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Investigation of the Similarities of Industrial Wood Production Statistics of Regional Directorates of Forestry in Turkey Using Cluster and Discriminant Analysis

İlker AKYÜZ[1*], Nadir ERSEN[2], Bahadır Çağrı BAYRAM[3], Mustafa ACAR[4],

Kadri Cemil AKYÜZ[1], Tutku ÜÇÜNCÜ[3]

[1]Karadeniz Technical University, Department of Forest Industry Engineering, Trabzon, TURKEY
[2]Artvin Çoruh University, Forestry and Forest Products, Artvin, TURKEY
[3]Kastamonu University, Forest Industry Engineering, Kastamonu, TURKEY
[4]Artvin Çoruh University, Faculty of Forestry, Forest Engineering, Artvin, TURKEY
[*]Corresponding Author:iakyuz@ktu.edu.tr

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Abstract

Aim of study: In this study, the amount of industrial wood production of the regional directorates of forestry in Turkey was examined deeply and the similarities between the regional directorates in industrial wood production were investigated by cluster and discriminant analysis.

Area of study: The study area is regional directorates of forestry in Turkey.

Material and Method: Seven different variables were used to construct similar clusters. The arithmetic mean of these seven variables was taken for 4 years (2013-2016). Cluster and discriminant analysis were used as method.

Main results: According to the clustering analysis results, it was determined that regional directorates of forestry could be divided into maximum 6 and minimum 2 groups. As a result of the discriminant analysis conducted to determine the highest success of the groupings, it was determined that the regional directorates of forestry distinguished in 100% success in 6 groups. Also, it was found that a Kastamonu regional directorate of forestry, which has the highest value in industrial wood production, has formed a group alone.

Highlights: For the production of industrial wood, the regional directorates of forestry can put more emphasis on the use of forest areas. Thus, we can avoid the dependence on foreign sources.

Keywords*:* Industrial Wood, Cluster Analysis, Discriminant Analysis.

Türkiye'de Orman Bölge Müdürlüklerinin Endüstriyel Odun Üretim Miktarı İstatistiklerinin Benzerliklerinin Kümeleme ve Diskriminant Analizi ile Araştırılması

Öz

Çalışmanın amacı: Bu çalışmada orman bölge müdürlüklerinin endüstriyel odun üretim miktarları detaylı bir şekilde incelenmiş olup, endüstriyel odun üretimi bakımından bölge müdürlüklerinin benzerlikleri küme ve diskriminant analiz yardımıyla araştırılmıştır.

Çalışma alanı: Türkiye'deki orman bölge müdürlükleri çalışma alanını oluşturmaktadır.

Materyal ve Yöntem: Benzer özellikleri taşıyan kümeleri oluşturmak için yedi farklı değişken kullanılmıştır. Bu değişkenlerin 2013-2016 yıllarındaki değerlerinin ortalaması alınmıştır. Araştırma yöntemi olarak ise kümeleme analizi ve diskriminant analizi kullanılmıştır.

Sonuçlar: Kümeleme analizi sonucuna göre, orman bölge müdürlüklerini en fazla 6 ve en az 2 gruba ayrılabileceği tespit edilmiştir. Oluşturulan gruplamalardan en yüksek başarıyı belirlemek için yürütülen ayırma analizi sonucunda orman bölge müdürlüklerinin 6'li gruplamada %100 başarı elde ettiği saptanmıştır. Ayrıca, endüstriyel odun üretiminde en yüksek değere sahip olan Kastamonu orman bölge müdürlüğünün tek başına bir grup oluşturduğu bulunmuştur.

Önemli Vurgular: Endüstriyel odun üretimi için orman bölge müdürlükleri orman alanlarının kullanımı ile ilgili çalışmalara daha fazla önem vererek dışa bağımlılığın önüne geçebiliriz.

Anahtar kelimeler*:* Endüstriyel Odun, Kümeleme Analizi, Diskriminant Analizi.

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Introduction

In Turkey, 28.6% of the total land area (22.3 million hectares) of Turkey is covered by forests. Forest areas without trees are not included in these areas. However, while 73% of Turkey's forests are high forests, others are coppice forests and 43% of these forests are degraded forests (GDF, 2015).

The forests that cover 28.6% of the country have many benefits. Forests in first years meet the needs of people such as sheltering, hunting and wood. Today, the way people take benefit of the forests and the priority of benefit from forests has changed a lot. The briefly known benefits of forests are as follows: (1) they are raw material and water storages, (2) they positively affects the climate, (3) they protect the soil, (4) they recreation area, (5) they are the source of oxygen, (5) they are the work place for people, and (6) they are the natural living place of wildlife (URL-1, 2017).

The products supplied from the forest are divided into primary and secondary forest products. Primary forest products consist of the industrial wood and firewood raw materials.

Industrial wood raw material used as intermediate goods in many industries such as manufacturing industry, mining and construction and it consists of log, mining pole, other industrial wood, pulpwood, fibre-chip wood, pole and wire pole (Güngör, Kayacan, & Korkmaz, 2004).

In recent years, there has been a serious increase in industrial wood production in Turkey depending on the increased capacity of the industry, growth potential in the construction sector and positive economic developments in General Directorate of Forestry (GDF). The production amount of industrial wood produced by GDF in Turkey is 17 million m^3 in 2016, while it was 7 million m^3 before 2002 (Figure 1). In the other words, the amount of industrial wood in Turkey increased by approximately 143% and according to 2016 data, 42% of industrial wood production is fibre-chip wood, 33% is log, 15% is pulpwood, and 10% is others (Anonymous, 2016; URL-2, 2017).

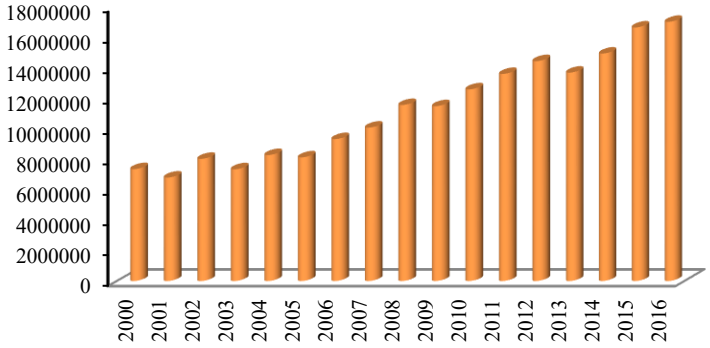

Figure 1. Amount of industrial wood production (m^3)

According to 2015 data, about 21.7million m^3 of industrial wood is produced in Turkey. 16.6 millionm^3 of this production is made by the General Directorate of Forestry, 3.5 million m^3 by the private sector. The rest of the production is imported. 51% of the industrial wood raw material imports in our country are made from Ukraine. More than 90% of the industrial wood produced outside the state forests consists of rapidly growing tree species such as poplar, eucalyptus. In terms of tree species, approximately 77% of GDF production constitutes coniferous species (Anonymous, 2016).

Also, in Turkey, about 29 million m^3 of round wood is consumed and 66% of which is provided by state forests. 77% of industrial wood is provided by sales from General Directorate of Forestry (GDF), 15% from private sector sales and 8% by import (Anonymous, 2016).

Literature Search

There are many studies on clustering and discriminant analysis and trade made in the field of forest products and furniture industry.

Akyüz, Cındık, Serin & Akyüz (2002b) investigated exports and imports total prices of forest product industry in the East Black Sea region according the data obtained from the Customs Manager. In the present paper, the development of the forestry industry enterprises in the 63 settlements in the Eastern Black Sea Region was investigated by using 32 variables. Discriminant Analysis method was used to evaluate the data (Akyüz, Cındık, Akyüz & Serin, 2002a). Akyüz (2006) evaluated the production, export and import values of 12 different product groups in the field of timber, wood board and paper products of Turkey and 25 different European Union countries using the hierarchical cluster and the discriminant analysis. Yıldırım, Akyüz, Gedik, Balaban & Çabuk (2008) tried to show to the position of Turkey among the member countries of the EU by using the hierarchical cluster and the discriminant analysis in terms of some product groups belonging to wood based panel industry situated in the forest products industry. In another study, the position of Turkey among the member countries of the EU by using the hierarchical cluster and the discriminant analysis in terms of some product groups belonging to the wood based panel industry situated in the forest products industry was investigated (Akyüz and Yıldırım, 2009). Bojnec and Fertö (2011) was investigated Austrian bilateral trade in raw and semi-finished wood products (AFWPs) with Hungary and Slovenia, respectively. As a result, raw and semi-finished wood products are among the most significant single traded AFWPs of Hungary and Slovenia with Austria. Hungary is a net exporter of raw and semi-finished wood products to Austria while Slovenia is a net importer of raw and semi-finished wood products from Austria. Akyüz, Balaban & Yıldırım, (2012) determined the place and importance of forest products industry in the manufacturing industry by means of balance sheet ratios. In evaluating these financial ratios, they used the hierarchical cluster and the discriminant analysis. They decided to divide the industrial branches into 3 homogeneous groups and found that the forest products industry was in the third group. In the other paper done by Bojnec and Fertö (2014), was analysed the forestry industry trade of the New Member States (NMS-11) of the European Union (EU) on the enlarged EU-27 markets. Tiryaki, Aydın & Üçüncü (2015), determining the status within the European Union members of Turkey furniture sector using hierarchical clustering analysis was aimed. Sujova, Hlavackova & Marcinekova (2015) was aimed to evaluate the impact of foreign trade in wood processing industry on the economic performance of the sector in Slovakia and the Czech Republic. It was found that in Slovakia and the Czech Republic, the foreign trade in the wood processing industries play a significant role on the economic performance. The aim of this paper is to analyse trade performance and competitiveness of the Slovak wood processing industry sectors and their comparison with the Visegrad group (Poland, Czech Republic and Hungary) countries (Palus, Parobek & Liker, 2015). The objective of paper done by Koebel, Levet, Van, Purohoo & Guinard (2016) was to analyse the role of the forest resource endowment for explaining wood products trade as well as, beyond the resource endowment, to explore the role of other determinants reflecting the industrial performance of sectors. Alem (2016) aimed to evaluate the trends of expenses from importing and incomes generated from exporting different processed wood products, to assess the processed wood products trade balance, and to forecast future expenses in importing processed wood products. Import and export data of processed wood products in the years of 2005–2013 was used for this. It was found that the self–insufficiency of the Ethiopia in producing different processed wood products and the heavy expenditure to import wood products to fill the gap. Akyüz, Yıldırım, Tugay, Akyüz & Gedik (2016) aimed to determine how the hazard classes varied within the manufacturing industry depending on years and how the forest products industry sub-sectors took place in

this change using the hierarchical cluster and the discriminant analysis. They found that the three sub-sectors of the forest products industry (wood products and cork, paper and paper products and furniture sectors) are included in the same cluster. This paper was analyzed the international trade in forest products from 2000 to 2014 and emphased Brazil's role (Maxir and Masullo, 2017).

In this study, in terms of the industrial wood production, the similarities between the regional directorates of forestry were investigated by cluster and discriminant analysis.

Material and Method

Material

Although there are 27 Regional Directorate of Forestry in Turkey, data related to Şanlıurfa Regional Directorate not be obtained. In the study, 26 Forestry Regional Directorate and the production quantities of the seven product groups (log, telephone pole, mining pole, other industrial wood, pulpwood, fibre-chipwood and pole), which form the industrial wood group are taken into consideration in terms of 2013, 2014, 2015 and 2016 years. Then, the mean values of these four years were used in the statistical analyzes to be performed. The free data was filled out with gives number 1.These data used in the study were obtained from the website of the General Directorate of Forestry (GDF, 2017). Making clusters of forest district directorates based on total amount of industrial wood production may not give realistic and meaningful results. For this, it is possible to give more realistic results in clustering analysis by writing the production quantities of the products forming the industrial wood group, separately. These seven product groups, which form the industrial wood group, constitute the decision variables of the study. Also, it can be determined which product is more important in industrial wood production by taking each product constituting the industrial wood group as a decision variable.

Table 1. The average values of forest regional directorates for selected years (2013-2016)

Regional Directorates of Forestry	Log (m^3)	Telephone Pole (m^3)	Mining Pole (m^3)	Other Industrial Wood (m^3)	Pulp Wood (m^3)	Fibre-Chip Wood (m^3)	Pole (m^3)
Adana	272810	806	69511	117107	10591	273093	156
Sakarya	108829	1	644	31579	71612	280889	24
Amasya	162897	2113	10550	39937	42588	559495	117
Ankara	95207	2523	13119	495	63576	171378	1297
Antalya	356214	243	62354	41486	110769	274707	116
Artvin	93160	8	760	1892	32640	12963	1
Balikesir	262863	744	31520	35237	188531	444996	473
Bolu	484910	3574	11851	5662	301365	305256	306
Bursa	274329	2169	17450	40744	163147	300728	90
Kayseri	41468	8589	21531	1537	13532	49030	40
Denizli	199713	4317	51131	25496	36400	282658	1516
Elaziğ	219	1	436	90	96	9936	45
Erzurum	43060	1041	7763	4338	19384	6353	1210
Eskişehir	38598	1778	10367	3176	36870	123718	348
Giresun	181126	2047	8798	10310	58133	219753	813
Isparta	145546	800	19948	8084	60690	148623	64
Istanbul	192480	1	40916	40210	52465	458381	11
Izmir	242833	407	21318	127766	98408	494023	345
K.Maraş	108108	300	26320	30552	6917	163132	66

Table 1 *(continued)*

Kastamonu	782616	3499	30904	15023	406036	710990	819
Mersin	181239	1	37634	40241	17759	173790	1525
Muğla	323740	1870	43492	52552	90817	312857	69
Trabzon	43482	1	10430	2369	47731	9598	21
Zonguldak	470954	104	4751	55580	186685	383575	76
Kütahya	164140	8264	39184	6815	111602	262663	1487
Konya	21370	1	4961	14792	10270	50884	74

Method

Clustering Analysis

Clustering analysis is the process of creating clusters, which is defined as a cloud analogy of similar objects (units) in multi-dimensional space (Yılmaz and Patır, 2011). The main purpose of clustering analysis is to classify ungrouped data into homogeneous groups according to their similarities. For this purpose different distance measures are used and clusters are formed (Giray, 2013). Squared Euclidean distance measure was used in the study.

The selection of appropriate clustering algorithms is critical to the effective use of cluster analysis. The clustering algorithm is divided into hierarchical and non-hierarchical clustering analysis. The hierarchical clustering analysis was used in the study. The hierarchical clustering is a series of steps that build a tree-like structure by either adding individual elements to or deleting them from clusters (Tekin, 2015; Ketchen and Shook, 1996). In hierarchical clustering techniques, the number of clusters can be visually decided by using dendrogram. Dendrograms resemble decision trees with short "limbs" that represent the joining of observations (Çakmak, 1999; Ketchen and Shook, 1996).

Discriminant Analysis

Discriminant analysis is a method that allows comparison of two or more groups depending on a large number of variables. In other words, discriminant variables are those variables which indicate the difference between the groups (Oğuzlar 2006; Filiz and Yaprak 2009). The discriminant analysis is similar to the clustering analysis. However, while classes are not known before hand in the clustering analysis, these classes are known before hand in the discriminant analysis (Akyüz, 2006).

Findings and Results

In this study, clustering analysis was performed by Ward method. Firstly, the number of clusters was analyzed without specifying the number of clusters. Then, the clustering in which the highest achievement was achieved with the help of discriminant analysis was determined. The obtained dendogram was given in Figure 2.

When the dendogram was examined, it was determined that the regional directorates of forestry could be divided into maximum 6 and minimum 2 groups. As a result of the discriminant analysis, the highest success rate was found when all samples were divided into 6 different groups at the $p<0.05$ significance level. The regional directorates of forestry of the identified groups are given in Table 3.

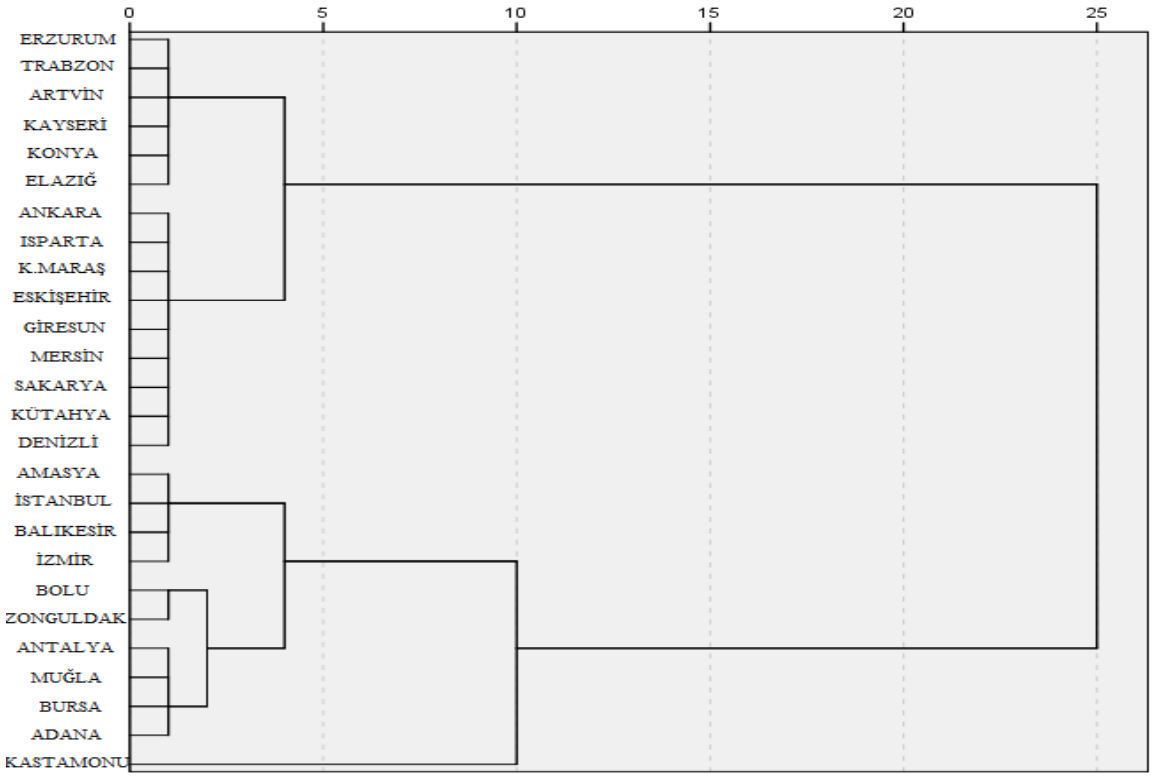

Figure 2. Dendogram of Regional Forest Directorates

The clusters formed as a result of the hierarchical clustering analysis can also be interpreted through the agglomerative table. In this table, the regional directorates of forestry most similar to each other according to coefficients of industrial wood variables are matched. In the agglomerative table, the number of stages is n-1. "n"refers the number of observations. According to Table 2, the regional directorates of forestry, which are most similar to each other, are: (1) Erzurum-Trabzon, (2) Kayseri-Konya, (3) Ankara-Isparta and so on., while the ones least similar to each other are: (1) Adana-Sakarya, (2) Adana-Kastamonu, (3) Sakarya-Artvin and so on.

Table 2. Agglomeration Schedule

Stage	Cluster Combined		Coefficients	Stage	Cluster Combined		Coefficients
	Cluster 1	Cluster 2			Cluster 1	Cluster 2	
1	Erzurum	Trabzon	413872844.5	14	Antalya	Bursa	44818319135.3
2	Kayseri	Konya	884884039	15	Sakarya	Giresun	54490916127.3
3	Ankara	Isparta	2469309600	16	Balıkesir	İzmir	64287330805.3
4	Antalya	Muğla	4163782708.9	17	Bolu	Zonguldak	75304555115.8
5	Artvin	Erzurum	5888384893.8	18	Adana	Antalya	90991154266.9
6	Kayseri	Elazığ	7863192024.7	19	Amasya	Balıkesir	109116871215.6
7	Ankara	K.Maraş	10527761905.7	20	Sakarya	Ankara	140173176220.7
8	Giresun	Mersin	13265133271.2	21	Adana	Bolu	216727897260.4
9	Sakarya	Kütahya	16844982636.7	22	Adana	Amasya	354181577882.3
10	Artvin	Kayseri	21193940570.8	23	Sakarya	Artvin	508267483030.1
11	Sakarya	Denizli	26646517154.7	24	Adana	Kastamonu	888875132670.4
12	Ankara	Eskişehir	32393373894.2	25	Adana	Sakarya	1872190919400.8
13	Amasya	İstanbul	38455069033.7				

Looking at Table 3, Kastamonu regional directorate of forestry forms a different cluster. In other words, Kastamonu regional directorate of forestry is different from other regional directorates in terms of industrial wood production. The cluster of other regional directorates of forestry is as follows:

Cluster 1: Adana, Antalya, Bursa and Muğla

Cluster 2: Sakarya, Ankara, Denizli, Eskişehir, Giresun, Isparta, K.Maraş, Mersin and Kütahya

Cluster 3: Amasya, Balıkesir, İstanbul and İzmir

Cluster 4: Artvin, Kayseri, Elazığ, Erzurum, Trabzon and Konya

Cluster 5: Bolu and Zonguldak

Cluster 6: Kastamonu

Table 3. According to the results of the ward test, clusters formed by the regional directorates of forestry

Clusters	1	2	3	4	5	6
Regional Directorates of Forestry	Adana	Sakarya	Amasya	Artvin	Bolu	Kastamonu
	Antalya	Ankara	Balıkesir	Kayseri	Zonguldak	
	Bursa	Denizli	İstanbul	Elazığ		
	Muğla	Eskişehir	İzmir	Erzurum		
		Giresun		Trabzon		
		Isparta		Konya		
		K. Maraş				
		Mersin				
		Kütahya				

As a result of this clustering, cluster mean values of telephone pole, and pole variables were not significant at the 5% significance level in the equality test (Table 4) and it was found that the other 5 variables were significant. As Wilks' lambda value approaches to 1, the effect of variables on the discrimination of groups decreases (Güzeller and Kelecioğlu, 2006). To discriminate the clusters, log and fibre-chipwood variables are more effective than other variables.

Table 4. Tests of equality of group means

Variables	Wilks' Lambda	F	Sig.
Log	0.049	77.254	0.000
Telephone pole	0.930	0.303	0.905
Mining pole	0.512	3.807	0.014
Other industrial wood	0.487	4.209	0.009
Pulpwood	0.179	18.365	0.000
Fibre-chipwood	0.052	73.543	0.000
Pole	0.687	1.818	0.155

In Figure 3, the centers of the six clusters and the distances of the cluster elements from the centers are observed. According to Figure 3, while the second and fourth clusters are the closest clusters, the fourth and sixth clusters are the most distant clusters to each other. The values of the distance values between the clusters were calculated to support the graph of canonical discriminant functions (Table 5). The results of distance value and Canonical discriminant functions graph are similar to each other

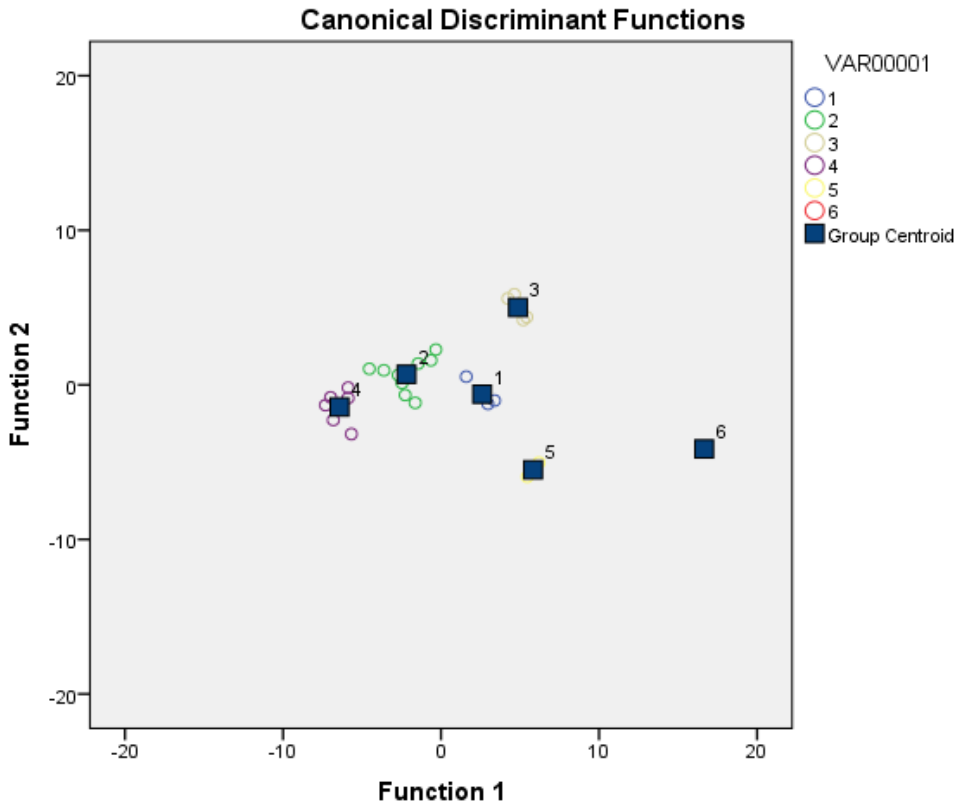

Figure 3. Distribution of cluster centers and cluster elements according to the discriminant function

Table 5. The distance values between the clusters

	1	2	3	4	5	6
1	0.0000	32.7105	43.0359	87.9240	42.5360	226.8277
2	32.7105	0.0000	70.2413	24.0144	104.7493	380.2448
3	43.0359	70.2413	0.0000	169.1847	111.5089	228.0457
4	87.9240	24.0144	169.1847	0.0000	167.3358	545.0479
5	42.5360	104.7493	111.5089	167.3358	0.000	125.2786
6	226.8277	380.2448	228.0457	545.0479	125.2786	0.0000

The comparisons of group mean values of the variables that are effective in the formation of groups as a result of the analyses were given in Table 6.

Table 6. The mean values of groups

Variables	1.Cluster	2.Cluster	3.Cluster	4.Cluster	5.Cluster	6.Cluster
Log	306773.25	135834	215268.25	40459.83	477932	782616
Telephone pole	1272	2225.67	816.25	1606.83	1839	3499
Mining pole	48201.75	23016.11	26076	7646.83	8301	30904
Other industrial wood	62972.25	17416.44	60787.50	4169.67	30621	15023
Pulpwood	93831	51506.56	95498	20608.83	244025	406036
Fibre-chipwood	290346.25	202956	489223.75	23127.33	344415.50	710990
Pole	107.75	793.33	236.5	231.83	191	819

If we examine the findings in Table 6,

(1) Regarding of log, telephone pole, pulpwood, fibre-chipwood productions and pole, it was found that the cluster having the highest production is 6th.

(2) Regarding of mining pole and other industrial wood productions, the highest cluster is 1th cluster.

(3) Regarding of log, mining pole, other industrial wood, and pulpwood and fibre-chipwood productions, cluster having the lowest production is 4th cluster.

(4) The clusters having lowest telephone pole and pole productions are 3th and 1th clusters, respectively.

In addition, Table 7 has been used to determine whether the Forest District Directorates efficiently utilize forest areas in the production of industrial wood or not.

Table 7. Distribution of forest land according to the regional directorates of forestry (Anonymous, 2015)

Regional Directorates	Total (hectar)	Regional Directorates	Total (hectar)	Regional Directorates	Total (hectar)
Adana	742495	Kayseri	619634	K.Maraş	869129
Sakarya	351453	Denizli	812168	Kastamonu	1239498
Amasya	1529275	Elaziğ	1287620	Mersin	840470
Ankara	775167	Erzurum	541924	Muğla	1156983
Antalya	1146062	Eskişehir	637836	Trabzon	641324
Artvin	403695	Giresun	560810	Zonguldak	606309
Balikesir	649115	Isparta	768816	Kütahya	646552
Bolu	628548	Istanbul	637364	Konya	704058
Bursa	761597	Izmir	1010558		

Although the Amasya regional directorate that has most forest land, regarding of industrial wood production is the Amasya regional directorate of forestry, it is the same cluster as Balıkesir and İstanbul regional directorates of forestry. These regional directorates have about half of the forest land that Amasya regional directorate owns. Although Elazığ regional directorate has a very high forest area, the production of industrial wood is very low. Although Eastern Black Sea Region is known as area that has the high forest, the regional directorates of forestry in Eastern Black Sea Region are not in good condition in terms of industrial wood production. In other words, it is seen that regional directorates of forestry in Eastern Black Sea Region such as Elazığ and Amasya regional directorates do not use forest areas effectively. The Sakarya regional directorate of forestry is in the same group with other forest regional directorates which is more than 2 times higher than the Sakarya regional directorate in terms of forest area. It is seen that the regional directorates of forestry that use the forest area most efficiently are Kastamonu, Zonguldak and Bolu regional directorates of forestry.

Conclusion

As can be seen from all these analyses, Kastamonu regional directorate of forestry has an important advantage than other regional directorates in the production of industrial wood. Kastamonu regional directorate of forestry has formed a different group because of the high production of log, pulpwood and fibre-chipwood. In other words, the Regional Directorate of Forestry, which produces the highest industrial wood, is Kastamonu. This is followed by Bolu and Zonguldak the Regional Directorates of Forestry.

The log production was found to be the most effective variable in the discriminant function. This variable is followed by fibre-chipwood variable. Regarding of industrial wood production, it ectorate of forestry and the regional direwas found that the Kastamonu regional dirctorates of forestry in

the 4th cluster are the most distant regional directorates to each other.

In general, it is seen that the regional directorates of forestry, which are close to each other in terms of forest land, are in the same group in terms of industrial wood production.

Although Turkey in the production of fibreboard and particleboard are in the top 3 list in Europe, the level of industrial wood production and quality, which is the raw material of these products, is not the desired level. The vast majority of industrial wood imports come from Russia. However, with the new forest law applied in Russia, very high taxes are applied for wood exports. Therefore, the amount of industrial wood that we import from Russia is likely to decline in the future (Anonymous, 2016). We have to increase our production of wood in terms of quality and quantity. The necessary precautions such as emphasis on forest maintenance, employment of personnel, new methods and practices, reforestation of coppice forests must be taken for this. The equipment needed to keep the forest roads open all year round is required to be renewed and forest roads should be built. Also, the costs of purchasing raw materials must be reduced so that the forest products industry can compete in international markets.

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