Future Business Journal

RESEARCH

Open Access

Forecasting methods in Greek coastal shipping: The case of Southwest Crete

Ioannis Sitzimis[1*]

Abstract

The aim of this paper is to exact the most effective model at capturing the seasonal and short-term components of passenger traffic in Southwest Crete coastal shipping. There has been no similar effort in the past. The passenger traffic forecast is crucial for the public and private sector, as it is necessary for decision making. In our analysis we considered the six largest ports of Southwest Crete. The seasonal repeated fluctuations and the quarterly observations made Winter's triple exponential smoothing, time series decomposition, simple seasonal model, seasonal ARIMA model and Lis' simplistic forecast suitable for our case. The results showed that in four of the six ports the Winters' method is best adapted. The port of Gavdos adapts better to the decomposition method and the port of Sougia to Li's method. No port led, through the seasonal ARIMA models or simple seasonal model, to better results. In most cases, traffic trend did not change over time, the seasonal component significantly affected the time series, and the time series smoothing was strong.

Keywords Greek coastal shipping, Cretan southwest ports, Passenger traffic, Smoothing and decomposition forecasting methods, Measures of forecast accuracy

JEL Classification R40, R41, C53

Introduction

Greek coastal shipping (GCS) is of special importance for the Greek economy as it comprises 100 ships and connects the mainland with 115 inhabited Greek islands [1]. It is one of the largest in Europe, with its contribution to GDP being 7.4% of the total GDP [2]. Including ferry lines, it serves more than 35 million passengers annually [3]. Its fleet accounts for approximately 7% of the world's passenger fleet. It consists of 28 companies that can accommodate 99,759 passengers and 26,313 vehicles [1]. It includes a lot of coastal lines, due to the large number of islands. In Europe incorporates 20% of the total passenger traffic [2].

*Correspondence:
Ioannis Sitzimis
isitzimis@hmu.gr
[1] Department of Business Administration and Tourism, Hellenic Mediterranean University, Heraklion, Greece

GCS is associated with the growth rates of Greece, offering both social and economic impacts. 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 (IOBE) (2021) [2] the total impact of GCS, in the year 2019, was estimated at € 13.6 billion, 331,600 citizens, and € 2.957 million, respectively. 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 largest contribution to GDP and employment was recorded in Crete and the southern Aegean Sea regions. In particular, the overall effect on the GDP of the island regions of the country amounts to €8.5 billion. Crete absorbs 41.3% of the total impact, supporting approximately 103,000 jobs and €429 million of disposable income.

Traffic forecast in this industry is important for both business and government policy. Examples of decisions made by ship owners include the number of routes, the size and number of ships they operate, their pricing policies and their public service commitments [4]. Also, state is interested in port infrastructure policies and the subsidy amount for barren lines. In the latter case, according to Official Government Gazette B, 15/04/20,1426 (article 2), there is a fundamental prerequisite for state financial support on barren lines. Passenger traffic must be reduced by 80% on average compared to the previous year [4]. The requirement for high occupancy rates on ships (using larger ships and decreasing routes) is related to the undeniable existence of scale economies in GCS (due to high fixed costs) [4, 5]. In any case, it is crucial for the public and private sector to be aware of the expected passenger traffic for all Greek coastal lines. A forecast is necessary for making decisions.

Furthermore, the European package of measures “Fit For 55” concerns the adjustment of Community policies with the aim of reducing greenhouse gas emissions by at least 55% by 2030. It is envisaged that maritime transport will gradually be included in the Emissions Trading System (EU-ETS) (from 2024), with a transitional period during which the percentage of emissions that should be covered (purchased) with “allowances” will increase, namely 40% in 2024, 70% in 2026 and 100% from 2027 onwards. This situation affects GCS, as ships are now required with low and zero gas emissions. Without fleet renewal it will increase the operating costs of the ships [6]. The reason is that companies will have to pay for every ton of oil they consume, the carbon dioxide they emit. This is a particularly high amount of charge which will be required to be paid by the user of the services, i.e., either the passenger or the State (if the ship serves barren lines) [7]. IOBE [8] emphasized that, covering the extra expenditure due to the “Fit For 55” package is expected to increase ticket prices by 5% in 2024 to 30% in 2026, which can lead to a decline in demand for coastal services. The relevant measure only concerns category A ships, with a capacity of 5,000 gross tons and above, that operate on international routes and on islands with more than 200,000 inhabitants.

The European Union recognizes a temporary exception until 12/31/29, from the above Regulation, for ships that do not have all these characteristics [1, 8]. That is the case in Southwest Crete. However, the local companies and the state should be ready for the great modifications and avoid the financial burden. For instance, the best possible traffic forecasting is expected to determine which are the coastal lines, in this area, with high-capacity demand. Along these lines the companies will have an economic interest in launching their newly built ships and setting higher ticket prices. Moreover, traffic forecasting can contribute to the determination of ship occupancy rates. This means that the future turnover of shipping companies and their ability to cover the increased operating costs due to their adaptation to the new environmental standards can be estimated. It is obvious that this will also affect the users of transport services as it will largely determine the potential pricing policy of the companies.

The primary purpose of this research is to determine the best forecasting method by answering the research question: Which model is the most effective at capturing the seasonal and short-term components of passenger traffic in Southwest Crete coastal shipping? Sitzimis [9] made a similar effort to find an effective model in GCS. There has been no similar effort either for the lines of Southwest Crete or for other Greek lines with the same market conditions. The best model specifically compares Box–Jenkins ARIMA, smoothing, and decomposition approaches [10–12]. According to Aivazidou [13], the first approach appears to be useful in estimating passenger traffic; whereas, the other two have not been chosen for investigation. The fundamental premise behind all three of the aforementioned approaches is that the current observations will continue to behave in the same way going forward [14]. In the period 2020–2021, due to the COVID-19 pandemic, this did not happen and there was a sudden and unexpected drop in passenger traffic [4, 15].

It should be mentioned that a similar survey, per port of Southwest Crete, has not been carried out before by earlier studies. Some isolated efforts have been made only in the main ports of Greece [4, 16]. Also, smoothing and time series decomposition techniques are used in only a few transport models, the majority of models use the more complicated Box–Jenkins ARIMA methodology. Our main contribution here is to show that in the specific coastal market simplified forecasting methods find better application and greater adaptability than advanced forecasting practices. In other words, we are carrying out this research to fill a gap in the relevant literature. Structurally, in this context and before establishing the appropriate forecasting method (Sects. "Methodology" and "Results") we will proceed on the one hand with a review of the coastal industry in Southwest Crete (Sect. "A review of the coastal shipping sector at Southwest Crete") and on the other hand with a literature review on the specific issue (Sect. "Literature review").

A review of the coastal shipping sector at Southwest Crete

IOBE, in an illustrative study [8], argued that the overall impact of GCS on the GDP of Crete is 37%, or € 3.516 million. In relation to employment, the percentage amounts to 41%, or in other words to 103,000 citizens. It is noteworthy that the shipping lines of Crete gather 14% of the total passenger traffic in the Greek area [1].

It is obvious that is a pillar of particular importance for the region's economy.

Heraklion, Souda, Sitia, Rethymno, Kasteli Kissamos, Agios Nikolaos, Agia Roumeli, Palaiochora, Loutro, Sougia, Chora Sfakion (Sfakia), and Gavdos are the principal ports of Crete [9]. The last six (6) ports concern southwestern Crete, while there are also two (2) smaller ones, Plakias and Agia Galini, recording consistently lower demand. In Crete, as well as throughout GCS, strong seasonality occurs during the summer months (third quarter of the year), with percentages frequently exceeding 50% [3–5, 16–18]. The central ports of Heraklion (43.98%), Souda (43.16%), and Rethymno (48.13%) stand out since they connect Crete with Piraeus and have traffic that is not exclusively made up of tourists. Very high percentages, on the other hand, are seen in the ports of Gavdos (75.08%), Kasteli Kissamos (77.19%), and Loutro (70.71%), where passenger traffic primarily consists of tourist flows [9]. It is noteworthy that 213,558 of passengers who traveled on the southwest Cretan lines chose the period between January and September 2022 (in percentage terms, this is equivalent to 20.39% of Cretan ports and 0.65% of Greek ports) [3]. Generally, all the lines in Southwest Crete exhibit this seasonality during the summer, with essentially no passenger activity during the first three months of the year (Fig. 1) [2, 9].

It should be noted that the three (3) largest companies in the industry rely heavily on Cretan coastal lines for their profits [1]. In 2021 they carried a total of 1,497,313 passengers and 565,239 vehicles, representing 11.7% and 17.2% respectively of the total passenger traffic in Greece [3]. In Cretan ports, between 2000 and 2021, approximately 31,258,707 passengers were served which constitute 6.38% of the total passenger traffic in Greece (489,741,110 passengers) [3]. This percentage varied to 9.23% in 2000, to 11.61% in 2006, to 3.81% in 2021 and to 3.17% the first three quarters of 2022. The average from 2000 to 2021 was 7.35% [3]. Heraklion (50.69%), Souda (27.14%) and Agia Roumeli (8.97%) showed the highest passenger traffic [9]. While Greece's total passenger traffic climbed by 99.07% (from 12,770,576 to 25,422,673 passengers), passenger traffic at Cretan ports decreased by 17.87% (from 1,178,746 to 968,079 passengers) [3]. Although national passenger flows appear to have increased, competition from other touristic locations of Greece (such as the Cyclades) appears to have increased at the same time [9].

From 2000 and 2021, Agia Roumeli (58.88%) held the largest market share among southwest Creran ports, followed by Chora Sfakion (22.04%), Loutro (11.27%), Palaiochora (3.21%), Sougia (2.69%), and Gavdos (1.91%) [3]. Agia Roumeli (– 48.34%), Palaiochora (– 29.81%), Sougia (– 43.01%), and Chora Sfakion (– 40.52%) show a drop in passengers embarked (HSA, 2000–2022) (Fig. 2). They confirm the downward trend of passenger traffic to

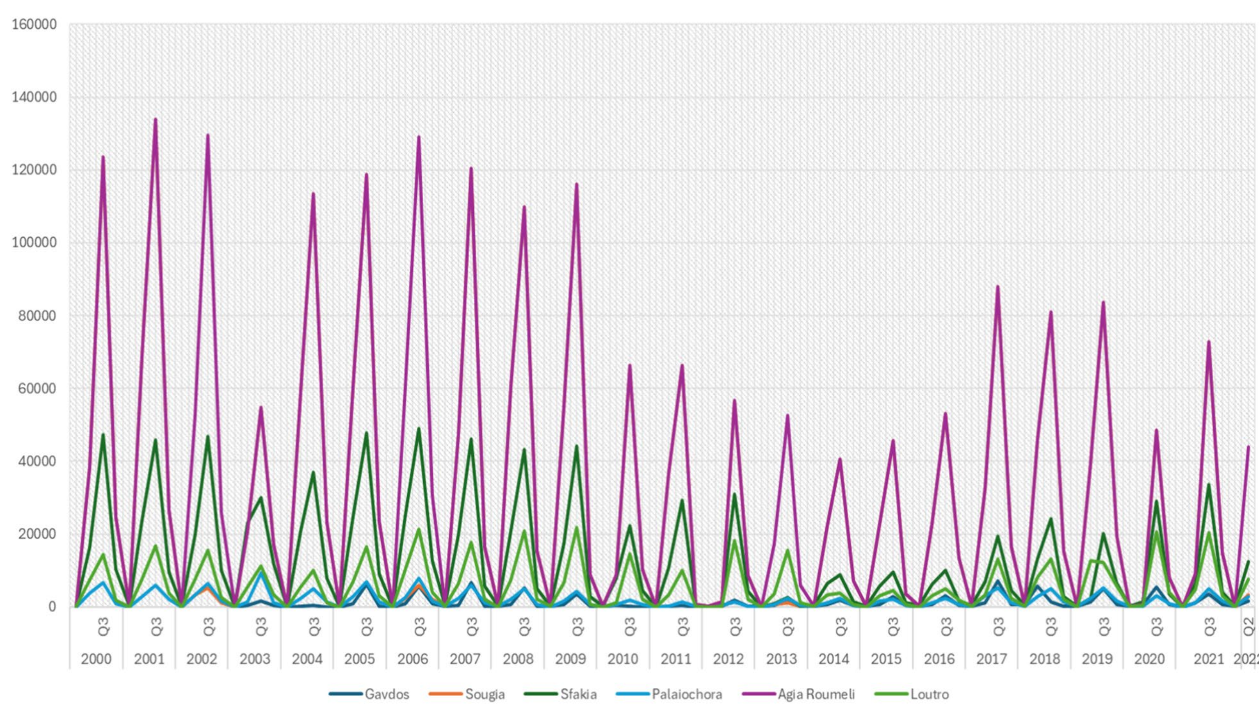


Fig. 1 Existence of seasonality in the ports of Southwest Crete for the third quarter of the year (2000–2021) Source: Our elaboration (2023)

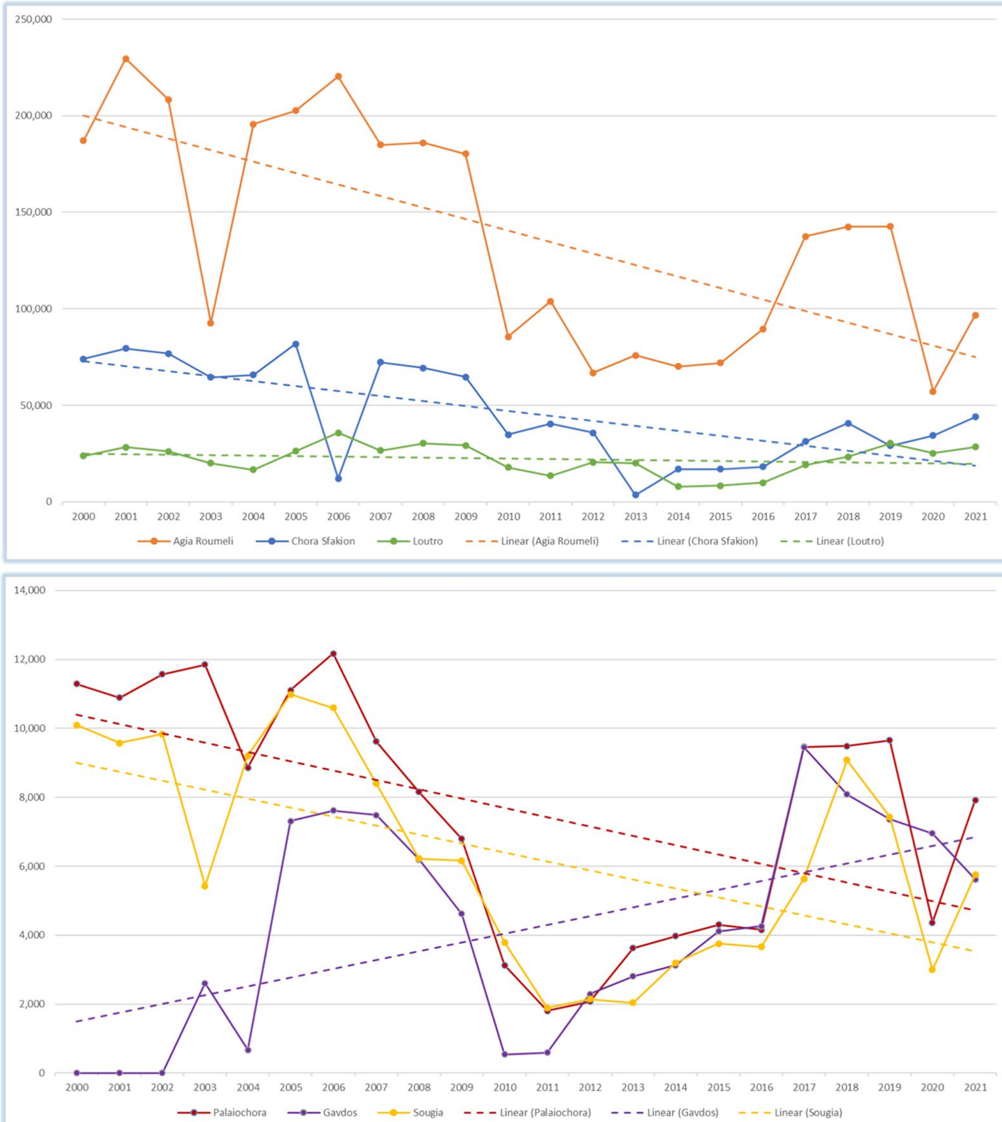


Fig. 2 Passenger traffic and linear trendline in the ports of southwestern Crete (2000–2021) Source: Our elaboration (2023)

Crete [9]. Only in ports of Gavdos and Loutro there is an increase (18.92%) [3] (Fig. 2), due to the improvement of coastal connections to mainland and their consolidation as important tourist destinations [9]. The passengers who traveled during this period were 4,763,575, accounting for 15.24% of the island's overall passenger traffic and 0.97% of Greece's overall passenger traffic [9]. For this period, there was a 38.52% overall passenger percentage decrease (from 306,460 to 188,419), as explained before [9].

Literature review

In terms of forecasting activities in the transportation sector, over 60% of publications concern passenger transportation forecasts [13]. These primarily pertain to aviation, road, and urban transportation. Banerjee et al. [19] created a list of researches by forecasting method and found the existence of 143 relevant papers. Of these, 31% concerned causal methods, 27% concerned time series methods, 17% artificial intelligence methods, 12% ancillary tools and the remaining 13% other methods. Indicatively, econometric models have been adopted by many researchers. For instance, Leng et al. [20] and Caseetta and Coppola [21] attempted to forecast passenger traffic in high-speed rail either algorithmically or using a simple utility function equation. SARIMA and ARIMA models were used by Shitan et al. [22] who tried them in Ampang Railways. Samagaio and Wolters [23] conducted a methodologically similar comparative study on Lisbon Airport transit, as did Cyprich et al. [24] in the bus industry.

However, there is no comparable scientific research on coastal passenger transport in the international literature [4]. The fundamental reason is because coastal shipping is a mode of transportation in a few countries. Only Ortuzar and Gonzalez's [25] investigation on the coastal line between the Canary Islands and Tenerife is noteworthy.

In relation to GCS some prediction efforts have taken place by a variety of academics, including Psaraftis [26], who attempted to methodically examine alternative scenarios for passenger demand after market liberalization. A dynamic model with an error correction model methodology was used by Spathi [27] to analyze the function of passenger demand. Similar research was done by Tsekeris [28], who presented an overall analysis of substitution and complimentary relationships among all of Greece's domestic transportation options. He proposed a notion of consumer demand-based model. The financial statements and passenger traffic of coastal companies were estimated simply, with polynomial and hyperbolic functions performing best (higher R squared) [29]. In 2014, an important study [30] employed the regression method to estimate demand elasticity for coastal shipping services in relation to ticket prices and household disposable income. [1] uses a variety of alternative forecasting methodologies on an annual basis.

Sitzimis [4] presented a meticulous, step-by-step methodology for ARIMA seasonal models and discovered that, in GCS, no coastal line produced better outcomes with this strategy. Five of the fourteen investigated routes integrated better to simple seasonal exponential smoothing model, one to time series decomposition model, and eight of the fourteen to Winter's triple exponential smoothing model. The research revealed that the traffic trend, particularly for the last method, did not vary over time, that the seasonal component had a significant impact, and that the time series' smoothing was more intense in some lines. Regarding the first approach, the level of smoothing varied by route and seasonality played a significant role. Indicatively, the slope of the linear trend equation of the "Piraeus–Dodecanese" coastal line was − 2287. This clarified an average drop of 2287 passengers per quarter, even if the second model appeared to be the best option.

However, time series models, rather than regression models or a combination between time series and regression models, are the basic forecasting techniques utilized for other passenger transport, according to Aivazidou [13]. Very few models are based on smoothing and time series decomposition techniques, instead, most models are based on the Box–Jenkins ARIMA methodology. In other words, we are conducting this study to fill a gap in the pertinent literature.

Methodology

Qualitative forecasting techniques depend more on human judgment than on current data analysis [31]. We chose the quantitative approach as we had quarterly data on passenger traffic between 2000 and 2022—up to the second quarter. A total of ninety (90) observations. We used the Statistical Package for Social Sciences (SPSS 22) to analyze the data. An exception was the calculation of the time series decomposition and some other cases, where the Minitab 19 software was used.

Regression analysis could be used to create a forecast for our dependent variable [32]. We would be able to identify the quantitative and causal correlation between the variables contributing to the interpretation of our dilemma in this way. Unfortunately, this approach is challenging to use in this situation because the independent factors affecting passenger traffic are not totally evident, it is challenging to get relevant statistics, and time series analysis models appear to work better in these circumstances [1, 33, 34].

Due to these factors, we may rely on established smoothing techniques like Box–Jenkins ARIMA models, which solely take into consideration the data as it is and ignore any potential relationships with other variables [11, 35, 36]. We restricted ourselves to smoothing techniques because they are simple to use and have a low level of computing complexity. We employ longitudinal data, which are historical observations made over an equal number of consecutive time periods. These time series offer accurate short-term forecasts and are unaffected by the scant amount of accessible data [32]. The simple moving average and simple exponential smoothing models work best when there is no trend and seasonality (stationary time series) for a short forecast range. Accordingly, if there is a trend but no seasonality, trend analysis or exponential smoothing with trend adjustment (Holt's method) are recommended for long-range forecasts; while, double exponential smoothing (Brown's method) or the double moving average method (double moving average or linear moving average) are recommended for short-range forecasts [14, 37, 38].

The data we had for passenger traffic on the ports of southwest Crete were quarterly and therefore there were indications of seasonality and non-stationarity. All the examined ports showed a strong increase in traffic in the 3rd quarter of the year (Fig. 1), with an intertemporal decreasing or increasing trend between the years 2000–2022 (Fig. 2). This means we couldn't use forecasting techniques like the ones above. The seasonal repeated fluctuations and the quarterly observations made

Winter's triple exponential smoothing (indicated when we have seasonality but no trend, for short-term forecasting), time series decomposition (indicated when we have trend and seasonality, for long-term forecasting), the simple seasonal model (indicated when we have no trend but only a fixed seasonal effect), and seasonal ARIMA (SARIMA) models suitable for our case [14, 32]. To all of this, we added Lis' simplistic forecast (EFML method), by removing seasonality, to make the corresponding comparisons [39].

The EFML method, as it is not widely known, is based on seven (7) consecutive steps, after some modifications: (1) We find the constant average of 4 consecutive quarters (4-point SA), (2) We find the central average (Centered MA—CMA) obtained as an average of 2 consecutive SAs, (3) We find the deviations between the actual passenger traffic and the CMA, 4) We make a simplistic working forecast that does not take into account seasonality (e.g., via moving average), depending on the lowest possible value in the forecast accuracy measures, (5) We find the average seasonal variations that result as the quarterly average of the deviations for all the available quarters, (6) We add the "simplistic working forecast" with the "average seasonal variations", (7) We find the appropriate forecast accuracy measures so that the method is directly comparable in terms of its predictability to the rest of the composite methods.

The main selection criterion we followed is which method best adapted to our data, i.e., it led to the smallest deviations between predicted and actual time series values (forecast error) [14, 37, 40]. We used the mean absolute percentage error (MAPE), which expresses the accuracy as a percentage, and the mean squared deviation (MSD or MSE) as measures of forecast accuracy [41]. The MSE expresses the average value of deviation squares and is considered statistically more reliable, consequently it is used more often. Because its interpretation is not easily understood, we mainly used the root mean squared error (RMSE) [37]. We also considered the MAE (mean absolute error), which expresses a measure of forecast accuracy in relation to the actual values, keeping the measurement units of the original time series. Its large values indicate method bias [14]. Finally, the Bayesian information criterion, developed by Schwarz (1978) (or BIC), was used, and selects the model that gives its minimum value [42]. The first three (3) criteria were used in all forecasting methods; while, the BIC was only used in the Winters method, the simple seasonal model and the seasonal ARIMA models. The main reason was that these methods were calculated in SPSS which had this capability (as opposed to Minitab software). We thought that the lower the value, the better the model in terms of estimate, for all forecasting accuracy criteria.

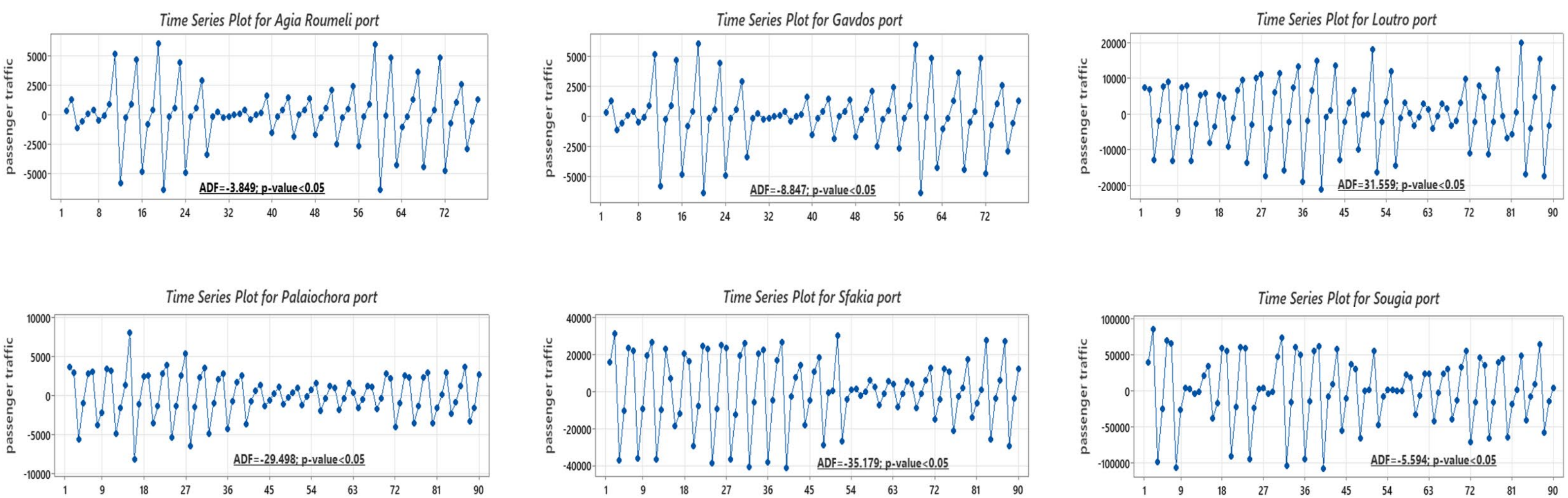
As we previously stated, seasonality (repetitiveness) is relatively steady and exhibits a declining or growing pattern in the quarterly data for the ports of Southwest Crete under examination (Fig. 2). Through the statistical software SPSS 22 we calculated the additive (WA) and multiplicative model of Winters' (WM) [41, 43–45], the seasonal ARIMA models (SARIMA) [10, 46, 47] and the simple seasonal exponential smoothing model (SS) [48] per port. The Minitab 19 software helped us calculate the additive and multiplicative model of decomposition. We took into account both trend plus seasonal (DMTS.T + S.A and DMTS.T + S.M, respectively) and only seasonal (DMTS.S.A and DMTS.S.M, respectively) [49]. This means that the results included a linear trend and seasonal indicators per quarter. Microsoft excel was used to calculate simplistic forecast according to Li [39]. We note that in the 4th step of the method, as a simplistic working forecast, we used the moving averages that showed the lowest value in the RMSE index per port. Also, in the 7th step, we relied on the RMSE and MAE indices, to make the necessary comparisons with the remaining methods.

The passenger traffic time series for the ports of Southwest Crete were examined for the first time, so we considered it appropriate to find the optimal values of the parameters for each method used [45]. That is, those values that minimize the MAPE, MAE, RMSE and BIC criteria (Table 2). In the case of conflicting results our main selection criterion was the majority of confirmatory measures of forecasting accuracy with the smallest values. Where no conclusion could be drawn, the model with the highest stationary R^2 was finally selected.

Of course, for ARIMA models, the time series must be stationary. This means that their values have the same variance and the same mean over time. For all ports, we checked the time series stationarity using Minitab 19 (Augmented Dickey–Fuller test) and found that none of them could reject the null hypothesis (p value > 0.05) [50, 51]. Additionally, through the XLSTAT 14 software, we performed both the KPSS test and the Phillips–Perron test (PP) to confirm our results [32]. In all three tests it was shown that the time series was not stationary. The most efficient way to convert a non-stationary series into a stationary one is through finding the first differences. We did this (lag 1) (Table 1) and saw that the three above tests agreed on the stationarity of the new time series. Therefore, we were led to the seasonal ARIMA models with the best fit for all ports (Table 2). The results for the best forecasting method did not change after this test.

Before selecting the final forecasting model per port, we checked them all for their "adequacy." We performed

Table 1 Checking for time series stationarity in the six (6) principal ports of Southwest Crete (Augmented Dickey–Fuller Test). The Augmented Dickey–Fuller Test (ADF), the Phillips–Perron test and the KPSS test gave us exactly the same results for the stationarity of the time series. Indicatively, we only present the results of ADF test Source: Our elaboration (2023)



The Augmented Dickey–Fuller Test (ADF), the Phillips–Perron test and the KPSS test gave us exactly the same results for the stationarity of the time series. Indicatively, we only present the results of ADF test

Table 2 **a** Best forecasting methods for the six (6) main ports of Southwest Crete. **b** The best forecasting methods for the six (6) main ports of Southwest Crete

Ports	Best method	Forecasting methods	Main features of method	Seasonal indices	Optimal parameters of forecasting equations	Stat. R^2	Ljung-Box (sig)	Decision criteria			
								MAPE	MAE	RMSE	BIC
The best forecasting methods for the six (6) main ports of Southwest Crete											
AGIA ROUMELI	**WM**	DMTS.T + S.M	Yt = 44,621–244.8xt	1: 0.003, 2: 1.091, 3: 2.452, 4: 0.454				200.0	11,114.0	15,461.1	
		DMTS.T + S.A	Yt = 50,056–342.7xt	1: − 34,030, 2: 4550.2, 3: 48,571.0, 4: − 19,091.2				9924.0	13,577.0	17,064.0	
		DMTS.S.M		1: 0.003, 2: 1.091, 3: 2.452, 4: 0.454				229.0	13,044.0	19,236.0	
		DMTS.S.A		1: − 34,030, 2: 4550.2, 3: 48,571.0, 4: − 19,091.2				550.0	13,091.0	19,247.1	
		WM			**$\alpha = 0.097$, $\gamma = 0.000$, $\delta = 0.044$**	**0.450**	**0.053**	**387.0**	**9014.9**	**14,416.0**	**19.302**
		WA			$\alpha = 0.184$, $\gamma = 0.001$, $\delta = 0.380$	0.348	0.406	25,674.9	10,716.0	15,637.9	19.465
		SS			$\alpha = 0.191$, $\delta = 0.383$	0.347	0.457	25,728.2	10,474.3	15,554.3	19.404
		ARIMA	ARIMA(0.0.0)(0.1.1)		Seasonal difference: 1, MA, seasonal lag 1: 0.540	0.197	0.441	171.0	12,296.6	17,585.2	19.602
		EFML	MA8 + ASV							18,016.1	
PALAIOCHORA	**WM**	DMTS.T + S.M	Yt = 1821 + 1.46xt	1: 0.035, 2: 1.012, 3: 2.451, 4: 0.502				89.0	819.0	1250.9	
		DMTS.T + S.A	Yt = 2584–14.98xt	1: − 1853.8, 2: − 37.55, 3: 2715.89, 4: − 824.55				214.0	832.0	1162.1	
		DMTS.S.M		1: 0.035, 2: 1.012, 3: 2.451, 4: 0.502				88.0	806.0	1225.7	
		DMTS.S.A		1: − 1853.8, 2: − 37.55, 3: 2715.89, 4: − 824.55				86.0	806.0	1225.5	
		WM			**$\alpha = 0.121$, $\gamma = 0.004$, $\delta = 0.128$**	**0.535**	**0.144**	**118.4**	**631.6**	**960.9**	**13.894**
		WA			$\alpha = 0.112$, $\gamma = 0.001$, $\delta = 0.593$	0.509	0.547	1170.8	621.3	970.3	13.913
		SS			$\alpha = 0.114$, $\delta = 0.592$	0.513	0.642	993.6	612.7	963.1	13.846
		ARIMA	ARIMA(0.0.1)(1.1.0)		Seasonal difference: 1, AR seasonal lag 1: 0.453, MA, lag 1: 0.823	0.465	0.813	70.6	651.8	989.1	13.898
		EFML	MA8 + ASV							1133.1	

Table 2 (continued)

Ports	Best method	Forecasting methods	Main features of method	Seasonal indices	Optimal parameters of forecasting equations	Stat. R^2	Ljung-Box (sig)	Decision criteria			
								MAPE	MAE	RMSE	BIC
CHORA SFAKION	**WM**	DMTS.T + S.M	Yt = 17,565–106.6xt	1: 0.015, 2: 1.062, 3: 2.502, 4: 0.421				181.0	4287.0	6532.6	
		DMTS.T + S.A	Yt = 20,097–171.6xt	1: − 11,407.8, 2: − 71.1, 3: 19,440.9, 4: − 7962.0				1413.0	5330.0	7174.9	
		DMTS.S.M		1: 0.015, 2: 1.062, 3: 2.502, 4: 0.421				197.0	5670.0	8429.1	
		DMTS.S.A		1: − 11,407.8, 2: − 71.1, 3: 19,440.9, 4: − 7962.0				407.0	5769.0	8446.9	
		WM			**α = 0.101, γ = 0.104, δ = 0.057**	**0.596**	**0.225**	**131.5**	**3162.9**	**5014.1**	**17.194**
		WA			α = 0.059, γ = 0.011, δ = 0.703	0.472	0.107	495.7	3315.4	5600.4	17.415
		SS			α = 0.062, δ = 0.702	0.475	0.152	249.4	3151.3	5556.5	17.348
		ARIMA	ARIMA(0.0.1)(0.1.1)		Seasonal difference: 1, MA seasonal lag 1: 0.322, MA, lag 1: 0.893	0.448	0.499	195.1	3764.6	5723.0	17.409
		EFML	MA8 + ASV							7153.6	
The best forecasting methods for the six (6) main ports of Southwest Crete											
GAVDOS	**DMTS**	DMTS.T + S.M	Yt = 426 + 22.89xt	1: 0.111, 2: 1.560, 3: 0.12, 4: 0.317				133.0	756.0	1395.5	
		DMTS.T + S.A	Yt = 837 + 9.61xt	**1: − 1043.59, 2: − 290.59, 3: 2027.28, 4: − 693.09**				**185.0**	**702.0**	**1210.8**	
		DMTS.S.M		1: 0.111, 2: 1.560, 3: 0.12, 4: 0.317				174.0	717.0	1267.3	
		DMTS.S.A		1: − 1043.59, 2: − 290.59, 3: 2027.28, 4: − 693.09				187.0	713.0	1229.9	
		WM			α = 0.000, γ = 0.186, δ = 0.057	0.666	0.087	140.1	702.2	1307.6	14.525
		WA			α = 0.001, γ = 1.212e-005, δ = 2.605e-006	0.692	0.030	191.3	703.5	1257.4	14.446
		SS			α = 0.200, δ = 1.233e-005	0.690	0.373	375.4	818.2	1256.3	14.387

Table 2 (continued)

		ARIMA	ARIMA(0.0.0)(1.0.0)		AR seasonal lag 1: 0.615	0.398	0.004	116.0	1185.3	2018.3	15.276
		EFML	MA4 + ASV							1399.2	
LOUTRO	**WM**	DMTS.T + S.M	Yt = 5624 + 7.6xt	1: 0.008, 2: 1.092, 3: 2.499, 4: 0.402				149.0	1999.0	3195.1	
		DMTS.T + S.A	Yt = 6159–12.9xt	1: − 5786.39, 2: 229.18, 3: 9190.75, 4: − 3633.53				336.0	1987.0	3089.1	
		DMTS.S.M		1: 0.008, 2: 1.092, 3: 2.499, 4: 0.402				148.0	1954.0	3143.9	
		DMTS.S.A		1: − 5786.39, 2: 229.18, 3: 9190.75, 4: − 3633.53				305.0	1996.0	3107.3	
		WM			**α = 0.072, γ = 0.043, δ = 0.020**	**0.645**	**0.103**	**132.8**	**1828.8**	**2854.8**	**16.066**
		WA			α = 0.198, γ = 6.334e-007, δ = 9.986e-007	0.565	0.002	840.5	2221.1	3103.6	16.233
		SS			α = 0.200, δ = 2.358e-005	0.566	0.003	854.3	2220.7	3084.9	16.170
		ARIMA	ARIMA(0.0.0)(0.1.0)		Seasonal difference: 1, Constant: 33.647	0.000	0.000	179.8	3057.8	4697.6	16.954
		EFML	MA4 + ASV							3182.5	
SOUGIA	**EFML**	DMTS.T + S.M	Yt = 33,779–125.9xt	1: 0.003, 2: 1.104, 3: 2.429, 4: 0.464				457.0	14,250.0	21,972.1	
		DMTS.T + S.A	Yt = 38,008–206.1xt	1: − 28,801.8, 2: 1485, 3: 43,512.8, 4: − 16,196				7408.0	15,412.0	22,083.0	
		DMTS.S.M		1: 0.003, 2: 1.104, 3: 2.429, 4: 0.464				471.0	14,735.0	22,862.7	
		DMTS.S.A		1: − 28,801.8, 2: 1485, 3: 43,512.8, 4: − 16,196				612.0	14,787.0	22,722.8	
		WM			α = 0.000, γ = 0.002, δ = 0.452	0.138	0.000	7119.2	18,026.0	27,786.3	20.620
		WA			α = 1.026e-005, γ = 0.001, δ = 0.400	0.120	0.000	8169.4	18,571.4	28,216.6	20.651
		SS			α = 1.484e-005, δ = 0.401	0.115	0.000	8381.3	18,314.2	28,140.4	20.594
		ARIMA	ARIMA (0.0.2)(0.1.1)		Seasonal difference: 1, MA, seasonal lag 1: 0.945, MA lag 2: 0.371	0.394	0.241	547.0	17,567.1	24,655.1	20.330
		EFML	**MA8 + ASV**						**883.6**	**935.2**	

Source: Our elaboration (2023)

Bold values indicate the best applicable forecasting methods per port and the relevant analysis results

Table 3 Final forecast of passenger traffic for the six (6) main ports of Southwest Crete (2022–2028).

Year	Quarter	Agia Roumeli	Chora Sfakion	Gavdos	Palaiochora	Sougia	Loutro
2022	Q3	63,881	26,429	3623	5113	3377	18,367
	Q4	11,183	4508	912	1260	832	2701
2023	Q1	64	259	571	117	1	74
	Q2	25,029	10,489	1334	2164	2061	7316
	Q3	60,952	27,697	3661	5053	3541	18,969
	Q4	10,665	4722	951	1245	966	2789
Total		96,709	43,167	6517	8579	6569	29,147
2024	Q1	61	271	610	115	169	76
	Q2	23,840	10,975	1372	2139	2158	7550
	Q3	58,023	28,965	3700	4994	3320	19,571
	Q4	10,146	4936	989	1230	1063	2877
Total		92,070	45,147	6671	8478	6710	30,074
2025	Q1	58	283	648	114	297	78
	Q2	22,652	11,461	1411	2113	1998	7784
	Q3	55,094	30,233	3738	4935	3300	20,173
	Q4	9627	5149	1027	1216	1111	2965
Total		87,431	47,127	6824	8378	6706	31,000
2026	Q1	55	295	687	113	397	81
	Q2	21,464	11,947	1449	2088	1986	8018
	Q3	52,165	31,502	3777	4876	3225	20,775
	Q4	9108	5363	1066	1201	1136	3053
Total		82,792	49,107	6978	8277	6744	31,927
2027	Q1	52	307	725	111	475	83
	Q2	20,275	12,432	1488	2063	1966	8252
	Q3	49,236	32,770	3815	4817	3175	21,378
	Q4	8590	5577	1104	1186	1159	3140
Total		78,153	51,087	7132	8177	6775	32,853
2028	Q1	49	319	763	110	550	85
	Q2	19,087	12,918	1526	2037	1954	8486
	Q3	46,307	34,038	3853	4757	3120	21,980
	Q4	8071	5791	1143	1172	1177	3228
Total		73,514	53,066	7285	8077	6801	33,780
Total 2023–2028		510,670	288,700	41,407	49,966	40,305	188,782
Mean 2023–2028		85,112	48,117	6901	8328	6718	31,464

Source: Our elaboration (2023)

an overall test of each model, through the chi-square test based on the Ljung–Box statistic (SPSS). A model whose residuals are random and independent (i.e., their correlation constitutes white noise) is sufficient. When the p value > 0.05 then the model does not describe statistically significant correlations between the residuals [52]. We can therefore assume that it adapts, in general, adequately to the time series. The interpretive ability of the model was also investigated through the stationary R^2. A measure that compares the stationary part of the sample to a simple sample mean. It is preferred over the traditional R-squared coefficient of determination when trend or seasonality is present. High index values indicate that the model fits the data better.

Finally, we proceeded to forecast the passenger traffic for the years 2022 (from the 3rd quarter) to 2028 (the 4th quarter), for all the examined ports (Table 3) (confidence interval width 95%). After the appropriate forecasting method was chosen for each port, a comparison of the EFML method with the most complex methods was made and the relevant conclusions were drawn. The final feedback of the process was done by comparing the actual with the predicted values in the last two quarters of 2022.

Results

The results of our analysis showed that in 4 of the 6 ports of Southwestern Crete, WM is better adapted (Table 2). It turned out to be the best forecasting model for short-term forecasts of seasonal data (quarterly), as many researchers have shown [41, 51]. The port of Gavdos adapts better to the DMTS method and the port of Sougia to the EFML method. No port led through the SARIMA models to better results, even after ensuring stationarity by finding the first differences (Table 2). The majority choice of the WM method shows that the smoothing methods show satisfactory accuracy rates compared to the SARIMA models and more generally in relation to more complex forecasting methods [32]. This is because they are not affected by the idiosyncrasies of data patterns or occasional outliers [51].

What we observed is that in all the ports where the WM method was chosen the parameter γ of the trend (Table 2) was almost zero, which means that the trend of passenger traffic does not change over time to a great extent. The slope of the trend line was almost constant over the observed period. A small exception is the port of Chora Sfakion where the slope component seems to change over time ($\gamma = 0.141$; Table 2; Fig. 2). Higher weights have more influence on recent data and lower weights the opposite. The zero-value shown for the port of Agia Roumeli means that WM ignores the trend (slope), so the model simplifies. In some ports the value of the parameter α (level) was higher (mainly in the ports of Palaiochora, where $\alpha = 0.121$ and Chora Sfakion, where $\alpha = 0.101$) which shows that in this case more weight is given to the most recent observations and less weight to the more distant ones [12, 37]. In other words, the component reacts better to current conditions. In the rest of the ports where the value of α was smaller, the smoothing of the time series was more intense, with the corresponding forecasting models fluctuating around the initial level and being slow to follow large changes in the historical data. The high weighting parameter δ for seasonal components (Table 2) showed mainly for the port of Palaiochora that the seasonal factor has larger effect ($\delta = 0.128$). This is reasonable given the observed seasonality in the GCS. For the rest of the ports the low value of γ indicates a stable seasonal effect [53].

The port of Gavdos was the only one that gave DMTS.T + S.A as the best model. The + 9.61 slope of the linear trend equation shows an average increase of 9.61 passengers per quarter. The corresponding values of the seasonal indices show that passenger traffic increased in the third quarter and decreased in the first, second and fourth. However, it is worth mentioning that here too the WM model showed a very good fit (DMTS was chosen because it had 2 out of 3 accuracy measures lower, even marginally). In fact, it shows a high value in parameter γ (= 0.186), confirming the significant upward trend of passenger traffic shown in Fig. 2. In the port of Sougia, where SPSS showed EFPL as the best model, we note that an 8-period moving average was used as a simplistic working forecast because it showed the lowest value in the RMSE accuracy measure (= 34,866.7). By adding the "simplified working forecast" with the "average seasonal variations" we found the RMSE (= 935.2) and MAE (= 883.6) indicators for this method. The RMSE index is the lowest obtained, in relation to the rest of the forecasting methods. It seems that in Sougia port complex forecasting methods are not applicable.

For all ports the Ljung—Box statistic indicated (where it could be calculated) that the errors had white noise behavior and the models were adequate. Also, in all lines the stationary coefficient of determination R^2 was relatively high, which shows the good interpretive ability of the models. Table 3 shows the final forecast of passenger traffic for the six (6) most important ports of Southwest Crete, per year and per quarter (2022c–2028).

Observing the last two quarters of 2022 (Q3 and Q4) and comparing the actual and predicted values of passenger traffic (best forecasting model), we observe relatively small deviations (Fig. 3). In relation to Q3, the ports of Chora Sfakion, Palaiochora and Sougia are typical examples (9.17%, – 9.09% and 19.31%, respectively). The discrepancy is greater in the ports of Agia Roumeli (36.52%) and Loutro (– 38.72%). This is normal because on the one hand the number of passengers in absolute terms is greater than the other ports and on the other hand Loutro is an intermediate station from Chora Sfakion to Agia Roumeli. We would say that user preferences have changed in favor of Agia Roumeli. In both Q3 and Q4 real prices are well ahead of forecasts, perhaps because of the full lifting of restrictions due to the COVID-19 pandemic. This observation applies to most ports of Southwest Crete. It is no coincidence that cumulatively for all six (6) ports the real passenger traffic is greater than the forecast by 16.55% (Q3) and 28.28% (Q4), respectively. In any case the sharp and unexpected drop in passenger traffic due to the pandemic (2020–2021) seems to have affected the forecast results.

Conclusions

GCS is critical to the Greek economy and society as it serves a high number of passengers and vehicles and emerges crucial economic and social impacts. Traffic forecasting in this industry is significant for passengers, companies and government policy. Apart from that, is reinforced by the necessity of adjustments to the new Community regulation "Fit For 55". This means that becomes more important for regions such as Southwest

Fig. 3 Comparison between real and forecast passenger traffic values for the last two quarters of 2022 Source: Our elaboration (2023)

Crete which are able to adapt in time to new legislative developments.

In Southwest Crete, passenger traffic forecasting had to be done per port. We focused on the ports of "Agia Roumeli," "Chora Sfakion," "Sougia," "Palaiochora," "Loutro" and "Gavdos," which incorporated the most boarded passengers over time. As an excellent forecasting method of passenger traffic, we chose the comparison of a simple forecasting method, ARIMA methods and those of smoothing and decomposition. In particular, the data we had were quarterly for the years 2000–2022 (up to Q2), with strong evidence of seasonality and non-stationarity. This led us to use the methods of WM, DMTS, SS, SARIMA models and the simple EFML method.

The results of the analysis showed that in four (4) of the six (6) ports of Southwest Crete, the WM method is best adapted (Agia Roumeli, Chora Sfakion, Palaiochora, Loutro). The port of Gavdos adapts better to the DMTS method and the port of Sougia to the EFML method. No port led, through the SARIMA models, to better results. For the ports where the WM method was selected the trend of passenger traffic does not change over time to a large extent. A small exception is the port of "Chora

Sfakion," where the trend seems to change over the years. For the port of "Palaiochora," the seasonal factor has a large effect, while for the rest of the ports the effect is constant. In the port of Gavdos, the DMTS.T + S.A model recorded an average increase of 9.61 passengers per quarter (increasing trend). Passenger traffic increased in the third quarter and decreased in the first, second and fourth quarters, respectively. In the port of Sougia, it was shown that the complex predictive methods do not find application, in contrast to the EFML model.

In all ports the errors behaved like white noise, the models were adequate and the coefficient of determination R^2 was relatively high. After ensuring models' interpretive ability, we made a quarterly forecast of passenger traffic from the 3rd quarter of 2022 to the 4th quarter of 2028. For example, in the port of "Agia Roumeli" 510,670 trafficked passengers were calculated, in the port of "Chora Sfakion" 288,700 passengers, in the port of "Gavdos" 41,407 passengers, in the port of "Palaiochora" 49,966 passengers, in the port of "Sougia" 40,305 passengers and in the port of "Loutro" 188,782 passengers. More generally, between 2023 and 2028 for the port of Agia Roumeli a drop in passenger traffic is expected, for the port of Sougia relative stability, for the port of Loutro an increase, for the port of Palaiochora a relative decrease, for the port of Chora Sfakion an increase and for the port of Gavdos increase. The process's final feedback was obtained by comparing real to predicted values in the last two quarters of 2022. We discovered some deviations, but the overall picture is that the results fit our approach well.

Discussion

In GCS, traffic forecasts are crucial for government and corporate policy. The quantity of routes, the size and number of ships they operate, the necessity of high occupancy rates, their pricing strategies, and their commitments to public service are a few examples of the decisions made by ship owners. The state is also interested in policies related to port infrastructure and the amount of subsidies for barren lines. The results of our research showed that in 3 of the 6 ports of Southwest Crete an increase in passenger traffic is expected soon. This means that specific government policies must be implemented in these ports. For example, adaptations are needed to the port infrastructures to cope with the increased traffic (shelters for passengers, expansion of the lighting network, configuration of an access road within the land zone of the ports, new port employees, new parking spaces, etc.). Also, in some ports serving subsidized lines (gavdos) the expected increase in traffic may modify the state policy by characterizing the coastal lines as non-barren. Finally, if the state wants to determine the financial and social sustainability of a port project, for example, through cost–benefit analysis and social impact assessment, as well as calculating environmental impacts such as air pollution and noise, our traffic forecast is critical. Either way, it is imperative that the public and private sectors are informed about the anticipated volume of passengers for all Greek coastal lines. Making decisions requires having a forecast.

Additionally, the state and local coastal companies in Southwest Crete should be prepared for the significant changes brought about by the European package of measures known as "Fit For 55" in order to minimize financial hardship. It is anticipated that the best traffic forecasting available will identify the coastal lines in this area that have high demand for capacity. In this sense, the companies will profit financially from the introduction of their recently constructed ships and the increased cost of tickets. Moreover, ship occupancy rates can be determined in part through the use of traffic forecasting. This implies that it is possible to estimate shipping companies' future revenue and their capacity to pay for the higher operating expenses resulting from their compliance with the new environmental regulations. Given that it will primarily determine the prospective pricing policy of the companies, it will also have an impact on the users of transport services.

The international literature lacks any scientific research of this kind on Southwest Crete. Only Sitzimis [4] demonstrated a similar methodical approach to ARIMA seasonal models, smoothing and decomposition methods, even if he limited his research to certain coastal shipping lines of Greece. Comparing the results with the research of Sitzimis it seems that in both cases the SARIMA models do not lead to better results. The most reliable method is WM and to a lesser extent DMTS. The main difference is that the SS method is not chosen in any port of Southwest Crete. Nevertheless, in both studies the traffic trend did not change over time, the seasonal component significantly affected the time series, and the time series smoothing was strong.

Of course, all the aforementioned approaches operate under the fundamental premise that the current set of observations will continue to act in the same way going forward. For instance, the COVID-19 pandemic does not allow safe conclusions for the predicting period of 2020–2022 and the relative data should be interpreted cautiously. In any event, the dramatic and unexpected decline in passenger traffic caused by the pandemic appears to have had an impact on the anticipated results.

Methodologically, it is worth noting that our data were partially suitable for the application of the Box–Jenkins approach as the Anderson–Darling test for normality showed that they are normally distributed in two (2) (palaiochora and loutro) of the six (6) examined ports. This means that in future research nonlinear models such as ARCH and GARCH could be developed.

Abbreviations

GCS	Greek coastal shipping
MAPE	Mean absolute percentage error
MSD or MSE	Mean squared deviation
RMSE	Root mean squared error
MAE	Mean absolute error
BIC	Bayesian information criterion
EFML	Lis' simplistic forecast method
WA	Additive model of Winters'
WM	Multiplicative model of Winters'
SS	Simple seasonal exponential smoothing model
SARIMA	Seasonal ARIMA model
DMTS.T+S.A	Trend plus seasonal additive model of decomposition
DMTS.T+S.M	Trend plus seasonal multiplicative model of decomposition
DMTS.S.A	Seasonal additive model of decomposition
DMTS.S.M	Seasonal multiplicative model of decomposition

Acknowledgements
None.

Author contributions
All aspect of the study was done by the author.

Funding
There was no funding received for this research.

Availability of data and materials
Data and materials used in this study are available upon request.

Declarations

Conflict of interest
Not applicable.

Ethics approval
Not applicable

Consent for publication
Not applicable

Received: 24 January 2024 Accepted: 22 May 2024
Published online: 14 June 2024

References

1. XRTC B (2020–2023) Annual survey on Greek coastal shipping. Athens
2. IOBE (2021) Passenger shipping in Greece in 2016–2020: performance, economic contribution and prospects. Foundation for economic and industrial research, Athens
3. HSA (2000–2022) Passengers embarked, by ports (coastal-ferries traffic) in Greece. Athens: Hellenic Statistical Authority
4. Sitzimis (2021b) An optimal forecasting method of passenger traffic in Greek coastal shipping. Int J Bus Econ Sci Appl Res (IJBESAR) 14(3):72–87
5. Sitzimis (2021a) An implementation proposal of innovative pricing in Greek coastal shipping. Oradea J Bus Econ OJBE 6(2):69–77. https://doi.org/10.47535/1991ojbe130
6. Tsirigotis P (2023) "Fit for 55" raises the costs for Adriatic and Crete. Greece. Accessed from https://www.naftemporiki.gr/maritime/1537310/to-fit-for-55-anevazei-ta-kosti-gia-adriatiki-kai-kriti/
7. Tsamopoulos M (2023) Coastal ferry tickets on the Adriatic and Crete lines will increase from 1–1–2024. Greece. Retrieved from https://www.newmoney.gr/roh/palmos-oikonomias/nautilia/akrivenoun-ta-aktoploika-isitiria-stis-grammes-tis-adriatikis-ke-tis-kritis-apo-1-1-2024
8. IOBE (2022) Effect of the bundle of proposals "Fit for 55" in passenger shipping and on insular Greece. Foundation for economic and industrial research, Athens
9. Sitzimis (2024) The characteristics and attitudes of passengers towards the quality of services provided on the coastal routes of Southwest Crete. Int J Econ Behav 14(1):5–22
10. Agoestanto A, Rosidah S (2016) Arima method with the software minitab and eviews to forecast inflation in semarang indonesia. J Theor Appl Inf Technol 94(1):1–18
11. Ahmad W, Ahmad S (2013) Arima model and exponential smoothing method: a comparison. In: AIP conference proceedings. Department of Mathematics, Faculty of Science and technology
12. Trull O, Garcia-Diaz J, Troncoso A (2020) Stability of multiple seasonal Holt-Winters models applied to hourly electricity demand in Spain. Appl Sci 10:2630
13. Aivazidou E (2015) Development of time series and regression models for the assessment of the effects of the economic crisis on maritime passenger and freight traffic in Greece. Thesis. Thessaloniki, Greece: UTH
14. Chalkos GE (2020) Statistics: theory and practice. Thessaloniki: Disigma
15. Boile M, Theofanis S, Perra V-M, Kitsios X (2023) Coastal shipping during the pandemic: spatial assessment of the demand for passenger maritime transport. Front Future Transp 4:1–7. https://doi.org/10.3389/ffutr.2023.1025078
16. Sitzimis (2021c) Pricing and market results of Greek coastal system after cabotage privilege removal (2002–2010): the example of European and global aviation. Bus Entrep J 10(2):1–24
17. Goulielmos A, Sitzimis I (2014) The Liberalization process of the Ferry System in Greece, 2001–2009: What have been the benefits to users of Aegean Sea Transportation? Spoudai J 64(4):39–66
18. Sitzimis (2022) Economies of scale in Greek coastal shipping: a survivor analysis. Trasporti Europei. https://doi.org/10.48295/ET.2022.88.7
19. Banerjee N, Morton A, Akartunali K (2020) Passenger demand forecasting in scheduled transportation. Eur J Operat Res 286:797–810. https://doi.org/10.1016/j.ejor.2019.10.032
20. Leng N, Guo G, Nie L, Wu X (2015) Passenger flow forecastings for chinese high speed rail network. In: Proceedings of the international conference on mechatronics, electronic, industrial and control engineering (pp. 675–678). Paris: Atlantic press
21. Caseetta E, Copolla P (2014) High speed rail (HSR) induced demand models. Transportation: Can we do more with less resources?—16th meeting of the euro working group on transportation-Porto (pp. 147–156). Amsterdam: Elsevier Science Bv
22. Shitan M, Karmokar P, Lerd Y (2014) Time series modelling and forecasting of ambang line passenger ridership. Pakistan J Stat 30(3):385–396
23. Samagaio A, Wolters M (2010) Comparative analysis of government forecasts for the Lisbon airport. J Air Transp Manag 16(4):213–217. https://doi.org/10.1016/j.jairtraman.2009.09.002
24. Cyprich O, Konecny V, Kilianova K (2013) Short-term passenger demand forecasting using uvivariate time series theory. Promet-Traffic Transp 25(6):533–541. https://doi.org/10.7307/ptt.v25i6.338
25. Ortuzar D, Gonzalez M (2002) Inter-island demand response with discrete choice models. J Transp Econ Policy 46(1):115–138
26. Psaraftis C (1994) Greek coastal shipping system: impact of market deregulation and new technologies on modal split. TRISTAN-2 conference. Capri, Italy
27. Spathi S (2005) A comparison between air and coastal services in internal routes: An econometric estimation of demand. Center of programming and economical research, Athens
28. Tsekeris T (2008) Consumer demand analysis of complementarity-substitution relationships among passenger transport modes in Greece. Int J Transp Econ 35(3):415–449
29. Sitzimis I (2012) Aegean ferry market: the consequences of cabotage removal with microeconomic tools. *Doctoral thesis*. University of Peiraus, Peiraus, Greece
30. IOBE (2014) The contribution of coastal shipping to the greek economy: performance and prospects. Foundation for Economic and Industrial Research, Athens
31. Babbie E (2018) An introduction to social research, 2nd edn. Kritiki, Athens
32. Petropoulos F, Asimakopoulos V (2013) Business forecasting. Symmetria, Athens

33. Tsui W, Balli H, Gilbrey A, Gow H (2014) Forecasting of Hong Kong airport's passenger throughput. Tour Manag 42:62–76
34. Rashidi S, Ranjitkar P (2015) Estimation of bus dwell time using univariate time series models. J Adv Transp 49:139–152
35. Munarsih E, Saluza I (2019) Comparison of exponential smoothing method and autoregressive integrated moving average (ARIMA) method in predicting dengue fever cases in the city of Palembang. ICMScE. J Phys Conf Series
36. Yonar H, Yonar A, Tekindal M, Tekindal M (2020) Modeling forecasting for the number of cases of the COVID-19 pandemic with the curve estimation models, the Box-Jenkins and exponential smoothing method. EJMO 4(2):160–165
37. Agiakloglou CN, Oikonomou GS (2019) Forecasting methods and decision analysis. Benou, Athens
38. Dimitriadis E (2016) Business statistics with applications in spss and Lisrel, 2nd edn. Kritiki, Athens
39. Li G (2008) The nature of leisure travel demand. In Graham AP, Papatheodorou A, Aviation and tourism: implications for leisure travel. Ashgate Publishing Ltd
40. Karmaker C, Halder P, Sarker E (2017) A study of time series model for predicting Jute Yarn demand: Case study. J Ind Eng
41. Dingari M, Reddy M, Sumalatha V (2019) Air traffic forecasting using time series models. Int J Recent Technol Eng 8(4):1061–1065
42. Zhang J, Yang Y, Ding J (2023) Information criteria for model selection. WIREs Comput Statist Early View. https://doi.org/10.1002/wics.1607
43. Hansun S, Vincent C, Subanar C (2019) Revitising the Holt-Winters' additive method for better forecasting. Int J Enterp Inf Syst 2(15):43–57
44. Dhali N, Barman N, Hasan B (2019) Determination of optimal smoothing constants for Holt-Winter's multiplicative method. Dhaka Univ J 2(67):99–104
45. Tamber AJ, Michael OO, Ojowu OJ (2021) The Holt-Winters multiplicative model of passengers' traffic forecast of the Nigeria airports. Int J Eng Comput Sci 3(1):35–40
46. Ma L, Hu C, Han Y (2018) ARIMA model forecast based on eviews software. APEE 2018. IOP conf. series: earth and environmental science 208
47. Sim S, Tay K, Huong A, Tiong W (2019) Forecasting electricity consumption using SARIMA method in IBM SPSS software. Univ J Electr Electron Eng 6(5B):103–114
48. IBM (2021) IBM SPSS Forecasting: Build expert forecasts in a flash. Retrieved from www.ibm.com: https://www.ibm.com/downloads/cas/OP3RLVLR
49. Kyriakidis M (2018) Telecommunications market analysis and forecasting techniques. *University notes*. National and Kapodistrian university of Athens, Athens
50. Hasudungan A, Pulungan A (2021) An analysis of the monetary transmission mechanism of M&A, greenfield FDI, DomESTIC INVestment, and GDP per capita growth: the structural vector correction model in Indonesia. Int J Bus Econ Sci Appl Res (IJBESAR) 2(14):29–42
51. Makatjane K, Moroke N (2016) Comparative study of Holt-Winters triple exponential smoothing and seasonal ARIMA: forecasting short term seasonal car sales in South Africa. Risk Gov Fin Markets Instit 6(1):71–82
52. Gujarati D, Porter D (2018) Econometrics: principles and applications. (P. Tsaliki, Ed.) Thessaloniki: Tziolas
53. Vujko A, Papic-Blagojevic N, Gajic T (2018) Applying the exponential smoothing model for forecasting tourists' arrivals—example of Novisad, Belgrade and Nis. Ekonomika Poljoprivrede, pp. 757–473

Publisher's Note