CLASSIFICATION OF SUB-LEVELS IN TURKEY WITH GUSTAFSON-KESSEL METHOD

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Abstract

The European Union paved the way for countries to be divided into sub-units and in a sense paved the way for the further elaboration of statistical calculations. Level-1 or Level-2 classifications, which are created not only by the cities but also with neighboring cities, are of great importance in the development calculations of countries. Fuzzy Clustering methods are very useful if the clusters are not separated from each other exactly or if some of the members are in zone of indecision about being a member of the cluster. Fuzzy clusters are functions that determine each unit between 0 and 1 defined as the membership degree for groups. Units which are very similar between them take part in the same cluster according to high membership degree. The purpose here is to determine homogenous city groups that have the same characteristics in terms of these indicators. In this study, one of the well known fuzzy clustering methods Gustafson-Kessel is used for classification SCTU Level-2 regions through development indicators. The results obtained from the Level-2 classifications were also used to rank the regions according to their importance. Thus, priority regions can be determined in investments.

Key Words: Gustafson-Kessel, Development Index, Classification, Fuzzy Clustering

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TÜRKİYE’DE DÜZEY-2 İSTATİSTİKİ BÖLGELERİNİN GUSTAFSON-KESSEL YÖNTEMİ İLE SINIFLANDIRILMASI

Özet

Avrupa Birliği, ülkelerin alt birimlere bölünmesinin yolunu açarak bir anlamda istatistiksel hesaplamaların detaylandırılmasının da yolunu açmıştır. Sadece şehirlerle değil aynı zamanda şehir komşulukları ile oluşturulan Düzey-1 ya da Düzey-2 sınıflandırmalarının ülkelerin gelişmişliklerinin hesaplanmasında büyük bir önemi vardır. Kümelerin biri diğerinden belirgin bir şekilde ayrılmıyorsa ya da bazı üyeler bir kümenin üyesi olma konusunda kararsız ise Bulanık Kümeleme yaklaşımının uygun bir yöntem olduğu ortaya çıkar. Bulanık Kümeler, her bir birimin birim üyeliğini 0-1 aralığında belirleyen fonksiyonlardır. Yüksek üyelik derecesine göre çok benzer birimler aynı kümede yer almaktadır. Buradaki amaç, bu göstergeler açısından aynı özelliklere sahip homojen şehir gruplarını belirlemektir. Bu çalışmada, iyi bilinen bulanık kümeleme yöntemlerinden biri olan Gustafson-Kessel yöntemi, İİBS Düzey-2 bölgelerinin gelişim göstergeleri ile sınıflandırılmasında kullanılmıştır. Düzey-2 sınıflandırmalarından elde edilen sonuçlar, bölgeleri önem derecelerine göre sınıflandırmak için de kullanılmıştır. Böylece yatırımlarda öncelikli bölgeler tespit edilebilir.

Anahtar Kelimeler: Gustafson-Kessel, Gelişmişlik İndeksi, Sınıflama, Bulanık Kümeleme

1. Introduction

The prior targets for national economies must be a high rate of growth, increasing levels of development and free management of the economies. The upward movement for most of the economics indicators also means higher living standards, high levels of welfare and better future. The concept of development is a process characterized by the economic life of a country, the competitiveness of the economy, the gross domestic product of the country, the national income per capita and the positive change in economic freedom. Socio-economic development can be summarized as the per capita income of the countries and the positive change in the social lives of individuals. In addition to this definition, structural reforms and humanitarian developments can be included in this view.

Socio-economic data can be used to investigate the social and economic relations between cities, regions or countries and make final plans. Socio-economic data are generally defined under 3 head lines: Social, Economic and Geographical.results close to accurate, are used to equilibrate among cities and areas of a country. Social indicators are demographic, educational, employment and social security indicators; economic indicators are monetary and financial, manufacturing industry, agriculture, international trade, energy, housing and substructure; geographical indicators are altitude, presence or absence of a shore, climate and structure of land (Sowell, 2010; Erilli, 2015).

In addition to the national development levels of the member states, regional development policies are of great importance for the European Union. Financial resources are provided to EU member countries in order to reduce regional development disparities and to improve the welfare levels of the regions. In order to find solutions to the economic and social problems at the regional level, the EU increasingly needs regional statistics at various levels. Turkey in the European Union as a candidate member countries in the field of statistical work in all areas as well as to fulfill the obligations of the member states of the European Union (Taskan, 2006). In this context, the classification of Statistical Region Units Classification (SCTU), which should be prepared by candidate member countries, was prepared by TUIK (Turkish Official Statistics Bureau) in 2001 and published in the Official Gazette dated September 22, 2002 with the Resolution of Council of Ministers no 2002/4720. NUTS is included in the National Program in line with the EU's demands. In this context, to be prepared by Turkey, “Turkey's National Program for the Adoption of the Acquis”, the Cabinet adopted on 13 March 2001. The Board on 24 March 2001 and published in the Official Gazette and entered into force. The main objectives in the preparation of SRE are; the collection and development of regional statistics, the socio-economic analysis of the regions, the determination of the framework of the regional policies, the establishment of a comparable statistical database in line with the European Union Regional Statistics System. In general, two main criteria have been taken into consideration in the preparation of the NUTS: The necessity of the merger of the lower level units of each higher level and the continuity of the regional units with each other in terms of geographical boundaries (Erilli, 2014). According to the Classification of Statistical Region Units; 81 Statistical Region Units are defined as 12 as Level 1, 26 as Level 2 and Level 3 (provinces). When the NUTS was formed, it was decided that the provinces should be Level 3. There are three main reasons for this. The formation of the provinces of basic administrative unit in Turkey, statistics to be compiled mostly in some provinces of the data (population, agriculture, industry etc.), and when the EU member population size in the NUTS 3 unit of the country and considering the number of units taken for Turkey provinces is not appropriate.

After defining Level 3, Level 2s were determined. Since the NUTS 2 regions are the units in which the underdeveloped regions are to receive the most assistance from the EU assistance, during the determination of the Level 2, care was taken to group the provinces with common problems, socioeconomic and culturally similar and geographically similar provinces. Level-2 regions and central provinces are given in Table.1.

Table.1 NUTS Level-2 Codes in Turkey

Code	Level-2	Code	Level-2
TR10	İstanbul	TR71	Kırıkkale
TR21	Tekirdağ	TR72	Kayseri
TR22	Balıkesir	TR81	Zonguldak
TR31	İzmir	TR82	Kastamonu
TR32	Aydın	TR83	Samsun
TR33	Manisa	TR90	Trabzon
TR41	Bursa	TRA1	Erzurum
TR42	Kocaeli	TRA2	Ağrı
TR51	Ankara	TRB1	Malatya
TR52	Konya	TRB2	Van
TR61	Antalya	TRC1	Gaziantep
TR62	Adana	TRC2	Şanlıurfa
TR63	Hatay	TRC3	Mardin

In this study, sub-regions in Turkey are classified by the Gustafson-Kessel Fuzzy Clustering method according to the development index. The regions are also listed according to fuzzy membership degrees after classification. Thus, the degree of importance is determined sub-region in Turkey. Investments to be made according to these rankings are considered to be important for the effective use of investment resources.

1.1. Short Literature View

In literature, there are many studies that used Fuzzy Clustering in the classification of persons, cities or countries. These methods are frequently used because of their advantages and success in clustering. In addition to this, there is no classification made with the Gustafson-Kessel method according to the development index of Turkey's cities. In this section, we briefly review studies with the Fuzzy Clustering Analysis.

Xiaohong et al. (2018) were clustered different types of data with Gustafson-Kessel fuzzy clustering algotihm. For the purpose of classifying tea varieties, allied Gustafson-Kessel (AGK) clustering was proposed to the cluster of tea samples. They were indicated that AGK's clustering accuracy reached the highest level compared to other fuzzy clustering algorithms. Krishna Priya et al. (2017) were to created clusters of agricultural fields using GK clustering algorithms methodologies. The studies done using K means and GK clustering algorithms indicated that K means algorithm has some limitations on the clustering patterns. Young-il et al. (2004) and Babak (2010) proposed new validity indices for the GK method to find solutions to traditional validity index problems differently than other studies. New validity indexes were used for different data sets. And the advantages of new indexes were emphasized. In Daniel and Witold (2007), Shawki A and Nesar (2010) and George and Hatzichristos (2012)'s paper GK clustering and Fuzzy C-Means (FCM) methods were compared. In the kernel-based clustering algorithms was not that much of an improvement over FCM and GK-FCM were found in the first study. In the other two studies, Gustafson- Kessel algorithm was showed better performance than the Fuzzy C Means algorithm. Clustering analysis of banking sub-sector companies based on 2014 CAMELS financial ratios using Fuzzy C-Means and Fuzzy Gustafson Kessel methods were made in Nur A. et al. (2016). In the conclusion of the study, the GK method was found to give better results than FCM and non-hierarchical. Lailly and Diah. (2015) were compared FCM with GK clustering method in the study. Their results showed that GK was better than Fuzzy Cluster Method, specifically in generating the objective function and the standard deviation ratio of the minimum group. This study was based on Xie and Beni as the validity index. When the studies are considered in the literature, it can be said that GK algorithm is shown generally performs better than FCM

2. Clustering Analysis

Clustering analysis can be summarized as subgrouping of observation values according to similarities. Thus, the best distinction is made by creating heterogeneous structure between homogeneous groups within the group. Clustering analysis is a method of unsupervised learning and a multivariate technique for statistical data analysis used in almost all scientific fields. It is a statistical classification technique in which a group of points with similar or closed characteristics are putted together in the same group which called clusters. It encompasses a number of varying algorithms and methods that are all used for classify objects of similar kinds into oredered categories. The purpose of clustering analysis is to obtain more information from the data and to help statistical arrangements by separating them into meaningful structures.

For the cluster analysis to be successful, the data should be best separated well into clusters. A good clustering method will produce high quality clusters with high intra class similarity and low inter class similarity. The quality of a clustering result depends on both the similarity, correlation or similarity measures used by the method and its implementation. The quality of a clustering method is also measured by its ability to discover some or all of the hidden patterns.

In clustering literature, methods can be described according to data structures. Crisp clustering, Fuzzy clustering, Soft set clustering, Grey clustering, Rough clustering are the techniques commonly used in recent years.

Fuzzy clustering approach is an appropriate method if clusters are not separated from each other explicitly or some objects are unstable in cluster membership. Fuzzy clustering methods, which are flexible methods, provide information about indefinite cluster memberships. These memberships also help to create the infrastructure of complex relationships between objects and clusters.

Fuzzy clusters are functions modifying each unit between 0 and 1 which is defined as the cluster membership for all units in the clusters. The units which are very similar to each other hold their places in the same cluster according to their membership degree. Fuzzy clustering is based on distance, correlation or similarity measurements as well like other clustering algorithms. Most important characteristics of fuzzy clustering can be given as follows (Naes and Mevik, 1999):

i. It provides membership values which are convenient to comment on.

ii. It is flexible on the usage of distance.

iii. When some of the membership values are known, they can be combined with numeric optimization.

The advantage of fuzzy clustering over crisp clustering methods is that it provides more detailed and useful informations on the data. The most important disadvantage of this method is that if there are too many clusters as a result of analysis, it requires more details and more comments. The more uncertainty is, the more complex the fuzzy clustering results are. (Oliveira and Pedrycz, 2007). In fuzzy clustering literature is Fuzzy C-Means, Gustafson-Kessel and Gath-Geva algorithms are most used and well-known methods. In this study, it is used the Gustafson-Kessel Fuzzy Clustering Algorithm to classify districts Level-2 in Turkey.

2.1. Gustafson-Kessel Fuzzy Clustering Algorithm

The Gustafson-Kessel algorithm is a fuzzy clustering algorithm developed to diagnose ellipse-like clusters instead of spherical clusters. The fuzzy C-means method does not yield good results in such clusters. (Gustafson and Kessel, 1979) used the Mahalanobis distance instead of Euclidian distance in the fuzzy clustering method. In this algorithm, in comparison with the fuzzy C-means algorithm, each cluster has a symmetric and positive *A* matrix in addition to cluster centers. This matrix causes $\|x\|_A = \sqrt{x^T A x}$ norm for each cluster.

The random picking of these matrices can cause small distances. To prevent the objective function from being minimized by the matrix with approximately zero, constant volume clusters are required such that det (*A*) = 1. Only the cluster formats are variable, the cluster sizes are not variable.

Algorithm for Gustafson-Kessel can be given as follows (Balasko et al., 2005; Höppner et al., 1999):

Given the data set *X*, choose the number of clusters $1 < c < N$, the weighting exponent $m > 1$, the termination tolerance $\varepsilon > 0$ and the norm-inducing matrix *A*. Initialize the partition matrix randomly such as $U^{(0)} \in M_{fc}$.

Repeat for $l = 1, 2, ...$

Step.1: Calculate the cluster centers.

$$v_i^{(l)} = \frac{\sum_{k=1}^{N} \left(\mu_{ik}^{(l-1)}\right)^m x_k}{\sum_{k=1}^{N} \left(\mu_{ik}^{(l-1)}\right)^m}, 1 \le i \le c$$

Step.2: Compute the cluster covariance matrices.

$$F_{wi}^{(l)} = \frac{\sum_{k=1}^{N} \left(\mu_{ik}^{(l-1)}\right)^m \left(x_k - v_i^{(l)}\right)\left(x_k - v_i^{(l)}\right)^T}{\sum_{k=1}^{N} \left(\mu_{ik}^{(l-1)}\right)^m}, 1 \le i \le c$$

Add a scaled identity matrix:

$$F_i = (1-\gamma) F_i + \gamma \left(F_0\right)^{1/n} I$$

Extract eigenvalues λ_{ij} and eigenvectors ϕ_{ij}, find $\lambda_{ij,\max} = \max_j \lambda_{ij}$ and set $\lambda_{ij,\max} = \lambda_{ij} / \beta$.

Reconstruct F_i by:

$$F_i = \left[\phi_{i,1} \ldots \phi_{i,n}\right] diag\left(\lambda_{i,1} \ldots \lambda_{i,n}\right) \left[\phi_{i,1} \ldots \phi_{i,n}\right]^{-1}$$

Step.3: Compute the distances.

$$D_{ik}^2 \left(x_k, v_i\right) = \left(x_k - v_i^{(l)}\right)^T \left[\left(p_i \det\left(F_i\right)\right)^{1/n} F_i^{-1}\right] \left(x_k - v_i^{(l)}\right)$$

Step.4: Update the partition matrix.

$$\mu_{ik}^{(l)} = \frac{1}{\sum_{j=1}^{c} \left(D_{ikA_i}\left(x_k, v_i\right) / D_{jk}\left(x_k, v_i\right)\right)^{2/(m-1)}}, 1 \le i \le c, 1 \le k \le N$$

Until $\left\| U^{(l)} - U^{(l-1)} \right\| < \varepsilon$

2.2. Cluster Validity Indices

One of the main problems in Clustering Analysis is what will be an optimal number of clusters. This is always a problem in all clustering analysis methods like crisp clustering, fuzzy clustering or soft set clustering etc. So we have to use cluster validity indices. If we have no prior knowledge about the number of classes, it is hard to make the right decision on the number of classes. Cluster validity indices tell us the quality of partition that was found and enables to determine optimal partitions. For these, validity indices can be used to search for the optimal number of clusters in the data set is not known in advance. In Literature, there so many validity indices for detecting the optimal number of clusters (In classical clustering nearly 10 indices are studying but in fuzzy clustering, there are more than 70 and researchers still working on it). In this article, it is used Artificial Neural Network based validity index which introduced by Erilli et al. (2011).

3. Application

In application, 26 regions of Level-2 in Turkey classified and sorted by the Gustafson-Kessel algorithm according to the development indices. Variables that contain development indices are GDP per capita, inflation rate, migration, literacy rate, unemployment rate, poverty rate, credit per capita and crime rates. The analyses were performed with the MATLAB.2017 package program.

As for ANN Fuzzy clustering validity index, it is found 4 clusters for the data. Results for Gustafson-Kessel method is given in Table.2:

Table.2 Gustafson-Kessel Clustering Results for Level-2 Regions

Cluster 1	Cluster 2	Cluster 3	Cluster 4
Istanbul	Izmir	Balikesir, Çanakkale	Tekirdag, Edirne, Kirklareli
Adana, Mersin	Aydin, Denizli, Mugla	Manisa, Afyon, Kütahya, Usak	Zonguldak, Karabük, Bartin
	Bursa, Eskisehir, Bilecik	Kocaeli, Sakarya, Düzce, Bolu, Yalova	Kastamonu, Çankiri, Sinop
	Ankara	Konya, Karaman	Erzurum, Erzincan, Bayburt
	Antalya, Isparta, Burdur	Hatay, Kahramanmaras, Osmaniye	Agri, Kars, Igdir, Ardahan
		Kirikkale, Aksaray, Nigde, Nevsehir, Kirsehir	Van, Mus, Bitlis, Hakkari
		Kayseri, Sivas, Yozgat	Gaziantep, Adiyaman, Kilis
		Samsun, Tokat, Çorum, Amasya	Sanliurfa, Diyarbakir
		Trabzon, Ordu, Giresun, Rize, Artvin, Gümüshane	Mardin, Batman, Sirnak, Siirt
		Malatya, Elazig, Bingöl, Tunceli	

As we look in Table.1, Istanbul which has more than 15 million people and the Adana-Mersin region which has the area where the largest trading port in Turkey, creates the first cluster. Moreover, it is observed that the regions where investment and population are relatively low (as expected) are the last cluster.

Each region is bound by membership degrees to their clusters. With the help of cluster membership levels, if we rank the Level-2 regions according to their level of development, we reach the results in Table.3.

Table.3 Ranking Level-2 Regions in Turkey

1	Istanbul
2	Adana, Mersin
3	Ankara
4	Aydin, Denizli, Mugla
5	Antalya, Isparta, Burdur
6	Izmir
7	Bursa, Eskisehir, Bilecik
8	Balikesir, Çanakkale
9	Manisa, Afyon, Kütahya, Usak
10	Konya, Karaman
11	Kayseri, Sivas, Yozgat
12	Trabzon, Ordu, Giresun, Rize, Artvin, Gümüshane
13	Hatay, Kahramanmaras, Osmaniye
14	Samsun, Tokat, Çorum, Amasya
15	Kocaeli, Sakarya, Düzce, Bolu, Yalova
16	Kirikkale, Aksaray, Nigde, Nevsehir, Kirsehir
17	Malatya, Elazig, Bingöl, Tunceli
18	Van, Mus, Bitlis, Hakkari
19	Mardin, Batman, Sirnak, Siirt
20	Gaziantep, Adiyaman, Kilis
21	Sanliurfa, Diyarbakir
22	Erzurum, Erzincan, Bayburt
23	Agri, Kars, Igdir, Ardahan
24	Kastamonu, Çankiri, Sinop
25	Zonguldak, Karabük, Bartin
26	Tekirdag, Edirne, Kirklareli

Looking at the ranking in Table 3, it is possible to say that big cities or economically strong regions are in the top 10. In the first place, Istanbul which is one of the biggest city in Europe is located. In the second place, the largest port in the region, the third place in the country's capital, Ankara. In the fourth place, the textile center of the country, the fifth largest tourism center, the sixth largest city in Izmir is located. In the seventh and seventh places, the regions where the industries were large, the ninth and tenth places were the regions where agriculture was strong.

4. Conclusion

Statistical classification can be used not only for classification of variables but also for sorting according to that criteria. In this study, the Level-2 regions were clustered with the Gustafson-Kessel method from the fuzzy clustering methods, and then the Level-2 regions were arranged according to their development level with the help of clustering results. It is certain that the regions in the lower ranks in the ranking need more investments. Therefore, the allocation of larger shares to these regions and the success of general investment balances can be achieved in the short term. In the long term, the deficiencies can be determined and measures can be taken by controlling the changes in the economic status of the regions at the bottom of the rankings and the development situations.

It should be kept in mind that economic policies depend not only on economic data but also on other factors. Therefore, index calculations such as the level of development, economic freedom or freedom of law should be done not only on the basis of provinces but also on the basis of regions.

In this study, the Gustafson-Kessel method of fuzzy clustering analysis, classification of Turkey in the region and is used for Level-2 glazed. More successful classification can be made with fuzzy clustering analysis, which gives successful results in the data sets where the number of observations and the number of variables used is close to each other. Thus, the bias in the data can be prevented. The results obtained in the study were found to be very close to the real state sequence. With such studies, diversification of economic researches will be ensured.

Demonstrating the development performance of the regions requires monitoring of the provinces and regions within the framework of various criteria, and accordingly, it is possible to develop concrete and effective policies by making use of measurable indicators. Findings and results obtained from socio-economic development studies, policies and projects carried out by the Ministry of Development, Social Support Program, Supporting the Infrastructure of Villages Project, Municipalities' Water and Sewerage Infrastructure Project, Supporting the Infrastructure of Municipalities Project and projects with central level institutions will contribute to the work of local Development Agencies, Regional Development Administrations, Governorships and Municipalities. However, the production of data based on administrative records as the primary source of current, reliable, comparable time and space dimension is seen as the main critical success factor.

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