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TÜRKİYE'DEKİ İLLERİN SANAYİ KAPASİTE RAPORU VERİLERİ ÜZERİNE BİR KÜMELEME ANALİZİ

Ahmet Bahadır ŞİMŞEK[1]

ÖZ

Bu çalışma, Türkiye Odalar ve Borsalar Birliği tarafından yıllık olarak yayınlanan Sanayi Kapasite Raporu'nda yer alan çalışanların illere göre dağılımına ilişkin verileri kullanarak Türkiye'nin ekonomik ve sanayi yapısını anlamaya odaklanmaktadır. Bu amaçla, K-ortalamalar kümeleme algoritması ile aşamalı bir kümeleme analizi gerçekleştirilmiştir. Analiz sonuçları, ülkenin farklı bölgelerindeki ekonomik ve sanayi merkezlerini tanımlamakta ve bu bölgeler arasındaki farklılıkları ortaya koymaktadır. Büyük şehirleri temsil eden ilk küme (C1) ekonomik ve endüstriyel merkezleri içerirken, ikinci küme (C2) bölgesel ekonomik merkezleri ve endüstriyel üretimde önemli rol oynayan şehirleri içermektedir. Üçüncü küme (C3) orta ölçekli şehirleri içerirken, dördüncü ve beşinci kümeler (C4 ve C5) genellikle kırsal ve daha az gelişmiş bölgeleri temsil etmektedir. Bulgular, Türkiye'nin farklı bölgelerindeki ekonomik ve endüstriyel yapıların belirlenmesine ve anlaşılmasına yardımcı olmaktadır. Bu da bölgesel kalkınma politikalarının ve ekonomik stratejilerin daha etkin bir şekilde formüle edilmesine olanak sağlamaktadır. Örneğin, C1 ve C2 kümesindeki illerde inovasyon ve teknolojiye dayalı ekonomik büyümeyi teşvik edecek, C3, C4 ve C5 kümesindeki illerde ise tarımsal ve kırsal kalkınmayı vurgulayacak politikalar uygulanabilir. Ayrıca bu analiz, yatırım ve kaynakların daha dengeli bir şekilde dağıtılmasını sağlayarak bölgeler arasındaki ekonomik ve sosyal dengesizliklerin azaltılmasına yardımcı olabilir. Bu çalışma, Türkiye'nin sanayi ve işgücü yapısının kapsamlı bir analizini sunarak, bölgesel kalkınma ve ekonomik büyüme için stratejik planlamaya katkıda bulunmaktadır.

Anahtar Kelimeler: *Sanayi Kapasite Raporu, Kümelenme Analizi, Bölgesel Kalkınma, Ekonomik Stratejiler*

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A CLUSTERING ANALYSIS ON INDUSTRIAL CAPACITY REPORT DATA OF PROVINCES IN TÜRKİYE

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ABSTRACT

This study focuses on understanding the economic and industrial structure of Türkiye by using the data on the distribution of employees by provinces in the annual Industrial Capacity Report published by the Union of Chambers and Commodity Exchanges of Türkiye. For this purpose, a stepwise cluster analysis is performed with the K-means clustering algorithm. The results of the analysis identify economic and industrial centers in different regions of the country and reveal the differences between these regions. The first cluster (C1), representing large cities, includes economic and industrial centers, while the second cluster (C2) includes regional economic centers and cities that play an important role in industrial production. The third cluster (C3) includes medium-sized cities, while the fourth and fifth clusters (C4 and C5) generally represent rural and less developed regions. The findings help to identify and understand the economic and industrial structures in different regions of Türkiye. This, in turn, allows for more effective formulation of regional development policies and economic strategies. For example, policies can be implemented in provinces in cluster C1 and C2 to promote innovation and technology-based economic growth, and in provinces in cluster C3, C4 and C5 to emphasize agricultural and rural development. Moreover, this analysis can help reduce economic and social imbalances across regions by ensuring a more balanced allocation of investment and resources. By providing a comprehensive analysis of Türkiye's industrial and labor force structure, this study contributes to strategic planning for regional development and economic growth.

Keywords: *Industrial Capacity Report, Cluster Analysis, Regional Development, Economic Strategies*

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1. INTRODUCTION

Industry, as a fundamental pillar in the global economy, forms the building block of modern societies (Regnerova et al., 2021). Economic growth, job creation and innovation are the main contributions of industry (Audretsch & Klepper, 2000). The industrial sector adds value by processing raw materials and thus contributes significantly to the increase in national income (Fuchs et al., 2022). With globalization, the role of industry has expanded further, strengthening the links between world economies through international trade and investments. While this process has the potential to increase the economic welfare of countries, it has also increased cooperation and economic interdependence across the world by promoting integration into global supply chains.

Industry is the key to development, especially for developing economies (Jawad et al., 2019). Industrialization accelerates the economic transformation of these countries, creates high-income jobs and generally raises living standards. Industry has a central role in the economic transformation of Türkiye, a developing country, and acts as a catalyst for the development (Karaalp-Orhana, 2019). With Türkiye's strategic location, young and dynamic labor force, rich natural resources and a strong industrial infrastructure, the industrial sector has the potential to increase its competitiveness not only in the domestic market but also in the international arena (Adıgüzel, 2022). Industry is also the cornerstone of employment and economic growth in Türkiye (Sarıdoğan, 2020). It directly supports economic development through expansion of production capacity, production of high value-added products and increase in exports. Moreover, the industrial sector contributes significantly to the technological progress of the country through technology transfer and innovation capacity. Türkiye's industrialization process occupies a central place in national development plans (Babayiğit Sunay, 2023). This process promotes the integration of local industries into global supply chains and supports the objectives of increasing economic diversification and reducing external dependence. In this framework, industrial development can help Türkiye to move out of the middle-income trap and become a high-income country.

Capacity reports are an issue from TOBB (Türkiye's Commodity Chambers and Commodity Exchange Union) for mapping out Türkiye's industrial output and reaching the economic and strategic plans and programs. Capacity report is an approved document that presents a production capacity of all public and private sector organizations who are involved in the production. The reports contain information such as annual production capacities, machinery park, the raw materials used, the capacity calculations, capital and employment info and contact details of the companies. For Türkiye, these crucial reports educate all levels of economic decision making starting from industrial policies planning. These reports disclose the country's industrial system, production assets, technical platforms and structure of the countrywide spheres. Some of the important roles and benefits of these reports for Türkiye can be summarized as follows:

1- Economic Planning and Strategy Development: Industrial capacity reports provide an objective analysis of the current state of Türkiye's industrial sector. This information allows the government and the private sector to develop informed strategies in areas such as investment decisions, capacity expansion, technology investments and workforce planning.
2- Investment Incentives and Resource Allocation: Industrial capacity reports reveal the regional distribution of industrial infrastructure, which helps the government to direct investment incentives and resources more effectively. They contribute to reducing regional development imbalances by encouraging industrialization, especially in developing or underdeveloped regions.
3- Sectoral Analysis and Policy Making: The reports identify the performance and capacities of various industrial sectors. This information is used to inform policy-making on a sectoral basis, for example, in determining which sectors should be given more support or which areas should be regulated.
4- Employment Policies: Capacity reports can also be used in guiding labor force planning and training policies. Employment data such as the number of engineers, technicians, craftsmen and workers on provincial and sectoral basis can be effective in arranging vocational training programs and university departments according to the needs.
5- Competitiveness and Foreign Markets: In Türkiye's efforts to increase its international competitiveness, data in industrial capacity reports show which products and sectors have export potential. In line with this information, export incentives and international marketing strategies can be determined.
6- Sustainable Development: The reports also offer the possibility to assess the sustainability of the industry in terms of energy consumption, raw material utilization and environmental impacts. This can provide guidance on investing in green technologies and shaping environmental sustainability policies.

TOBB aims to disseminate the most recent and more detailed information on the state and developments of the industrial sector in Türkiye, through its monthly bulletin reports, on the industrial capacity. The transparent and up-to-date information provided through these bulletins is an important source of data for the business world, investors, policy makers and the public. Through provisions of analyses on economics and sectors, they serve as a tool of tracking economic fluctuations, growth rates and sectoral growth by time. Furthermore, these bulletins are instrumental both as a source of knowledge and in decision-making to the support of long-term plans and investment decisions. Investors obtain a valuable advantage through the consistent reporting about the manufacturing sector of Türkiye. The information provided helps them to decide whether a particular sector is growing and whether it would be advisable to invest in a particular region of the country. The bulletins as well as other sources of statistical data boost the performance of firms and government agencies to adjust rapidly to changing market conditions via identifying industrial backwardness and making forecasts. In terms of international competitiveness, TOBB's bulletins also provide an important platform to showcase Türkiye's industrial capacities and competitive position internationally.

In addition to the monthly bulletins, TOBB also produces the Annual Industrial Capacity Reports. The annual report as well shares the proportion of employees by province. The sharing of the statistics in terms of the engineer, technician, craftsman, worker, and administrative personnel in different provinces, which constitute a total of 81 province of Türkiye, would provide a detailed analysis on the industrial workforce structure and the regional distribution in the country. This data has, therefore, become very instrumental for policymakers and investors when drawing long-term strategic plans and predetermining where to allocate resources. For instance, studying the regional development discrepancies, shows how regional development policies are designed to be more useful. In addition, it helps in personnel planning and gives policy directives for education for the labor force. Therefore, these statistics will become a fundamental tool to get a better understanding and management of industrial sector in Türkiye, decrease inter-regional imbalances and utilize economic potential optimally.

This analysis includes a stepwise clustering in which the distribution of engineers, technicians, craftsmen, laborers and administrative personnel across the 81 provinces is utilized in the Industrial Capacity Report for 2023. This analysis, in fact, is a determining factor in formulating a coherent picture of the country and what regions are focused on the industrialization process. It helps to identify the special interests and opportunities of each of the groups as well as to show provinces that have similar features. Therefore, it enables the government to carry out more productively policy making, resources allocation and development plans. More importantly, aligning education, employment and investment policies to those distinct to a region enables a more even growth of the economy as well as offers an effective solution for reducing the gap in the regional development disparities. Stepwise clustering analysis is in a way that it helps in bringing economic strategies of Türkiye to the sectors of trade and labor force planning, through the joint assessment.

2. RELATED STUDIES

This section deals with the existing literature on the issues that form the basis of the study under sub-headings.

2.1. Industrial Capacity and Economic Development

Industrial capacity has a significant impact on economic development. Studies in the literature show that industry is strongly associated with factors such as economic growth, employment growth, raising income level and technological innovation. Aydin (2018) and Karagöl et al. (2007) examined this relationship using different methods in their studies on the relationship between industrial energy consumption and economic growth and revealed how energy consumption affects economic growth. In addition, studies analyzing the effects of exports and imports on economic growth (Saraç, 2013), research on the relationship between economic growth and women's employment (Pata, 2018), studies analyzing the relationship between economic freedom and tourism and economic growth (Gövdeli, 2018) offers different perspectives such as.

There are studies conducted to understand the relationship between industrial capacity and macroeconomic variables. Şit & Karadağ (2018) examined the relationship between public expenditures and economic growth in Türkiye, Kaya & Çadırcı (2022) examined the relationship between globalization and economic growth, Sağdiç et al. (2020) examined the relationship between foreign direct investment, tax revenues and economic growth from various perspectives.

Research to understand the effects of industrial capacity on economic development has analyzed in detail the contribution of employment in different sectors to economic growth, the impact of energy consumption on growth, the effects of foreign trade on growth and the relationship with other macroeconomic variables.

2.2. Labor Force Distribution and Regional Differences

In order to investigate the impact of labor force distribution on economic structure in various regions of Türkiye, it is crucial to take into account regional development theories, labor market dynamics and studies that examine the effects of labor force distribution on industrial production and local economies. Cengiz (2020) discussed the significance and whatsoever responsibility that technology progress exerts on job creation in Türkiye. Emphasis of the study on the fact that there is a negative relationship with unemployment/R&D expenditure shows the importance of technological development in that relationship.

Also, Ünlü (2022) investigated the effects of Information and Communication Technologies (ICT) on labor productivity and employment in Türkiye using ARDL bounds test approach and Toda-Yamamoto causality test on data from 2001 to 2020. ICT use is found to have statistically significant, albeit small, negative long-term effects on both labor productivity and employment. Furthermore, a bidirectional causality relationship was identified between ICT use and labor productivity and employment and labor productivity, highlighting complex interactions between these variables. Despite the negative impacts, the study suggests that the negative effects of ICT on labor productivity and employment can be mitigated over time through adequate complementary investments and the development of new business sectors.

Also, Görenel (2015) investigated the unsuccessful processes around the European Monetary Union and the Greek debt crisis. This investigation spotlights the way in which regional disparities and economic stability are influenced by economic structures within unions and that is why it is vital to review the impact of labor scattering on economic outcomes.

The research studies synopsis shows that labor distribution importantly reshapes the overall economic structure of the region. Technological breakthroughs, and macroeconomic scenarios form the confluence that determines the labor force distribution and how it is utilized in different regions, thus the economic growth models get affected.

2.3. Global Trends and Türkiye's Position

In order to analyses Türkiye's role in the global economy, it is crucial to consider various elements such as international trade, strategic advantages and challenges. Türkiye's position in the global economic environment is influenced by factors such as international competitiveness, strategic partnerships.

Neyapti et al. (2007) investigated the effects of the customs Union Agreement between Europe and Türkiye on Türkiye's trade behavior, and report positive impact on trade and responsiveness to key variables. Karaalp (2010) emphasized the role of comparative advantage in various sectors in this study on Türkiye's success in Eurasia. This comparative advantage analysis gives the idea of Türkiye's importance and deterioration in some sectors compared to its regional rivals.

Furthermore, the study by Kanellopoulos & Galanis (2022) on Türkiye's energy strategic planning in the Eastern Mediterranean stressed the significance of business planning, problems and measures in the energy sector. Energy plane is a key for Türkiye's economic development and foreign relations; hence, energy planning is inevitable for long-term sustenance.

Türkiye's position in the global economy is shaped by trade agreements, comparative advantages, and energy planning. By taking these factors into account, Türkiye can increase its competitiveness, overcome challenges and capitalize on strategic opportunities in the international arena.

3. METHOD

In this study, K-means algorithm was applied to the clustering technique. The K-means clustering algorithm is a very popular clustering technique because it can be applied to almost any data set and is relatively simple and computationally efficient. Nevertheless, the K-means clustering algorithm may present one of the biggest obstacles which is related to the sensitivity of initial states that result in the final solution to be reached at one of the local optima (Karaboga & Ozturk, 2011). In order to mitigate the difficulties associated with the K-means method, many scholars have proposed changes that would help to improve its efficiency

and effectiveness (Celebi et al., 2013; Fahim et al., 2006; Kanungo et al., 2002). Pokharel et al. (2021) used the K-means algorithm and its variations to compare their performances in the clustering tasks. While the k-means clustering algorithm is a fundamental method in cluster analysis, ongoing research aims to improve its performance, address its limitations, and explore its applications in various domains.

K-means clustering algorithm is frequently preferred in various fields. Wahyuni et al. (2023) used the K-means algorithm to predict electoral clusters based on voter patterns and aims to reduce budgeting risks by identifying areas with high abstention rates. Muttaqin (2022) used K-means cluster analysis to classify Sumatra's districts and cities into high, medium and low areas according to Human Development Index indicators. Wang (2023) utilized K-means cluster analysis to create a student health monitoring system that aids physical health planning based on biochemical data. Zamani et al. (2023) analyzed public service satisfaction using the K-means Clustering algorithm to categories data into different clusters based on similarities and differences. Fa'rifah & Pramesti (2022) used K-mean cluster analysis to group East Java districts according to overarching economic development indicators and to identify clusters with above or below average economic growth. Chi (2021) applied K-means clustering to analyses student achievement data, aid project grouping, assist personalized teaching and estimate course importance for educational improvements. Muttaqin & Zulkarnain (2020) used K-mean cluster analysis to classify Indonesia's districts/cities according to the Human Development Index and identify high, medium and low areas with different characteristics.

The stages of the K-means algorithm with an iterative process are as follows.

1- An initial clustering is formed by randomly determining k cluster centers from the dataset.
$C = \{c_1, c_2, \dots, c_k\}$ consists of k randomly selected cluster centers.
Each c_i center represents a data point. $D = \{x_1, x_2, \dots, x_n\}$ is the set of data points.

2- For each data point, the distances from all cluster centers are calculated and the data is assigned to the cluster which is closer to the cluster center.
For each data point x_i, assign it to the nearest cluster center. If x_i is assigned to c_j, then $x_i \in S_j$.
$S_j = \{x_i : \|x_i - c_j\| \leq \|x_i - c_l\| \; \forall \, l, 1 \leq l \leq k\}$ where $\|\square\|$ represents the Euclidean norm.

3- The new cluster centers are recalculated with the average of all data points assigned to clusters.

$$c_j = \frac{1}{|S_j|} \sum_{x_i \in S_j} x_i$$

4- If the center points of the formed clusters are the same as the previous center points, the process is terminated, if not, the process is repeated over the new cluster centers from step 2.

The quality of clustering is assessed by the internal consistency of clusters and the distinction between different clusters. As a result of a good clustering, elements in the same cluster should be similar to each other while elements in different clusters should be different from each other. In this study, clustering quality is evaluated with the Silhouette Score. For each data point, the Silhouette Score measures the difference between the similarity of that point to other points in its cluster and the similarity of that point to points in the nearest cluster. It takes values between -1 and +1. Values close to +1 indicate that the data points are well placed in their clusters and that there is good separation between different clusters. The analysis is completed with the number of clusters with the highest Silhouette Score among the clusters with different k values.

In some cases, even clustering with a high Silhouette score may not be useful for the decision maker. In a clustering analysis of a data set, let the Silhouette score have a high value when the number of clusters is 2 and there is a large size difference between these two clusters. This situation has various pros and cons for the decision maker. A high Silhouette value implies that the clustering algorithm is working well generally. This shows decision makers that there's a certain pattern in the dataset and the resulting clusters are good enough for analytical purposes. On the other hand, the different size between clusters may induce some issues like imbalance and heterogeneity between two small and large clusters. Thus, making it hard for the decision makers to make conclusions when scrutinizing the outcome. This is because small cluster are usually more distinct and meaningful, whilst large cluster tend to be broader and heterogeneous, so some useful findings may not be discovered. Sub-clustering can be used to reveal patterns hidden in the large cluster without manipulating the data set. Also it can be used to better understand the intra-cluster structure and to identify more homogeneous sub-groups by dividing the large cluster into smaller sub-clusters by re-clustering the elements in the large cluster.

The sub-clustering approach involves separating large clusters into smaller clusters. This approach is used in several disciplines for instance in computational biology, computer science and data mining. For instance, Louwen et al. (2023) highlighted the need for scalable computational methodologies for sub-cluster detection, indicating the challenges in dealing with large datasets. Similarly, Saeed et al. (2020) illustrated a multi-phase clustering method that starts with the generation of sub-corpuses and then clustering in order to demonstrate sub-clustering application in text document summarization. Furthermore, Kurasawa et al. (2009) discussed the division of large clusters into smaller regions controlled by pivots, emphasizing the role of sub-clustering in similarity search indexes. Kim et al. (2012) evaluated the ability of repeated clustering to increase the discrimination power in identifying TDLP (Typical Daily Load Profile) of each cluster. Jiao et al. (2016) focused on distributed clustering, which involves dividing large-scale datasets into small chunks and then aggregating the results, showcasing the practical implementation of sub-clustering in handling large datasets. The sub-clustering approach has been utilized in various domains to address the challenges posed by large clusters and datasets, demonstrating its versatility and applicability in different research and application areas.

It is seen that researchers call the sub-clustering approach different names such as multi-stage clustering (Saeed et al., 2020), repeated clustering (Kim et al., 2012). In this study, we have named the sub-clustering approach as stepwise clustering in order to be easily understood by the readers.

3.1. Data Set

In the annual Industrial Capacity Report published by TOBB for the year 2023, the number of companies with approved capacity reports in the provinces and the total number of engineers, technicians, craftsmen, workers and administrative employees working in these companies are shown in Table 1. In the study, clustering analysis was applied without any additional processing of the data set.

Table 1 Data Set

Province	Number of Companies	Engineer	Technician	Craftsman	Laborer	Administrative
Adana	2083	3678	3298	6256	60535	8930
Adıyaman	412	225	250	711	15101	595
Afyon	1073	743	818	1572	21338	2323
Ağrı	90	93	70	335	3422	245
Aksaray	370	754	689	892	13296	1351
Amasya	260	411	297	866	11101	956
Ankara	6672	38842	28169	18510	112623	31288
Antalya	1877	2896	2137	4577	33343	6388
Ardahan	40	9	48	79	350	44
Artvin	120	160	185	337	2348	225
Aydın	965	1695	1794	2066	26680	3839
Balıkesir	1257	2685	2959	4017	38418	5199
Bartın	139	229	225	497	10097	636
Batman	475	161	226	1197	20344	805
Bayburt	18	15	16	25	223	21
Bilecik	350	1220	1277	1440	21698	2556
Bingöl	113	91	105	219	3899	158
Bitlis	163	42	62	496	6941	193
Bolu	354	820	1506	1039	20026	1659
Burdur	399	320	179	828	8398	851
Bursa	6508	16893	11634	18532	251213	38037
Çanakkale	464	982	1358	1059	16096	1465
Çankırı	119	360	588	510	10082	1054
Çorum	470	588	441	1776	14284	1762
Denizli	1876	2096	2398	4693	63102	9137
Diyarbakır	742	401	474	1517	19486	1677
Düzce	522	1188	1204	1858	27316	3404
Edirne	316	406	320	974	13624	1120
Elazığ	339	527	383	1381	8506	908
Erzincan	158	244	186	468	4053	474
Erzurum	187	225	176	637	4320	517
Eskişehir	986	4988	4421	4575	50243	6007

Table 1 Data Set

Province	Number of Companies	Engineer	Technician	Craftsman	Laborer	Administrative
Gaziantep	3299	2898	2824	7473	110323	12834
Giresun	238	269	408	553	8411	927
Gümüşhane	88	172	113	232	1679	265
Hakkari	39	47	21	122	488	59
Hatay	794	1399	2271	2716	22329	3644
Iğdır	56	25	21	100	899	67
Isparta	405	511	477	786	9995	1113
İstanbul	26915	42871	37873	42718	552151	108153
İzmir	6167	15566	15335	16160	179346	36853
Kahramanmaraş	868	1092	1813	3998	47165	3652
Karabük	188	505	234	481	9785	1217
Karaman	370	559	505	1759	13698	1442
Kars	91	55	75	270	1100	170
Kastamonu	349	380	335	882	11427	903
Kayseri	2160	3023	1813	5016	71086	9119
Kırıkkale	174	455	297	352	5709	674
Kırklareli	461	1182	1328	1494	27507	3776
Kırşehir	140	122	78	222	7347	318
Kilis	112	108	95	308	3680	405
Kocaeli	3704	16345	13978	15665	157336	38962
Konya	4086	4638	3237	7729	73646	13181
Kütahya	548	1444	1404	3803	28332	2514
Malatya	646	746	563	2151	28866	1969
Manisa	1961	6001	5251	7635	97825	12834
Mardin	430	213	164	552	10982	768
Mersin	1622	2250	2191	4525	39053	6080
Muğla	771	854	1033	1575	13104	1817
Muş	115	85	58	297	3845	310
Nevşehir	306	183	157	447	5510	655
Niğde	261	391	271	681	7088	910
Ordu	409	393	323	1191	16905	1620
Osmaniye	306	505	548	1031	11688	1468
Rize	292	456	399	944	12562	1056
Sakarya	1421	4252	3306	5063	62326	8204
Samsun	823	1162	1660	2093	25115	3269
Siirt	80	113	123	535	1936	136
Sinop	185	84	138	401	6702	466
Sivas	364	705	780	1932	10468	1229
Şanlıurfa	1061	228	201	1435	26490	520
Şırnak	203	115	198	773	3525	137
Tekirdağ	2261	6800	7663	9900	131033	20023
Tokat	321	245	387	975	17162	951
Trabzon	514	491	893	1061	10587	1529
Tunceli	36	23	28	36	495	53
Uşak	679	411	501	999	22910	1335
Van	292	185	255	667	8056	632
Yalova	277	1747	887	1720	8190	2114
Yozgat	203	222	178	427	6667	604
Zonguldak	338	1364	716	3627	22839	3354

4. FINDINGS

In the implementation, the k-means algorithm was repeated with various values of k to decide the optimal number of clusters (k) and the Silhouette scores of the clusters were checked. The Silhouette score reached the highest value (0.873) when the number of clusters was k=2. In this setting, cluster 1 (C1) has 76 provinces and cluster 2 (C2) has 5 provinces (see Step 1 in Table 2). C2 includes large industrialized cities in Türkiye. The fact that this cluster is formed is not surprising and easy to interpret and make sense of.

However, it is also clear that there is a heterogeneous structure in the 76 provinces in cluster C1. C1 contains important patterns that are meaningful for the research but still hidden.

To overcome the challenges caused by the size difference between clusters mentioned in the method section, the clustering process was repeated to identify the sub-clusters of the large cluster C1. And it continued step by step until homogeneous clusters were obtained. This clustering sub-clustering process, the optimal number of clusters, Silhouette score and clusters at each step are shown in Table 2. The combined clustering, also shown in Table 2, was formed by joining together the clusters that split at each step. This combined clustering is a more meaningful and interpretable finding for the decision maker.

Table 2 Clustering Results

Silhouette Score	0,873	0,744	0,558	0,465	
Number of Clusters	2	2	2	2	
C1	76	64	49	24	
C2	5	12	15	25	
			Clusters		
Province	**Step 1**	**Step 2**	**Step 3**	**Step 4**	**Combined Clustering**
Ankara	C2	-	-	-	C1
Bursa	C2	-	-	-	C1
İstanbul	C2	-	-	-	C1
İzmir	C2	-	-	-	C1
Kocaeli	C2	-	-	-	C1
Adana	C1	C2	-	-	C2
Antalya	C1	C2	-	-	C2
Balıkesir	C1	C2	-	-	C2
Denizli	C1	C2	-	-	C2
Eskişehir	C1	C2	-	-	C2
Gaziantep	C1	C2	-	-	C2
Kayseri	C1	C2	-	-	C2
Konya	C1	C2	-	-	C2
Manisa	C1	C2	-	-	C2
Mersin	C1	C2	-	-	C2
Sakarya	C1	C2	-	-	C2
Tekirdağ	C1	C2	-	-	C2
Afyon	C1	C1	C2	-	C3
Aydın	C1	C1	C2	-	C3
Bilecik	C1	C1	C2	-	C3
Bolu	C1	C1	C2	-	C3
Çanakkale	C1	C1	C2	-	C3
Düzce	C1	C1	C2	-	C3
Hatay	C1	C1	C2	-	C3
Kahramanmaraş	C1	C1	C2	-	C3
Kırklareli	C1	C1	C2	-	C3
Kütahya	C1	C1	C2	-	C3
Malatya	C1	C1	C2	-	C3
Muğla	C1	C1	C2	-	C3
Samsun	C1	C1	C2	-	C3
Yalova	C1	C1	C2	-	C3
Zonguldak	C1	C1	C2	-	C3
Adıyaman	C1	C1	C1	C2	C4
Aksaray	C1	C1	C1	C2	C4
Amasya	C1	C1	C1	C2	C4
Batman	C1	C1	C1	C2	C4
Burdur	C1	C1	C1	C2	C4
Çankırı	C1	C1	C1	C2	C4
Çorum	C1	C1	C1	C2	C4
Diyarbakır	C1	C1	C1	C2	C4
Edirne	C1	C1	C1	C2	C4
Elazığ	C1	C1	C1	C2	C4
Giresun	C1	C1	C1	C2	C4

Isparta	C1	C1	C1	C2	C4
Karabük	C1	C1	C1	C2	C4
Karaman	C1	C1	C1	C2	C4
Kastamonu	C1	C1	C1	C2	C4
Mardin	C1	C1	C1	C2	C4
Niğde	C1	C1	C1	C2	C4
Ordu	C1	C1	C1	C2	C4
Osmaniye	C1	C1	C1	C2	C4
Rize	C1	C1	C1	C2	C4
Sivas	C1	C1	C1	C2	C4
Şanlıurfa	C1	C1	C1	C2	C4
Tokat	C1	C1	C1	C2	C4
Trabzon	C1	C1	C1	C2	C4
Uşak	C1	C1	C1	C2	C4
Ağrı	C1	C1	C1	C1	C5
Ardahan	C1	C1	C1	C1	C5
Artvin	C1	C1	C1	C1	C5
Bartın	C1	C1	C1	C1	C5
Bayburt	C1	C1	C1	C1	C5
Bingöl	C1	C1	C1	C1	C5
Bitlis	C1	C1	C1	C1	C5
Erzincan	C1	C1	C1	C1	C5
Erzurum	C1	C1	C1	C1	C5
Gümüşhane	C1	C1	C1	C1	C5
Hakkari	C1	C1	C1	C1	C5
Iğdır	C1	C1	C1	C1	C5
Kars	C1	C1	C1	C1	C5
Kırıkkale	C1	C1	C1	C1	C5
Kırşehir	C1	C1	C1	C1	C5
Kilis	C1	C1	C1	C1	C5
Muş	C1	C1	C1	C1	C5
Nevşehir	C1	C1	C1	C1	C5
Siirt	C1	C1	C1	C1	C5
Sinop	C1	C1	C1	C1	C5
Şırnak	C1	C1	C1	C1	C5
Tunceli	C1	C1	C1	C1	C5
Van	C1	C1	C1	C1	C5
Yozgat	C1	C1	C1	C1	C5

Cluster of C2 in Step 1 (see Figure 1) indicates that they are placed at higher level than those in cluster C1. These provinces are generally large and developed provinces and play important roles in terms of industry, trade and economy. This cluster, which includes large metropolises such as Ankara, Bursa, Istanbul, Izmir and Kocaeli, reflects Türkiye's leading position in industrial production. The industrial facilities and large workforce are chiefly based in these provinces as they are an integral part of economic growth. In the same way, they are an attractive proposition to the investors as they have among others high educational levels and job opportunities in a multitude of sectors.

Figure 1 Map Representation of Step 1 Clustering

The provinces in cluster C2 in Step 2 (see Figure 2) are generally smaller and relatively less developed than the larger provinces in cluster C2 in Step 1. These provinces play a role as regional economic centres. Although they are smaller in scale than the provinces in cluster C2 in Step 1, they still play important economic roles. In particular, provinces such as Adana, Antalya, Balıkesir, Denizli, Eskişehir, Gaziantep, Kayseri, Konya, Manisa, Kayseri, Konya, Manisa and Mersin play an important role in sectors such as agriculture, tourism, textile, food and automotive. These provinces play a key role in promoting regional development and economic diversification.

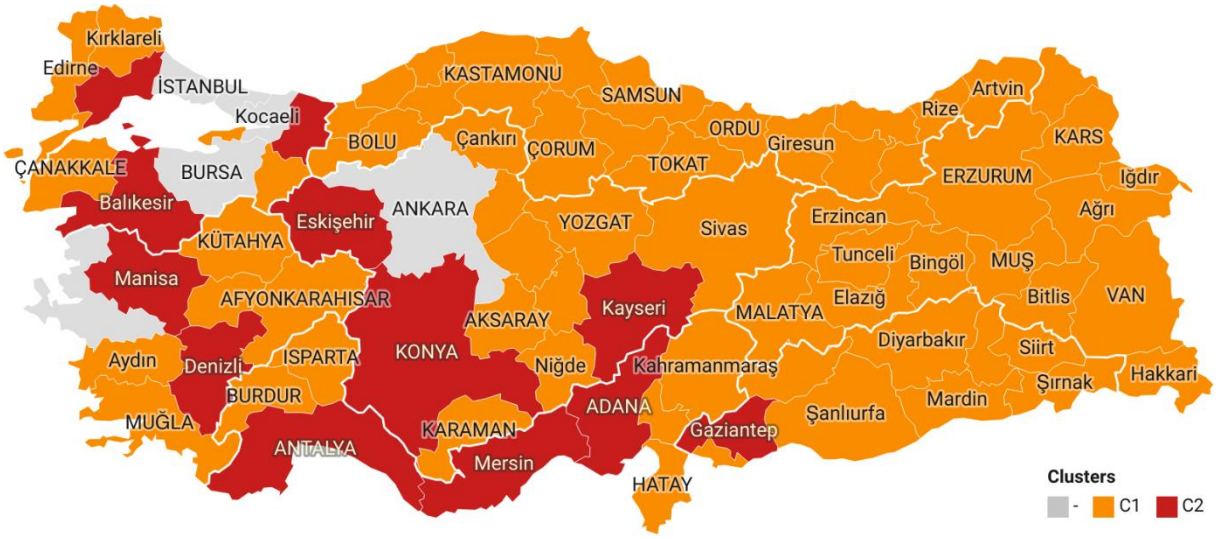

Figure 2 Map Representation of Step 2 Clustering

Provinces in cluster C2 in Step 3 (see Figure 3) have lower population and economic activity compared to provinces in Steps 1 and 2, but can still play an important role in a particular industry or sector. These provinces are often the ones that need to be supported for regional development and the promotion of economic diversification. They also play an important role for the planning and implementation of regional development policies, reflecting the economic and social structure in various regions of Türkiye.

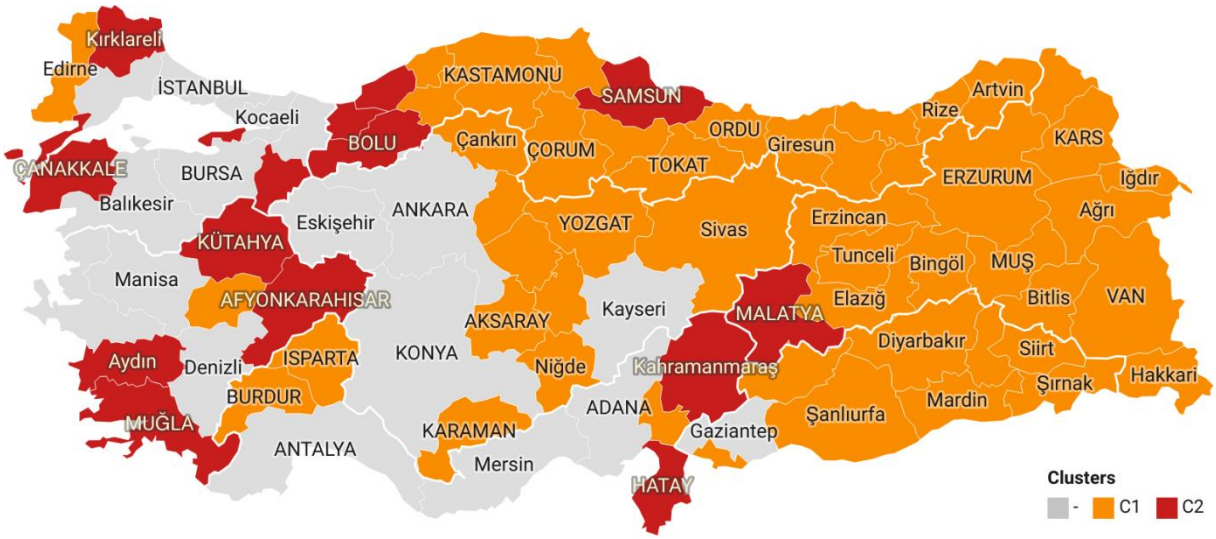

Figure 3 Map Representation of Step 3 Clustering

The provinces in group C1 which were identified in step 4 (see Figure 4) mostly are the provinces for which regional development and economic diversification are needed to be given much attention. These provinces might be the less developed economically and voiced their willingness to be helped to boost their development capability. The provinces in cluster C2 are relatively more developed and have diverse industries.

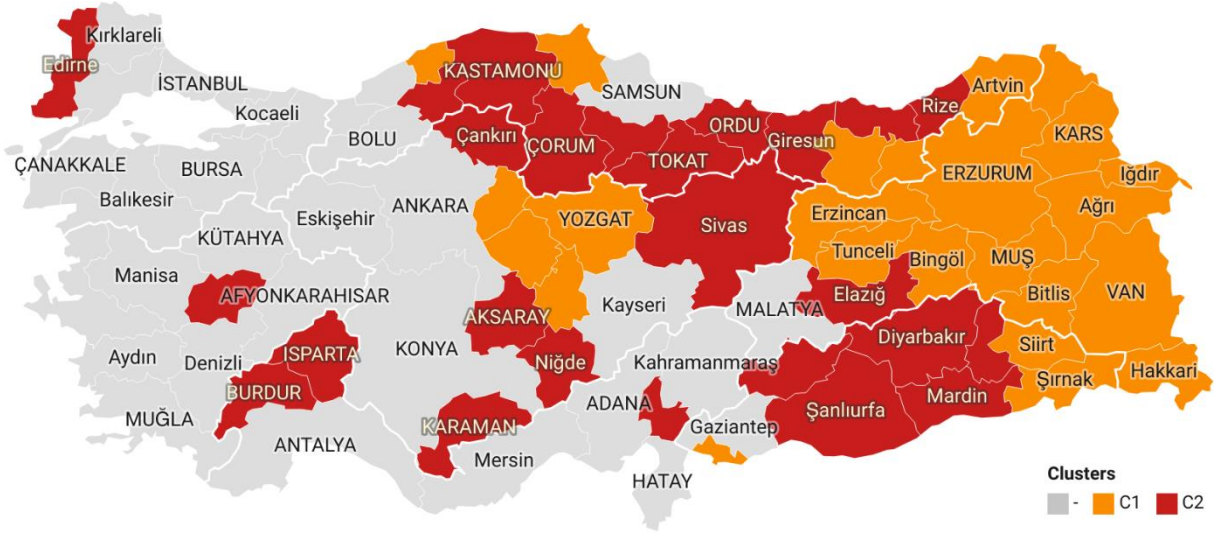

Figure 4 Map Representation of Step 4 Clustering

When the clusters in the steps are combined, the provinces in Türkiye can be divided into 5 homogenous clusters (C1, C2, C3, C4 and C5, see Figure 5). Managerial implications from combined clustering are discussed under the subtitle of policy making.

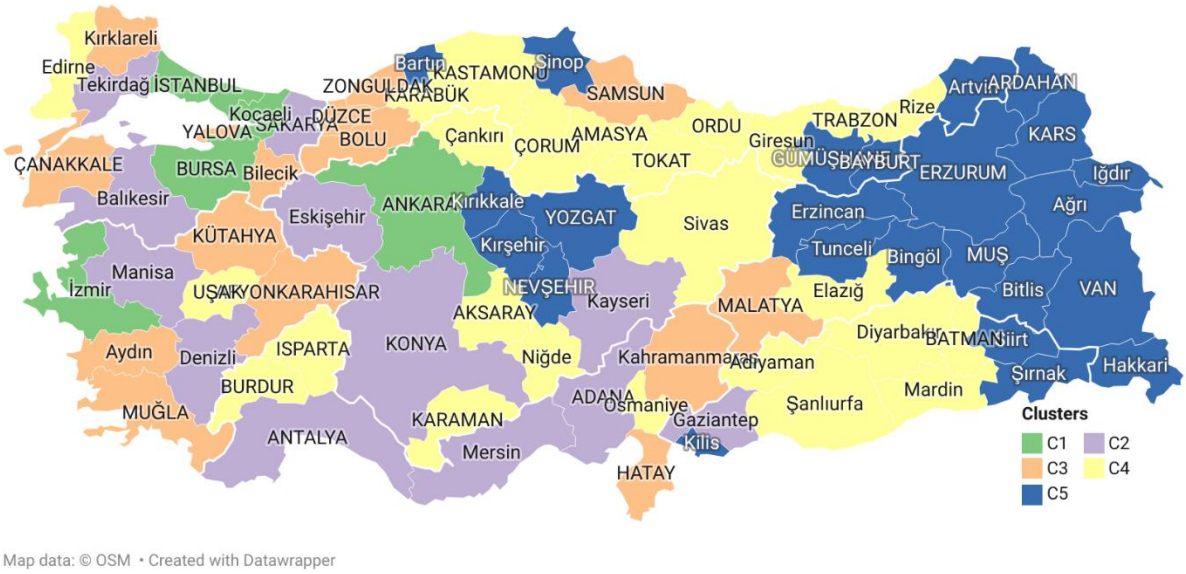

Figure 5 Map Representation of Combined Clustering

4.1. Policy Making

Türkiye has been facing many economic challenges in recent years, such as rising inflation, unemployment and exchange rate fluctuations. This situation makes it difficult for decision makers to develop regional development strategies and utilize their resources more effectively. The results of this research can be used to provide concrete recommendations to decision makers in this context:

Regional Investments: The results can be used to loosely indicate the priority in which the regions can be invested in based on the likely outcome. Cluster C1 provinces can invest their budgets on high technology, finance and education, which will help to tackle under development problems. Under the cluster C2, investments capable of enhancing the local industrial development and export potential can be taken to plan. Medium provinces in the cluster C3 may be improved by using investments to develop agriculture and tourism infrastructure. Clusters C4 and C5 can widen local tax base to invest in infrastructure and build the strong community engagement and employers with whom they collaborate.

Development Programs: As a result of the mentioned data end results are the programs which are created by the public authorities with the specific purpose to provide aid to definite regions. For the provinces in C1, programs such as the innovation and the entrepreneurship program can be established. Cluster C2 can involve a creation of tools to foster industrial clusters as well as help in accessing the external markets. For cluster C3, programs promoting rural development and supporting local firms can be devised for provinces. In the C4 and C5 clusters, regional development can be attained by investing in infrastructure and education programs.

Employment Policies: The findings can guide the hiring policies that the areas possessing different employment market needs demand. In the clusters C1 provinces the training programs can be developed in order to satisfy in regards of what a qualified labor force is needed for. In C2 cluster relations, the systems can be developed that are to enhance skills of the workers in the industrial sphere. In the provinces of cluster C3, accelerated programs of employment in agriculture and tourism may be built. The particular education and job retraining programs within C4 and C5 clusters should be built to strengthen the community's workforce.

Social Policies: The findings can be used to develop social policies to address regional inequalities and social problems. Social assistance programs and social development programs can be developed to address problems such as poverty and income inequality in clusters C3, C4 and C5.

The findings of this research are an important tool that can help Türkiye plan its socioeconomic development taking into account regional characteristics. Decision makers can work to realize a sustainable

and inclusive development model in different regions of Türkiye by taking these recommendations into consideration.

5. CONCLUSION

This research implies a stepwise cluster analysis done about 81 provinces of Türkiye to find out distribution of engineers, technicians, craftsmen, laborers and administrative personnel. In detail, the cluster analysis helps to see the main principles of economic structure of the country, define areas of competitive advantages and develop the policy in different regions.

The base on the cluster center results, cluster C1, which covers the metropolitan areas of Türkiye, comprised the country's main economic and industrial centers, while cluster C2 represents the regional economic centers and cities which participated in industrial production. In cluster C3 big cities are represented, while in clusters C4 and C5 mostly small cities or rural areas with developing region are shown.

This research contributes to a better understanding of the economic and industrial structure of different Turkish regions. As a result, such an approach would facilitate the designing of regional development policies as well as economic strategies. Specifically, innovation and technology-enabled regional economic development can be targeted in clusters C1 and C2, whereas the emphasis can be on agriculture and rural development in C3, C4 and C5. Moreover, this analysis will aid to cut down the economic and social differences among the regions by contributing a fair distribution of investment and resources.

It can be concluded that this research will give you a chance to strategize the planning for regional development and economic growth by giving you a comprehensive analysis of the Turkish industrial and labor force structure.

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ETHICAL CONSIDERATION

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to.

In this study, all the rules specified to be followed within the scope of "Higher Education Institutions Scientific Research and Publication Ethics Directive" were complied with. None of the actions specified under the title of "Actions Contrary to Scientific Research and Publication Ethics", which is the second part of the directive, were not carried out.

CONFLICT OF INTEREST

The authors declare no conflict of interest. The study did not provide support from any organization.

GENİŞLETİLMİŞ ÖZET

Sanayi sektörü, modern toplumların temel yapı taşı olarak ekonomik büyüme, istihdam yaratma ve yenilikçilik gibi önemli katkılar sağlar. Küreselleşme ile birlikte, sanayinin rolü daha da genişlemiş ve uluslararası ticaret ve yatırımlar aracılığıyla dünya ekonomileri arasındaki bağlantıları güçlendirmiştir. Bu süreç, ülkelerin ekonomik refahını artırma potansiyeline sahipken, aynı zamanda küresel tedarik zincirlerine entegrasyonu teşvik ederek dünya genelinde işbirliği ve ekonomik bağımlılığı artırmıştır. Özellikle gelişmekte olan ekonomiler için, sanayi kalkınmanın anahtarıdır. Sanayileşme, ekonomik dönüşümü hızlandırır, yüksek gelirli işler yaratır ve genel olarak yaşam standartlarını yükseltir. Türkiye gibi gelişmekte olan ülkeler için sanayi, ekonomik dönüşümün merkezi bir unsuru ve katalizörüdür. Türkiye'nin stratejik konumu, genç ve dinamik işgücü, zengin doğal kaynaklar ve güçlü bir sanayi altyapısı ile sanayi sektörü, rekabetçiliğini artırma potansiyeline sahiptir.

Türkiye Odalar ve Borsalar Birliği (TOBB) tarafından hazırlanan sanayi kapasite raporları, Türkiye'nin sanayi sektöründeki mevcut durumunun objektif bir analizini sağlar. Bu raporlar, ekonomik planlama, strateji geliştirme, yatırım teşvikleri, sektörel analiz ve politika yapımı gibi alanlarda bilinçli stratejiler geliştirmeye yardımcı olur. Ayrıca, istihdam politikalarının yönlendirilmesi, rekabet gücü ve dış pazarlara erişim gibi konularda da önemli bir kaynak teşkil ederler. TOBB'un aylık bültenleri, Türkiye'deki sanayi sektörünün durumu ve gelişmeleri hakkında güncel ve detaylı bilgiler sağlar. Bu bültenler, iş dünyası, yatırımcılar, politika yapıcılar ve kamuoyu için önemli bir veri kaynağıdır. Ayrıca, Türkiye'nin uluslararası rekabet gücünü artırmak için de önemli bir platform sunarlar.

Çalışmada, 2023 yılı Sanayi Kapasite Raporu üzerinden yapılan kademeli kümeleme analizi, Türkiye'nin iş gücü yapılanmasını ve bölgesel sanayi kapasitelerini daha iyi anlamak için kullanılmıştır. Bu analiz, benzer özellikler gösteren illeri gruplandırarak, her bir grubun özgün ihtiyaçlarını ve potansiyellerini belirlemeye yardımcı olur. Hedeflenmiş ve verimli politika yapımı, kaynak dağıtımı ve kalkınma stratejileri geliştirilmesine olanak tanır. Bu da Türkiye'nin ekonomik büyüme ve kalkınma hedeflerine ulaşmasına katkıda bulunur.

Literatürdeki çalışmalar, sanayi kapasitesi, işgücü dağılımı ve Türkiye'nin küresel konumu gibi konuların ekonomik kalkınma üzerindeki etkilerini anlamak için önemli bir temel oluşturmaktadır.

Bu çalışmada K-means kümeleme analizi kullanılmıştır. K-means algoritması farklı alanlarda sıklıkla kullanılmaktadır. Örneğin, Wahyuni et al. (2023) seçim kümelerini tahmin etmek için K-means algoritmasını kullanarak bütçeleme risklerini azaltmaya çalışmıştır. Muttaqin (2022) Sumatra'nın ilçelerini ve şehirlerini İnsani Gelişme Endeksi'ne göre sınıflandırmak için K-means küme analizini kullanmıştır. Kümelemenin kalitesi Silhouette Skoru ile değerlendirilir. Silhouette Skoru, her bir veri noktası için, o noktanın kendi kümesindeki diğer noktalara olan benzerliği ile en yakın kümedeki noktalara olan benzerliği arasındaki farkı ölçer. Yüksek Silhouette Skoru, iyi bir kümeleme sonucunu gösterir. Bu çalışmada, K-means kümeleme analizi kullanılarak elde edilen sonuçlar Silhouette Skoru ile değerlendirilmiştir. En yüksek Silhouette Skoruna sahip küme sayısı ile analiz tamamlanmıştır.

Uygulama sırasında farklı küme sayılarıyla K-means algoritması tekrarlanmış ve en yüksek silhouette skorunu veren küme sayısı ile analiz gerçekleştirilmiştir. Kümeleme sonuçları ve Silhouette skorları Tablo 2'de sunulmuştur. Tüm illerin dahil olduğu Tablo 2'de, Kademe 1 sütununda gösterilen kümelemede illerin sayısal olarak homojen dağılmadığı gözlenmiştir. Bu durum, az sayıda il barındıran kümenin yorumlanmasını kolaylaştırırken, çok sayıda il barındıran kümenin yorumlanmasında zorluk yaşanmasına neden olmaktadır. Bu nedenle, çalışmada kademeli bir kümeleme yaklaşımı benimsenmiştir. Bu yaklaşım, az sayıda eleman barındıran küme elemanlarının sonraki kademede analiz dışında bırakılarak daha homojen ve anlamlı kümelerin oluşturulmasını sağlar. Bu, kümeleme sonuçlarının daha net ve anlaşılır olmasını sağlar ve karar vericilerin daha doğru ve güvenilir sonuçlar elde etmelerine yardımcı olur. Ayrıca, kademeli yaklaşım, çok sayıda il barındıran kümelerin yorumlanmasında yaşanan zorlukları azaltır. Kümelemeyi adım adım yaparak, her bir kademede daha az sayıda il içeren ve daha spesifik olan kümeler elde edilir, bu da analizin daha derinlemesine ve odaklanmış bir şekilde yapılmasını sağlar.

Her aşamadaki kümeleme sonuçları birleştirildiğinde Türkiye'deki iller homojen 5 kümeye (C1, C2, C3, C4 ve C5) ayrılabilmiştir. Kümelere yönelik çeşitli yönetsel çıkarımlar şöyledir.

C1 kümesindeki iller genellikle büyük metropollerden oluşur ve ülkenin ekonomik ve endüstriyel merkezlerini temsil ederler. Bu iller, yüksek teknoloji, finans, eğitim ve sağlık gibi sektörlerde güçlü bir

potansiyele sahiptir. Bu nedenle, C1 kümesindeki illere yönelik stratejik odak, yenilikçilik ve teknoloji tabanlı ekonomik büyümeyi desteklemek olabilir. Ayrıca, bu illerdeki insan kaynakları ve altyapı yatırımlarının güçlendirilmesi, uluslararası rekabet gücünün artırılmasına katkı sağlayabilir.

C2 kümesindeki iller genellikle bölgesel ekonomik merkezlerdir ve sanayi üretiminde önemli bir rol oynarlar. Bu iller, tarım, tekstil, otomotiv gibi sektörlerde güçlü bir altyapıya sahiptirler. C2 kümesindeki illere yönelik stratejik odak, endüstriyel dönüşümü desteklemek, rekabetçi avantajları güçlendirmek ve iş gücü verimliliğini artırmak olabilir. Ayrıca, bu illerdeki küçük ve orta ölçekli işletmelerin desteklenmesi ve ihracat potansiyellerinin artırılması, ekonomik çeşitliliğin ve kalkınmanın teşvik edilmesine katkı sağlayabilir.

C3 kümesindeki iller genellikle orta ölçekli şehirlerdir ve tarım, turizm, gıda işleme gibi sektörlerde faaliyet gösterirler. Bu iller, genellikle ekonomik açıdan daha zayıf durumda olabilirler ve bölgesel kalkınma politikalarıyla desteklenmelidirler. C3 kümesindeki illere yönelik stratejik odak, tarımsal ve kırsal kalkınmayı desteklemek, turizm potansiyelini artırmak ve yerel işletmelerin rekabet gücünü artırmak olabilir.

C4 ve C5 kümesindeki iller genellikle kırsal ve az gelişmiş bölgelerdir. Bu iller, tarım, hayvancılık ve doğal kaynaklara dayalı endüstrilerde faaliyet gösterirler. C4 ve C5 kümesindeki illere yönelik stratejik odak, kırsal kalkınmayı desteklemek, yerel iş gücünü güçlendirmek ve altyapıyı geliştirmek olabilir. Ayrıca, bu illerdeki işletmelerin teknoloji ve yenilik kapasitelerinin artırılması ve pazar erişimlerinin geliştirilmesi, ekonomik büyümenin ve kalkınmanın teşvik edilmesine yardımcı olabilir.

Çalışma, Türkiye'nin farklı bölgelerindeki ekonomik ve endüstriyel yapıları belirlemeye ve anlamaya yardımcı olur. Bu da bölgesel kalkınma politikalarının ve ekonomik stratejilerin daha etkili bir şekilde oluşturulmasına olanak tanır. Örneğin, C1 ve C2 kümesindeki illerde yenilik ve teknoloji tabanlı ekonomik büyüme teşvik edilirken, C3, C4 ve C5 kümesinde tarımsal ve kırsal kalkınma ön planda olabilir.

Bu analiz, yatırım ve kaynak dağıtımının daha dengeli bir şekilde yapılmasını sağlayarak, bölgeler arası ekonomik ve sosyal dengesizlikleri azaltmaya yardımcı olabilir. Sonuç olarak, bu çalışma Türkiye'nin sanayi ve iş gücü yapılanması üzerine bir analiz sunarak, bölgesel kalkınma ve ekonomik büyüme için stratejik planlamaya katkıda bulunur.