,784	12,731				451,259
43	7,717						7,717
Total	1,194,836	205,216	274,915	346,367	444,647	5,665	2,471.646

From Tables 1 to 4 it can be seen that from all passengers who traveled without a vehicle in the sub-network in 1990, 43% used the airplane and the rest (57%) took the ship. Overall, 68% of the passengers went by ship, and 32% went by plane.

Of course, making a projection to 2004 just from 1990 data is impossible, so in principle we need to repeat this procedure for several years prior to 1990. Published coastal shipping data in Greece exists from 1964 on. Unfortunately however, individual route data is not available in a uniform way, and MMM's Statistical Service was unable to provide such information for prior years, as it did for 1990. To circumvent this new obstacle, it was decided to produce some coefficients, which express the data in the 1990 O-D tables as functions of passenger and vehicle flows into the ports of the sub-network. Then we would use these same coefficients to produce the O-D tables from port passenger and vehicle flows in prior years.

Of course, the assumption that these coefficients stay the same is a debatable assumption. However, given that no major changes in the network have occurred in the past, we feel that it is an assumption that can be justified (lacking a better way to proceed).

No similar problem existed for the air transport O-D data, as this was readily available from Olympic Airways for the period of interest.

Having all these O-D tables for the period 1964-1990, the next substep is to project these into the future. A critical assumption here is that the possible introduction of new technology ships within the network in the future will not generate new demand (other than what would be generated anyway, ie even if these ships are not introduced).

This is also a debatable assumption, and one that can be patently false, as demonstrated by several cases in the past (see effect of hydrofoils in the Volos- Euvoia- North Sporades trade, as mentioned earlier). However, counterexamples also exist. In Psaraftis (1993), an analysis of the Argosaronikos system (the heaviest in hydrofoil traffic) in the period 1977-1990 showed that the effect of hydrofoil entry into that market in the mid-seventies was only a shift of demand from conventional ships to hydrofoils, with no documentable generation of new demand. In fact, growth in the above period was only 18% for the Argosaronikos system, as opposed to 111% for the entire network, a clear sign of demand saturation. So in this case hydrofoils did not generate new demand.

Being unable to say whether or not this will be the case for our sub-network, we chose to be conservative and assumed zero generation of new demand because of the possible introduction of fast ships. Of course, our methodology can still be applied if an alternative assumption is used.

Based on this, regression analyses were conducted individually for all inter-zone links of the sub-network, so as to project demand on those links. The results (see Psaraftis (1993) for details) can be summarized in the following two tables: Table 5 is the equivalent of Table 3, and shows the O-D flows of passengers accompanying a vehicle in 2004. Table 6 is the equivalent of Table 4, and shows the O-D flows of passengers without a vehicle in 2004.

Table 5: O-D table for passengers traveling with a vehicle, 2004.

From/To	11	21	31	41	42	43	Total
11		70,762	78,306	251,449	313,767	13,384	727,668
21	69,948		1,871				71,819
31	85,571	1,442			1,147		88,160
41	238,525						238,525
42	296,953		935				297,888
43	13,671						13,671

Total	704,668	72,204	81,112	251,449	314,914	13,384	1,437,731

Table 6: O-D table for passengers traveling without a vehicle, 2004.

From/To	11	21	31	41	42	43	Total
11		275,338	372,470	703,576	787,292	33,697	2,172,373
21	282,204		64,254		4,544		351,002
31	377,819	64,757			25,590		468,166
41	680,042						680,042
42	771,730	5,238	22,030				798,998
43	34,418						34,418
Total	2,146,213	345,333	458,754	703,576	817,426	33,697	4,504,999

One immediate observation is that projected flows to 2004 are by no means simple multiples of those flows in 1990, as flows in distinct links are projected to grow in a different way.

In 1990, only two modes of transport were present on the sub-network, conventional P/C vessels (capturing the entire demand of passengers with vehicles (Table 3) and also receiving a share of the demand of passengers without vehicles, Table 4) and air transport (receiving the rest of the demand of passengers without vehicles, Table 4).

Having produced the O-D tables for 2004, we are now ready to make some assumptions on the modes of transport that will be available on the sub-network at that time.

<u>STEP 3: Make some assumptions on what kinds of transport modes provide service on this network, and for each evaluate the transit times for the relevant links of the network.</u>

We assume that a total of five (5) modes of transport will be available in this network in 2004:

Mode 1: Air transport.
Mode 2: Conventional P/C vessels.
Mode 3: Hydrofoils.
Mode 4: Surface effect ships (passenger only).
Mode 5: Fast P/C vessels.

Note first that whereas all modes potentially cater to passengers traveling without a vehicle (those of Table 6), modes 2 and 5 cater only to passengers traveling with a vehicle (those of Table 5).

The second remark is that not all modes are assumed to provide service to every inter-zone link of the network. For instance, it would be unreasonable to assume direct hydrofoil service between Piraeus and Crete, or any type of service between Hania and Iraklio in Crete.

The modes that are assumed to be operational for each link of the sub-network are as follows:

Link 11-21: All modes.
Link 11-31: All modes except mode 3.
Link 11-41: All modes except mode 3.
Link 11-42: Modes 1, 2, and 5.
Link 11-43: Modes 1, 2, and 5.
Link 21-31: All modes.
Link 21-42: Mode 1.
Link 31-42: All modes.

No modes are assumed to operate (at least directly) on other links of the sub-network.

The following additional assumptions have been made:

1) A passenger's trip starts from the time he or she leaves home to the time he or she reaches the trip's ultimate destination.

2) A 30-minute waiting time is uniformly assumed for all modes at both ends of the trip for embarkation and disembarkation.

3) Times from a traveler's home to the port (or airport) of origin and from the port (or airport) of destination to the traveler's ultimate destination have been estimated for each case separately, by making some assumptions on the "centroid" of the location of either end of the trip. The centroid is assumed to be close to the center of the corresponding metropolitan area, and trip times between the centroid and the corresponding port or airport have been calculated separately for each case.

4) To calculate ship transit times, the following average speeds have been assumed: Conventional P/C, 14 knots. Hydrofoil, 30 knots. SES and fast ferry, 40 knots.

Notice that the assumed speed for conventional P/C ship is rather low. This is to reflect the fact that in the existing network of lines, these ships make several stops from zone 11 to zones 21 and 31, and the fact that the trips from zone 11 to zones 41, 42, and 43 are usually made overnight, with an average speed that is very close to the assumed. Overall, the sailing times implied by this speed are very close to the actual ones.

For the fast ships, non-stop services among zones were assumed, and this reflects the speed values assumed.

Inter-zone flight times are given in Table 7 below, and inter-zone sailing distances are given in Table 8 below. Based on these assumptions, it is straightforward to calculate the trip times for all relevant combinations of modes and inter-zone links.

<u>STEP 4: Make some assumptions on the fares charged by each mode.</u>

Full information exists on the fares charged by the two modes that were operational in 1990, for all links of the network served by each. Table 7 shows that in 1990 Olympic Airways had two fare increases (trip times are also shown in that table). Our analysis uses as airfare the average of the three fares that prevailed.

Table 7: Airfares for three periods in 1990 (GRD) and trip times in minutes.

Link	1/1-7/5	8/5-24/9	25/9-31/12	minutes
11--42	8,700	11,200	12,200	45
11--41	7,400	9,500	10,400	45
11--21	6,000	7,700	8,400	45
11--31	7,600	9,700	10,700	55
11--43	11,800	15,100	16,600	85
42--31	5,500	7,100	7,700	40

Table 8 shows the 2nd-class and passenger car fares charged by conventional P/C ships for the various links of the network. All fares are in GRD (1990) and include all relevant taxes and supplements. The last column in Table 8 shows inter-port distances in nautical miles.

Table 8: 2nd class and passenger car conventional P/C fares in 1990 (GRD).

From	To	2nd	Pass.	Distance
Piraeus	Hania	5,080	9,349	146
Piraeus	Rethymno	5,364	9,349	161
Piraeus	Iraklio	5,364	9,349	175
Piraeus	Ag. Nikolaos	6,866	10,765	197
Piraeus	Thira	3,926	12,276	127
Piraeus	Mykonos	3,137	8,970	94
Rafina	Mykonos	2,647	7,366	70
Mykonos	Thira	2,639	7,327	64
Thira	Iraklio	2,326	6,705	69
Thira	Ag. Nikolaos	2,082	8,311	84
Ag. Nikolaos	Sitia			24

Notice that no fares are given between Ag. Nikolaos and Sitia in Crete. This is so because no traffic between these two ports is examined, Sitia's traffic from other ports going through Ag. Nikolaos.

For fares that will be charged in 2004, the following baseline assumptions are made:

1) All mode 1 and mode 2 fares remain constant in 1990 GRD prices.

2) All mode 3, 4, and 5 fares are 15% higher than the equivalent mode 2 fare.

Of course, both sets of assumptions are debatable. In particular, the second assumption may be characterized as not very strong (15% is too low). However, 15% was the increase used by both the GUIZZO and the HOVERSPEED GREAT BRITAIN, so it would be reasonable to want to see what would happen if this were applied to Greece as well. In addition, in Step 7 we shall examine alternative increases and see what happens then.

The assumption of fare constancy (in 1990 terms) in modes 1 and 2 is also debatable, as either of these two modes may decide to adopt a different pricing policy as 2004 approaches. We shall discuss these alternative scenarios and their implications later on.

STEP 5: Calculate the monetary value of the time of the passengers.

How much a passenger values his or her time is a critical factor in the analysis, for this would ultimately determine the traveler's willingness to pay in order to make the trip faster. The relevant question for our problem is whether we can say anything for the value of time of passengers using this particular network.

There are two ways to ascertain somebody's value of time. The first, and generally the best, is the "stated preference" method, in which the traveler answers a detailed questionnaire in order to explicitly define his or her utility function of time versus money. Unfortunately, this method is very expensive and time consuming, and, as such, was not used here.

The second method is the "revealed preference" method, and consists of using historical data on travelers' modal choices in order to draw conclusions on how much the traveler values time.

In Greece, Lioukas (1982, 1993) used a logit model for travelers using rail transport. In his latest study, conducted in the context of the Athens-Piraeus subway system, he derived a value of about 800 GRD per hour (1993 prices).

Of course, it is far from clear whether such a value is applicable for the case of coastal shipping in Greece. In Japan, Akagi (1991) showed a value of time on the order of 3,000 Yen per hour on the average. Obviously, it would be inappropriate to use such a value for our analysis.

The only alternative left was to see if we could derive an appropriate value of time using existing data on the Greek coastal shipping system. As such, we decided to use the 1990 data on the sub-network (Tables 1 to 4), in which there is a clearly revealed preference of those passengers traveling without a vehicle, between air transport and conventional P/C ship.

To use this data, we assume that for a specific trip the travelers' preferences are according to the following multinomial logit model:

$$f_i = \exp(a_i+bp_i+ct_i) / \sum_k \exp(a_k+bp_k+ct_k) \qquad (1)$$

where f_i is the fraction of travelers using mode i, p_i is the fare charged by mode i, t_i is the trip time using mode i, and a_i is the "preference constant" of mode i, reflecting possible natural biases in favor of or against that mode. b and c are the same for all modes, and are both negative.

For two modes i and k, we can see that

$$\ln(f_i/f_k) = \Delta a_{ik} + b\Delta p_{ik} + c\Delta t_{ik} \qquad (2)$$

where $\Delta a_{ik} = a_i - a_k$, $\Delta p_{ik} = p_i - p_k$ και $\Delta t_{ik} = t_i - t_k$.

This expression means that an increase of the fare by one unit can be offset by a reduction of the trip time by b/c. Alternatively, the ratio c/b is the amount the traveler is willing to pay in order to recuce trip time by one unit. Therefore, the value of time we want is the ratio c/b.

A linear regression analysis of (2) with the 1990 data (looking only at passengers traveling without vehicles- Table 4), and with the additional assumption that $\Delta a = 0$ (there is no initial documented bias in favor of either mode) produces the value of c/b = 415 GRD/hr.

It should be noted that the R**2 for this analysis was not that spectacular (0.54), implying that there are probably more factors affecting traveler preference and behavior than those examined by this model (fare and trip time). For instance, it is certainly true that different classes of passengers have different values of time (a businessman who travels by plane has a different value of time from a tourist who enjoys being on the deck of a ship during the entire morning, or from a traveler who enjoys an overnight journey in a cabin). Having no way to measure such differences, we had to settle with the "average" value of time calculated above. We shall use such a value with caution, knowing that it is only an average, and one that probably overestimates the value of time of some travelers (those traveling by ship) and underestimates the value of time of other travelers (those taking the plane).

To validate this model, we applied the value of 415 GRD/hr to the O-D data shown in Table 4 (passengers without vehicles, 1990) to produce what the logit model gives for total passengers traveling without a vehicle and who prefer sea transport for 1990. We then added the passengers captive to sea transport (those of Table 3), and produced Table 9. A comparison with Table 1 shows generally acceptable results.

Table 9: Validation of modal split: "predicted" passengers traveling by ship, 1990 (compare with Table 1).

From/To	11	21	31	41	42	43	Total
11		145,767	182,363	341,807	409,816	7,289	1,087,042
21	143,650		22,784				166,433
31	185,167	21,806			11,661		218,634
41	331,072						331,072
42	412,494		9,224				421,718
43	8,229						8,229
Total	1,080,611	167,573	214,371	341,807	421,477	7,289	2,233,129

We finally note that comparing the 415 GRD/hr value with the value of Lioukas (1993), 415 GRD/hr of 1990 are equivalent to about 625 GRD/hr in 1993, which is lower than (although same order of magnitude with) the 800 GRD/hr produced by him.

STEP 6: Run the logit model to determine the modal split on each branch of the network.

Having calibrated the logit model by calculating an appropriate value of time, and having validated it by comparing Table 9 with Table 1, we now run it for 2004 as follows.

First, as to what the value of time will be in 2004, we assume that this will grow (in constant 1990 prices) as the rate of annual growth of Greek gross domestic product. Assuming a 1.5% average growth (in real terms), this value becomes about 510.6 GRD/hr in 1990 prices (unless otherwise noted, all our analysis is expressed in 1990 GRD). This asumption is plausible, for a person will probably value time more if he or she makes more money.

So we examine modal split in 2004 with a value of time equal to 510.6 GRD/hr (1990 prices). Note however that in 2004 the number of possible modal choices in our sub-network is 5 and not 2, as in 1990. Since the value of 510.6 was derived assuming two modes, a question is whether we can use it for the 3 additional modes assumed in 2004. Another question is whether we can use this value for those passengers traveling with a vehicle. Such passengers, having no choice but to use the conventional P/C ship in 1990, have the fast P/C ship as an alternative in 2004.

There is no foolproof way to address either of these two questions. In fact, in a strict sense, the correct answer to both questions is "no," particularly to the second one (somebody traveling with his car will generally have a different value of time from somebody traveling without it). However, the average value of 510.4 GRD/hr is about the only piece of information on travelers preferences we got, and short of scrapping this analysis altogether, we decided to use it in our analysis as best we could. "As best we could" means a number of additional assumptions concerning the way the modal split calculations are made. These are as follows.

a) In 2004 there will be no capacity constraints on the number of available ships or aircraft to meet projected demand on each link of the sub- network.

b) The value of time for all passengers in the system (traveling with or without vehicles) is 510.6 GRD/hr (1990 prices).

c) The fare assumed to be paid by each passenger traveling with a vehicle (those of Table 5) is the second class fare, plus 1/2.5 the corresponding private car fare. This assumption is reasonable for passengers traveling with their private cars (since on the average each car carries 2.5 persons), but neglects possible fare differentiations for bus, truck or motorcycle travelers. These are estimated to be minor. For these passengers, modal split is made between 2 modes, 2 and 5 (binomial logit model) and is shown in Tables 10 and 11 below.

d) The most important assumption concerns how the modal split should be made for passengers traveling without a vehicle. All 5 modes are present here, and a straightforward way to run the model would be to apply the multinomial logit formula with all 5 modes present, and let the results fall where they may. The initial set of runs were in fact made this way, and showed fast ships and air transport combined capturing from 70% to 88% of total passenger traffic without vehicles if the value of time is 510.6 GRD/hr and if the fast fare surcharge goes from 15% to 100%. If the fast fare surcharge is kept constant at 15%, this combined percentage ranges from 88% to a striking 99.7% of the passenger traffic without vehicles, the latter case (in which conventional ships receiving almost zero passengers without cars) happening if the value of time is tripled. Judging these results as unrealistic, we decided to adopt a different philosophy on how the modal split is made, as follows.

Instead of a multinomial model (split among 5 modes), we used a binomial model in a pairwise sequential fashion. The first split was between air and all ships combined. The second split was between conventional P/C ships and and all fast ships combined. The third split was between hydrofoils and other fast ships combined (SES and fast P/C ships). The fourth split was between SES and fast P/C ships. Notice that each split (except the fourth) is between a distinct single mode and a set of other modes combined. The time and fare parameters of the combined modes were assumed to be those of the one among these modes for which the "generalized fare" (fare plus trip time multiplied by value of time) was the lowest. This is tantamount to assuming that the traveler makes his choice in a sequential fashion, and at each step he or she always compares a mode with the best (in terms of generalized fare) among all other modes still under consideration.

There is no a priori way of telling what selection biases are introduced by this scheme, or whether these biases are systematic. This is so because there is no systematic ranking of the modes according to their generalized fares (as much as there is one according to their trip times and another one according to their fares). However, from the results (and from a comparison with the multinomial logit runs) we speculate that the biases are primarily against the fast ships. In that sense, we consider these runs (coupled with the assumption that the fast ships generate no new additional demand) to be on the conservative side with respect to the future of these ships.

Tables 10 to 16 summarize the results of these runs as follows.

1) Passengers traveling with vehicles (modal split of Table 5 passengers):

Table 10: Passengers who will travel by conventional P/C (mode 2).

From/To	11	21	31	41	42	43	Total
11		44,413	48,706	150,869	185,143	7,830	436,961
21	43,857		1,188				45,045
31	83,225	916			724		54,865
41	143,115						143,115
42	175,202		590				175,792
43	7,998						7,998
Total	423,397	45,329	50,484	150,869	185,867	7,830	863,776

Table 11: Passengers who will travel with fast P/C (mode 5).

From/To	11	21	31	41	42	43	Total
11		26,349	29,600	100,580	128,624	5,554	290,707
21	26,091		683				26,774
31	32,346	526			423		33,295
41	95,410						95,410
42	121,751		345				122,096
43	5,673						5,673
Total	281,271	26,875	30,628	100,580	129,047	5,554	573,955

2) Passengers traveling without vehicles (modal split of Table 6 passengers):

Table 12: Passengers who will travel by air (mode 1).

From/To	11	21	31	41	42	43	Total
11		62,805	86,778	152,819	150,107	5,911	458,420
21	65,163		19,463		4,544		89,170
31	86,213	19,754			7,015		112,982
41	149,233						149,233
42	150,504	5,238	6,054				161,796
43	6,037						6,037

Total	457,150	87,797	112,295	152,819	161,666	5,911	977,638

Table 13: Passengers who will travel by conventional P/C (mode 2).

From/To	11	21	31	41	42	43	Total
11		85,913	122,772	177,190	184,671	8,195	578,741
21	89,139		26,524				115,663
31	121,973	26,921			10,892		159,786
41	173,032						173,032
42	185,160		9,400				194,560
43	8,370						8,370
Total	577,674	112,834	158,696	177,190	195,563	8,195	1,230,152

Table 14: Passengers who will travel by hydrofoil (mode 3).

From/To	11	21	31	41	42	43	Total
11		35,470				0	35,470
21	36,801		10,411				47,212
31		10,567			4,150		14,717
41							0
42			3,582				3,582
43							0
Total	36,801	46,037	13,993	0	4,150	0	100,981

Table 15: Passengers who will travel by SES (mode 4).

From/To	11	21	31	41	42	43	Total
11		10,194	42,307				52,501
21	10,577		2,992				13,569
31	42,301	3,037			1,193		46,531
41							0
42			1,029				1,029
43							0
Total	52,878	13,231	46,328	0	1,193	0	113,630

Table 16: Passengers who will travel by fast P/C (mode 5).

From/To	11	21	31	41	42	43	Total
11		10,194	42,307	122,118	138,746	6,207	319,572
21	10,577		2,992				13,569
31	42,031	3,037			1,193		46,261
41	119,252						119,252
42	139,113		1,029				140,142
43	6,340						6,340
Total	317,313	13,231	46,328	122,118	139,939	6,207	645,136

To get the total picture for modes 2 and 5 (which are the only modes catering to both categories of passengers), we also have:

Table 17: Total passengers who will travel by conventional P/C (mode 2), sum of Tables 10 and 13.

From/To	11	21	31	41	42	43	Total
11		130,326	171,478	328,059	369,814	16,025	1,015,702
21	132,996		27,712				160,708
31	175,198	27,837			11,616		214,651
41	316,147						316,147
42	360,362		9,990				370,352
43	16,368						16,368
Total	1,001,071	158,163	209,180	328,059	381,430	16,025	2,093,928

Table 18: Total passengers who will travel by fast P/C (mode 5), sum of Tables 11 and 16.

From/To	11	21	31	41	42	43	Total
11		36,543	71,907	222,698	267,370	11,761	610,279
21	36,668		3,675				40,343
31	74,377	3,563			1,616		79,556
41	214,662						214,662
42	260,864		1,374				262,238
43	12,013						12,013
Total	598,584	40,106	76,956	222,698	268,986	11,761	1,219,091

STEP 7: Interpret results and perform sensitivity analysis.

As these results concern only a limited application of modal split (sub-network and not entire network), they should be interpreted with caution. For instance, the percentages of each mode depend not only on passenger preferences, but also on our very assumption on what links of the subnetwork are served by each mode. So these results should only be considered an output of a "what if" analysis, and not as predictions of what will actually happen in 2004. At the same time, we consider useful to perform a sensitivity analysis on some of the parameters so as to obtain some additional insights. Sensitivity analysis concerns two main parameters: The fare differential between conventional and fast ships (assumed in the baseline scenario at 15%), and the value of time (assumed in the baseline scenario equal to 510.6 1990 GRD/hr).

In 1990, of those passengers who traveled in the sub-network without a vehicle, 43% traveled by air, and the rest (57%) by conventional P/C ship. In total, 68% took the ship, and 32% used the plane.

In 2004, for those who will travel without a vehicle, 32% will take the plane, 40% will go by conventional P/C ship, 3.3% will take the hydrofoil, 3.7% will use SES, and 21% will go by fast P/C ship. For those who will travel with a vehicle, 60% will go by conventional P/C, while 40% will go by fast P/C.

These percentages, if interpreted narrowly, may be misleading. For instance, for passengers who travel without vehicles, the small hydrofoil and SES percentages (as compared to that of the fast ferries) are mostly due to our assumption on what links of the subnetwork are served by these modes and less on actual preferences. In fact, SES and fast P/C have the same speed and charge the same fare, so on one should expect a tie of these modes on the links served by both. This happens indeed (Compare Tables 15 and 16). However, not all links are served by both modes, by our own assumption, and that is why the overall shares of mode 5 are higher than those of mode 4.

In addition, these percentages do not differentiate between short and long-haul routes. If we are more careful, we can see that hydrofoils raise their percentage on short-haul routes and other new technology ships do so for longer-haul routes.

The general observation from these runs is that the overall percentage of traffic that goes to the new technology ships (modes 3, 4 and 5) can be significant. This is mainly against the airplane for passengers without cars and against conventional ferries for passengers with cars. One possible reason for this is the small (15%) fast fare surcharge assumed. Irrespective of whether these ships can survive on such a small fare (this will be examined in Section 4), one natural question is what happens to modal split if the fast fares become higher.

To investigate this, we examine what happens if the fast ship fare is 30%, and 50% over the conventional one (ceteris paribus). The results are again differentiated between passengers without vehicles, and passengers with vehicles:

For the former pasenger category, if the fast fare surcharge is 30% (50%) the shares of each mode become: Air, increase to 34% (36%); conventional ferry, slight increase to 41% (41%);

hydrofoil, decrease to 2% (1.9%); SES, decrease to 3.1% (2.8%), and fast ferry, decrease to 19.9% (18.3%). For pasengers traveling with a vehicle, the share of the conventional ferry increases to 64% (68%), while that of the fast ferry goes down to 36% (32%). In other words, the main beneficiary of a more expensive fast ship fare is the airplane for passengers traveling without a car and the conventional ship for passengers traveling with a car.

We next examine what happens if the value of time is twice or three times what was originally assumed (with a 15% fast fare surcharge).

For passengers without cars, if the value of time is doubled (tripled), the new shares are: Air, increased to 35% (37%); conventional ships, decreased to 36% (31%); hydrofoil, decreased to 2.4% (2.6%); SES, decreased to 3.6% (3.4%); and fast ferry, increased to 23% (25.4%). For passengers with cars, the shares are: Conventional ferries, dropped to 55% (49%), while fast ferries increase their share to 45% (51%).

We see that if the value of time increases, for both passenger classes the main loser is the conventional ferry, while the main beneficiary is the fast ferry and the airplane. Interestingly enough, the other two fast ship modes see their shares slightly decrease.

4. ECONOMIC FEASIBILITY ANALYSIS

In view of the promising results of the previous section with respect to the possible share of passenger demand that new technology ships might be able to attract in 2004, a pertinent question is what is the economic potential of these vessels. Clearly, a modal split analysis would be incomplete if the economic viability of these vessels is not also assessed. Although such an analysis is not the central focus of this paper (see Psaraftis (1993) for complete details), we provide here a summary of its main results.

The project team collected (and/or estimated) technical and economic data (not reproduced here) for the following categories of new technology vessels:

1) The fast monohull GUIZZO (mainland Italy - Sardinia).
2) The swath AEGEAN QUEEN (under design at NTUA- see Papanikolaou et al (1991)).
3) The wave-piercer catamaran HOVERSPEED GREAT BRITAIN (Channel service).
4) The swath PATRIA (Tenerife service).
5) The SES CORSAIR 900 (under construction in Germany)
6) The hydrofoil KOMETA (in service in Greece).

Of these, vessels 1, 2, 3, and 5 can carry cars, while vessels 4 and 6 can only carry passengers.

A parametric analysis was performed on two important parameters: The vessel's capacity utilization (ranging from 30% to 70%, with 60% assumed as the baseline value), and the company's required return on investment (ranging from 0 to 40%, with 20% assumed as the baseline value).

The vessel's economic performance depends not only on the above parameters, but also on the route it serves, as well as the operating scenario for that route. For instance, if the MMM imposes a mandatory requirement of provision of year-round service, the ship would have to collect higher fares to stay viable than if no such requirement were imposed. So we formulated seven possible scenarios, the following:

Scenario a: Route Piraeus - Mykonos (94 nm), 2 roundtrips per day for the 3 summer months, 1 roundtrip per day for 8 months, 1 month out of service.

Scenario b: Same as scenario a, but 2 roundtrips per day for 11 months, and 1 month out of service.

Scenario c: Same as scenario a, but route is Piraeus - Santorini (126 nm).

Scenario d: Same as scenario b, but route is Piraeus - Santorini.

Scenario e: Same as scenario a, but route is Piraeus - Iraklio (175 nm).

Scenario f: Same as scenario b, but route is Piraeus- Iraklio.

Scenario g: Same as scenario e, but 1 daily roundtrip for 11 months and 1 month out of service.

The purpose of scenarios b, d, and f is not so much to examine the performance of these vessels if the two daily roundtrips of the summer are extended during the rest of the year, but to simulate a scenario in which the shipowner can remove his ship from service during the 8 months of the off-season, and employ the ship outside the Greek system. The assumption is that this alternative employment is equivalent in terms of revenue.

We also note that some of these scenarios do not match some of the vessels. For instance, the AEGEAN QUEEN cannot make the two roundtrips to Crete (scenarios e and f), due to lower speed. Similarly, the PATRIA and KOMETA (that do not carry cars) are not examined at all on this route.

There are 34 vessel- scenario combinations. All are shown in Table 19. The table shows two fares for each vessel- scenario combination:

(i) the (minimum) required passenger fare to break even (on a net present value sense) over the ship's lifetime (codenamed RFR, and expressed in 1990 GRD).

(ii) the passenger fare that maximizes revenue, assuming a binomial logit modal split between the vessel and a conventional ferry charging the conventional fare (codenamed MAX, and also expressed in 1990 GRD).

Psaraftis (1993) provides more detail on how both fares are calculated. MAX is obtained by taking the derivative of the logit equation and then iteratively solving a set of non-linear equations. No retaliation is assumed from conventional vessels.

Also shown in the table are the 2nd class conventional vessel fare, and the airfare for each route.

Table 19: Economic performance of vessels for each scenario.

	Scenario:	a	b	c	d	e	f	g
Ship	Fare							
GUIZZO	RFR	10,453	7,477	11,226	8,250	12,408	9,432	14,640
	MAX	2,825	2,825	3,403	3,403	4,668	4,668	4,668
AEGEAN QUEEN	RFR	5,757	3,936	6,011	4,191			7,123
	MAX	2,686	2,686	3,194	3,194			4,316
HOVERSPEED	RFR	8,092	5,521	8,439	5,869	8,973	6,402	10,901
	MAX	2,732	2,732	3,254	3,254	4,449	4,449	4,449
PATRIA	RFR	5,339	3,566	5,497	3,724			
	MAX	2,693	2,693	3,230	3,230			
CORSAIR	RFR	9,723	6,682	10,246	7,145	10,896	7,854	13,177
	MAX	2,825	2,825	3,403	3,403	4,668	4,668	4,668
KOMETA	RFR	5,158	3,575	5,432	3,849			
	MAX	2,590	2,590	3,054	3,054			
2nd class fare		3,137	3,137	3,926	3,926	5,364	5,364	5,364
airfare		10,558	10,558	11,620	11,620	12,550	12,550	12,550

Several remarks can be made from this table. First, and with the possible exception of the PATRIA and the KOMETA, all other vessels require fares considerably higher than both the conventional fare and their own revenue maximizing fare. These fares become prohibitive (compare for instance with airfares) for scenarios a, c, and e, which require the maintenance of a year- round service.

By contrast, if the year- round service requirement is lifted (scenarios b, d, and f), the RFR's drop considerably.

The above scenario assume a 60% utilization and a 20% required return on investment. If the utilization is increased and/or the rate of return is decreased, the RFR's drop somewhat (see Psaraftis (1993 for the full sensibility analysis).

The above results certainly do not paint a particularly rosy picture for the future of fast ships in Greece, and neutralize, to a significant extent, the promising results of the previous section. They boil down to the realization that although fast ships can attract a significant share of passenger traffic if the fares they charge are modest (15% to 50% over the conventional fares), the economic viability of such vessels is likely to be problematic because they need much higher fares to break even. As these fares are often close to the level of air transport fares, very few people would accept them, rendering the overall operation problematic.

Several factors contribute to this outlook, and to the extent that some or all of these factors change, the outlook itself can change for the better. These are the following:

a) Low level of conventional fares. If those were higher, the prospects would be better.In fact, MAX is not a linear function of the conventional fare. As conventional fares are under the strict control of the MMM, the prospect of deregulation of these fares by 2004 could relieve some of the pressure from new technology vessels. See also b below.

b) High relative cost of fast ships. By "relative" we mean per unit passenger capacity, as compared to conventional ships. As conventional ships in Greece are mostly conversions and not new designs, this relative cost of fast ships is even higher. Of course, the strict control of the fares by the MMM is one of the reasons for this state of affairs, for keeping fares at low levels provides little incentive for a shipowner to buy a new ship. This situation seems to be changing lately, as several shipowners have ordered newbuildings for their fleet. Even though most of these new ships will go to the Italy- Greece services (which are not governed by the same fare structure as the internal cabotage services), this will eventually bring pressure to the MMM to deregulate fares sooner rather than later.

c) Low value of time in Greece. It is interesting to report that the income maximizing fare for the GUIZZO in Italy is at about the same level as the actual fare charged (Psaraftis (1993)). This is assuming a value of time for Italy about 3 times the Greek level. So the GUIZZO, although probably subsidized in her early runs, is more profitable in Italy than it would be in Greece, for the traffic could bear the higher rates more easily. Of course, a higher value of time in Greece can be associated with (and be the result of) a substantially higher income per capita.

d) Operating scenario controlled by the MMM. Above we saw that if these vessels are required to provide a year- round service, their economic viability is much lower. The same would happen if the MMM sets unreasonable conditions as prerequisites for granting licences to such ships (for instance, calling at 10 ports, as we noted earlier). It is our view that come 2004 the MMM will have no right to impose such conditions on fast ships, even though it will (as per the EU Regulation on cabotage) retain such authority for a select subset of the network, on which "public services" will be imposed and provided. Psaraftis (1993) and Sturmey, et al (1994) provide more details on this issue.

At the same time, the outlook can get more complicated if the other modes (1 and 2) cease to adopt a "do-nothing" fare policy (as we assumed) but formulate a fare structure that is explicitly designed to make life even more difficult for new technology ships. The analysis of the impications of such policies (which may contain elements of gaming and oligopolistic price equilibrium theory) are left for a future phase of this research.

5. CONCLUDING REMARKS

This paper presented some modal split scenarios for the Greek coastal shipping system, in view of the lifting of cabotage privileges by 2004. All of these scenarios are hypothetical, but we feel they have a substantial degree of realism so as to be able to perform a "what if" analysis of what is likely to happen.

Our analysis would be stronger if a "stated preference" data set were available instead of the "revealed preference" one, for the latter was seen to exhibit some limitations. Also, a broader analysis for a larger part of the network could provide some additional insights.

In terms of policy recommendations, a lot of work needs to be done in the 10 years to 2004, both by the MMM and by private industry, in order to be able to best adapt to the new game that will be played. Many of such recommendations are listed elsewhere (see Psaraftis (1993) and Sturmey et al (1994)). Within the scope of this paper, we feel that the analysis presented supports the following policy recommendations.

1) Put an end to the tightly controlled fare structure, well before the end of 2003, at least for some types of service.

2) For those routes and services that do not belong to the "public service" sector, allow competition and freedom to set routes and fares.

3) The MMM should set up criteria for the determination of which will be the "public service" routes, and on how licenses will be granted for those.

4) Market surveys should be carried out to determine the "stated preference" of travelers. These are essential so as to be able to predict modal split with an acceptable degree of confidence.

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