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Clustering OECD Countries According to Tax Indicators

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A B S T R A C T

This study aims to cluster a particular group of countries (OECD countries) according to tax indicators and to determine essential variables in clustering. The recent data on taxation percentages 2021 in OECD countries were obtained from the OECD website. Since the number of clusters was not known a priori, the hierarchical clustering analysis and two-stage clustering methods were used, and the findings of both methods were compared. Research findings show that OECD countries are classified into two meaningful clusters regarding statistically significant tax indicators (goods and services tax, personal income tax, and property tax) for both methods. The first cluster's goods and services tax average is lower than the second. The personal income tax average of the first cluster is higher than the second. The property tax average of the first cluster is higher than the second. The tax differences indicate that countries in the first cluster collect more personal income and property taxes but fewer goods and services taxes than countries in the second cluster, which points out the characteristics of developed countries in the scope of tax policies.

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1. Introduction

Cluster analysis methods are methods used to classify a data set (Morey, Blashfield & Skinner, 1983: 309). Clustering involves collecting objects with high similarity under the same groups and those with low similarity under different groups (Shih et al., 2010: 11). The analysis aims to create homogeneous groups (Gore, 2000: 298). Group members can be individuals, countries, or variables (Landau & Ster, 2010:

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72). In grouping objects, two broad classes of algorithms were designed that are the hierarchical and nonhierarchical clustering methods (Timm, 2002: 522; Tatlıdil, 2002: 334). When the cluster number is unknown, hierarchical clustering is the proper method (Bülbül & Camkıran, 2018: 371). The number of clusters is discovered using a tree diagram called a dendrogram. When the cluster number is known, the nonhierarchical clustering method is proper. When prior knowledge about the number of clusters is not available, the two-stage clustering analysis method can also be used (Kayri, 2007: 91; Alpar, 2011: 314; Giray, 2016: 16; Bülbül et al., 2017: 23).

Cluster analysis was first discussed in the social sciences during the 1930's (Blashfield & Aldenderfer, 1978: 272). It has a long history. As can be seen in detail in the recent literature review in the second part of this study, there are many studies that subject OECD countries to cluster analysis according to many different issues such as health indicators, agricultural performance, economic indicators, number of traffic accidents, carbon emission indicators, labor force indicators, innovation indicators and so on. However, the literature review shows that more cluster analysis studies on taxation in OECD countries must be conducted. In this respect, this study is essential and contributes to the relevant literature.

This study aims to cluster a particular group of countries (OECD countries) according to tax indicators and to determine essential variables in clustering. In this context, the study will seek answers to the following research questions: (i) Are OECD countries divided into clusters? (ii) If so, how many clusters are they divided into? (iii) Do the clusters consist of meaningful country groups? and (iv) Which tax indicator variables are statistically significant in dividing OECD countries into clusters? The findings (similar countries in the context of tax indicators) will be interpreted. Based on the research questions, the study has the following sections: A literature review related to the clustering of OECD countries was conducted in the second part. In the third part, the research design of this study and the findings were given. The last part contains the conclusion.

2. Recent Literature Review on Clustering of OECD Countries

When the literature was reviewed, it was seen that cluster analysis studies had been carried out on various subjects related to OECD countries. However, the literature review shows that more cluster analysis studies on taxation in OECD countries need to be conducted. OECD countries' research subjected to cluster analysis within the scope of taxation are as follows: Birkalan & Tekeli (2022) clustered OECD countries according to tax wedge using 2021 data. Researchers found a 3-cluster solution. When researchers evaluated the country clusters they obtained, they concluded that Türkiye was seen to be in the same cluster (Cluster 3) together with European Union member countries in terms of its tax wedge. Ünal (2021) clustered OECD countries according to tax burden

and shadow economy using 2017 data. The researcher found a 3-cluster solution. When the researchers evaluated the country clusters they obtained, they concluded that Türkiye was seen to be in the same cluster (Cluster 1) as Colombia, Costa Rica, Ireland, South Korea, Mexico, and the United States. Gülşen (2019) clustered OECD countries according to tax payment periods using 2004-2015 period data. The researcher found a 3-cluster solution. When researchers evaluated the country clusters, they obtained that Türkiye was in the same cluster (Cluster 3) with the following countries: Germany, Czechia, Greece, Slovakia, Hungary, Portugal, Mexico, Poland, Italy, Chili and Slovenia. The analysis in the article proves the theoretical idea that personal income taxes are fairer than goods and services taxes. In this respect, it is a study that contributes to the literature.

Recent domestic studies on different topics in which OECD countries were clustered are illustrated in Table 1.

Table 1. Recent Domestic Studies on Various Topics Clustering OECD Countries

Author(s)	Clustering Indicator(s) or Data Used
Filiz & Budak (2024)	Health Data
Dağ (2023)	Exported and Imported Product Groups
Kutlar et al. (2023)	Economic Indicators
Madenoğlu (2023)	Covid-19 Pandemic
Bulut (2023)	Economic Freedom
Eroğlu & Özen (2023)	Corruption
Köse (2022)	Health Indicators
Ayabakan (2022)	Global Gender Gap Index Data
Güler & Veysikarani (2022)	PISA Scores
Yılmaz (2022)	Labor Index
Alkaya & Alkaş (2021)	Health Indicators
Eren & Ömürbek (2021)	Logistics Performances
Akçakaya & Ömürbek (2021)	Democracy Indicators
Değirmenci & Yayan (2020)	Health Indicators
Kandemir (2020)	Traffic Accident Data
Çetintürk & Gençtürk (2020)	Health Expenditure Indicators
Sel (2020)	Carbon Emission Indicators
Keklik et al., (2020)	Better Life Index
Aslan & Açıkgöz (2019)	Labor Market Flexibility Indicators
Arı & Gülcemal (2019)	Insurance Market Share
Akdamar (2019)	Labor Market Indicators
Şen & Varüer (2019)	Suicide Rates
Taşçı & Özarı (2019)	Economic Freedom Criteria
Soydan & Yakut (2018)	Renewable Energy
Güler & Veysikarani (2018)	Innovation Indicators
Arı & Yıldız (2018)	Migration Statistics
Engin (2018)	Information Economy Index
Yorulmaz et al. (2018)	Factors Affecting Foreign Direct Investments

Akça et al. (2017)	Corruption Indicators
Kuşkaya & Gençoğlu (2017)	Green Gas Emission
Aksaraylı & Pala (2017)	Life Satisfaction and Innovation Levels
Mut & Akyürek (2017)	Health Indicators
Ertaş & Atik (2016)	Development Indicators
Alptekin & Yeşilaydın (2015)	Health Indicators
Kangallı et al. (2014)	Economic Freedom
Dalkılıç (2013)	Private Pension Funds
Akın & Eren (2012)	Education Indicators
Çemrek et al. (2010)	CO_2 Emissions

3. Research Design and Findings

The recent data in percentages of taxation for the year 2021 of OECD countries were taken from the official website of the OECD (https://data.oecd.org/) in May 2024.

Table 2. OECD Countries' List

Australia		Japan
Austria		Korea
Belgium		Latvia
Canada		Lithuania
Chile		Luxemburg
Colombia		Mexico
Costa Rica		Netherlands
Czechia		New Zealand
Denmark		Norway
Estonia		Poland
Finland		Portugal
France		Slovak Republic
Germany		Slovenia
Greece		Spain
Hungary		Sweden
Iceland		Switzerland
Ireland		Türkiye
Israel		United Kingdom
Italy		United States

Data consists of 5 tax indicators (or variables) for 38 OECD countries: personal income tax, corporate profits tax, payroll tax, property tax, and goods and services tax. Variables were coded as is seen in the Table 3 below:

Table 3: Tax Indicators on OECD Countries (% of Taxation)

Symbols	Names
T1	Personal income tax
T2	Corporate profits tax
T3	Payroll tax
T4	Property tax
T5	Goods and services tax

Statistical analyses were done by using SPSS 23. Descriptive statistics and F test results are illustrated in Tables 4 and 5, respectively:

Table 4: Descriptive Statistics of Tax Indicators on OECD Countries

	N	Minimum	Maximum	Mean	Variance
T1	38	6.216	52.810	23.740	113.329
T2	38	2.794	23.714	10.230	30.780
T3	38	0.000	11.994	1.312	6.089
T4	38	0.563	15.065	5.643	14.498
T5	38	16.550	53.060	31.918	65.464

Table 5: F Test (Analysis of Variance Test) Results

	Cluster		Error		F	Sig.
	MS	df.	MS	df.		
T1	2155.648	1	56.598	36	38.087	0.000
T2	5.540	1	31.481	36	0.176	0.677
T3	2.247	1	6.196	36	0.363	0.551
T4	109.813	1	11.850	36	9.267	0.004
T5	1454.635	1	26.876	36	54.125	0.000

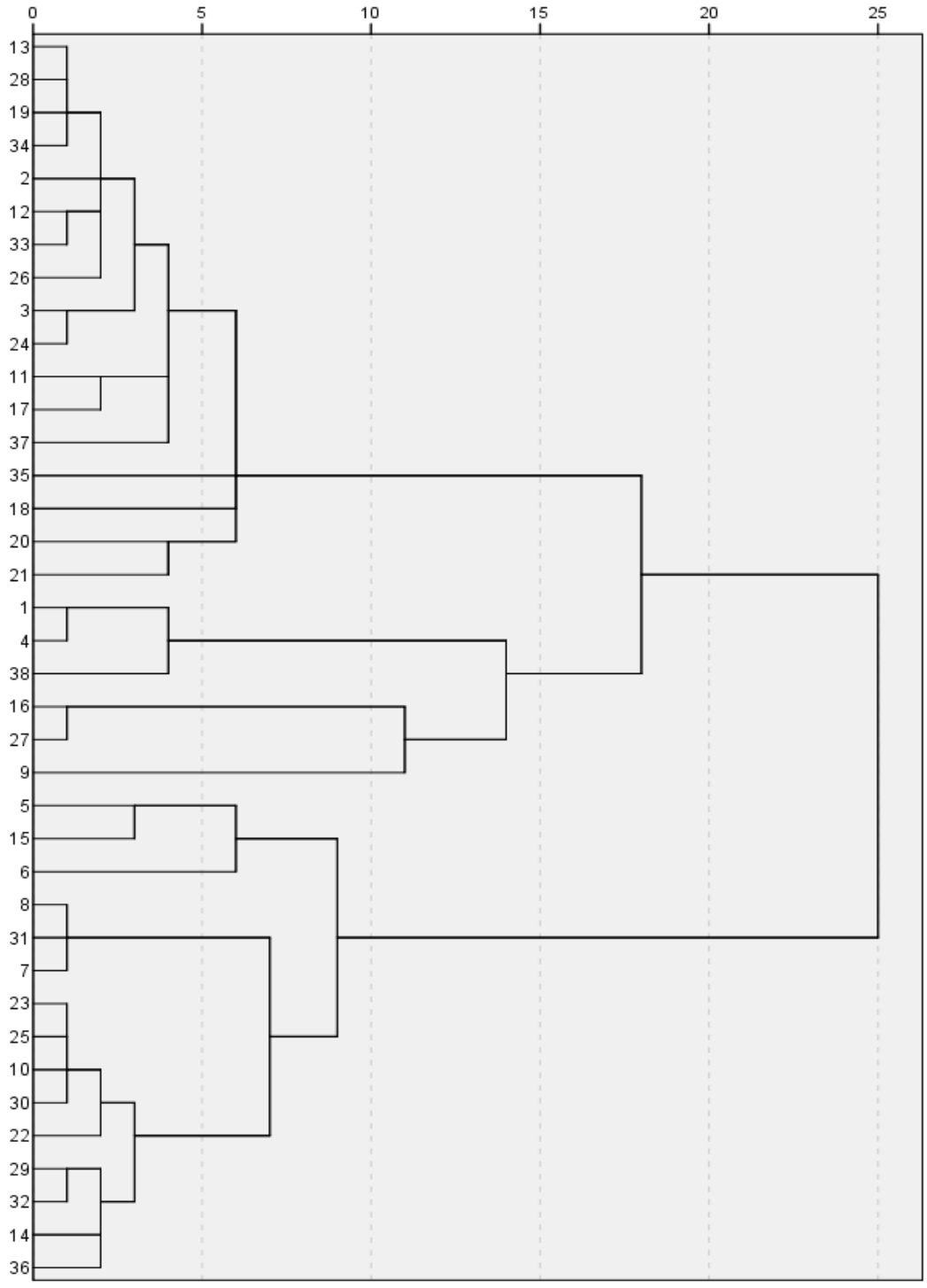
Analysis of Variance Tests showed that while the ratios containing the variables T1, T4, and T5 are statistically significant (Sig. < α=0.05), the ratios containing the variables T2 and T3 are statistically insignificant (Sig. ≥ α=0.05). Therefore, cluster analyses were conducted with variables T1, T4, and T5.

3.1. Hierarchical Cluster Analysis Findings

In general, in cluster analysis, cluster numbers are not known in advance, and clusters are obtained only based on the current state of the data (Turanlı et al., 2006: 97). In such situations when there isn't prior knowledge about the cluster numbers. Generally, it is discovered by using hierarchical clustering analysis methods (Bülbül &

Camkıran, 2018: 371). The centroid clustering method is robust against outliers (Rencher & Christensen, 2012: 529). Therefore, the centroid clustering method was used. A squared Euclidean distance was used.

Figure 1: Dendrogram Plot for Tax Indicators



When a vertical line is drawn on the far right side of the dendrogram chart in Figure 1, it is seen that the vertical line first intersects two horizontal lines. The fact that the vertical line drawn crosses two horizontal lines indicates that OECD countries are divided into two clusters, which means a two-cluster solution was obtained with three statistically significant input data (or variables). The numbers on the branches connected to each horizontal line show the row numbers of the countries in the relevant clusters. The upper horizontal line contains the first cluster members, while the lower horizontal line contains the second cluster members.

When the dendrogram graph is examined in Figure 1, it is seen that 23 countries were grouped in the first cluster, and 15 countries were grouped in the second cluster. Country names for the first group: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxemburg, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, United Kingdom, and the United States. Country names for the second group: Chile, Colombia, Costa Rica, Czechia, Estonia, Greece, Hungary, Latvia, Lithuania, Mexico, Poland, Portugal, Slovak Republic, Slovenia, and Türkiye.

3.2. Two-Step Cluster Analysis Findings

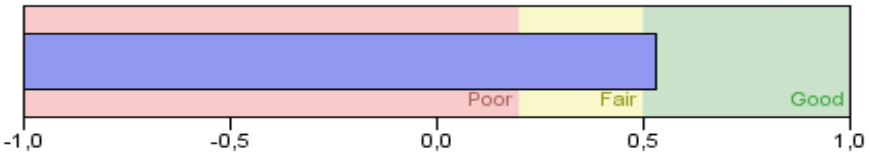
Hierarchical cluster analysis yielded a meaningful two-cluster solution. However, we need to confirm this solution. To do so, the next strategy we follow is to apply a two-stage cluster analysis method that automatically discovers the unknown cluster number. The two-stage clustering method is a method that can be used when there is no prior knowledge about the cluster numbers (Giray, 2016: 16; Bülbül et al., 2017: 23). When applying the two-stage cluster method; Euclidean distance was used since continuous variables were used. Akaike Information Criteria (AIC) or Schwarz's Bayesian Criterion (BIC) determines the number of clusters. The two-step cluster analysis procedures evaluated the importance of cluster quality and predictor (T variables). Depending on the analysis results, a two-cluster solution was obtained with three input data (or variables). OECD countries determined cluster memberships for the related clusters as shown in Table 6 below:

Table 6: Clustered OECD Countries and Cluster Memberships

Row Number	Cluster 1		Row Number	Cluster 2
1	Australia		5	Chile
2	Austria		6	Colombia
3	Belgium		7	Costa Rica
4	Canada		8	Czechia
9	Denmark		10	Estonia
11	Finland		14	Greece
12	France		15	Hungary
13	Germany		22	Latvia
16	Iceland		23	Lithuania
17	Ireland		25	Mexico
18	Israel		29	Poland
19	Italy		30	Portugal
20	Japan		31	Slovak Republic
21	Korea		32	Slovenia
24	Luxemburg		36	Türkiye
26	Netherlands			
27	New Zealand			
28	Norway			
33	Spain			
34	Sweden			
35	Switzerland			
37	United Kingdom			
38	United States			

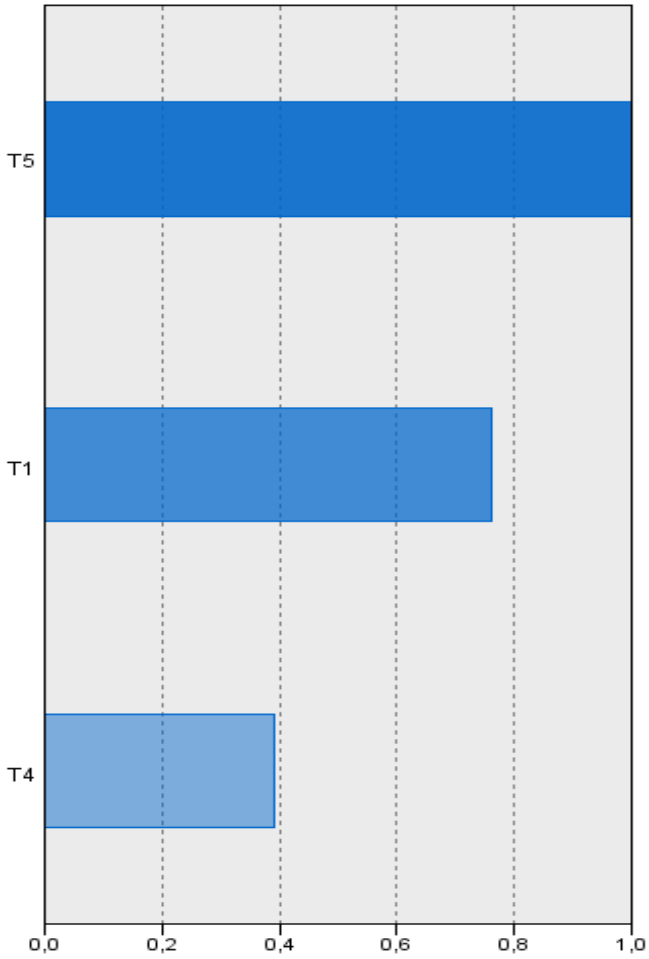
Cluster quality is illustrated in Figure 2:

Figure 2: Cluster Quality: Silhouette Measure



In this Figure, the Silhouette measure, which measures cohesion and separation, shows that cluster quality is good. Figure 3 shows the predictor variable importance.

Figure 3: Predictor Variable Importance



The order of significance levels of the predictor variables that are important in the formation of clusters are respectively as follows: goods and services tax (T5) is ordered in the first place with 1.0, personal income tax (T1) is ordered in the second place with 0.76, and property tax (T4) is ordered in the third place with 0.39.

4. Conclusion

This study sought answers to the following research questions: (i) Are OECD countries divided into clusters? (ii) If so, how many clusters are they divided into? (iii) Do the clusters consist of meaningful country groups? and (iv) Which tax indicator variables are statistically significant in dividing OECD countries into clusters? Research findings show that OECD countries are divided into two meaningful clusters depending on the tax indicators (in order of importance, goods and services tax, personal income tax, and property tax). Moreover, two separate clustering methods (hierarchical and two-stage) used without prior information about the number of clusters gave the same

results: they all pointed to a two-cluster solution and the same cluster elements (or countries). The first cluster countries are composed of 23 countries that are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxemburg, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, United Kingdom, and United States. The second cluster countries are composed of 15 countries: Chile, Colombia, Costa Rica, Czechia, Estonia, Greece, Hungary, Latvia, Lithuania, Mexico, Poland, Portugal, Slovak Republic, Slovenia, and Türkiye.

The most crucial variable dividing into two clusters is the goods and services tax. The 2021 OECD tax average for goods and services is 31.91%. The first cluster's goods and services tax average (26.87%) is lower than the OECD average. The second cluster's goods and services tax average (39.65%) is higher than the OECD average. Personal income tax is the second most crucial variable divided into two clusters. The 2021 OECD tax average for personal income tax is 23.74%. The personal income tax average for the first cluster (29.76%) is higher than the OECD average. The personal income tax average for the second cluster (14.49%) is also lower than the OECD average. The third important variable in dividing into two clusters is property tax. The 2021 OECD tax average for property tax is 5.64%. The property tax average for the first cluster (7.25%) is higher than the OECD average. The property tax average for the second cluster (3.17%) is also lower than the OECD average. These tax differences indicate that countries in the first cluster collect more personal income and property taxes but less goods and services taxes than countries in the second cluster, which points out the characteristics of developed countries regarding tax policies.

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Selim Tüzüntürk - Idea, Design, Data Collection, Interpretation of Data, Drafting, Critical Review, Final Approval and Responsibility, Literature Review, Supervising. Overall Contribution - 100%.
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