Estimation and Analysis of Fish Catches by Category Based on Multidimensional Time Series Database on Sea Fishery in Greece

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Abstract. Multidimensional database on fishery in Greece stores statistical time series on quantity of fish catches by areas, species, months, kind of fishery, fishing tools and category as well as by value and employment. The averages of total fish quantity by category for the period 2004-2015 compared to 1992-2003 period generally decrease. An exception is the quantity of fish category I, caught by Trawl Nets (Open Sea) and Ring Nets, where there is almost balance between the average values of catches. Trend modeling and exponential means methods are applied as smoothing and forecasting techniques. The decreasing rate per year on total fish catches for the period 2004-2015 is -3.44%, while the rate by category I, II and III is -2.67%, -2.96% and -3.71%, respectively. Exponential means is proven to be the proper method for forecasting the fish catch quantity because there is a big fluctuation in the time series values.

Keywords: time series database, fish category, trend, exponential means, forecasting

1 Introduction

Greece supports marine fishery in order to enhance domestic sea food consumption and increases export to other countries. The fishery sector is still suffering from overfishing, fleet over-capacity, heavy subsidies, low economic resilience and decline in the volume and size of fish caught. In Mediterranean European countries, 85% of the assessed stocks are currently overfished compared to a maximum sustainable yield reference value (MSY) (Colloca et al, 2011). A management system that can encourage a spread of fishing effort without penalizing any one section of the fleet would be welcomed (Thomson, 1984). Taking into account all these threats sustainability has to be in priority. Sustainable development meets the needs of the current generation without compromising the ability of future generations to meet their own needs (OECD, 2002).

The Hellenic Statistical Authority (ELSTAT) announces the results for every year with a delay of two years. For comparability reasons, data for the two previous years

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are also made available. It constructs three year-long time series but longer ones are needed for statistical estimations and analysis. ELSTAT database is a reliable source of fishery data in Greece. The collected statistical data concern different aspects of activities regarding fishery sector as: economical, technical, biological, space and time. Multidimensional FTS (Fishery Time Series) database on fishery in Greece, created by using statistical data from ELSTAT database, stores 2241 time series on quantity of fish catches by areas, species, months, kind of fishery, fishing tools and category as well as by value and employment for the period 1990-2015 (Tegos & Onkov, 2015).

The aim of this paper is to estimate fish catches by category based on multidimensional time series database on sea fishery in Greece in order useful information for fishery, economy and fish resources to be derived.

2 Materials and Methods

Figure 1 presents the three basic statistical units regarding fishery in Greece: quantity and value of fish catch, and employment. The number of dimensions and attributes is shown in parentheses. The whole set of data has temporal character. The relational data model of FTS database is based on the hierarchical principle. This approach has positive characteristics that can be generalized as follows: a) it facilitates time series visualization and querying, b) it abstracts spatial and temporal details in datasets and c) it stores, vertically, numerical data in time series in the lowest level of hierarchy, so as the yearly updating is made easy.

Quantity and Value of catch are both counted, by Kind of fishery and Fishing tools and then distinguished into three Categories according to their quality: “first”, “second” and “third”.

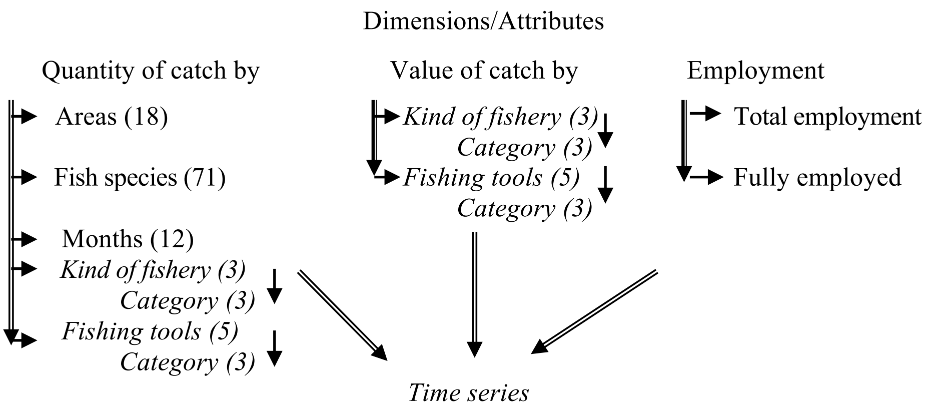

Fig. 1. Multidimensional data on fishery in Greece

Fish catch quantities concern natural resources and their exploitation while values depend on quantities and are reliant on economic indicators: inflation, market features etc. Therefore, it is logical this study to give emphasis on fish catch quantity.

The following methods are used for the analysis of fish catch by categories:

Computing descriptive statistics is applied on time series for the following two periods: 1992-2003 and 2004-2015. This distinction will give the opportunity to compare catch quantity and value by categories.

Calculation of shares of catch quantity and value by categories presents the dynamics of the rates between first (I), second (II) and third (III) category.

Trend modelling is a usual approach for time series analysis. Trend analysis is carried out on time series for the period 2004-2015, concerning catch quantity of fish category I, II, III and total, as well. The polynomial (linear, second and third degree) and exponential trend models are studied. Trend models adequacy is proved by applying F-test at α=0.05 level of significance. If linear trend model is adequate, the yearly increase/decrease of fish catch quantities can be estimated.

Forecasting based on Exponential means method. Exponential means method is considered to be the proper method for forecasting fish catch quantity because there is big fluctuation in total values (Tegos, 2005). Whenever the development of a certain event is studied over a long period of time, it is usual certain changes to occur that will influence the model parameters. The value of the studied event for a given period will be determined to a great degree by the development conditions, which were applied during the recent period and less to the distant one. Then, the model parameters will be determined by assigning greater weight to the more recent historical values of the event than the distant ones. This is the basic characteristic of the Exponential means method. Each time series is smoothed through weighted moving averages, which contribute to the exponential distribution law by their weights.

Theoretically the exponential means method lays behind the following recurrent formula for the exponential mean S_t^p of the p-degree at the moment t (Velichkova, 1981):

$$S_t^p = \beta S_t^{p-1} + (1-\beta) S_{t-1}^p \quad , \quad 0 < \beta < 1 . \qquad \textbf{(1)}$$

For the explanation of the essence of the exponential means method the equation (1) is transformed in the first degree and related to the time series values as follows:

$$S_t^1 = \beta \sum_{i=1}^{n} (1-\beta)^i y_{t-i} \quad . \qquad \textbf{(2)}$$

The performance of the exponential means method as a smoothing and forecasting tool for time series is determined by the correct choice of the value of the β parameter ($0 < \beta < 1$). When it is close to 1, the main influence refers to the last members of the historical time series while, when it is close to 0, this influence weakens in favor of the more distant members of the historical time series. There is no established method of choosing the optimum value of β (Velichkova, 1981). The values of β are varying in the interval (0, 1), for instance with constant step, and performing all needed computations the forecasting values will be obtained. The criterion C_β is calculated for each value of β to ensure the forecasting values corresponding to the smallest standard error S_y between real and smoothed values of the historical time series. The algorithm and software of the exponential means method application was created in (Tegos, 2005) PhD dissertation work and it is used for the current study. Experts consider that, by this method, the longer the series is, the more exact the forecasted values are.

3 Results, Analysis and Discussion

There is an important correlation between datasets on Quantity and Value by Categories:

Tables on *Fishing tools and Category*		Tables on *Kind of Fishery and Category*
Trawl Nets (Overseas)	=	Overseas Fishery
{Trawl Nets (Open sea) + Ring Nets}	=	Open Sea Fishery
{Seine Nets (Open sea) + Others}	=	Inshore Fishery

In this paper the results on Fishing tools and Category as well as Totals are mainly discussed. Special attention is given and the discussion is extended when specific features appear on Kind of fishery and Category.

For fish category I, caught by Trawl Nets (Open Sea) and Ring Nets is important to point out that the average catch quantity, for the period 2004- 2015, is greater than that one for the period 1992-2003. The least decrease in total quantity is observed for category I fish species (-5.3%) while for category II and III is (-56.4) and (-38.5), respectively. Average fish catch values during the second time period are greater than the first one when fishing by Trawl Nets (Open Sea) and Ring Nets. Comparing the average values of the total quantity for the periods 1992-2003 and 2004-2015, it is noticed that there is almost a balance between these Values, since the difference is only -1.6 %. This fact is not surprising taking into account the basic market principle – supply and demand law. The decrease in quantity by -41.7% in the second time period indicates that almost half quantity of fish catch is lost but this decrease is not delivered to fish catch values (-1.6%), confirming so the mentioned law. Of course, in order to be more accurate the inflation has to be deducted from the last period values.

The shares of fish category I and III in quantity and value increases, while the share of category II decreases. The share of fish category I in quantity is 13.06% for the period 2004-2015, while its share (26.56%) in value is double as much. Fish category I, economically the most important one, during time period 2004-2015 is mainly caught by two types of fishing tools: Trawl Nets (Open Sea) and Others. It is worthy to mention that the biggest variations are noticed for fish category II.

Adequacy of linear trend model is proved for catch quantity of fish category I, II, III and total, as well. The decreasing rate per year on total fish catches for the period 2004-2015 is -3.44%, while the rate by category I, II and III is -2.67%, -2.96% and -3.71%, respectively. The least decrease of catch quantity concerns fish category I. These results are in accordance with the tendency of the decreasing quantity of fish resources in Mediterranean Sea. It is important for the economy that category I fish species contributes to hold the high values in the fish market but the most essential is to preserve sustainability for fish resources for the benefit of future generations.

The forecasting results on the Quantity of fish catch category I, by using trend models (linear and exponential) and by exponential means method are presented in Figure 2.

Trend models are used for short term forecasting. The attained projections are simple consequence of the trend line extrapolation. Trend models are not considered very reliable because values of the studied time series on the fish catch quantity for the first time period (2004-2010) are characterized by a relatively strong decrease while for the second one (2011- 2015) they are almost stable.

This study empirically shows that for forecasting purposes exponential means method is more suitable and reliable than trend models. The forecast obtained by this method is reasonable and acceptable. The forecasting results regarding catch quantity of fish category II and III are similar.

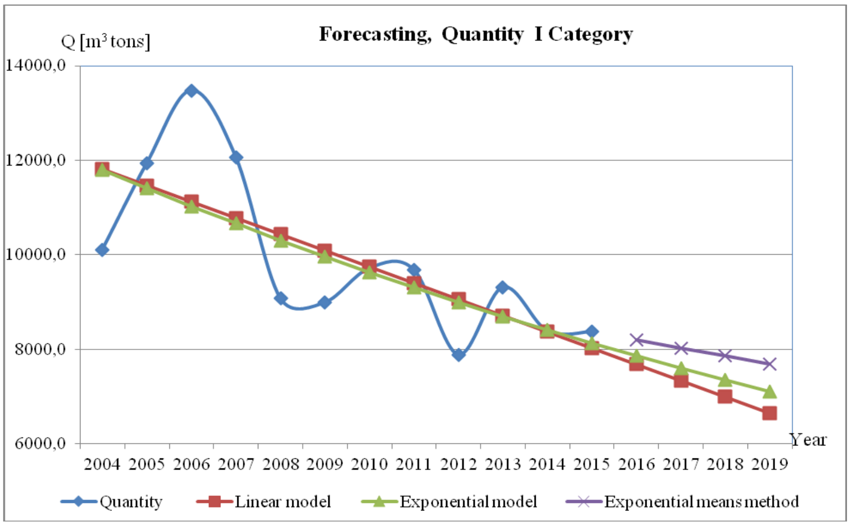

Fig. 2. Forecasting results of catch quantity category I, based on trend models and exponential means method

4 Conclusion

This study is based on multidimensional time series database on sea fishery in Greece. The decreasing rate per year on total fish catches by category for the period 2004-2015 is in accordance with the decreasing tendency of fish resources quantity in Mediterranean. The least decrease is attained on quantity of fish category I. Despite the encouraging outcome in category I, the fishing effort has to be spread to all fish species and not directed only to this category because there is the risk of depletion of the related fish resources. Exponential means is proven to be the proper method for forecasting the fish catch quantity because there is a big fluctuation in time series values.

Analytical information obtained in this study can be useful for taking decisions in the use of fishing tools and in fishery resources management.

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