Chapter 2

Determining Türkiye's Place Among OECD Countries in Terms of Tax Wedge Using K-Means Method and Sigma Convergence[1]

Abdülhamid Özgün Birkalan[2]

Recep Tekeli[3]

Abstract

The tax wedge defines the difference between the total cost of an employee to an employer and the net wages the employee receives. It represents the burden of taxes and premiums on wages. The OECD publishes tax wedge statistics yearly for countries as a proportion of labor expenses. This approach enables a comparative assessment of taxes and other wage-related premiums at the national level. This study seeks to ascertain Türkiye's position among OECD nations regarding the tax wedge. The K-means clustering method, classified as a non-hierarchical clustering method, was chosen for this purpose. The Elbow method was used to determine the number of clusters, indicating that the optimal number is three. The K-means clustering algorithm was then implemented according to this specified number. The analysis categorized OECD countries into two groups based on 2021 and 2024 tax wedge data. Türkiye's tax wedge closely resembles that of EU countries. When compared with the OECD averages, Türkiye's tax wedge decreased until 2013 and started to converge to the OECD average between 2009 and 2013 but diverged after 2014. The study also reveals evidence of sigma convergence in tax wedge.

1 This article is an expanded version of the paper titled "Determining Turkey's Place Among OECD Countries in Terms of Tax Wedge Using the K-Means Method" presented at the 12th International Conference on Social Research and Behavioral Sciences, 12-13 November 2022, Antalya / Turkey.

2 Arş Gör., Aydın Adnan Menderes Üniversitesi Siyasal Bilgiler Fakültesi, a.ozgun.birkalan@adu.edu.tr, ORCID: 0000-0003-1369-8922.

3 Prof. Dr., Aydın Adnan Menderes Üniversitesi Siyasal Bilgiler Fakültesi, rtekeli@adu.edu.tr, ORCID: 0000-0001-6403-9383.

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1. Introduction

The state is broadly defined as a sovereign and independent community governed by political authority within defined borders, encompassing all public legal entities such as central administration, provinces, municipalities, and communes. (Ay, 2019: 3). Communities form the foundation of the state. The cohabitation of different communities generates various requirements that must be addressed by the state mechanism. In the literature, these requirements are referred to as public needs, while the financial outlays to satisfy them are termed public expenditures. The state requires many sources of revenue for public expenditures. During the Middle Ages, property and enterprise revenues were among the principal sources of state income; but, in contemporary times, with the proliferation of market and mixed economies, taxes have become the foremost source of state revenues.

Diverse metrics are employed to assess a nation's public finances. Tax burden shows how much of the resources (national income) in a country is transferred to the state. When the tax load surpasses the tax capability, it can lead to numerous adverse effects. If the tax burden stays beneath the tax capacity, it may result in insufficient funding for public spending. The tax wedge is a concept that expresses the tax burden on wage income. The tax wedge describes the disparity between the total cost incurred by an employer for an employee and the net salary received by the employee. It can be described as the burden of taxes and premiums on wages. A high tax wedge may lead to operating costs to rise and the substitution effect to increase. A reduced tax wedge may induce an income effect for employees.

This study evaluated OECD nations based on tax wedge indicators. The K-means clustering method was used. 37 OECD nations were divided into clusters in this way. In the K-means clustering method, the number of clusters must be predetermined. The algorithm runs according to the number of clusters. Consequently, the Elbow method was used to determine an appropriate and meaningful number of clusters. Then, the clusters obtained as a result of the analysis and Türkiye's place among OECD nations were assessed.

However, determining the tax wedge position of countries in a specific year may be insufficient to explain the dynamic distribution of this indicator over time. Therefore, this study also incorporates the sigma convergence approach to examine whether tax wedge differences among OECD countries have decreased over time.

2.Theoretical Framework

2.1. Tax Wedge

The tax burden, representing the share of national income transferred to the public sector in a country, is calculated by relating tax revenues to GDP. The tax burden in a comprehensive sense is calculated by dividing the sum of consolidated budget revenues, local administration taxes, fund-related tax revenues and parafiscal revenues by GDP. This is a crucial indicator to evaluate for purposes such as determining the tax burden, regulating tax policies, comparing tax amounts on a sectoral basis, abolish some taxes and implementing new taxes (Çağdaş, 2020: 83). Tax wedge is a concept used to express the tax burden on wage income (Nar, 2015: 686). The tax wedge represents the disparity between the total cost of an employee to the employer and the net wage received by the employee. In other words, it can be defined as the burden of taxes and premiums on wages. Consequently, both taxes and tax-equivalent financial responsibilities are encompassed within the definition of the tax wedge.

The tax wedge can be mathematically represented in Equation (1):

$$Tax\ Wedge = \frac{Total\ Labor\ Cost - Net\ Wage}{Total\ Labor\ Cost} \tag{1}$$

OECD publishes tax wedge data yearly for countries as a percentage. This indicator is calculated by dividing the tax and other premium amounts paid by an average single worker without children by the labor cost to the employer. This enables comparative assessment of taxes and other surcharges on wages at the national level. This data reveals a decline in the OECD average from 2000 to 2024. Conversely, in Austria, Belgium, France, Germany and Italy, it is seen that taxes and tax-related financial obligations increase labor costs. It can be said that in countries such as Chile, Mexico and Sweden, taxes and similar financial obligations are lower than in other OECD countries. Türkiye's tax wedge varied from 2000 to 2024, although consistently maintained around 40% (OECD, 2025).

2.2. Elbow Method

One of the most important factors that enable the K-means algorithm to yield precise results is choosing the correct ***k*** value. In the literature, there are various approaches to determine the number of clusters in the K-means algorithm.

The Elbow method is a technique utilized to assess the validity of cluster analysis by identifying the optimal number of clusters within a dataset (Liu and Deng, 2020: 987). This method is based on the idea that an optimum ***k*** value must be determined for the K-means algorithm to yield precise outcomes. Consequently, the sum of squared errors (SSE) is computed for each value of ***k***. The method continues by transferring the obtained record to a graph and selecting the elbow point (Nanjundan et al., 2019: 1). The extreme difference in the graph illustrating the elbow angle indicates the optimal number of clusters.

The Elbow method algorithm for identifying the optimal ***c*** value in the K-means clustering method is presented in stages below;

1- The ***c*** (cluster) value is initially determined as 0.

2- The ***c*** value is gradually increased.

3- The sum of the error squares is calculated for each increased ***c*** value.

4- The obtained results are transferred to a two-dimensional graph with the sum of the error squares on the vertical axis and the ***k*** value on the horizontal axis.

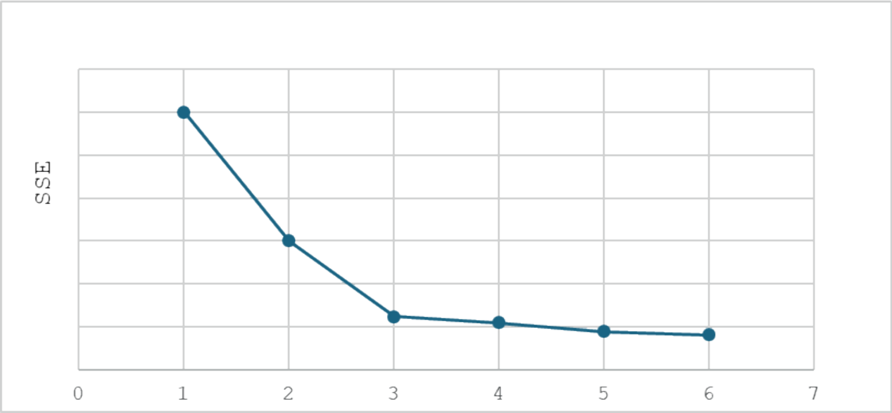
5- The most extreme difference illustrating the elbow angle (the sum of the error squares illustrates a significant decrease) is selected in the graph.

The mathematical formulation of the sum of squared errors is presented in Equation (2):

$$SSE = \sum_{i=1}^{n} (d)^2 \qquad (2)$$

where *d* is the distance between the data and the cluster center.

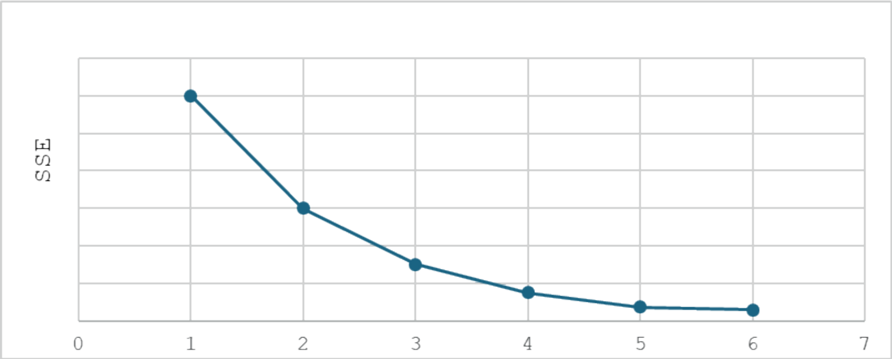
Graph 1. Sample Design Creating the Appropriate Elbow Point



Source: Created by the authors.

One of the main problems of the elbow method is that the elbow point cannot always be defined precisely. Because in some cases, the elbow point may not appear at all or more than one elbow point may appear (Kodinariya and Makwana, 2013: 92). When Graph-2 is examined, it can be seen that a suitable elbow point does not appear. Therefore, in such cases, the Elbow method fails to yield suitable and significant outcomes in identifying the optimal number of clusters.

Graph 2. Sample Design where the Appropriate Elbow Point is not identified



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2.3. Cluster Analysis

Despite its initial proposal in the 1930s, cluster analysis did not receive the attention it deserved until the early 1960s, primarily due to the inadequacy of advanced computer technology. Its significance was recognized following the publication of "Principles of numerical taxonomy" by Sokal and Sneath in 1963. Since then, studies on cluster analysis have been conducted in many fields such as biology, sociology, psychiatry and statistics (Blashfield, 1976: 377). Despite its numerous uses in these areas, the main purpose of cluster analysis is to divide the units in a data set into subgroups that exhibit maximal similarity. Aldenderfer and Blashfield (1984) defined cluster analysis as "*"Cluster analysis" is the generic name for a wide variety of procedures that can be used to create a classification.(…) More specifically, a clustering method is a multivariate statistical procedure that starts with a data set containing information about a sample of entities and attempts to reorganize these entities into relatively homogeneous groups.*" (Aldenderfer and Blashfield, 1984: 7).

Most clustering algorithms rely on two basic techniques: hierarchical and non-hierarchical clustering methods. Hierarchical clustering methods initially begin with a process in which each unit forms a single cluster (separative hierarchical clustering method) or each unit forms a separate cluster (aggregative hierarchical clustering method). This process ends when each unit forms an individual cluster or when all units from disparate clusters amalgamate into a singular cluster. In hierarchical methods, the separation process is irreversible. Hierarchical classifications are represented in a two-dimensional diagram known as a dendrogram (Everitt et al., 2011: 71-72).

Non-hierarchical clustering method algorithms are different from hierarchical clustering methods. In non-hierarchical clustering methods, data points are allocated to ***k*** clusters instead of a hierarchical arrangement. The process continues with the optimization of the benchmark function using these assigned points (Xu and Wunsch, 2009: 63-64). In non-hierarchical clustering methods, the number of clusters is predetermined through several approaches. The K-means clustering approach, predicated on the sum of squares criterion, is one of the most prevalent non-hierarchical clustering methods.

The K-means clustering method is a prototype-based clustering algorithm. The user initially assigns ***k*** center points randomly. Subsequently, units are allocated to the nearest centroid based on the variables. The centroid of each cluster is recalibrated based on the units allocated to that cluster. The process concludes when there is no alteration in the cluster centroid (Wu, 2012: 7).

2.4. Sigma Convergence

Two essentially distinct perspectives on convergence exist. One of them is beta (β- convergence) and the other is sigma (σ- convergence) convergence (Kıral and Esen, 2013: 176). Beta convergence refers to the phenomenon whereby lower-income nations experience more rapid economic growth compared to higher-income nations. Sigma convergence refers to the reduction of income disparity over time (Akkoç and Şahin, 2019: 199). Sigma convergence, defined by Barro and Sala-i Martin (1995), was utilized to assess the level of income differences. Sigma convergence occurs if the spread in income decreases over a certain time dimension. This distribution can be measured using the standard deviation (σ) of income across regions or the coefficient of variation (CV). In this study, σ-value and CV coefficient were used to assess the distribution of the tax wedge among OECD nations. Also, we can use this method to assess whether the differences in tax wedge converge, or not.

3.Literature Review

In the study conducted by Šimková (2015), hierarchical cluster analysis techniques were applied to 27 European Union countries in order to analyze the development and current status of the tax burden on capital. The analysis was carried out based on the average tax burden data on consumption, labor and capital of 27 European Union countries between 1995 and 2012. As a result of the analysis, it was concluded that the countries with the highest tax burden are the Scandinavian countries (Denmark, Sweden and Finland); while the countries with the lowest tax burden are Romania, Latvia and Lithuania (Šimková, 2015: 95-107).

In the study conducted by Ünal (2021), it was aimed to examine the mutual relationship between the informal economy and tax burden by using the K-means clustering method in OECD countries. The analysis was repeated with tax burden and shadow economy data, respectively, to identify cluster differences between countries. As a result of the analysis, it was revealed that Mexico, Colombia, Korea, Costa Rica and Türkiye stand out from the other countries in both analyses and have high levels of informal economy despite low tax burden levels.

In the study conducted by Syakur et al. (2017), the K-means method was applied to the data obtained from the survey filled by customers in order to facilitate the policies and analysis of SMEs in the sales of goods and services in Indonesia. The Elbow method was used to determine the number of clusters. As a result of the analysis based on 100 and 300 customer profiles, it was concluded that the ideal number of clusters was 3 (Syakur et al., 2017: 1-6).

In the study conducted by Gürler et al. (2020), 168 countries were divided into clusters using the K-means method in order to cluster the people living in the countries based on the causes of death. At the same time, 168 countries were divided into clusters using the K-means method in order to investigate whether there is a relationship between the human development levels of the clustered countries. In the study, 28 different variables showing the causes of death in 2015 were used. Four separate models were created by taking as reference the grouping made by the World Health Organization for the causes of death. The Elbow method was used in each model to determine the number of clusters. As a result of the analysis, Model 1 was divided into 9 clusters; Model 2 into 5 clusters; Model 3 into 8 clusters; and Model 4 into 6 clusters (Gürler et al., 2020: 111-124).

In the study conducted by Giray (2013), fuzzy clustering method and K-means clustering method were used to classify countries according to tourism indicators. In the analysis, three basic international tourism statistics of 159 countries belonging to the World Bank were used. As a result of the fuzzy cluster analysis, Türkiye was in the same cluster with Austria, France, Germany, Hong Kong, Italy, Malaysia, Mexico, Russia, Spain, Ukraine, England and the USA. In the K-means method, Türkiye was in the same cluster with other countries except Hong Kong. Similar cluster results were obtained in both methods (Giray, 2013: 695).

In the study conducted by Ahmar et al. (2006), it was stated that one of the main problems of Indonesia is population and it was emphasized that dividing the provinces into clusters could be beneficial for the government. For this purpose, Indonesia's provinces were divided into clusters using the K-means method according to population density, school attendance rate, human development index and unemployment rates. Within the framework of the results obtained, the provinces of Indonesia were divided into 5 clusters, centered in South Sumatra, Lampung, DKI Jakarta, Central Java and West Kalimantan (Ahmar et al., 2018: 1-6).

4.Data and Statistical Application

The study's dataset consists of tax wedges data (2021 and 2024) from 37 OECD nations were obtained from the OECD database (excluding Colombia due to insufficient data). This data is published annually and shows the ratio between the taxes paid by an average single worker without children and the overall labor cost for the employer by the company.

4.1. Sigma Convergence

Table-1: Tax Wedge Convergence in OECD and Türkiye

Year	μ_-TR	Türkiye	σ_-TR	CV_-TR	Türkiye/ OECD_μ (%)
2000	37,10	40,36	11,60	0,31	8,80
2001	36,65	43,60	11,46	0,31	18,98
2002	36,55	42,48	11,22	0,31	16,24
2003	36,40	42,19	11,12	0,31	15,93
2004	36,46	42,76	11,20	0,31	17,26
2005	36,26	42,80	11,13	0,31	18,03
2006	36,21	42,69	11,05	0,31	17,89
2007	36,19	42,22	10,87	0,30	16,68
2008	35,79	38,72	10,96	0,31	8,19
2009	35,33	**36,74**	10,87	0,31	**3,99**
2010	35,38	**36,98**	10,59	0,30	**4,51**
2011	35,85	**37,03**	10,71	0,30	**3,27**
2012	35,98	**37,13**	10,69	0,30	**3,18**
2013	36,10	**37,36**	10,53	0,29	**3,50**
2014	36,09	38,09	10,44	0,29	5,53
2015	36,11	38,19	10,36	0,29	5,75
2016	36,05	38,24	10,13	0,28	6,08
2017	35,89	38,90	9,99	0,28	8,37
2018	35,74	39,24	9,92	0,28	9,79
2019	35,71	39,57	9,77	0,27	10,83
2020	35,48	39,47	9,61	0,27	11,24
2021	35,41	39,88	9,42	0,27	12,64
2022	35,59	38,16	9,21	0,26	7,23
2023	35,75	38,12	9,24	0,26	6,64
2024	35,78	39,04	9,33	0,26	9,11

Note: μ: Mean , CV: Coefficient of Variation, σ: Standard Deviation, -TR: Value Excludes Türkiye

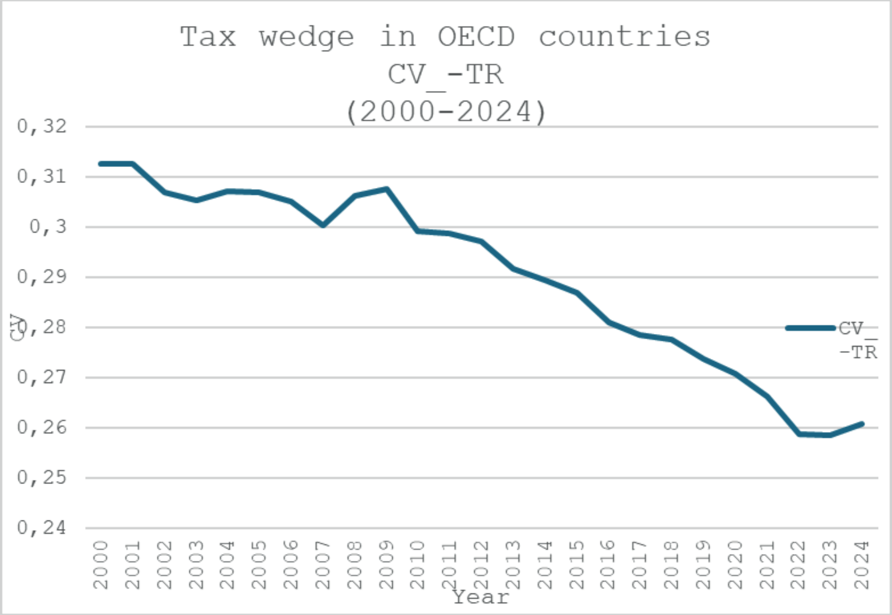
Source: Based on OECD database the authors' own calculations (See https://l24.im/sey23wB)

In order for σ-sigma convergence in the tax wedge among OECD nations, the standard deviation (σ) or the coefficient of variation (CV) measuring the tax wedge distribution must decrease over a period. It is observed from Graph 3 and Graph 4 that excluding Türkiye's data the σ value and the CV coefficient, which show the distribution of the tax wedge between OECD countries, have gradually decreased compared to 2000.

Graph 3. Standard Deviation of Tax Wedge in OECD Countries

Source: Created by the authors based on Table 2

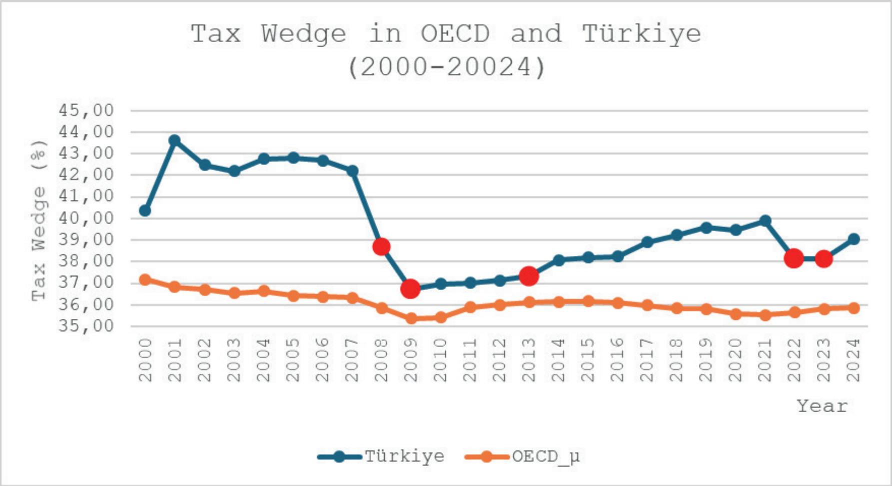
Graph 4. Coefficient Variation of Tax Wedge in OECD Countries



Source: Created by the authors based on Table 2

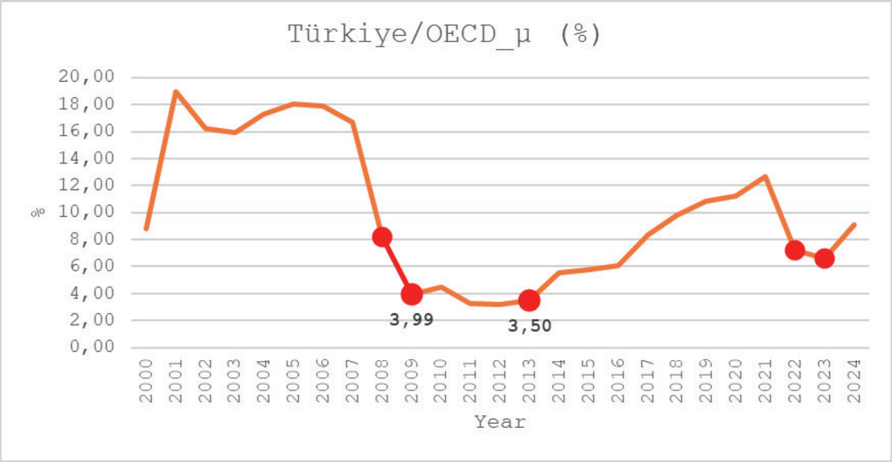
However, in Türkiye, the tax wedge showed a significant increase in 2001 compared to 2000 and then decreased until 2013 (see Table 2 and Graph 5). We can also see that the Türkiye's tax wedge ratio has decreased between the period 2008 and 2013. It is observed from the graph that the Türkiye's tax wedge ratio has increased since 2014 but it dropped in 2022 and 2023 when there was mass covid 19 related pandemic effects.

Graph 5. Tax Wedge in Türkiye and OECD



Source: Created by the authors based on Table 2.

Graph 6. Ratio of Türkiye's Tax Wedge to OECD average



Source: Created by the authors based on Table 2.

On the other hand, when compared with the OECD averages, it is seen that the deviation of Türkiye's tax wedge from OECD average has decreased from 2008 until 2013. We could also infer from Graph 6 that the Türkiye's tax wedge ratio started to converge to the OECD average strikingly from 2008 to 2013. However, it has again diverged from the OECD average since 2014 even though there were falls in 2022 and 2023 (see Graph 6).

4.2. Elbow Method

In the K-means method, the sum of squared errors for each ***k*** value was calculated with the Python programming language as it helps determine the number of clusters appropriate for the data set. The table below shows the sum of the squared errors calculated for each **k** value, based on data from 2021 and 2024 respectively.

2021	
1	3200,11
2	1097,65
3	641,31
4	404,13
5	194,06
6	100,45
7	79,01
8	59,11
9	39,65

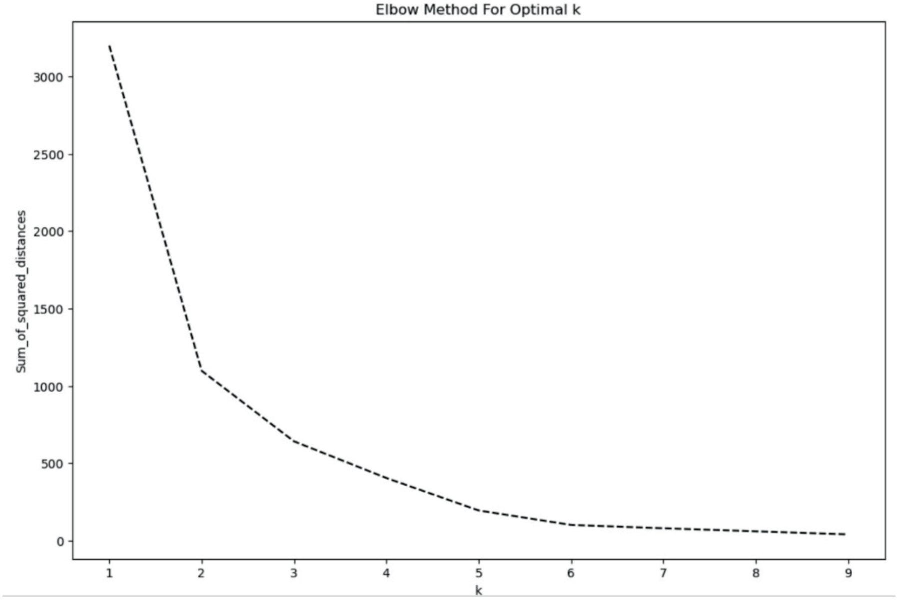
2024	
1	3098,50
2	1059,29
3	685,79
4	342,88
5	146,27
6	77,21
7	46,86
8	36,14
9	27,28

Source: Created by the authors based on the obtained data.

After calculating the sum of squared errors for each cluster, the values were recorded in tables. The elbow points were determined on the resulting tables. As a result of the examinations, it was seen that the ideal number of clusters was 2, both for 2021 and 2024.[4]

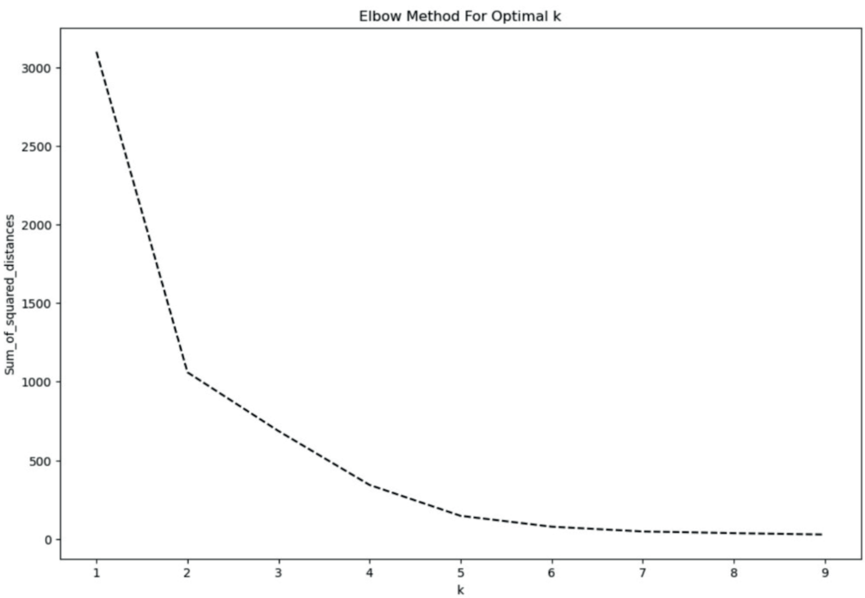
4 We have done the same analysis for 2019 to compare before covid period, but the result was not much different from the current graph.

Graph 7. Defining the Elbow Point (2021 data)



Source: Created by the authors based on the obtained data.

Graph 8. Defining the Elbow Point (2024 data)



Source: Created by the authors based on the obtained data.

4.3. K-means Method

After determining the appropriate and meaningful number of clusters, the data sets were transferred to the SPSS program and the K-means clustering algorithm was run. The application yielded the following cluster centers:

2021

Cluster	1	2
Cluster Center	23,86	40,87

2024

Cluster	1	2
Cluster Center	25,89	41,08

The classification of tax wedge 2021 data for OECD nations utilizing the K-means clustering method resulted in 13 nations in cluster 1, 24 in cluster 2. Analysis using 2024 data reveals similar results. Table 2 below lists the nations associated with each cluster (similar for both years).

Table-2: Classification of Tax Wedge Data of OECD Nations by K-Means Clustering Method

Cluster 1	**Cluster 2**	
Australia	Austria	Luxembourg
Canada	Belgium	Netherlands
Chile	Czechia	Norway
Costa Rica	Denmark	Poland
Iceland	Estonia	Portugal
Israel	Finland	Slovak Republic
Japan	France	Slovenia
Korea	Germany	Spain
Mexico	Greece	Sweden
New Zealand	Hungary	Türkiye
Switzerland	Ireland	
United Kingdom	Italy	
United States	Latvia	
	Lithuania	

5.Conclusion

The impact of taxes on labor supply has been a subject of extensive discussion and research for many years. Because it is known that an increase or decrease in wages has an effect on work effort. Taxes and tax-related financial obligations levy on wages also have a special importance in terms of work effort as they affect wages, similarly to wage increases and decreases.

If tax and tax-like financial liabilities are at a low level, employees may prefer to work rather than not work, as employees will earn more income. On the other hand, the high tax and tax-like financial liabilities imposed on wages may cause employees in these countries to think that working is not worth it and therefore prefer leisure time instead of working.

The sigma convergence evidence reveals that tax wedge differences among OECD countries have decreased in the long run, and taxation structures on wages have converged over time. However, Türkiye appears to have only a limited share of this general trend. The convergence trend observed in Turkey towards the OECD average during the 2008–2013 period can be attributed to the policy adjustments implemented during that period. However, the emergence of a divergence trend in tax wedge indicators after 2014 indicates that the convergence process has not been sustained. In this context, the sigma convergence results suggest that the tax wedge in Turkey has not followed a stable course within a long-term convergence process with OECD countries but instead exhibits periodic fluctuations. We can also infer that policies implemented to ease the negative effects of Covid-19 pandemic have resulted in tax wedge decrease in 2022 and 2023.

The aim of the cluster analysis is to determine Türkiye's position among OECD countries. For this purpose, the K-means method was used. To implement the K-means method, there must be a priori knowledge about the number of clusters or a reasonable decision of the researcher. Accordingly, the Elbow method was employed to identify the appropriate number of clusters. The findings indicated that two clusters provided the optimal classification, and the K-means analysis was conducted based on this determination. The results reveal that OECD countries are grouped into two distinct clusters with respect to tax wedge levels. Upon overall evaluation, it was found that Türkiye's tax wedge was more similar to EU countries.

The clustering results suggest that the tax wedge is not a random variable among countries, but rather a characteristic reflecting their approach to the labor market. The cluster of countries with a low tax wedge may represents an approach that incentivizes labor and prioritizes net wages, while the cluster with a high tax wedge, which includes Türkiye, may points to a tax architecture where social security financing is predominantly provided through wages. On the other hand, analyzing the tax frameworks of the nations in the study may facilitate more precise conclusions regarding the assessment of taxes and tax-related financial obligations on earnings. Because the tax system of a country can be categorized into two distinct types: direct and indirect taxes. While taxes imposed on wages, which are the income from labor, are classified as direct taxes, indirect taxes imposed on the prices of goods and services as a result of the spending of wages can cause decreases in the income of employees. This situation may cause the real burden on wages to differ. Therefore, analyzing both direct and indirect taxes on wages is crucial for a comprehensive understanding of the overall tax burden on employees. By considering the impact of both types of taxes, policymakers can make more informed decisions regarding tax policies that affect the income of workers.

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