Takvim-i Vekayi

Çay Üretiminde Öncü Ülkelerin Çay Üretilen Bölgelerinin İklim Özellikleri Arasındaki İlişkilerin Analizi

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TELHİS (ÖZ)

Bu çalışmada Hiyerarşik sınıflandırma yöntemleri kullanılarak çay üretiminde önde gelen ülkelerin çay üretimi yapılan bölgelerinin aylık ortalama sıcaklık ve aylık ortalama toplam yağış miktarı arasındaki ilişki araştırıldı. Bu makalede en küçük örten ağaç yöntemi kullanmak, zor ve karmaşık ilişkiyi çok açık bir şekilde görselleştirmemizi sağlamıştır. Benzer ortalama sıcaklık ve yağış miktarı değişimleri gösteren ülkeler aynı grupta birbirlerine bağlanmaktadırlar. Çay üretimi yapılan ülkelerin genellikle sıcaklık değişimleri bakımından benzer karakteristikler gösterdiği ve aynı grupta yer aldığı görülmüştür. Elde edilen sonuçlara göre çay üretiminde aylık sıcaklık değişimi ve aylık ortalama yağış miktarının etkili olduğu anlaşılmaktadır.

Analysis of the Relationship Between the Climate Characteristics of the Tea Producing Regions of the Leading Countries in Tea Production

Research Article

ABSTRACT

In this study, the relationship between the monthly average temperature and the monthly average total precipitation of the tea producing regions of the leading countries in tea production was investigated using hierarchical classification methods. Using the minimum spanning tree method in this article has allowed us to very clearly visualize the difficult and complex relationship. Countries that show similar average temperature and precipitation changes are linked in the same group. It has been observed that tea producing countries generally show similar characteristics in terms of temperature changes and are in the same group. According to the results, it is understood that monthly temperature changes and monthly precipitation rates is effective in tea production.

KEYWORDS

Hierarchical Classification, Tea Production and Climate, Minimum Spanning Tree, Temperature and Precipitation.

1. INTRODUCTION

In recent years, analysis of financial (Mantegna and Stanley 2000; Gorski et. al. 2008; Naylor et. al. 2007; Keskin et. al., 2011; Kantar et. al. 2011; Kocakaplan et. al., 2012) social (Buda, 2013; Park, 2010; Galam, 2008; Adamatzky, 2012), and political (Galam, 2012; Bati and Yıldız 2017) data as a statistical physics and mathematical application has been of great interest and many studies have been carried out. As a result of successful physical models of economic, social and political events, econophysics and sociophysics have become a field of application of physics (Chakrabarti, 2007).

The most important hierarchical structure methods used for the analysis of hierarchical classification and correlation structures are the minimum spanning tree (MST) and the hierarchical tree (HT). The history of hierarchical classification methods is based on the Boruvka algorithm developed in 1926, which is used in combination optimization problems (Graham, 1985). Kruskal (1956), Prim (1957), Dijkstra (1959), and Sollin (1965) developed various algorithms to form a minimum spanning tree. MST and HT are the most commonly used to analyze the money markets and in particular to find the clustering structures of currencies and the key currency in each cluster (Gorski, 2008; Keskin, 2011; McDonald, et. al. 2005; Mizuno et. al., 2006; Ortega and Matesanz 2006; Brida, et. al., 2009; Matesanz and Ortega, 2013). It is used for the relationship between the stock market and companies in many countries (Mantegna, 1999; Vandewalle, Brisbois, Tordoir, 2001; Bonanno et. al., 2003, 2004; Eom, Oh, Kim, 2007; Brida and Risso, 2007, 2009, 2010; Garas, and Argyrakis, 2007; Ulusoy, et. al., 2012; Bonanno et. al., 2000; Sensoy, and Tabak, 2014). MST has been used in researches in various fields of economy and social life. In this context, studies such as the structure of the scientific cooperation network (Garas, and Argyrakis, 2008) the examination of the international hotel industry (Brida, et al., 2010), the classification of wind speed by regions (Bivona, et. al., 2008), the structure of interest rates (Tabak, Serra, and Cajueiro, 2009) and the analysis of election results (Bati and Yıldız 2017) were conducted. In recent years, the structure of foreign trade (Kantar, 2011; Kocakaplan, 2012), the relationship between energy consumption and economic size (Kantar, et. al., 2016; Kantar, and Keskin, 2013) and the borrowing structure of their country (Kantar, Deviren, and Keskin, 2014) have been examined using these trees. These methods have also been used in road networks (Adamatzky, 2012), in the analysis of Roman historical routes (Galam, 2012) and moreover in investigating outbreaks of hepatitis C virus (HCV) in the hospital (Spada, et al., 2004). As can be seen, important studies have been made in many areas by using hierarchical structure methods.

On the other hand, the use of these methods in a wide range of areas shows the power of classification and analysis. Graphically grouping the most relevant ones of very complex relationships makes it much easier to interpret the results.

Many research has used the clustering method to determine climate areas around the world (Badr, Zaitchik, and Dezfuli, 2015; Nojarov, 2017; Stooksbury, Michaelsi, 1990; Fovell, and Fovell, 1993; Marx, Haunschild, and Bornmann, 2017; TopicTea, 2020) A two-stage clustering analysis performed at 449 climate stations was used by Stooksbury and Michaels (Stooksbury, Michaelsi, 1990) to identify climatic zones in the United States. Using a hierarchical cluster analysis based on temperature and precipitation data of 24 variables, including monthly surface temperature averages and precipitation, Fovell and Fovell (1993) identified US climatic zones spanning a 50-year period between 1931 and 1980.

In this study, the leading countries in tea production in the world will be connected for the first time by using the MST methods in terms of climate. Tea has become the world's second-most consumed liquid (Haunschild, and Bornmann, 2017). It is one of the most popular and low-cost beverages (after water). China is the world's leading tea grower, with India, Kenya, Sri Lanka, Vietnam, and Turkey following closely behind (TopicTea, 2020). The tea plant thrives in a wide range of conditions, making it difficult to pinpoint an optimal environment. The monsoonal climate of Northeast India, with its alternate wet and dry seasons, as well as the high elevations of subtropical highlands in China, India, and Sri Lanka, give ideal growing conditions for tea (Haunschild and Bornmann, 2017). Tea production is dependent on proper temperatures and evenly distributed rainfall, regardless of the climate. Turkey lies in the transition zone between the temperate and subtropical climate zones. Turkey has a wide range of climate regimes due to its high and varied topography (Sen et. al., 2012). Precipitation and evaporation are well-known components that play an essential role in the climate system (Türkeş, Koç, and Sariş, 2008). Variation of precipitation, different types of climate and physical geography conditions affect tea production. Since tea is thought to grow in moist areas, a climatic comparison will be made between the places where tea grows. In this article, the relationship between the average monthly temperatures of the tea producing regions of the countries where tea is produced and the monthly average precipitation amounts they receive will be examined.

2. METHOD

In this section we give a brief description of the methodology. The MST, which contains only n-1 connections, can then be constructed from the resulting hierarchical graph (Mantegna, and Stanley, 2016). In our research, we use the methodology of Mantegna (2016). First, let $\boldsymbol{T_i(t)}$ be the monthly mean temperature or average precipitation of i th country at mount t (where i = 1, 2, ... , 20). To construct networks, we calculate the logarithmic return of 20 leading countries in tea production. $\boldsymbol{R_i(t)}$ is defined as

$$\boldsymbol{R_i(t) = ln(T_i(t)) - ln(T_i(t-1))} \tag{1}$$

Pearson correlation coefficients between i and j currencies are defined by the following equation

$$\boldsymbol{C_{ij} = \frac{\langle R_i R_j\rangle - \langle R_i\rangle\langle R_j\rangle}{\sigma_i \sigma_j}} \tag{2}$$

where σ is standard deviation $\boldsymbol{\sigma_i = \sqrt{\langle R_i^2\rangle - \langle R_i\rangle^2}}$ and ⟨⋯⟩ stands for the average over interested period. All the diagonal elements of correlation matrix (C) are $\boldsymbol{C_{ii} = 1.}$

To construct the MST, we first need to convert the correlation matrix C into a distance matrix (D). We use the following mapping:

$$\boldsymbol{D_{ij} = \sqrt{2(1 - C_{ij})}} \tag{3}$$

D matrix is symmetric $\boldsymbol{(D_{ij} = D_{ji})}$ and has zero diagonal values. Since −1 ≤$\boldsymbol{C_{ij}}$ ≤ 1, we have 0 ≤$\boldsymbol{D_{ij}}$ ≤ 2. This distance matrix D can be thought to represent a fully connected graph with edge weights $\boldsymbol{D_{ij}}$. In the terminology of graph theory, a 'forest' is a graph where there are no cycles (Brida, and Risso, 2007; 2009). It serves as the issue to derive the "minimum spanning tree" which connects distance weighted graph consisting of n nodes and n-1 edges and containing no loops. The "minimum" attribute means that the sum of all weights of edges is minimal among all trees defined on the distance matrix (smaller distance values define higher correlation values). The Kruskal's, Prim's and Boruvka's algorithms are the most frequently used algorithms to identify MST.

3. RESULT AND DISCUSSION

In this section we describe the relationships between countries producing tea in the world in terms of average temperature and total precipitation by using interdisciplinary hierarchical clustering methods.

Climate change causes changes in normal climatic conditions such as precipitation and temperature. In particular, climate change has a significant impact on agricultural products that are dependent on consistent climatic conditions. The climate and soil of the region have a direct impact on tea production. The fact that precipitation between particular temperatures and a given volume of precipitation is consistent throughout the year, and humidity levels are above normal, is one of the most essential aspects of the tea plant's growth. Tea is best grown in regions with hot and humid climates that receive at least 1000 millimeters of rainfall per year. In order to continue producing tea in the future, tea farmers must develop climate change adaption techniques. As a result, it is critical to investigate the climate features of tea. In the regions where tea production is made, country relations were analyzed by using MST method in terms of monthly average temperature change and average monthly precipitation amounts. The leading countries in tea production and the abbreviations of these country names are given in Table 1.

Table 1. Tea producing country and their abbreviations

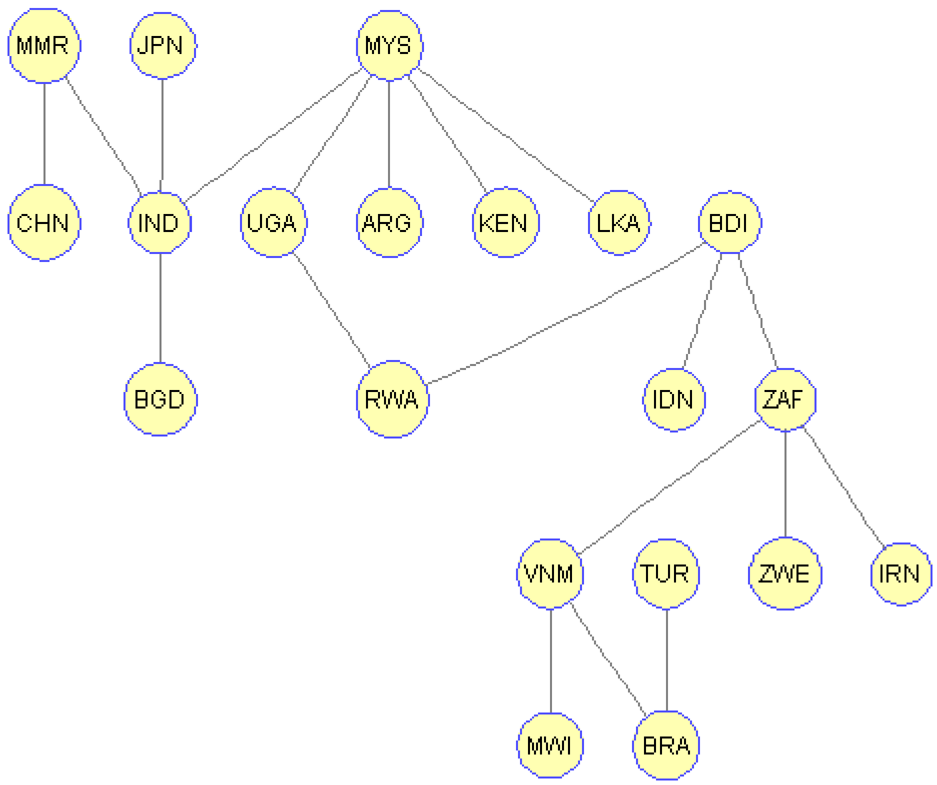
Country	Abbreviation
Argentina	ARG
Burundi	BDI
Banglades	BGD
Brazil	BRA
China	CHN
Indonesia	IND
India	IDN
Iran	IRN
Japan	JPN
Kenya	KEN
Myanmar	MMR
Malawi	MWI
Malaysia	MYS
Rwanda	RWA
Sri Lanka	LKA
Turkey	TUR
Uganda	UGA
Vietnam	VNM
Zimbabwe	ZWE
South Africa	ZAF

Tea farmers must adapt to climate change for their future tea production. Therefore, it is important to examine the climate characteristics of tea. In the regions where tea production is made, country relations were analyzed by using MST method in terms of monthly average temperature change and average monthly precipitation amounts. The monthly average temperatures (°C) and the average monthly total rainfall (mm) of the tea producing regions of the tea producing countries are shown in Table 2.

Table 2. Tea producing countries' average monthly temperatures (°C) and average monthly total rainfall (mm) of tea production region

Country		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
ARG	°C	25.2	24.9	23.2	20	17.1	15.4	15.3	16.7	18.4	20.9	22.9	24.4
	mm	143	129	136	139	166	116	96	96	106	156	146	117
BDI	°C	16.8	17	16.8	16.7	16	15.1	15.3	16.1	16.9	16.8	16.6	16.6
	mm	162	165	196	200	110	14	4	14	69	118	177	194
BGD	°C	18.8	21.5	25.5	28	28.4	28.1	28.2	28.3	28.6	27.4	23.8	20.1
	mm	12	20	64	154	272	461	382	324	233	175	45	3
BRA	°C	21.5	21.4	20.5	18.5	16.6	15.5	15.4	16.2	17.4	18.5	19.8	20.3
	mm	218	205	149	64	56	49	35	43	71	123	137	190
CHN	°C	14	16	19.2	22	24	24.6	24.3	24.3	23.4	20.9	17.4	14.2
	mm	15	13	18	33	94	186	223	216	128	105	54	19
IND	°C	17.9	19.8	23.5	25.7	26.7	27.2	27.6	27.7	27.5	26.1	22.5	19.2
	mm	24	39	148	257	461	573	485	456	337	222	53	7
IDN	°C	25.8	26.1	26.4	27	27	26.6	26.3	26.6	26.9	27.4	27.1	26.6
	mm	350	303	281	290	237	135	107	129	147	208	255	292
IRN	°C	1.4	2.6	6.8	12.5	18.6	24.4	28.5	28.3	24.1	17.8	10.3	3.7
	mm	72	65	89	71	35	31	27	40	91	132	115	94
JPN	°C	4.8	5.2	8.1	13.1	17.3	20.6	24.6	25.7	22.4	16.8	12.1	7.3
	mm	61	80	133	172	176	259	210	232	248	189	110	69
KEN	°C	4.8	5.2	8.1	13.1	17.3	20.6	24.6	25.7	22.4	16.8	12.1	7.3
	mm	64	91	151	241	221	125	131	162	129	124	130	90
MMR	°C	16.5	17.8	21.8	25	24.3	23.5	23	22.9	23.2	22.3	19.6	16.8
	mm	3	3	14	47	209	233	260	292	250	179	78	16
MWI	°C	25.3	25.3	25.1	24.5	23.6	21.9	21	22.5	24.8	26.7	27.1	25.7
	mm	193	152	143	43	11	10	15	7	5	22	79	171
MYS	°C	25.1	25.6	26.1	26.3	26.6	26.5	26.3	26.2	26.1	26	25.5	25.2
	mm	95	144	220	257	273	174	173	229	278	373	316	209
RWA	°C	21.1	20.9	21.3	21	21	20.8	20.9	21.3	21.1	21.2	21.1	20.7
	mm	93	100	120	139	103	40	19	48	107	123	117	119
LKA	°C	23.1	24.1	25.4	25.9	25.6	24.8	24.3	24.4	24.3	24.3	24	23.4
	mm	26	100	109	170	195	144	145	123	151	292	312	216
TUR	°C	6.8	7.1	8.3	12	15.9	19.9	22.4	22.4	19.9	16	12.3	8.9
	mm	184	143	123	82	82	118	99	130	168	218	196	202
UGA	°C	19.1	19.3	19.2	19	18.9	18.5	18.6	19.2	19.2	19	18.8	18.7
	mm	72	78	113	138	100	40	36	85	128	138	151	118
VNM	°C	15.6	17	19.6	23.6	27.5	28.9	28.8	28.5	27.4	24.7	21.1	18
	mm	17	42	52	99	248	330	420	418	207	96	38	22
ZWE	°C	22.3	21.9	21.1	20	17.3	14.6	14.6	16.3	19.2	21.7	21.9	22.1
	mm	172	157	94	31	13	9	7	7	15	43	95	166
ZAF	°C	24.3	24	23	20.8	17.3	14.6	14.5	16.6	19.6	21.9	22.9	23.8
	mm	123	133	82	56	19	10	7	9	23	53	96	123

Figure 1. MST in terms of total monthly precipitation rates



Firstly, the correlation between the changes in the monthly total rainfall in the tea producing regions of the countries was examined. For this purpose, MST in Figure 1 was drawn. When MST is examined, it is seen that MYS and IND form a central group and UGA, ARG, KEN, and LKA show similar changes with MYS. JPN, BGD, and MMR show similar changes with IND. ZAF, BDI and VNM form another correlated central group. In this central group, it is seen that it connects with BDI, RWA and IND, ZAF with VNM, ZWE and IRN, and VNM with MWI and BRA. It is understood that it is similar to CHN with MMR and TUR with BRA, but CHN and TUR show a different precipitation change by remaining outside the groups.

When the changes in monthly average temperature are examined (see Figure 2), it is seen that they are in the same cluster. The UGA, RWA, MWI, BDI cluster is associated with RWA and another central cluster is IND-center cluster. RWA, IND, BGD and CHN show similar temperature changes. It is seen that countries leading in tea production in the world such as CHN, IND, VNM, KEN, and TUR are in a close group. This shows that the monthly temperature change is effective in tea production.

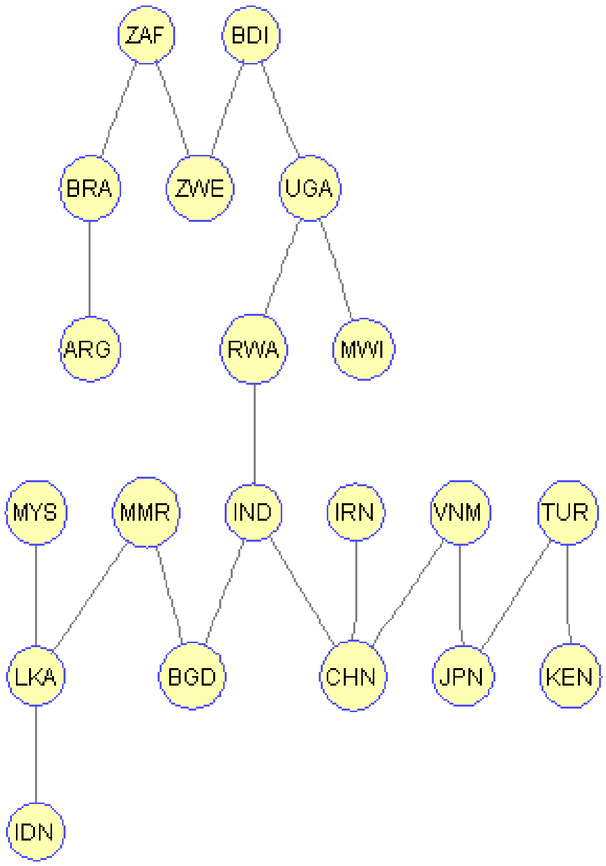


Figure 2. MST in terms of average monthly temperature

4. CONCLUSIONS

We describe the relationships between countries producing tea in the world in terms of average temperature and total precipitation by using interdisciplinary hierarchical clustering methods. It has been observed that the temperature changes of the tea producing countries generally show similar characteristics. It is understood from many analyses that the minimum spanning tree method is a useful tools as statistical classification method. Using minimum spanning tree method enables us to visualize difficult and complex relation in very obvious manner. The climate characteristics in the world can be considered as a whole by using such studies. Climate diversity can be seen by identifying regions with similar climate characteristics in the world. Such studies can provide very useful information about climate change.

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