European Transport \ Trasporti Europei (2022) Issue 88, Paper n° 7, ISSN 1825-3997

https://doi.org/10.48295/ET.2022.88.7

Economies of scale in Greek coastal shipping. A survivor analysis

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Abstract

Although Greek coastal shipping is a very important shipping industry, there are not a lot of scientific efforts calculating economies of scale and minimum optimal firm size in the past. In our opinion, Stigler's survivor technique is the best-fitted method for researching these issues. It examines the configuration of companies' sizes over time and argues that only the companies with the lowest long-term average costs will survive in a market. Methodologically, we divided coastal companies into size classes regarding the number of employees per company and the contribution of companies per size class to gross production value, gross added value, and revenue without vat. Then we checked the statistical significance of changes in market share distribution. The analysis led to the conclusion that economies of scale exist in Greek coastal shipping and the minimum firm size pertains to the employment of 20-49 employees or the operation of two ships per shipping company.

Keywords: Greek coastal shipping, economies of scale, Stigler's survivor technique, minimum optimal firm size.

1. Introduction

The law 2932/2001 attempted to make Greek legislation and the operating framework of the coastal shipping system in Greece adapt to the rules set by Regulation 3577/1992 of the European Union Council. According to this law, the principles of free economy and competition are implemented in the Greek coastal system. In practice, there was a long transition (lasting 12 years), from a regulatory regime to a regime of a free market. This regulation was partly implemented in 2002 and fully in 2006.

Nowadays, Greek Coastal Shipping (GCS) is closely associated with the growth rates of Greece, offering both social and economic impacts. Besides the transportation of domestic passengers and vehicles, even to remote regions, it supports tourism services and a large part of freight traffic from and to the rest of Greece. For the year 2020, 20.082.761 passengers, 6.594.840 vehicles, and 27.847.687 merchandise were transported through GCS on all domestic and coastal lines[1]. If we add the Adriatic Sea

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[1] Ferry lines mainly concern sea links between two usually opposite coasts, while the coastal lines concern transport between nearby ports of the same country. From the total number of passengers transported, 9,330,604 (46.5%) referred to the inland coastal lines and 10,752,157 (53.5%) to the ferry lines. For vehicles, the corresponding numbers were 2,164,237 (32.8%) and 4,430,603 (67.2%).

market, in which GCS companies are dynamically active, the total numbers for passengers were 20.783.566, for vehicles 7.112.821, and for goods 150.397.484 (Elstat, 2008-2020).

In particular, GCS's contribution to the Greek economy is translated into terms of Gross Domestic Product (GDP), employment, and tax revenue. According to a study conducted by the Foundation for Economic and Industrial Research (FEIR) (2021) the total impact of GCS on domestic lines, in the year 2019, was estimated at $ 2 billion, $ 33.5 billion, and $ 728 million respectively[2]. The largest contribution to GDP and employment was recorded in Crete and the southern Aegean Sea regions. If we take into consideration the coastal transport activity on the Adriatic Sea lines (0.8% of total GDP for 2019), its importance becomes even more prominent.

The increase in tourist arrivals from abroad, after 2013, led to a steady increase in demand for coastal services in Greece. The situation changed after 2020, due to the COVID-19 pandemic. Restrictions on passengers' transportation reduced domestic passenger traffic by about 55% compared to 2019 and vehicle traffic by 36% (FEIR, 2021). This affected both the revenues and the profits of the shipping companies.

In addition, if we compare the transport activity of the listed large companies in the sector and the rest of the companies, we will ascertain its intertemporal reduction. For passengers from 38% in 2018, it fell to 36% in 2019, with the remaining 64% being covered by the smallest companies in the industry. It is characteristic that between 2010-2018 the percentage of listed companies shrank from 70% to 38% (XRTC, 2020). We are therefore observing a trend of strengthening market shares for the smaller shipping companies in the industry. The introduction of new companies, with a dynamic increase in their fleet and new investments, the reduction of the fleet of listed companies by 50%, and the bankruptcy of traditional companies (due to wrong business practices) constitute the main causes (XRTC, 2020).

2. Scope

In several shipping industries, increasing firm size leads to reduced long-term average cost as its production scale increases, ie in economies of scale (Rogers, 1992; Goulielmos & Sitzimis, 2012; Goulielmos & Sitzimis, 2014; Ma, 2020). The bigger the size of the services provided, the lower the unit production cost and the bigger the competitiveness of large companies (Oustabasidis & Katsoulakos, 1999).

For GCS, the measurement of economies of scale is quite important because, on the one hand, the existence of the advantages that can arise from the increase in the size of the ships can be ascertained and, on the other hand, the minimum size of the firm with the lowest average cost in the industry can be defined. The Average Cost (AC) may not continue to decline indefinitely as the size of production increases. There is a Minimum Optimum Size (MOS) for the shipping company, after which the unit cost remains stable as production increases. After this area of fixed average cost, each increase in firm size causes an increase in AC. In other words, the minimum optimum coastal firm size means that a larger order of magnitude (for example larger ship capacity) will not have a lower AC.

However, little scientific work has been developed to analyze and calculate economies of scale in this industry (Sitzimis, 2021c; KEPE, 1992; Goulielmos & Sitzimis, 2014).

[2] The data include inland coastal shipping and not the ferries and the cruises.

Some efforts have only been made in the cruise industry, which displays similar features to coastal shipping (Chaos, et al., 2020; Pallis, 2015; Papatheodorou, 2006).

This article aims to fill this gap in the literature, by searching for and answering the following research questions: a) Are there economies of scale in GCS, or in other words, is there a relationship between the operational coastal firm size and efficiency, which is perceived in average cost terms? b) Which is the best-fitted method for calculating economies of scale and MOS in GCS? c) Between 2008 and 2018, is the loss of market shares for the largest shipping companies in the industry associated with economies of scale and with the MOS for the entry of a company in GCS? The answers to these questions are the methodological contribution of this study.

3. Related work

There are several ways to determine the cost structure in industry and consequently the existence of economies of scale (Norton & Norton, 1986). It is usually preferred to evaluate the parameters of a production function or cost (Giordano, 2003). By applying accounting data and then statistical techniques, it is attempted to record the relationship between the average cost and the produced result, to establish the existence of fixed, increased, or decreased economies of scale. Unfortunately, as McGee also stresses (1974), this method does not always lead to accurate and consistent results as there is a difficulty in financial evaluation and comparison of these data. So, the present or future relationship between the business cost and the size of an industry is not adequately reflected (Rogers, 1992; Saving, 1961).

A second method concerns engineering approaches. It is based on the opinions of the company experts who are responsible for making decisions about appropriate firm size (Giordano, 2008). Unfortunately, several times the lack of availability of input prices does not allow the assessment of the minimum efficiency of business size in the industry. Different levels of input prices (see the cost of labor and capital) may lead to erroneous conclusions about business size at the lowest cost. Also, the engineer's subjective view gives several times greater importance to the companies that are at the forefront of technology. But this does not mean that the older companies could not adequately survive in this financial environment. This specific method was adequately applied by Bain (1956). In his classic work on entry barriers (he correlated the prices with the entry barriers), he examined the contribution of economies of scale to the existence of entry barriers in a market (Oustabasidis & Katsoulakos, 1999). According to Bain's view, there are some key features of the nature of economies of scale in any industry, where the leading one is the MOS which is expressed as a percentage of the total value of industrial production. If the MOS is relatively high, then the number of start-ups that can enter the market is small and the industry concentration is high.

The survivor technique, the third method, was first used by Stigler (1958), who was inspired by Mill (1848). In the years that followed, several authors applied it in the context of their research (Saving, 1961; Shepherd, 1967; Blair & Vogel, 1978; Norton & Norton, 1986; Giordano, 2003; Giordano, 2008). However, there are several practical drawbacks. At first, it cannot determine the exact nature and size of the advantage of an effective-sized class. Secondly, several times its results are not easy to interpret, as both small and large orders of magnitude can appear effective. Thirdly, the criterion for dividing companies into size classes can change the conclusions of the analysis (Rogers, 1992).

In our analysis for GCS, available statistics and the easy implementation of the method allow the choice of the survivor technique. In any case, the applied solution method is

novel, since neither economies of scale have ever been adequately calculated in this industry nor has this method been used in the past. Stigler (1958) is clear by saying «…avoids both the problems of valuation of resources and the hypothetical nature of technological studies». This method is suitable for industries where firm sizes vary and changes in demand are common (Sengupta, 2004). This is the case with GCS as its services constitute derived demand and depend to a large extent on other areas of economic activity (Goulielmos & Sambrakos, 2002). According to Rogers (1992) although the engineering technique explains why a class is effective, its size evaluation is clearly subjective. After all, following the logic of Shepherd (1967), as expanded by Giordano (2008), evidence from cost or production function estimations should be screened against survivor analysis. So, the use of it, even supplementarily to the other methods, is of particular importance for the calculation of economies of scale in GCS.

4. Economies of scale in GCS

As previously mentioned, the term "economies of scale" refer to the reduction of long-term AC as the scale of production increases. If a company's fixed cost (FC) is high, the same cost is apportioned to more production units. This means that AC decreases. Economists point out that economies of scale exist if AC is larger than Marginal Cost (MC) and anti-economies of scale on the contrary (Oustabasidis & Katsoulakos, 1999; Gwilliam & Mackie, 2017). The existence of economies of scale in a market is one main reason for its non-competitiveness. It leads to "market failure" , potential inefficiency and as a result to state intervention in the production of private goods and services (Stiglitz, 2000).

In GCS higher production means faster or higher or more ships per company, while the FC is quite high. It mainly concerns crew costs (41.5%), repairs, maintenance and stores (14.4%), insurance (3.5%), and administration cost-general expenses (8.8%). In other words, the 68.2% of the total cost of a coastal company. The remaining 31.8% is variable (voyage) cost and includes fuel and lubricants (22%) and port expenses (9.8%) (KEPE, 1992). In the year 2016 and for three of the largest companies in the industry (Blue Star Ferries, ANEK Lines, Hellenic Seaways) FC stood at 70.2% and VC at 29.8% (FEIR, 2021). Therefore, we can assume that larger production in GCS means larger scale (Goulielmos & Sitzimis, 2014).

If we define MC as the cost of an extra coastal voyage, then it is equal to the voyage's variable cost (VC). This means that there is a huge deviation between FC and MC in GCS. So, the perception that the maximization of profits is achieved at the point where Price (P) = Marginal Cost (MC) = Marginal Revenue (MR) (full competition) does not apply to the liberalized coastal market. A typical coastal company, due to the high FC that it deals with, faces declining long-term AC (economies of scale) and low MC. This means that if it sets prices equal to MC, as the theory requires, it will be led to losses (MC < AC). In the long run, it will possibly leave the market. It is common practice to set prices larger than the MC to cover the AC (Goulielmos & Sambrakos, 2002).

The declining AC at GCS exists not only per shipping company but also per ship. In this case, AC could be set as the total production cost divided by passengers' miles (Goulielmos & Sitzimis, 2014). The AC curve would continuously descend to the point where ship's occupancy rate would reach 100%. Then it would increase sharply as it would be illegal to transport more passengers. We must also notice that there isn't AC with zero coastal production since the estimated capacity utilization must be at a bare minimum. When the loss from the voyage exceeds the loss from not providing service

the ship does not pre-announce any voyage. The maximization of profits per ship voyage would be described by the intersection point of AC and demand curves. Essentially it is the point where MC=MR and the number of passengers per voyage satisfy demand at the pier and in the booking office (Goulielmos & Sitzimis, 2014).

Unfortunately, GCS cannot adapt supply completely to demand, as airlines or road transport, for example. Coastal fleets include two types of ships. Slow-speed vessels (conventional) or high-speed vessels (XRTC, 2020). So they are inflexible and they cannot exactly satisfy demand (at different distances, port limitations, periods, etc). Given the low elasticity of demand for coastal services and the timeless indifference of companies to passenger's preferences, there is a possibility of wasted ship capacity, excess supply, or both of them (Goulielmos & Sambrakos, 2002).

In any case, it is a fact that GCS is an industry with strong economies of scale and we will take it for granted. It is no coincidence that the concentration degree of the Greek coastal market is high per line and that shipping companies have chosen to expand their business through horizontal mergers and acquisitions to achieve the MOS (Goulielmos & Sitzimis, 2012). In this way, the number of high-cost shipping companies is restricted, and the production is rationalized so that economies of scale can be capitalized. After all, economies of scale exist in all types of ships (cruise ships, bulk ships, containerships, ro-ro ships) (Chaos, et al., 2020; Ma, 2020). The interesting issue is calculating economies of scale and determining the minimum efficient size, regarding the entry of a company into this market. Indicatively, Sitzimis (2012) applied the survivor analysis in GCS considering it as a whole. He showed that in the years between 1999-2005, the small companies (0% -7% of total market revenue) and the bigger ones (over 25% of total market revenue) of the sector were inefficient because they had higher average operating costs. On the contrary, medium-sized enterprises (7.1% -25% of total market revenue) were more profitable as they increased over time their corresponding size in the market (as a percentage of the total turnover of the industry). The data were modified after the year 2006 (ie after the full liberalization of the market), when the largest companies in the sector were strengthened, with an opposite course for the rest. The MOS for a company entering GCS was estimated at 7% of the total industry size (ie approximately € 30,500,000 annual turnover).

5. Methodology and application of survivor technique

Stigler's (survivor technique) (1958) is based on the idea that in a market only the most efficient can survive. The method claims that companies with the lowest average long-term cost will survive over time because the competition between companies of different sizes contributes to their faster growth and the stay of the most profitable of them in the industry. Consequently, by examining the formulation of the magnitude of companies in a sector, in different periods, it can be determined what is the shape of the AC curve, the existence or not of economies of scale, and the MOS of market entry. This method studies the long-term cost considering that it is based on changes in the magnitude formulation of firms over a long period of time (over 5 years).

The survival method attempts to determine the shape of the long-run AC curve extracted from the data. Classes that lose market share over time are considered inefficient (McGee, 1974). The logic is that when the smaller classes shrink, they face available and untapped economies of scale and are in the range of increasing returns of scale. This is equivalent to the passthrough of their shares to larger and more efficient classes. Respectively, when the larger classes show a decrease in their market shares, they are

considered to be part of the range of decreasing returns of scale, with a benefit for the smaller classes. The most efficient classes are those that acquire or at least maintain their market shares over time, achieving a constant return to scale (Giordano, 2003; Saving, 1961).

Nevertheless, we must be careful in the case of pure monopoly, as the survivor technique cannot be applied. Lack of competition does not create incentives for the minimization of AC to the monopolist. In GCS, before cabotage removal, there were several cases of coastal lines collecting these characteristics (Sitzimis, 2021c). After the liberalization of the market, most lines are oligopolistic or duopolistic (Goulielmos & Sitzimis, 2012). As Giordano (2003) states, this is sufficient at a minimum as «even a pair of duopolists could provide enough competition for a meaningful survivor analysis». Moreover, for the application of the method, the industry services need to be homogeneous. This aspect means two major things. At first, the survival in every class should not depend on the demand for the differentiated product or service, but only be attributable to its cost efficiency. Secondly, it must be secured that all cost elements (input prices, advertising costs, taxes, etc.) are the same for all companies and in each class (Giordano, 2003). In GCS shipping companies have always set prices based on cost, without being able to assume large differences in cost elements, especially for listed companies (Sitzimis, 2021b). Also, GCS does not constitute a single market but consists of several sub-markets (coastal shipping lines) which must be analyzed separately because they face different market conditions (Goulielmos & Sitzimis, 2012; Sitzimis, 2021c). However, while on paper coastal services are diversified[3] (equipment, speed, arrival-departure schedule, amenities, service), in several lines, there is a strong homogeneity. Especially during the summer months, the freedom of entry led the "young" and "quality" competitors in serving the most efficient markets (peak periods) (cream skimming) and not the poorest and weakest in terms of demand (Goulielmos & Sambrakos, 2002). Along these lines the lower price elasticity of demand, allowed coastal companies to set out equally quality ships, providing relatively homogeneous services[4].

In order to apply the survivor technique in GCS, we relied on statistics for the economic activity sector "water transport" (H50) (Elstat, 2008-2020). This sector includes the sub-sectors "sea and coastal passengers transport" (H50.1), "sea and coastal freight transport" (H50.2), "inland waterway passengers transport" (H50.3), and "inland waterway transport of goods" (H50.4). GCS belongs to the H50.1 sector (FEIR, 2014). This economic activity includes the transport services on main coastal lines (starting from major ports of the country, such as Piraeus, Rafina, Volos, and Patras), on secondary lines (routes from regional ports, Aegean and Ionian islands) and ferry lines (short distance routes). However, apart from GCS, passengers' transport in yachts-tourist ships, hydrofoils or hovercraft, excursion boats, and boats are also integrated. So, some segregation from these companies is required.

According to Stigler (1958) class boundaries are expressed as a percentage of the total size of the entire industry. However, it is legitimate to use absolute sizes, in case the

[3] The Greek shipping market could be overall characterized as an oligopolistic market of differentiated form (there are few companies that produce differentiated service. Differentiation refers to the production of a service with different characteristics from other companies). But per line it is mainly a monopolistic market, duopolistic or oligopolistic, with characteristics in some cases of homogeneous oligopoly (relative homogeneity of the provided shipping service).

[4] For example, on the "Heraklion - Piraeus" line, the companies ANEK Lines and Minoan Lines have launched the same quality ships "Kriti I" and "Festos Palace" with the same departure and arrival time.

industry is not growing rapidly. This is a fact for GCS. Between 2008-2018 the change in total passenger traffic for 13 main itineraries was almost stable (-6%) (Sitzimis, 2021a). In fact, in GCS it is difficult to find financial data for all companies in the industry. Such data exist only for listed companies. The only feasible solution in our research was the use of detailed data regarding the number of employees per company and the contribution of companies per size class to gross production value, gross added value, and revenue without vat[5] (for all companies). This is an innovative approach to calculating economies of scale in industry.

Thus, to initially separate GCS from the other H50.1 industry categories, we relied on the number of employees for the entire H50 industry. Available statistics included classes 0-9, 10-19, 20-49, 50-249, 250 employees and more. By observing the long-term employment data of the shipping companies, we found that all the companies employed more than 10 employees (crew and land). So, we only dealt with the last four classes, considering that 0-9 employees are employed in non-coastal companies (for example tourist ships or excursion boats). Besides, as Giordano (2003) states, at least three classes are required so that the growing, declining and, constant economies of scale could be adequately represented. Fewer classes run the risk of losing market share changes among companies or classes. Most classes hide the risk of non-statistically significant changes.

Due to our involvement with the subject, we supposed that over 250 employees are mainly employed by the listed companies that operate more than 7 ships per year, 50-249 employees by the companies that operate 3-6 ships per year, 20-49 employees by the companies that use two ships and 10-19 employees by companies with only one ship. So, we classified the shipping companies into classes, according to the number of employees they employ. Class I: shipping companies with 10-19 employees (very small size), class II: shipping companies with 20-49 employees (small size), class III: shipping companies with 50-249 employees (medium size), and class IV: shipping companies that employ over 250 employees (large size).

We found data on shipping companies per class through the Ministry of maritime affairs and insular policy. Per year (voyage period), according to article four of law 2932/01 (AD 145), each shipping company is required to submit a declaration of regular routing. By thoroughly analyzing the intertemporal statements of all companies (2008-2018) we found the annual number of coastal vessels, the number of coastal companies, and finally the coastal companies per class. Having data on the number of shipping companies included in these classes and knowing the total number of companies on the sea and coastal transport of passengers per class (H50.1) per year, we used the percentage of coastal companies per class on the total of the companies as a weighting factor for what is the contribution of the shipping companies to the Greek economy, regarding the total gross value of production, the total gross added value and the total revenue without vat (table 1). For instance, in 2008, for Class I, the total number of companies of the sea and coastal transport of passengers were 257, in contrast to 127 coastal companies (about 49.4% of the total). So, taking into account that the gross production value of total companies was € 489,208, the 49.4% calculated as € 241,748.7.

[5] "Turnover without VAT" includes sales of goods or services to third parties invoiced by shipping companies during the reporting period. "Gross production value" measures the quantity actually produced by coastal shipping companies based on sales, including alterations in inventories and resale of goods and services. The "gross added value (at cost prices of production factors)" corresponds to the total gross income from operating activities of the shipping companies.

At this point, we applied a first chi-squared (x^2) test of statistical significance to see if the intertemporal fluctuations of market shares, in all classes, exceed those fluctuations which happen due to random fluctuations. We checked annually the statistical significance of changes in market share distribution. For computing the chi- squared statistics we used the type:

$$X^2 = \Sigma\left[\frac{(O_{it} - E_{it})2}{E_{it}}\right] (1)$$

Where Oit is the annual class outputs for i=…n size classes, Eit is the previous year's market share of the class (t-1) in percent multiplied by the total market output (Ot) of the current year.

The null hypothesis (Ho) of our analysis was that the current year distribution is the same as the prior year's distribution. There were n-1 degrees of freedom (d.f.) and in our case 10 d.f. (Giordano, 2003). So, beneath table 1 we have shown the critical x^2 values, with 10 d.f. The Ho is rejected if the computed x^2 value is greater than the critical value. This means that the possible distribution shift of market shares is statistically significant.

After classifying and finding the rest of the data, we calculated the annual output share distributions by size for each kind of output value (table 2). We basically calculated the respective size of each class in the whole industry, which we based: a) on the total gross production value, b) on the total gross added value, and c) on the total revenue without a vat of the sector. If the respective size of each class decreased over time, the conclusion was that the specific class is inefficient. This shows that companies of this size have higher AC.

Then we exacted the ratios of coastal companies' market shares by size (table 3). We divided the examined years into three periods. The first was the period 2008-2013, when the financial crisis in Greece was at its peak. The second concerned the period 2008-2013, when there was an improvement in the macroeconomic figures of the Greek economy, and the third was the whole period 2008-2018 (total) (table 3). Finally, we performed a chi-squared test (x^2) of significance for changes in the size distribution of firms by size category (2008 vs 2018) (table 4) (Blair & Vogel, 1978; Ginsburg & Frech, 1974). Our aim was to determine whether each class individually has a statistically significant influence on the annual change in the distribution of market shares between the years 2008-2018.

For computing the chi-squared statistics we used the type:

$$X^2 = \left[\frac{(O_i - E_i)2}{E_i}\right] + \left[\frac{(O_j - E_j)2}{E_j}\right] (2)$$

Where Oi is the output of size class i in the year 2018 and Oj is the sum of outputs of all other classes in the same year. Ei is the year 2008 market share in percent multiplied by the year 2018 total market output and Ej is the sum of the above mathematical operation for all other classes. Our null hypothesis was that the size class i has the same market share in year 2018 as in year 2008. There is 1 d.f. as all size classes are treated as a single class (Giordano, 2003). So beneath table 4 we have shown the critical chi-squared values, with 1 d.f. The Ho is rejected if the computed x^2 value is greater than the critical value. This means that there is a statistically significant change in separate size class (Norton & Norton, 1986).

6. Analysis and results

Table 2 shows for the year 2008 that the 127 shipping companies, concerning in class II (10-19 employees), contribute about 35% to the total production value, about 45% to the total gross added value, and by about 33% to the total income without vat. These percentages are converted for 2018 respectively to 36%, 29%, and 36% (with an increase of the companies to 131). So, the smallest class (I) raised in terms of market share for the first and third kinds of output value. Class II shows an increase both in the 3 categories of output value and in the number of shipping companies. The same is true for class III, except that the number of shipping companies has remained stagnant. The largest class (IV) shew a sharp decline for the first and third categories of output value, even if the number of coastal companies raised.

To get a clearer picture of these changes we compared the ratio of market shares over time (table 3). During the financial crisis (2008-2013) almost all classes are relatively efficient since the ratios of market shares are greater than one (Norton & Norton, 1986). An exception was class IV where a big decline is evident. Thus, this class appears to be less efficient. After 2008 and until 2013 GCS faced two main problems. The increase in the international fuel prices and the sharp drop in passenger traffic due to the global and domestic financial crisis (approximately -25%) (FEIR, 2014). This resulted in adverse financial consequences for the industry, with strong implications, especially for the large shipping companies (listed companies), in which there was strong loan pressure and a lack of liquidity. Between 2007-2012 their turnover decreased by 4.5%, their operating expenses increased by 6.7%, their total assets decreased by 5.3% and their total liabilities increased by 5.1%. It is typical that the profits of 2007 (€ 129 million) were converted in 2012 into losses of € 276 million (FEIR, 2014). The first questions about the viability of these shipping companies were reasonably raised.

After the financial crisis (2013-2018) only II and IV classes exhibit ratios of more than 1. The other two classes seem relatively inefficient. From 2013 onwards the situation at GCS changed. Coastal passenger traffic has increased mainly due to the increase in tourist traffic from abroad (FEIR, 2021). For the big companies in the industry, between 2013-2018, this meant an improvement in their financial figures. However, the compression of the market share of large companies in favor of small ones is gradually beginning to emerge (XRTC, 2020).

Taking into consideration the total period 2008-2018, the first three classes seem more efficient than the largest one (table 4). The loss of market shares of the largest companies in the industry is not accidental. The small companies took advantage of the forced deleveraging and the restriction of the activity of the listed companies, after the crisis. New business practices followed, launching high-speed ships only during peak periods and raising their capital from off-exchange sources or banks (XRTC, 2020). Also, the second and the third class made notably larger gains in market shares than the first one. With few exceptions, this applies to all 3 kinds of output values. This means that the survivor analysis does not support the wide assumption that the economies of scale in GCS would lead to the largest firm classes prevailing at the expense of smaller classes (Blair & Vogel, 1978).

However, we must distinguish between induced random and enterprise efficiency changes. In order to do that, changes in each separate size class must be examined. Basically, all other classes must be treated as a single class. The chi-squared (x^2) test of statistical significance shows significant shifts in the size distribution for any level of statistical significance (.01, .05, .1) (table 4). Taking as an example the total gross

production value, significant increases are observed for classes I, II, and III and a significant decrease for large coastal companies in IV size class.

Furthermore, in table 1 is clear that for all pairs of consecutive years, between 2008-2018, the chi-squared (x^2) distribution presents significant annual shifts. For each of these pair of years, the null hypothesis is rejected at all confidence levels. So we can conclude that the size distribution of GCS firms in 2018 was significantly different statistically from that of every other year (Blair & Vogel, 1978).

Table 1: Class sizes, output value produced (in thousand €), and chi-squared test in GCS (2008-2018)

Year	*Total output*	*Class I output value:10-19 employees*	*Class II output value:20-49 employees*	*Class III output value:50-249 employees*	*Class IV output value:over 250 employees*	*x^2 test*
	694,184.57	241,748.70	37,480.84	42,958.03	371,997.00	
2008	340,149.79	154,161.20	21,863.09	19,235.00	144,890.50	-
	759,684.51	248,353.19	50,602.58	62,270.74	398,458.00	
	615,157.53	155,928.58	37,259.18	101,798.17	320,171.60	123,324.30
2009	295,169.72	100,092.38	23,031.57	39,881.37	132,164.40	41,897.40
	631,894.04	154,882.76	38,903.68	119,268.80	318,838.80	101,550.60
	709,716.29	156,973.07	20,708.63	100,113.20	431,921.40	27,611.40
2010	192,281.46	61,392.96	11,826.91	18,903.00	100,158.60	5,120.00
	707,094.94	159,479.28	20,825.45	100,138.00	426,652.20	34,953.00
	552,666.30	146,865.20	39,067.56	74,767.54	291,966.00	43,585.00
2011	191,019.14	89,918.56	20,233.63	18,425.35	62,441.60	33,657.70
	553,335.60	148,765.32	39,111.18	73,546.31	291,912.80	42,110.10
	489,146.50	187,191.69	37,419.31	51,376.50	213,159.00	36,642.70
2012	156,383.85	80,862.46	13,238.79	19,469.10	42,813.50	4,005.60
	488,245.26	187,996.62	36,922.45	50,357.70	212,968.50	35,668.00
	425,533.50	174,976.12	42,061.53	84,233.19	124,262.67	58,838.40
2013	145,612.51	66,487.40	16,522.00	26,433.78	36,169.33	6,605.30
	419,214.77	170,303.60	40,896.43	83,426.07	124,588.67	59,077.40
	377,896.57	142,803.94	31,383.94	30,955.43	172,753.25	62,962.20
2014	182,987.73	61,271.50	17,500.42	17,189.81	87,026.00	52,212.80
	393,062.86	143,510.85	30,653.10	30,349.90	188,549.00	76,526.10
	424,956.01	169,911.12	23,776.40	87,323.76	143,944.73	96,553.60
2015	233,857.75	94,819.62	10,841.19	48,752.94	79,444.00	51,155.30
	431,108.86	169,617.39	22,913.82	90,959.65	147,618.00	121,213.00
	408,478.29	157,010.80	46,675.02	58,504.84	146,287.64	33,231.40
2016	215,846.12	80,074.80	24,557.23	33,162.10	78,052.00	25,210.80
	403,901.97	155,643.03	45,774.82	58,459.03	144,025.09	36,229.20
	451,866.30	170,865.00	55,835.06	42,012.48	183,153.75	11,165.40
2017	240,644.34	82,024.00	26,225.77	22,425.58	109,969.00	12,413.20
	448,452.33	168,568.00	55,999.57	42,315.52	181,569.25	11,427.80
	510,216.71	183,691.21	65,171.96	59,575.29	201,778.25	3,741.90
2018	249,256.47	71,547.24	33,774.16	31,489.57	112,445.50	6,682.70
	503,960.08	181,798.79	64,728.72	56,484.57	200,948.00	2,083.40

Source: Hellenic statistical authority 2008-2018. Our elaboration.

Note 1: For 10 d.f., the critical chi-squared (x^2) value for statistical significance of .01 is 23.209, of .05 is 18.307 and that of .1 is 15.987.

Note 2: The rows in each year concern the kind of output value. The first one is “total gross production value”, the second one is “total gross added value” and the third one is “total revenue without vat”.

Table 2: Annual output share distributions in GCS

Year	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	
Size class (number of employees) by output produced	*Market share distributions by size*											*Number of coastal companies and kind of output value*
10-19	34,82%	25,35%	22,12%	26,57%	38,27%	41,12%	37,79%	39,98%	38,44%	37,81%	36,00%	total gross production value
	45,32%	33,91%	31,93%	47,07%	51,71%	45,66%	33,48%	40,55%	37,10%	34,09%	28,70%	total gross added value
	32,69%	24,51%	22,55%	26,89%	38,50%	40,62%	36,51%	39,34%	38,53%	37,59%	36,07%	total revenue without vat
	127	*123*	*125*	*122*	*120*	*107*	*108*	*111*	*118*	*126*	*131*	*number of coastal companies*
20-49	5,40%	6,06%	2,92%	7,07%	7,65%	9,88%	8,30%	5,60%	11,43%	12,36%	12,77%	total gross production value
	6,43%	7,80%	6,15%	10,59%	8,47%	11,35%	9,56%	4,64%	11,38%	10,90%	13,55%	total gross added value
	6,66%	6,16%	2,95%	7,07%	7,56%	9,76%	7,80%	5,32%	11,33%	12,49%	12,84%	total revenue without vat
	13	*13*	*8*	*11*	*9*	*11*	*10*	*7*	*13*	*17*	*21*	*number of coastal companies*
50-249	6,19%	16,55%	14,11%	13,53%	10,50%	19,79%	8,19%	20,55%	14,32%	9,30%	11,68%	total gross production value
	5,65%	13,51%	9,83%	9,65%	12,45%	18,15%	9,39%	20,85%	15,36%	9,32%	12,63%	total gross added value
	8,20%	18,87%	14,16%	13,29%	10,31%	19,90%	7,72%	21,10%	14,47%	9,44%	11,21%	total revenue without vat
	5	*8*	*6*	*7*	*9*	*8*	*4*	*7*	*5*	*4*	*5*	*number of coastal companies*
over 250	53,59%	52,05%	60,86%	52,83%	43,58%	29,20%	45,71%	33,87%	35,81%	40,53%	39,55%	total gross production value
	42,60%	44,78%	52,09%	32,69%	27,38%	24,84%	47,56%	33,97%	36,16%	45,70%	45,11%	total gross added value
	52,45%	50,46%	60,34%	52,76%	43,62%	29,72%	47,97%	34,24%	35,66%	40,49%	39,87%	total revenue without vat
	2	*2*	*3*	*2*	*2*	*1*	*3*	*2*	*2*	*3*	*3*	*number of coastal companies*

Source: Hellenic statistical authority 2008-2018. Our elaboration.

Table 3: Ratios of coastal companies' market shares by size

	During financial crisis	*After financial crisis*	*Total*	
Year	*2013/2008*	*2018/2013*	*2018/2008*	*Number of coastal companies and kind of output value*
Size class (number of employees) by output produced	*Ratios of market shares*			
10-19	1,18	0,88	1,03	total gross production value
	1,01	0,63	0,63	total gross added value
	1,24	0,89	1,10	total revenue without vat
	0,84	*1,22*	*1,03*	*number of coastal companies*
20-49	1,83	1,29	2,37	total gross production value
	1,77	1,19	2,11	total gross added value
	1,46	1,32	1,93	total revenue without vat
	0,85	*1,91*	*1,62*	*number of coastal companies*
50-249	3,20	0,59	1,89	total gross production value
	3,21	0,70	2,23	total gross added value
	2,43	0,56	1,37	total revenue without vat
	1,60	*0,63*	*1,00*	*number of coastal companies*
over 250	0,54	1,35	0,74	total gross production value
	0,58	1,82	1,06	total gross added value
	0,57	1,34	0,76	total revenue without vat
	0,50	*3,00*	*1,50*	*number of coastal companies*

Source: Our elaboration.

Therefore, taking into consideration, on the one hand, the larger gains of second and third class and, on the other, that in first class one output value (total gross added value) shows a decrease, we can conclude that second class (II) consists the MOS of coastal companies in GCS. The MOS concerns the employment of 20-49 employees or otherwise the routing of 2 ships on the ferry lines. Per year, if we divide every kind of output value of class II by the number of shipping companies (class II) and deduce the average (2008-2018), we will find that in absolute terms the MOS is expressed as € 5,431,000 for total gross production value (1.06% of the total output of all classes), as € 2,814,510 for total gross added value (1.27% of the total output of all classes) and € 5,394,060 for total revenue without vat (1.03% of the total output of all classes) (table 5).

This means that if a new shipping company with a size less than MOS enters the industry, it will have a higher cost than other companies in the industry (which are equal in size or greater than MOS). Then the latter will have the opportunity to sell at lower prices than the new company, which will eventually be forced to move away from the industry.

7. Conclusions and discussion

The importance of GCS for the Greek economy is special, contributing drastically to its growth rates. It has a positive effect on GDP, employment and tax revenues. Despite the continuous increase in the demand for coastal services, after 2013, the Covid-19 pandemic created severe problems in the financial figures of the industry and especially in those of large companies.

GCS has shown high FC, decreasing long-term AC, and low MC over time. This theoretically means that it is an industry with strong economies of scale. However, as we saw, this conclusion does not support the wide assumption that the economies of scale in GCS would lead to the largest firm classes prevailing at the expense of smaller classes.

Table 4: x^2 test of significance for changes in the size distribution of firms by size category (2008 vs 2018)

Size class (number of employees) by output produced	*Coastal companies output value*	*% Change in market share*	*Change in number of firms*	*X^2*
10-19	total gross production value	1,18%	4,00	311,81
	total gross added value	-16,62%	4,00	27.774,49
	total revenue without vat	3,38%	4,00	2.620,27
20-49	total gross production value	7,37%	8,00	54.318,42
	total gross added value	7,12%	8,00	21.024,15
	total revenue without vat	6,18%	8,00	30.988,08
50-249	total gross production value	5,49%	0,00	26.472,02
	total gross added value	6,98%	0,00	22.752,76
	total revenue without vat	3,01%	0,00	6.072,59
over 250	total gross production value	-14,04%	1,00	40.438,45
	total gross added value	2,52%	1,00	645,44
	total revenue without vat	-12,58%	1,00	31.961,82

Source: Our elaboration.

Note: For 1 d.f., the critical chi squared (x^2) value for statistical significance of .01 is 6.635, of .05 is 3.841 and that of .1 is 2.706

The best-fitted method of calculating economies of scale and MOS in GCS is Stigler's survivor technique. Of course, there are a lot of drawbacks to this method and should be treated with skepticism. This method, by examining the composition of the size of the enterprises of industry and arguing that only the enterprises with the lowest long-term average costs will survive over time, determines not only the existence of economies of scale but also the minimum efficient size of entering a market. In GCS, after we used assize classes (classes) the number of employees of the shipping companies [(class I: 10-19 employees (very small size), class II: 20-49 employees (small size), class III: 50-249 employees (medium size) and class IV: over 250 employees (large size)], we calculated the respective size of each class in the whole industry.

We found out that the market share distributions, between 2008-2018, of every size class of GCS, except the largest one, are growing as a percentage of the output values of total gross production value, total gross added value, and total revenue without VAT. Also, it is observed an increase in the number of coastal firms in the first two classes which indicates relative efficiency. The other two classes shew stability over the same period. All isolated size classes exhibit highly significant changes in any level of statistical significance. The same is true for the changes in the overall size distribution of GCS firms. Especially, during the financial crisis (2008-2013) all classes seem relatively efficient, except for class IV. After the financial crisis (2013-2018) the situation is changing for the largest companies in the industry, due to the sharp increase in tourist traffic from abroad.

In conclusion, our analysis showed that the MOS in GCS concerns class II and specifically the employment of 20-49 employees or the operation of 2 ships per shipping company. This is translated as € 5,431,000 for total gross production value, € 2,814,510 for total gross added value, and € 5,394,060 for total revenue without vat. It is therefore a fact that although in GCS economies of scale exist, we cannot always and with certainty assume the competitive advantage of the largest companies in the industry.

Table 5: The minimum optimal size of coastal companies in GCS (2008-2018) (values in thousand €)

Year	*Total output value in GCS*	*Class II output value (20-49 employees)*	*Number of coastal companies (Class II)*	*Class II output value per coastal company*	*% of total output per coastal company*
	694,184.57	37,480.84		2,883.14	0.42%
2008	340,149.79	21,863.09	13,00	1,681.78	0.49%
	759,684.51	50,602.58		3,892.51	0.51%
	615,157.53	37,259.18		2,866.09	0.47%
2009	295,169.72	23,031.57	13,00	1,771.66	0.60%
	631,894.04	38,903.68		2,992.59	0.47%
	709,716.29	20,708.63		2,588.58	0.36%
2010	192,281.46	11,826.91	8,00	1,478.36	0.77%
	707,094.94	20,825.45		2,603.18	0.37%
	552,666.30	39,067.56		3,551.60	0.64%
2011	191,019.14	20,233.63	11,00	1,839.42	0.96%
	553,335.60	39,111.18		3,555.56	0.64%
	489,146.50	37,419.31		4,157.70	0.85%
2012	156,383.85	13,238.79	9,00	1,470.98	0.94%
	488,245.26	36,922.45		4,102.49	0.84%
	425,533.50	42,061.53		3,823.78	0.90%
2013	145,612.51	16,522.00	11,00	1,502.00	1.03%
	419,214.77	40,896.43		3,717.86	0.89%
	377,896.57	31,383.94		3,138.39	0.83%
2014	182,987.73	17,500.42	10,00	1,750.04	0.96%
	393,062.86	30,653.10		3,065.31	0.78%
	424,956.01	23,776.40		3,396.63	0.80%
2015	233,857.75	10,841.19	7,00	1,548.74	0.66%
	431,108.86	22,913.82		3,273.40	0.76%
	408,478.29	46,675.02		3,590.39	0.88%
2016	215,846.12	24,557.23	13,00	1,889.02	0.88%
	403,901.97	45,774.82		3,521.14	0.87%
	451,866.30	55,835.06		3,284.42	0.73%
2017	240,644.34	26,225.77	17,00	1,542.69	0.64%
	448,452.33	55,999.57		3,294.09	0.73%
	510,216.71	65,171.96		3,103.43	0.61%
2018	249,256.47	33,774.16	21,00	1,608.29	0.65%
	503,960.08	64,728.72		3,082.32	0.61%
	514,528.96	**65,171.96**		**5,431.00**	**1.06%**
Average (2008-2018)	**222,109.90**	**33,774.16**	**12,00**	**2,814.51**	**1.27%**
	521,814.11	**64,728.72**		**5,394.06**	**1.03%**

Source: Our elaboration.

Note: The rows in each year concerns the kind of output value. The first one is "total gross production value", the second one is "total gross added value" and the third one is "total revenue without vat".

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