REGIONAL MORTALITY AND HEALTH STATUS IN GREECE (1990-2020)

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Abstract

In this paper we investigate regional mortality and health status in Greece, using data from the European Statistical Office (Eurostat) for the period 1990-2020. Firstly, a logistic function is fitted to the data series of each period life table, in order to estimate and smooth the age specific death rate in older ages. Using these age-specific death rates and through a dynamic model with stochastic simulation, we estimate the health state function across the 13 regions of Greece for each year of study and sex. Through the parameters of the health state function, we estimate the median age at death and the total health state for the population of each life table. Furthermore, a hierarchical cluster analysis is performed on the results of the previous analysis in order to determine possible groupings in the regions of study. The results show an overall increasing of the median lifetime and total health state in Greece, but with significant regional and gender variations. Finally, the study offers interesting results for the mortality and health status during the Greek economic crisis and the subsequent austerity measures (2008-2015).

Key words: Greece, Mortality, Stochastic, Clustering, Logistic

JEL Code: I1, I15

Introduction

Over the last years, Greece has witnessed substantial demographic and economic shifts. Greek demographic trends include an ageing population, decreased birth rates, increased mortality rates and significant immigration patterns. At, the same time, the economic crisis of 2008, the austerity measures of 2011-2015 and the recent COVID-19 pandemic have posed important challenges to its healthcare and social welfare systems. In this paper, we will determine the annual trends of lifetime and health state indicators of Greece's regions between the years 1990-2020 for males and females, through applying a model derived from stochastic analysis. Furthermore, using cluster analysis we will try to determine which regions have similar patterns in the annual trends of longevity.

1 Data

The European Statistical Office (EUROSTAT) database contains period life tables for Greece and its regions according to the NUTS standard. We extracted the life tables for Greece and its 13 regions classified as NUTS-2 (peripheries), for males and females and for the years 1990-2020. In total, we acquired 840 life tables, from which the Age-Specific Mortality column mas extracted using EXCEL. For the Greek data, the Age-Specific Mortality column spans from 0 to 85+ years of age, meaning that the Old-Age-Specific Mortality (85+) is cumulated at the last element of the column, a problem that will be addressed in the methods section.

2 Methods

The model that Janssen and Skiadas proposed in 1995 (Janssen & Christos C.H. Skiadas, 1995) for the mortality curve is a probability density function of the form:

$$g(t) = \frac{H(t)(1-c)+c}{\sigma\sqrt{2\pi t^3}} \exp\left[-\frac{[H(t)]^2}{2\sigma^2 t}\right] \quad (1)$$

where c: exponential and σ: standard deviation and H(t) the health state function.

The parameters of the model will be approximated using non-linear regression.

From 1995, Skiadas and Skiadas have proposed different forms for the health state function (Skiadas & Skiadas, 2014) The simplest form of the Health State Function (Janssen and Skiadas 1995) is:

$$H(t) = 1 - (bt)^c \quad (2)$$

This is a decreasing exponential-type function starting from 1 and hitting the x-axis for t=l/b.

Furthermore, by computing the area under the health state function (from “birth” to “death”) for each life table, we determine the Total Health State of a population.

$$Total\ Health\ State = \int_0^{\frac{l}{b}} H(t)dt \quad (3)$$

The Kannisto model for old-age mortality

As forementioned, life table data from Greece span from ages 0 to 85+, cumulating older-age mortality in the last element. This poses a challenge for the stochastic model, as it tends to overestimate the mortality curve between ages 80 and 110. To counteract this, we used the

Kannisto model for old age mortality (Thatcher et al. 2003), where we fitted a logistic function of the form:

$$m_x(a,b) = \frac{ae^{b(x-80)}}{1 + ae^{b(x-80)}} \quad (4)$$

in order to expand the age specific mortality vector from ages 0-85+ to ages 0-110+.

Cluster Analysis and Similarity Metrics

In order to determine possible groupings of regions and time periods, the agglomerative hierarchical cluster analysis (AHC) was applied on the result matrices. AHC operates on the basic principle of iteratively merging data points or clusters into larger ones, creating a hierarchical tree-like structure known as a dendrogram. This process facilitates a comprehensive exploration of relationships within the result matrix.

The method consists of calculating the distance between each pair of objects, otherwise called "proximity matrix", using a distance function. Then, the similarity between the clusters is determined using a "linkage" function. Lastly, a set of "nested" clusters is created and the results are visualized on a dendrogram.

For the clustering of regions, the Dynamic Time Warping Algorithm (DTW) will be used as a distance metric. The DTW algorithm can be used to determine the degree of similarity between two temporal time series and in this case, to determine the similarity between the annual trends of the Median Age at Death of the different regions.

3 Results

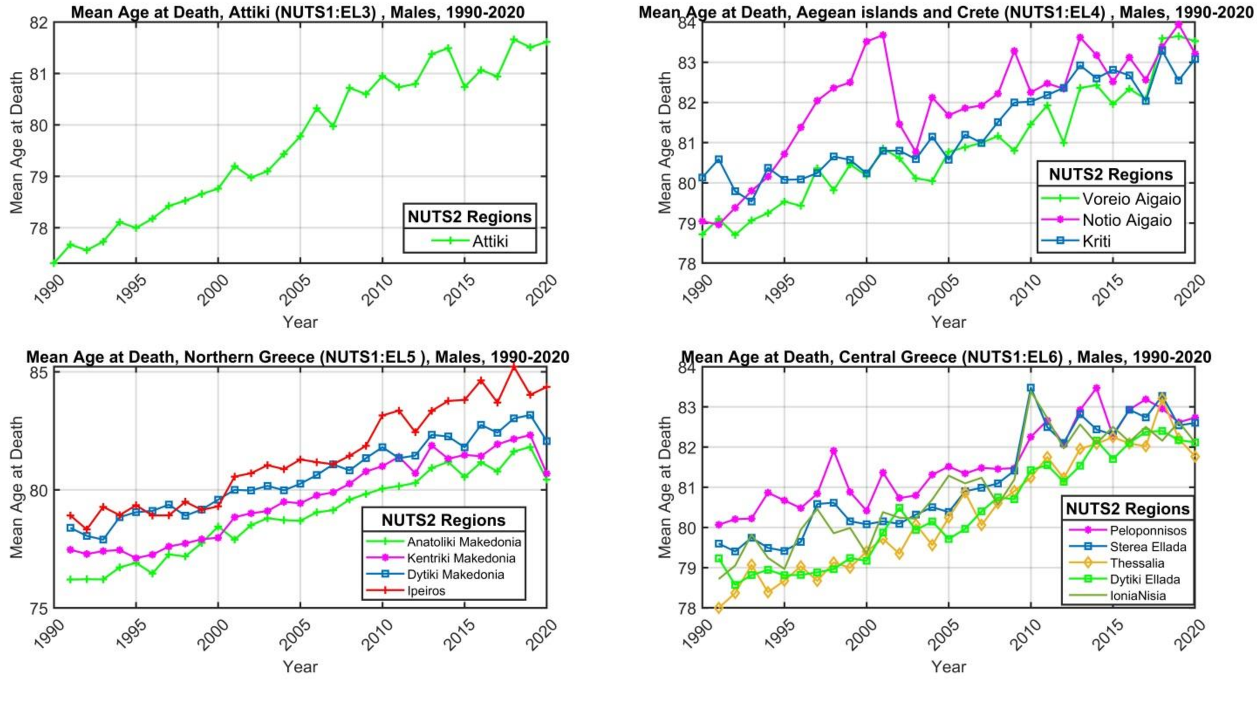
The First Exit Time model (Skiadas and Skiadas, 2014) is applied to all 840 life tables, after the Age Specific Mortality column was expanded using the Kannisto model (Thatcher et al., 1995). The results are gathered into four figures, two for the Median Age at Death (males and females) and two for the Total Health State (for males and females).

Median Age at Death

In the case of males, a longitudinal increase in median life expectancy is observed in all regions. Almost all regions show the same behavior over time, with coordinated falls and rises of the index. More specifically, Attica has a small overall increase and relatively low values of the index compared to the rest of the regions. The North Aegean and Crete show a similar course, with significantly higher values of the index, while the South Aegean differs quite a bit, as it shows an increase with a peak in 2000-2001. In the case of Northern Greece, Epirus shows a better performance and significantly higher values of the index, while Western, Eastern and Central Macedonia show a slight increase in the index. It is worth noting that Central and Eastern Macedonia have the highest mortality in Greece. Finally, in Central Greece there is an identification of the Ionian Islands and Central Greece as well as Thessaly with Western Greece, while the Peloponnese seems to start from higher levels. Also, of interest is the increase in the index throughout Central Greece in 2010-2011 and the subsequent drop in 2012.

In the case of females, a longitudinal increase in median life expectancy is equally observed in all regions. The values of the index are higher than the males, which was expected. Many of the regions show similar behavior, while the fluctuations are more intense from 2010 onwards. More specifically, Attica shows an overall increase and slightly lower values of the index compared to the rest of the regions, while a strong decrease of about 2 years can be seen in 2011. In the Aegean and Crete islands, all regions have similar values and trends from 1990 to in 2010, while they differ slightly in the period 2011-2020. It is interesting that the increased values of the index around 2011 in the men of the South Aegean are reflected to a very small extent in the women (magenta line). In the case of Northern Greece, Epirus shows significantly higher values of the index and a smaller overall increase, while Western, Eastern and Central Macedonia show a mild and coordinated increase in the index. Finally, in Central Greece, similar behavior is observed in all regions, with the Peloponnese being slightly different.

Fig. 1: Median Age at Death, NUTS-2 Regions, Greece, Males, 1990-2020



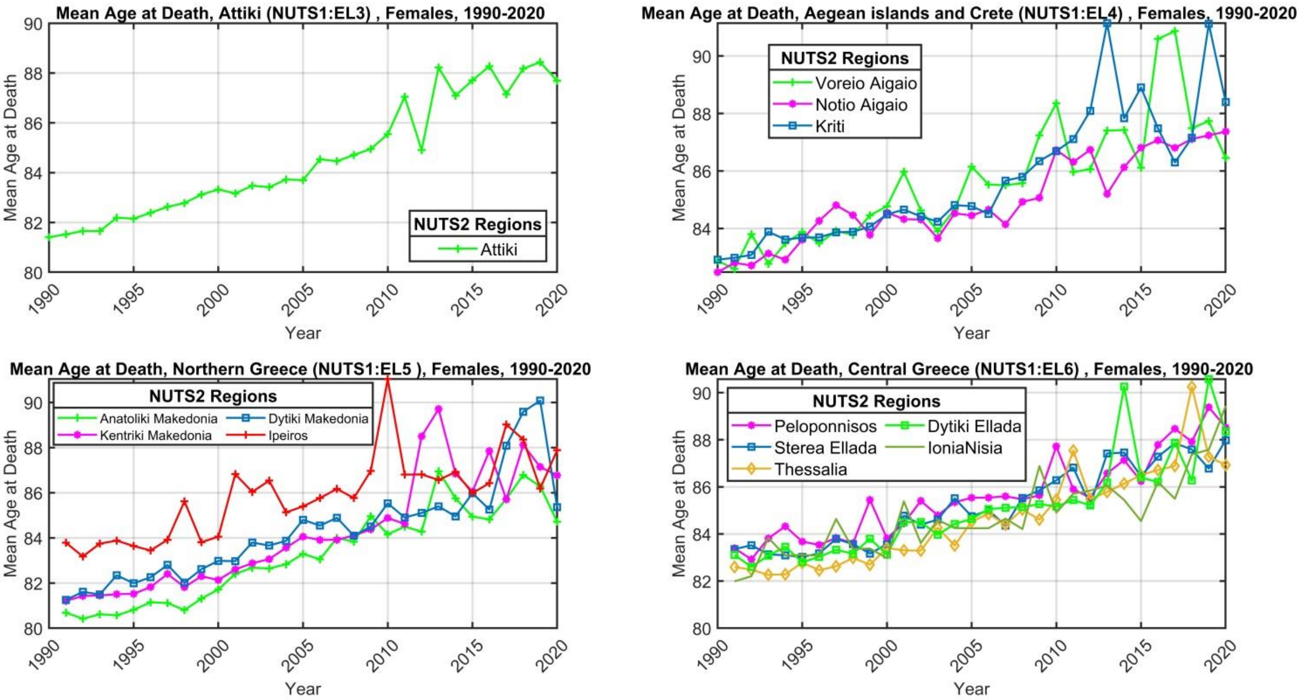


Fig. 2: Median Age at Death, NUTS-2 Regions, Greece, Females, 1990-2020

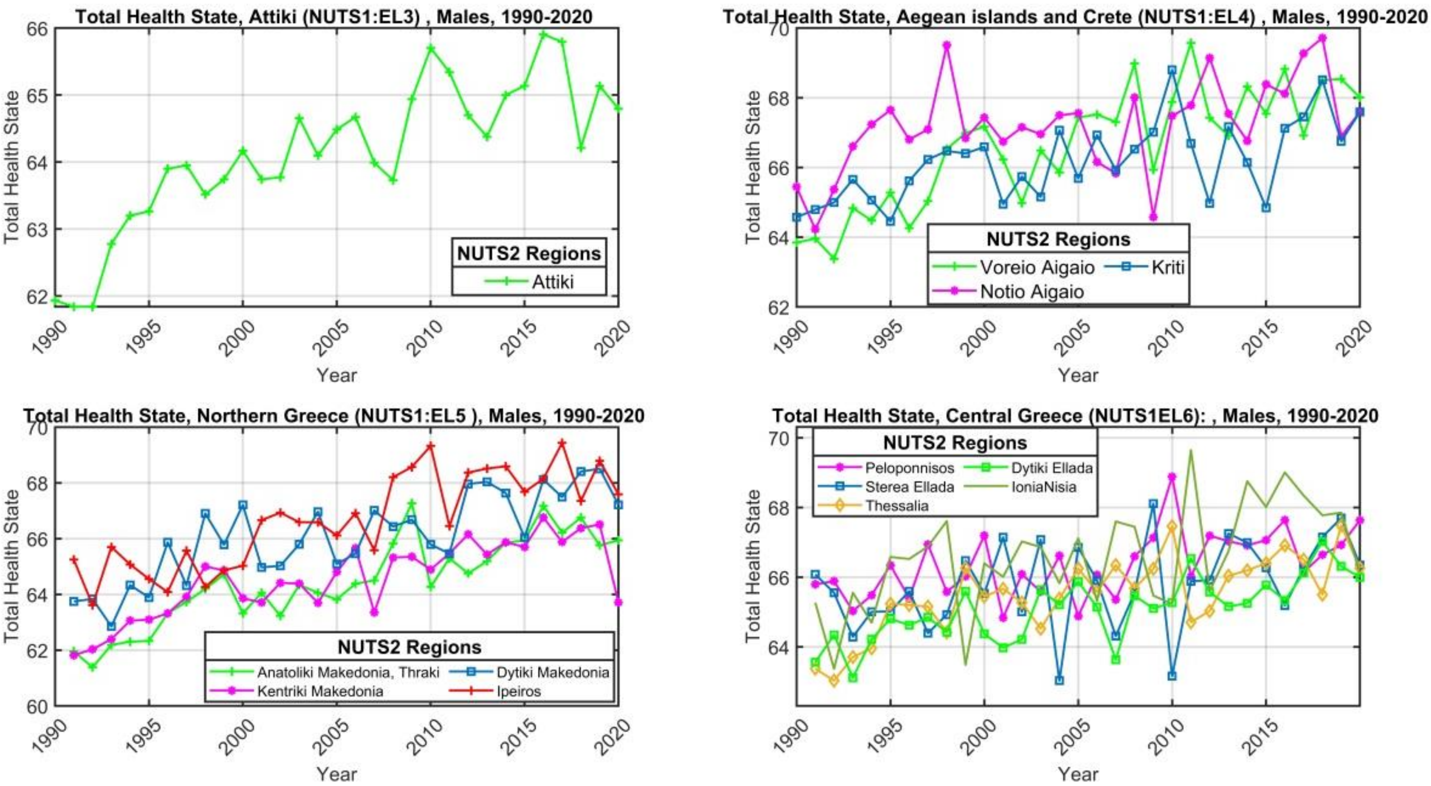
Total Health State

As mentioned in the methods chapter, overall health status is calculated as the area enclosed by the health status function, for ages 0 to the median age of death.

In the case of men, the overall state of health shows an increase and strong fluctuations in all regions. Attica follows an upward trend over time, but with strong fluctuations. Significant decreases occur in 2008 and 2013, while the beginning of a decline can be seen after 2019. For the Aegean Islands and Crete, until 2005 the South Aegean is quite differentiated from the North Aegean and Crete, while in the following years it follows a trend equivalent to Crete. On the contrary, the North Aegean is quite identified with Crete until 2005, while in the following years it diverges. All three regions show an increase in the index, but with large variations. In the case of Northern Greece, Central Macedonia and Eastern Macedonia-Thrace have historically had lower values and a similar course, while Epirus and Western Macedonia start from higher values of the index in 1990 and remain throughout at higher levels. Epirus presents a quite different course with the rest of the regions, while all of them show a decrease between 2019 and after with the exception of Eastern Macedonia and Thrace. Finally, in Central Greece, the overall state of health seems to have strong fluctuations in all regions, while its long-term course is mildly upward or even stagnant. The Peloponnese, Central Greece and Western

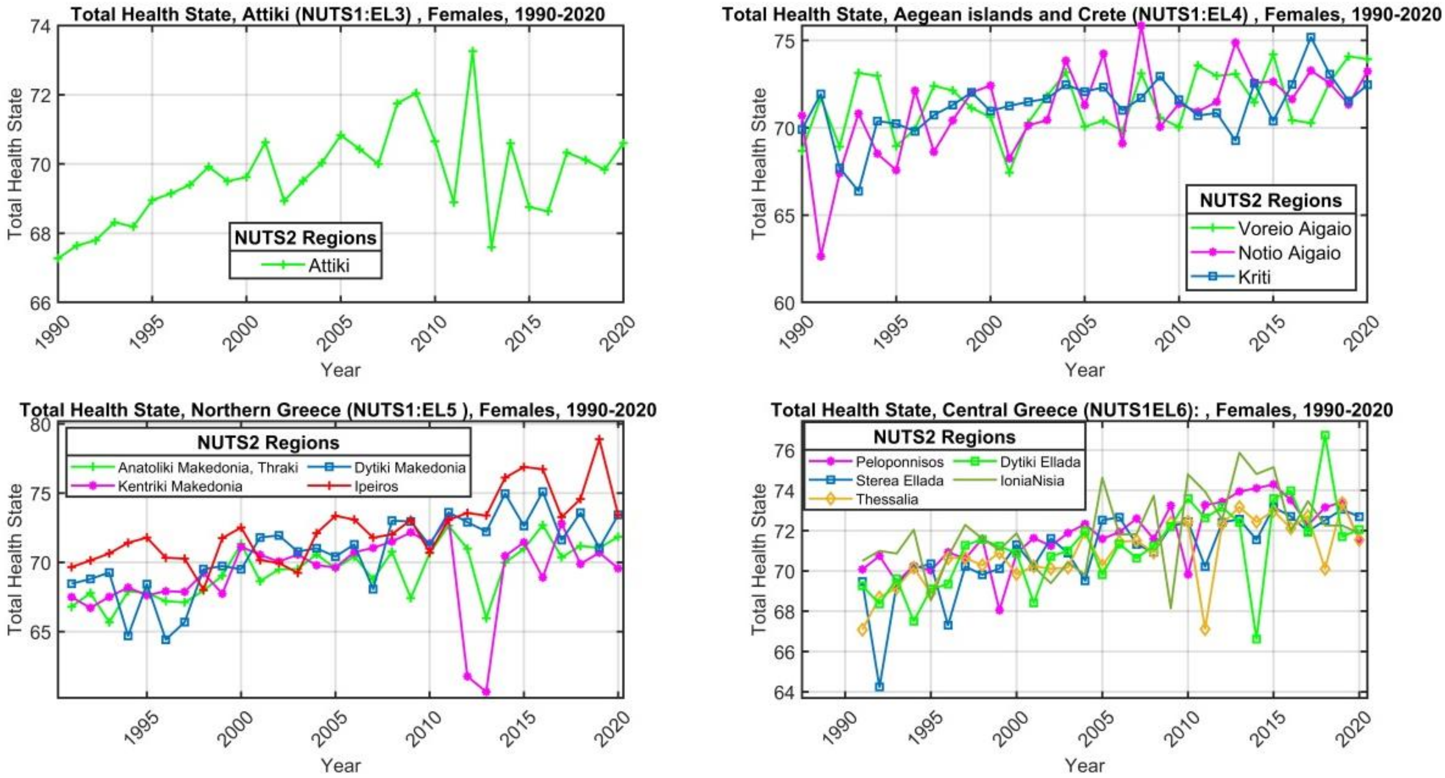
Greece show a coordinated decrease in the index in the year 2007, while the Ionian Islands differ greatly from the course of the rest of Central Greece after 2005.

Fig. 3: Total Health State, NUTS-2 Regions, Greece, Males, 1990-2020



In the case of females, the results for Attica show an initially upward trend, but after 2009 it is downward. Some sharp variations appear, especially in the years 2011, 2012 and 2013. For the Aegean islands and Crete, the three regions show a similar trend, while the South Aegean differs from the other two in some points, for example in the sharp decrease in 1991 In northern Greece, Central Macedonia and Eastern Macedonia-Thrace have a similar course over time, while Epirus and Western Macedonia remain throughout at higher levels and a similar course. Epirus initially presents a quite different course to the rest of the regions, while it is almost identical to Western Macedonia in recent years. In the years 2012 and 2013, Central Macedonia and Eastern Macedonia, Thrace show a significant decrease compared to the rest of the regions. Finally, in central Greece, the overall health situation seems to follow a similar path in all regions, in contrast to men, while Central Greece and the Ionian Islands show limited differences.

Fig.4: Total Health State, NUTS-2 Regions, Greece, Males, 1990-2020



Cluster Analysis of the Regions

For males , the quality of the clustering is quite good, while 2 main clusters have been formed. Examining the dendrogram further, South Aegean, Epirus and Eastern Macedonia -Thrace are assigned to separate single-element clusters, showing their high differentiation from the rest of the regions.

Attica and Central Macedonia are in the same cluster, which is to be expected, as they are the two heavily urbanized regions of Greece.

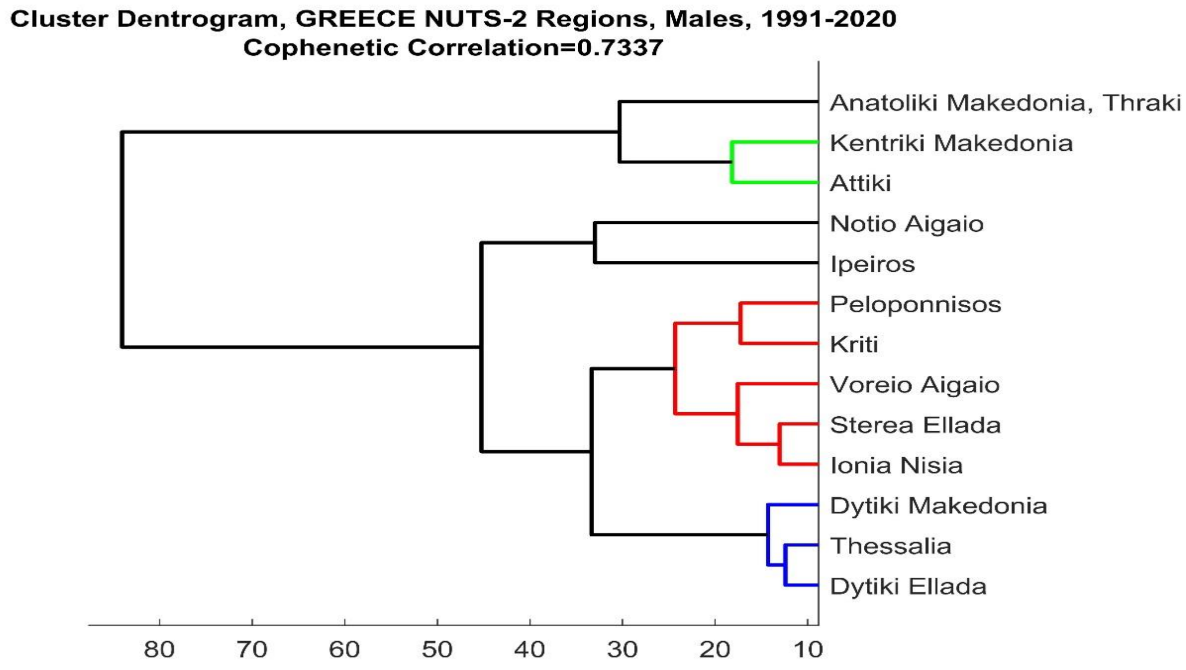
The Peloponnese, Crete, Central Greece, the Ionian Islands and the North Aegean are in the same cluster, i.e. they have a similar temporal behavior, while they express a part of Southwest and also island Greece

Finally, Western Macedonia, Western Greece and Thessaly form another cluster. These are regions of mountainous and mainland Greece, where geographically they occupy the Central and North-Western part of the country

For females, the quality of clustering is better than males, and 2 main clusters are formed.

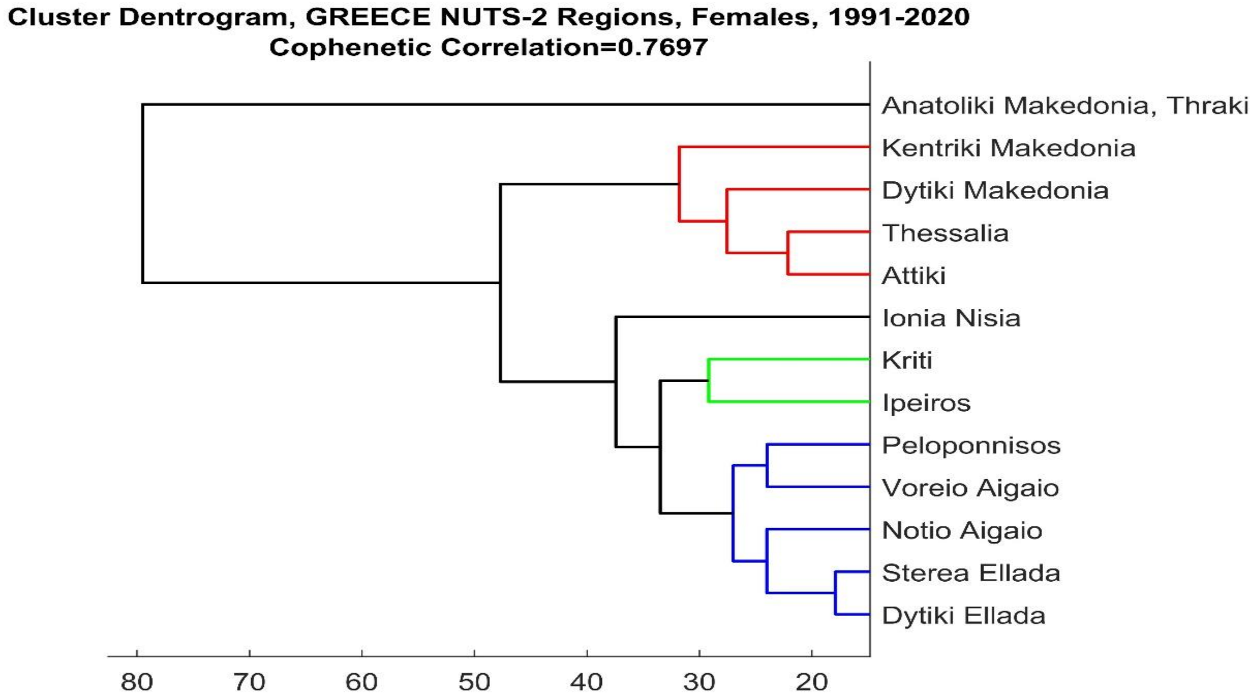
With further analysis of the graph, it emerges that the Ionian Islands and Eastern Macedonia, Thrace have been assigned to separate single-element clusters, showing their great differentiation from the rest of the regions

Fig.5: Cluster Dendrogram NUTS-2 Regions, Greece, Males, 1990-2020



Attica and Central Macedonia are again in the same cluster, as large urban areas, together with Western Macedonia and Thessaly. Another cluster is formed by the regions: Peloponnese, Northern and Southern Aegean, Sterea and Western Greece, i.e. the southwestern and insular part of the country. The last cluster includes the regions of Crete and Epirus

Fig.6: Cluster Dendrogram NUTS-2 Regions, Greece, Females, 1990-2020



Conclusion

The application of the dynamic model to the life tables of the Greek population during the years 1990-2020, as well as the cluster analysis, offered remarkable results from which important conclusions can be drawn. Overall, the median lifespan and the Total Health State of the Greek population increase over time. As expected, females show higher total health state and longer lifespan compared to males but the male health condition deteriorates earlier and has a smoother course. Accordingly, the female health status remains at a high level for a longer period of time, but deteriorates much more sharply in the last years before death.

Moreover, males show increased death rates between ages 15-28 compared to females. Many of the regions show a decline in life expectancy and overall health status after 2019. This may be due to the COVID-19 pandemic, but this claim requires verification when the data are released. The clustering of the regions showed that urban areas are clustered together and have worse health status than peripheral areas. Clusters differ between males and females, showing regional gender inequalities, Furthermore, the clustering is not done purely by geographical criteria, as areas located in the same cluster do not border on the map.

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