Tarım Ekonomisi Dergisi
Turkish Journal of Agricultural Economics
ISSN 1303-0183
http://journal.tarekoder.org

# Complex Network Analysis of International Olive Oil Market

Semanur SOYYİĞİT[1], Kıymet YAVUZASLAN[2]

[1]Erzincan Üniversitesi, İktisadi İdari Bilimler Fakültesi, İktisat Bölümü, Erzincan
[2]Aydın Adnan Menderes Üniversitesi, Aydın İktisat Fakültesi, İktisat Bölümü, Aydın

***Makale Künyesi***

***Araştırma Makalesi /***
***Research Article***

***SorumluYazar /***
***Corresponding Author***
*Kıymet YAVUZASLAN*
*kiymet.yavuzaslan@adu.edu.tr*

*Geliş Tarihi / Received:*
*30.03.2018*
*Kabul Tarihi / Accepted:*
*09.08.2018*

*Tarım Ekonomisi Dergisi*
*Cilt:24 Sayı:2 Sayfa:117-129*
*Turkish Journal of*
*Agricultural Economics*
*Volume: 24 Issue: 2 Page: 117-129*

DOI 10.24181/tarekoder.453488

***Abstract***

Olive oil, as one of the symbols of healthy life, has become an irreplaceable nutrition in today's world. World consumption of olive oil has increased significantly since 1990's. However, there is a small number of countries which have comparative advantage in this market since olive is only produced in the Mediterranean countries. On the other hand, the fact that a product which is marketed by such limited producers also increases the importance of the countries concerned in terms of sustainable development in agriculture. Policies which will increase the supply of these countries yearly is important in terms of sustainable development in agriculture in order to meet the increasing demand in parallel with the world population growth.
In this sense, the world olive oil trade from 1995 to 2015 is analyzed in this study. Network approach that has gained popularity in recent years is used since it gives healthier results than standard statistical methods. In this market, where the findings indicate that there is core-periphery structure, the centrality measure is examined to determine the impact of countries as an importer/exporter and evolution of this structure over the period.
**Key words:** International Trade, Network Analysis, Olive Oil Export

***Uluslararası Zeytinyağı Piyasasının Kompleks Ağ Analizi***
***Özet***

Sağlıklı yaşamın sembollerinden biri haline gelen zeytinyağı tüketimi dünyada 1990'lardan itibaren artış göstermiş ve günümüz dünyasında vazgeçilmez bir besin haline gelmiştir. Ancak zeytinyağının ana maddesi olan zeytin ürünü dünyada sadece belirli bölgelerde yetiştirilebildiğinden, bu pazarda karşılaştırmalı üstünlüğü olan az sayıda ülke bulunmaktadır. Diğer taraftan bir ürünün bu denli sınırlı üretici tarafından piyasaya sürülmesi de tarımda sürdürülebilir kalkınma açısından söz konusu ülkelerin önemini arttırmaktadır. Dünya nüfus artışı ile paralel olarak artan talebi karşılamak üzere, bu ülkelerin ürün arzını yıldan yıla arttıracak politikalar izlemeleri, tarımda sürdürülebilir kalkınma açısından önemlidir.
Bu anlamda çalışmada, dünya zeytinyağı ticaretinin 1995 yılından 2015 yılına kadar olan dönem içerisindeki analizi yapılmaktadır. Çalışmada, standart istatistiki metotlara göre daha sağlıklı sonuçlar vermesi nedeniyle son dönemlerde popüler özellik kazanan ağ yaklaşımı kullanılmaktadır. Bulguların merkez-çevre yapısı olduğunu ortaya koyduğu bu pazarda, ağdaki merkez ülkeler ve bunların zamansal değişimlerini belirlemek üzere merkezilik ölçümü incelenmiştir.
**Anahtar kelimeler:** Uluslararası Ticaret, Ağ Analizi, Zeytinyağı İhracatı

## 1.INTRODUCTION

The olive product is the basis of the economy of the Mediterranean and Aegean regions where represent the world's production area with 95 percent of the olive production. It is possible to examine the production, consumption, exports and imports of countries as olive, table or olive oil as the preferences of people derived from the food culture are also reflected in the olive consumption style. Additionally, from the past it is seen that daily production of olive is also the subject of many basic commodities trades such as; medicine, cosmetics, raw material and soap to oil (Mattingly, 1988).

As the preferences of people derived from the food culture are also reflected in the olive consumption style. The olive is not a product that can be produced in any region of the world because of climate conditions and land conditions. Thus, the trade of olives, which is a scarce source, has international importance. It is also an important issue in terms of sustainable development which is described as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (BM, 2018). In this context, future of this agricultural product is in possession of a few countries. Our motivation to analyze global trade of olive oil is to evaluate the evolution of this structure and the position of its exporters. Depending on these results, it becomes possible to focus on national economies in terms of efficiency of their policies in this sector. Network tools enable us to see the whole picture and the evolution of it.

Many researchers have noted olive oil from the agricultural perspective so the olive oil trade should be examined from an economic perspective, the importance of the olive oil in the world will be revealed in this paper with the situation of the countries' olive oil trade. However standard economic analysis methods are used in the researches about the olive oil trade.

The network analysis is more informative than the results of standard analyze tools since it provides all bilateral connections between countries. While the standard investigation of international trade reflects country-specific characteristics (first-degree indicators), network approach provides better results taking into account indirect trade relationships. It is vital to see the production and trade system as a whole in terms of sustainability of agricultural product such as olive oil which cannot be produced in any region of the world. That's the reason why we aim to analyze global trade structure of olive oil.

This paper is organized as follows: in section 2, a brief literature review is presented, focusing on the olive oil trade in the world. In section 3, there is a methodological explanation about network approach and some information about the data. In fourth section, the findings of the analysis are evaluated in terms of comparison of network statistics with first-degree indicators over the period.

## 2. LITERATURE and THE OLIVE OIL TRADE IN THE WORLD

As a reason for being an agricultural product, it is possible to come across studies olive industry, in the field of agriculture so it is seen that the number of academic studies in the olive sector evaluated economically is extremely limited. Literature on olive trade seems not to be widespread in publications made by the economists. On the other hand, with increasing awareness of the benefits of olive oil in terms of health have been conducting studies on olive trade with various reports (Rabobank International, 2012; Pomarici and Vecchio, 2013). Some studies are made in terms of agricultural economics base. They have discussed the historical and ecological situation of the olive production (Scheidel and Krausmann, 2011). Because of limited production and the importance of olive oil, nowadays its exporting rates are increasing.

Thanks to the support provided by the EU policies, Spain, Italy and Greece seem to be world leaders in table olive and olive oil exports. Because of this, the EU is the major participant in the international olive oil market (Mill, 2007) and there are many studies made about the olive oil trade in the EU countries (Mili and Zuniga, 2001; Harwood and Yaqoop, 2002; Milli, 2007; Kailis and Harris, 2007; Karipidis et al., 2005; Crescimanno, Di Marco and Guccione, 2002; Anania and Pupo D'Andrea, 2007; Blery and Kapsopoulou, 2007).

Mili and Zuniga (2001) researched the future developments in international olive oil trade and marketing carried out forecasts broad future trend for Spain olive oil trade and they provide a snapshot of the environmental issues. Anania and Pupo D'Andrea (2007), explored the global trends in the olive oil market from the EU countries perspective as well. Especially the EU countries have a big market share in olive oil market and as a result of the drastic 2004 reform of the EU domestic policy for olive oil, which fully decoupled support Spain, Italy and Greece advanced their producing and trading. These reforms supported the production of the EU counties' and also their export rates have been increasing (Bayramer and Tunalıoğlu, 2016). For example; the EU countries import the “bulk” olive oil from the other olive oil producer countries such as Turkey and Tunisia. So, these countries do not have the advantages of the olive oil exporting added-value (Tunalıoğlu, 2010).

Turkey is a significant olive oil exporter so, there are more reports on olive trade, reports issued by various institutions, and studies on agricultural economics as a reason for being an agricultural product in the literature.

Turkish olive oil sector has been analyzed in terms of consumption and foreign trade within the scope of the annual statistical production values by Özturk et al. (2009), In this study contains a qualitative analysis of the situation in Turkey's olive oil sector within the framework of trade is only rated and Özturk et al. (2009) determined the sector problems and solutions for these problems.

Tunalıoğlu et al. (2012) used the survey method in the study and they measured take olive oil and the olive reached the results related to micro-level demand of consumers in Aydın province. Socio-economic factors which are effective in consumption and confidence levels of consumers in the olive oil sector have been determined in the study. On the other hand, the analysis of consumer behavior in olive oil consumption in Turkey, more comprehensive and performed in different regions, it is important to consider the comparative results and evaluation (Tunalıoğlu, et al., 2012).

Metin and Atlı (2016) prepared a market research report for the olive sector in Turkey and in the world production, export and import data and they analyzed comparatively. One of the most important issues highlighted in the study, olives just in case the growth in certain regions of Turkey is a significant exporter in the world because of the geographic advantage of Turkey. So, they highlighted that Turkey should use this advantage in foreign trade and Turkey should increase olive oil export potential (Metin and Atlı, 2016).

As mentioned above the olive is produced in geographically limited regions and especially the olive oil has emerged as a popular nutrient in recent years as a result of healthy life. In addition, the olive oil is one of the basic foodstuffs of various meals, so it has caused the increase in the demand for the olive oil and this product has increased its value day by day (Duran, 2006). As can be seen from Table 1, the consumption of the world olive oil has been increased 79 % over the last 26 years.

**Table 1.** World Olive Oil Consumption (thousand tons)

| Country | 1990/1991 | 2016/2017 | Difference |
|---|---|---|---|
| Japan | 4 | 55 | 1275% |
| United Kingdom | 6,8 | 58,4 | 759% |
| Germany | 10,3 | 61,6 | 498% |
| Brazil | 13,5 | 59,5 | 341% |
| Russia | 5 | 19,5 | 290% |
| France | 28 | 94 | 236% |
| United States | 88 | 315 | 258% |
| Portugal | 27 | 70 | 159% |
| Turkey | 55 | 155 | 182% |
| Spain | 394 | 457,2 | 16% |
| Italy | 540 | 514 | -5% |
| Greece | 204 | 105 | -49% |

*Source: Olive Oil Times, 2018.*

Looking at the ranking by the rate of increase the world olive oil consumption from 1990 to 2016 in Table 1, the olive oil consumption increased 1.400 % in Japan. On the other hand, it is seen that China started to consume the olive oil recently.

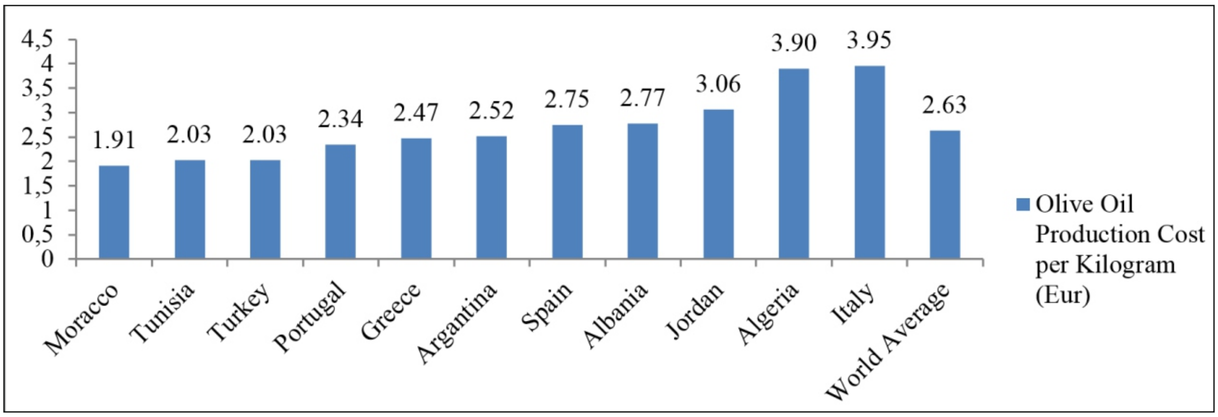
According to reports published by the International Olive Council (IOC) which was established in 1956, representing 93 percentage of the world's olive oil production and 96 percentage of the world's olive oil exporting, world olive oil demand is increasing every year (IOC, 2017). Due to the fact that olive production takes place in the Mediterranean and other similar countries, a limited number of countries export olive oil (Karabulut, 2013). Nowadays olive oil has an important place in the export revenues of olive producer countries.

**Table 2.** Ranking of Top Ten Olive and Olive Oil Producers

| Country | Olive (thousand tons) | Country | Olive Oil (thousand tons) |
|---|---|---|---|
| Spain | 5.277 | Spain | 1.359 |
| Italy | 3.221 | Italy | 598 |
| Greece | 2.232 | Greece | 353 |
| Turkey | 1.292 | Syria | 168 |
| Tunisia | 846 | Tunisia | 150 |
| Morocco | 745 | Turkey | 144 |
| Syria | 731 | Morocco | 95 |
| Egypt | 332 | Algeria | 56 |
| Portugal | 326 | Portugal | 53 |
| Algeria | 299 | Argentina | 23 |

*Source: IOC, 2017.*

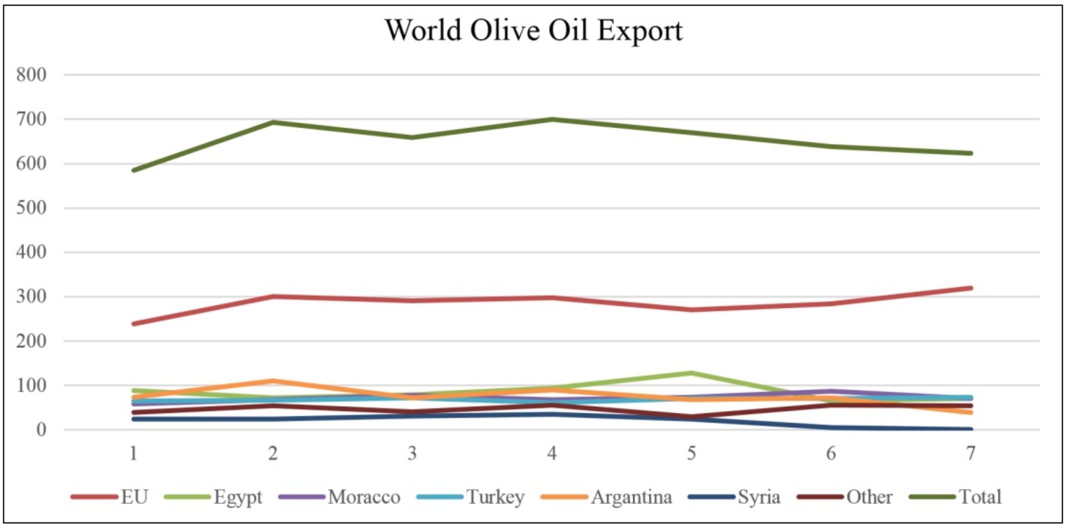
In Table 2, the total exports of the countries with the highest exports are listed in terms of years, and the EU member exporting countries are listed separately. While the volume of world olive oil trade in 2014 is around 2 billion dollars, the total olive oil exports in the world from 2010 to 2014 increased by 20 %. As it can be seen in Table 3, the European countries such as Spain, Italy and Greece have the highest exports throughout the years. Because these countries and Portugal have coasts in the Mediterranean Sea and the EU supports the olive producing with exorbitant sum. The production of olive and olive oil in certain regions in the world increases the importance of trade networks among the countries (Metin and Atlı, 2016). With the complex network analysis approach, it is possible to reveal the complex structure of the commodity trading networks of many international traded products and analyze the trade networks from high-level perspective.




*Source: https://www.oliveoiltimes.com, 2015*

**Figure 1.** Olive Oil Production Cost per Kilogram (Euro)

Figure 1 illustrates the average cost of producing olive oil in the world is about 2.63 Euros. Tunisia, Morocco and Turkey produce olive oil at a cost below this average; Lebanon, Uruguay, Italy and Israel produce at a cost above the average of the world production cost. Despite the olive oil cost above the average, Italy is the highest export rate in the EU. On the other hand, Tunisia, Morocco and Turkey have lower export rates than the EU countries. Because the production at competitive costs in the world olive oil market, cooperative practices, increasing productivity for control of supply, application of licensed warehouse, etc. are not successful on issues yet (Tunalıoğlu, 2012).




*Source: Metin and Atlı (2016).*

**Figure 2.** World Olive Oil Export

In Figure 2, the total exports of the countries with the highest exports are listed in terms of years, and the EU member exporting countries are listed separately. While the volume of world olive oil trade in 2014 is around 2 billion dollars, the total olive oil exports in the world from 2010 to 2014 increased by 20%. As it can be seen in Figure 2, it has been the EU which achieved the highest exports throughout the years. A large part of the EU's export of olive oil is carried out by Spain, Italy, Greece, Portugal and France.

## 3. METHODOLOGY and DATA

In this analysis, we aim to analyze global olive-oil trade with reference to the increasing importance of it. Within this scope, it is important to reveal the advantageous countries in this market and evolution of their performances. In the literature, there are a various number of studies that use standard statistical approach to international trade. However, it has been revealed recently that this standard approach and its measures may not capture the real importance of countries in this global structure since interconnectedness of this global actors' matter. In this context, international trade as well as a lot of economic phenomena is stated as complex system. As a result, complex network analysis has become prominent method widely used in economics.

Before explaining the data used in this analysis, we will give some methodological information so that the data structure will be well-understood. A complex network is defined as a system comprised of uncontrolled parts (nodes) exhibiting emergent complex behavior and interactions among them (links) (Mitchell, 2006). It is necessary to separate a complex system into its parts in order to analyze it (Reichardt, 2009).

In mathematical notation, a network is represented as *G=(V,E,f)*. In this notation, V represents a finite set of nodes and E represents a set of links among these nodes while f represents a mapping that links the elements of E and V. This is the simplest expression of a network that not taking heterogeneous structure of links into consideration. In weighted networks, each link has a weight to reflect this heterogeneity. In this case, the network notation turns into this: *G=(V,E,f),* where W represents the set of weights $W=\{w_1,w_2, \ldots w_m\}$ These connections are transformed into data via matrices. If any two nodes (node i and node j) are connected to each other in the network, then they are said to be adjacent. In this context, adjacency matrix is used to build data containing all of these connections. The data belong to a binary (unweighted) network is built as follows (Estrada, 2015):

$$A_{ij} = \begin{cases} 1 & if\ i,j\ \in E \\ 0 & otherwise \end{cases} \quad (1)$$

A network is investigated in terms of some extents in order to reveal topological features of the network. These extents are connectivity, clustering, centrality, assortativity and degree distribution.

Connectivity is measured both in node-level and in network-level. It is measured by node degree/ node strength (depending on network type) in node-level and by density coefficient in network level. Node degree refers to number of neighbors of a node in binary networks while node strength refers to sum of the weights that a node has with its neighbors. The higher the node degree/node strength the stronger impact the node has (Howell, 2012). In network level, density is a ratio of existing count of links to maximally possible count of links in network (Newman, 2010). Density coefficient is a number between 0 and 1. As the value of coefficient approaches to 1, connectedness of the network increases, vice versa.

Degree distribution is another informative feature that should be examined in a network. Most real-world networks are shown to follow power-law distribution in the network literature (Barabasi, 1999). Networks which follow power-law degree distribution are called 'scale-free networks' and they have a property of including small number of hubs which mean nodes with high degree/node strength (Mitchell, 2006). In general, they also include heterogeneity of connectivity since node degrees/strengths are over a very large range. Another property of scale-free networks is self-similarity, meaning that even one rescales and reshapes the distribution by focusing on a smaller part of the curve, the shape obtained will exactly look like the previous. As a result, scale-free networks have small-world property requiring small average path length and high degree of aggregating. Power-law distribution is involved in the class of fat-tailed distribution and is represented as follows:

$$P\ (k) \approx\ k^{-\gamma} \quad (2)$$

In Equation (2), P(k) represents probability of occurrence of nodes with 'k' degree in the network. $\gamma$ has a crucial importance for this distribution meaning that a lower value of leads to a higher probability of nodes with many links. A network with a lower value of has a higher quantity of super-nodes which have many links compared to a network with a higher value of. It can also be explained as such that higher exponent level means less heterogeneity of connectedness (Leon and Berndsen, 2014).

It is possible to form an opinion about fat-tailed distribution by investigating kurtosis value. If kurtosis has positive value, then distribution follows fat-tail distribution (Decarlo, 1997). It is also stated that most real-world networks have right-skewed distribution and they approximate power-law distribution (Leon Rincon, et al., 2015). Skewness, as a measure that give an idea about distributional asymmetry, is used to determine on which side fat-tail is. If it has positive value, it is said that fat-tail is on right side and then distribution is right-skewed (Lovric, 2010). However, it is better to prove fitness to power-law statistically. One of the methods to determine is to apply Kolmogorov-Smirnov test. Null hypothesis represents coherence of distribution with power-law and H1 hypothesis represents the opposite case. If the p-value is above 0,05, then H0 hypothesis is not rejected meaning that coherence of distribution with power-law is undeniable.

Another prominent topological property of a network is assortativity / disassortativity. This property also helps us to perceive importance of 'centrality' concept. In assortative structure, nodes with high degree/strength tend to have connections with nodes which have high degree/strength. In disassortative case, nodes with high degree/strength tend to have connections with nodes which have low degree/strength and vice versa (Reichardt, 2009). We have two methods to determine assortative/disassortative structure in a network. One is to plot degree and ANND statistics on the same graph and to see the relationship between them. ANND is a statistic shows how linked neighbours of node i are with one another (Fagiolo et al., 2010). It is measured as the average degree of neighbours of i. It can be formulized as follows (Barrat et al., 2004):

$$< k_{nn,i} >= \frac{1}{k_i} \sum_j k_j \quad (3)$$

It is possible to find out whether there is a disassortative structure in a network. If the relation between the degree and the ANND is positive, then we may think that there is an assortative structure in the network. If the relation is negative, then there is a disassortative structure in the network.

Second method to determine assortativity/ disassortativity in the network is calculation of a correlation coefficient. Newman defines assortativity coefficient by adjusting standard Pearson correlation coefficient as shown below (Newman, 2010):

$$r = \frac{\sum_{ij} ij\ (e_{ij} - a_i b_j)}{\sigma_a \sigma_b} \qquad (4)$$

Where $ai = \sum_j e_{ij}$ and $b_j = \sum_i e_{ij}$ are fraction of edges start and end at node i and node j, respectively. And $\sigma_i$ and $\sigma_j$ are the standart deviations of the distributions of $a_i$ and $b_j$. This assortativity measure lies in the interval [-1,1]. If r = 1, then it is said that there is perfect assortativity between i and j. If r = -1, then there is perfect disassortativity between node i and node j.

Disassortative structure is one of the reasons of core-periphery structure in a network. If we determine a disassortative structure in a network, then centrality measure help us to detect the nodes in the core and in the periphery. There are a vast number of measures for centrality such as degree centrality, betweenness centrality, closeness centrality, eigenvector centrality etc. In this study, w-HITs algorithm has been applied to the data by following Kleinberg's methodology. Kleinberg based his study on a directed network in his original study (Kleinberg, 1999). Since direction of a link is taken into consideration in a directed network, links in such a network is separated into two types: coming-links and going-links. Hub nodes are nodes that have a lot of going-links and authorities are nodes that have a lot of coming-links.

Kleinberg developed an algorithm that calculates two distinct centrality measures for these distinct types of nodes (Kleinberg, 1999).

Kleinberg (1999) states that these distinct types of nodes exhibit mutually reinforcing relationship. It means that a good authority is a node which is pointed to by many good hubs and similarly a good hub is a node that points to many good authorities. With reference to this relationship, he developed an algorithm that follows an iterative process. Mathematical notation of this mutually reinforcing relationship is shown as follows:

$$\begin{aligned} x^{<p>} &\leftarrow \sum_{q:(q,p)\in E} y^{<p>} \\ y^{<p>} &\leftarrow \sum_{q:(p,q)\in E} x^{<q>} \end{aligned} \qquad (5)$$

In Equation (5), $x^{<p>}$ is authority weight of node p and $y^{<p>}$ is hub weight of node p. Kleinberg also defines two operations ($\mathcal{J}$ and ) that update these weights within this iterative process. $\mathcal{J}$ updates the x weights and $\mathcal{O}$ updates the y weights during the iterations. As it is seen in Equation (5), authority weight of a node is proportional to the hub weights of the nodes that point to it. In a similar manner, hub weight of a node is proportional to the authority weights of the nodes that it points to.

Kleinberg (1999) defined a vector y which consists of $y^{<p>}$ values and a vector x which consists of $x^{<p>}$ values. Assuming that G = (V,E) with V={$p_1$, $p_2$, …, $p_n$} and A is adjacency matrix of graph G, Kleinberg proved that y and x vectors converge to their equilibrium vectors y* (hub centrality) and x* (authority centrality) at the end of this iteration process. He concluded that x* (authority centrality vector) is the principal eigenvector of $A^TA$ and y* (hub centrality vector) is the principal eigenvector of $AA^T$.

Kleinberg's algorithm uses the same way used to calculate eigenvector centrality. Nevertheless, it eliminates zero-centrality problem of eigen-pair analysis by calculating hub and authority centralities of nodes at the same time and iteratively depending on that mutually reinforcing relationship. Leon and Perez summarized this iterative process as the estimation of eigenvector centrality of two modified versions of adjacency matrix (Leon and Perez, 2013). On this basis, $M_{hub}=AA^T$ and $M_{auth}=A^TA$ can be called as hub matrix and authority matrix of which eigenvector centralities refer to hub centrality and authority centrality, respectively (Kolaczyk, 2009).

The logic behind these hub and authority matrices, was explained by Leon and Perez as (Leon and Perez, 2013). Multiplication of a directed (non-symmetrical) adjacency matrix with transpose of itself enables one to identify second-order adjacencies. Clearly, in the case of $M_{auth}$ multiplication of $A^T$ with A sends weights backwards towards the pointing node. However, multiplication of A with $A^T$ sends weights forwards towards to the pointed node. Since $M_{hub}$ and $M_{auth}$ are symmetrical matrices with non-negative elements, hub and authority centrality vectors will also contain positive and non-zero scores.

As explained above, the mathematical formation of the data used in network analysis is 'adjacency matrix'. In this meaning, we used bilateral olive oil export values (US $) of the countries in the world. The data have been obtained from the database of UN Comtrade. After this brief methodological information, the findings of the analysis will be discussed in the following section.

## 4. FINDINGS

First of all, some descriptive statistics of international olive oil trade network is shown in Table 4. It is observed that counts of the trade partners and the trade connections among them have increased year by year. This increase of nodes and links become clearer by taking the increase of density coefficient into consideration. Because density coefficient that imply the ratio of counts of actual links in the network to maximal possible counts of links has risen from year to year. This statistic increased from 0,02 in 1995 to almost 0,05 in 2015.

**Table 3.** Some Descriptive Statistics

| Years | Nodes | Links | Clustering Coefficient | Density Coefficient | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| 1995 | 161 | 577 | 0.838539 | 0.0223991 | 6.388857 | 43.66971 |
| 2000 | 178 | 894 | 0.8363611 | 0.0283756 | 8.264295 | 74.2053 |
| 2005 | 193 | 1231 | 0.7556386 | 0.03322 | 9.106404 | 91.41509 |
| 2010 | 198 | 1661 | 0.7875076 | 0.0425832 | 10.14704 | 111.2715 |
| 2015 | 204 | 1956 | 0.8156434 | 0.0472327 | 8.918351 | 90.19183 |

Clustering coefficient indicates in what ratio connected two countries that have a common trade partner are. It is observed in Table 4 that clustering coefficient displays a fluctuant look however it decreases in the last instance. When the increase of density coefficient and the decrease of clustering coefficient are evaluated together, it can be said that some countries becomes more dominating in international olive oil trade network during the period of analysis. This issue will be addressed in detail within the scope of centrality.

Skewness and kurtosis values in Table 3 are also significant for the analysis. As mentioned in methodology section, positive and higher values of these measures give an idea about the fitness to power-law distribution. However, it is not enough to investigate only these values in order to be convinced about the fitness to power-law distribution. That's why Kolmogorov-Smirnov test has also been applied to the out-strength values to the countries, in Table 4.

**Table 4.** Kolmogorov-Smirnov Test Results

| **Years** | **ϒ** | **p-value** | **K-S statistic** |
|---|---|---|---|
| 1995 | 1.335405 | 0.7147401 | 0.1601076 |
| 2000 | 1.347977 | 0.9990989 | 0.0637798 |
| 2005 | 1.326466 | 0.9917669 | 0.0646787 |
| 2010 | 1.327464 | 0.7367805 | 0.0958559 |
| 2015 | 1.37559 | 0.9652059 | 0.0690611 |

As mentioned in methodology section, if the p-value is above 0,05, then H0 hypothesis is not rejected meaning that coherence of distribution with power-law is undeniable. It is seen in Table 4 that the degree distribution of international olive oil trade network follows a power-law meaning that there are a lot of countries with low trade connections while there is a small number of countries with high trade connections. Thus, it is said that countries display a heterogeneous structure from one another in terms of trade volumes.

Assortativity / disassortativity is another topological property in network analysis. There are results of assortativity correlation coefficient for each year in Table 5.

**Table 5.** Assortativity Correlation Coefficient

| Years | 1995 | 2000 | 2005 | 2010 | 2015 |
|---|---|---|---|---|---|
| Assortativity Correlation Coefficient | -0.0531655 | -0.0752034 | -0.0797858 | -0.0597936 | -0.06681378 |

Assortativity correlation coefficients in Table 5 are negative for all years so that it is said there is a disassortative structure in the international olive oil trade network even if not perfect disassortativity. Disassortative structure indicates the existence of core-periphery structure in the network. At this point, centrality measures enable us to determine these core countries in the network. Centrality measures developed by Kleinberg are used to determine these countries. As explained in methodology, HITs algorithm of Kleinberg provides us two measures: hub centrality and authority centrality. We call hub centrality of any country as export centrality since a hub refers to a node with of a lot of going-links. Similarly, we call authority centrality of any country as import centrality since an authority refers to a node with a lot of coming-links.

**Table 6.** Comparisons of First-Degree and High-Degree Indicators in Terms of Olive Oil Export

| Ranking according to export centrality | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Rank** | **1995** | | **2000** | | **2005** | | **2010** | | **2015** | |
| 1 | GRC | 0.832 | ESP | 0.839 | ESP | 0.895 | ESP | 0.969 | ESP | 0.877 |
| 2 | TUN | 0.389 | GRC | 0.397 | GRC | 0.323 | GRC | 0.169 | GRC | 0.347 |
| 3 | ESP | 0.374 | TUN | 0.357 | TUN | 0.275 | TUN | 0.143 | TUN | 0.287 |
| 4 | TUR | 0.103 | ITA | 0.107 | ITA | 0.096 | ITA | 0.105 | ITA | 0.147 |
| 5 | ITA | 0.074 | TUR | 0.008 | TUR | 0.085 | MAR | 0.014 | PRT | 0.075 |
| 6 | FRA | 0.024 | FRA | 0.002 | SYR | 0.044 | PRT | 0.008 | ARG | 0.014 |
| 7 | MAR | 0.008 | PRT | 0.001 | MAR | 0.023 | AUS | 0.004 | MAR | 0.013 |
| 8 | AUT | 0.007 | USA | 0.001 | ARG | 0.010 | CHL | 0.003 | CHL | 0.009 |
| 9 | PRT | 0.004 | ARG | 0.001 | PRT | 0.002 | ARG | 0.003 | AUS | 0.007 |
| 10 | BEL | 0.001 | BEL | 0.000 | USA | 0.002 | TUR | 0.001 | FRA | 0.003 |
| **Ranking according to export shares** | | | | | | | | | | |
| **Rank** | **1995** | | **2000** | | **2005** | | **2010** | | **2015** | |
| 1 | GRC | 0.278 | ESP | 0.397 | ESP | 0.401 | ESP | 0.469 | ESP | 0.379 |
| 2 | ESP | 0.254 | ITA | 0.304 | ITA | 0.265 | ITA | 0.279 | ITA | 0.222 |
| 3 | ITA | 0.222 | GRC | 0.127 | GRC | 0.102 | GRC | 0.072 | TUN | 0.146 |
| 4 | TUN | 0.133 | TUN | 0.123 | TUN | 0.091 | TUN | 0.067 | GRC | 0.101 |
| 5 | TUR | 0.067 | TUR | 0.019 | TUR | 0.050 | PRT | 0.034 | PRT | 0.068 |
| 6 | FRA | 0.018 | FRA | 0.008 | SYR | 0.023 | SYR | 0.015 | ARG | 0.018 |
| 7 | MAR | 0.007 | PRT | 0.007 | MAR | 0.021 | ARG | 0.010 | MAR | 0.011 |
| 8 | PRT | 0.005 | ARG | 0.003 | ARG | 0.013 | MAR | 0.009 | CHL | 0.010 |
| 9 | ARG | 0.005 | USA | 0.003 | PRT | 0.011 | TUR | 0.008 | FRA | 0.008 |
| 10 | BEL | 0.002 | GBR | 0.003 | BEL | 0.005 | FRA | 0.006 | PSE | 0.007 |

There is rank order of first ten countries in this global olive oil network in terms of export centralities and export shares in Table 6. This table enables us to compare first-degree indicators (export shares of countries) with high-degree indicators (export centralities of countries). On this basis, Greece that ranks first according to both indicators in 1995 loses its position and Spain becomes the first country according to the both indicators in following years. Both export centrality and export share of Spain has an increasing trend over the period except 2015. Italy ranks fourth in terms of export centrality although it seems like the second best exporter according to export share. High export centrality measure of a country reflects not only the high export volume, but also the importance of trade partner of this country in the network. In this context, real export impact of Italy in international olive oil trade network is lower than its export share shows. More striking finding is that Greece and Tunisia rank higher place according to export centrality which is a high-degree indicator than export share.

These visualizations summarize the all explanations in Figure 3. In these networks, size of the nodes represents the hub centralities (export impacts) of countries. In other words, they indicate how strong impact countries have as an exporter in this international market. Thus, decreasing impact of Greece on olive oil trade network from 1995 to 2015 can be observed. Besides, it is also possible to see the increasing power and predominance of Spain in this global market. Decreasing impacts of Turkey and Tunisia is also observed in the networks. However, growing importance of Italy over the period can also be seen in these visualizations.

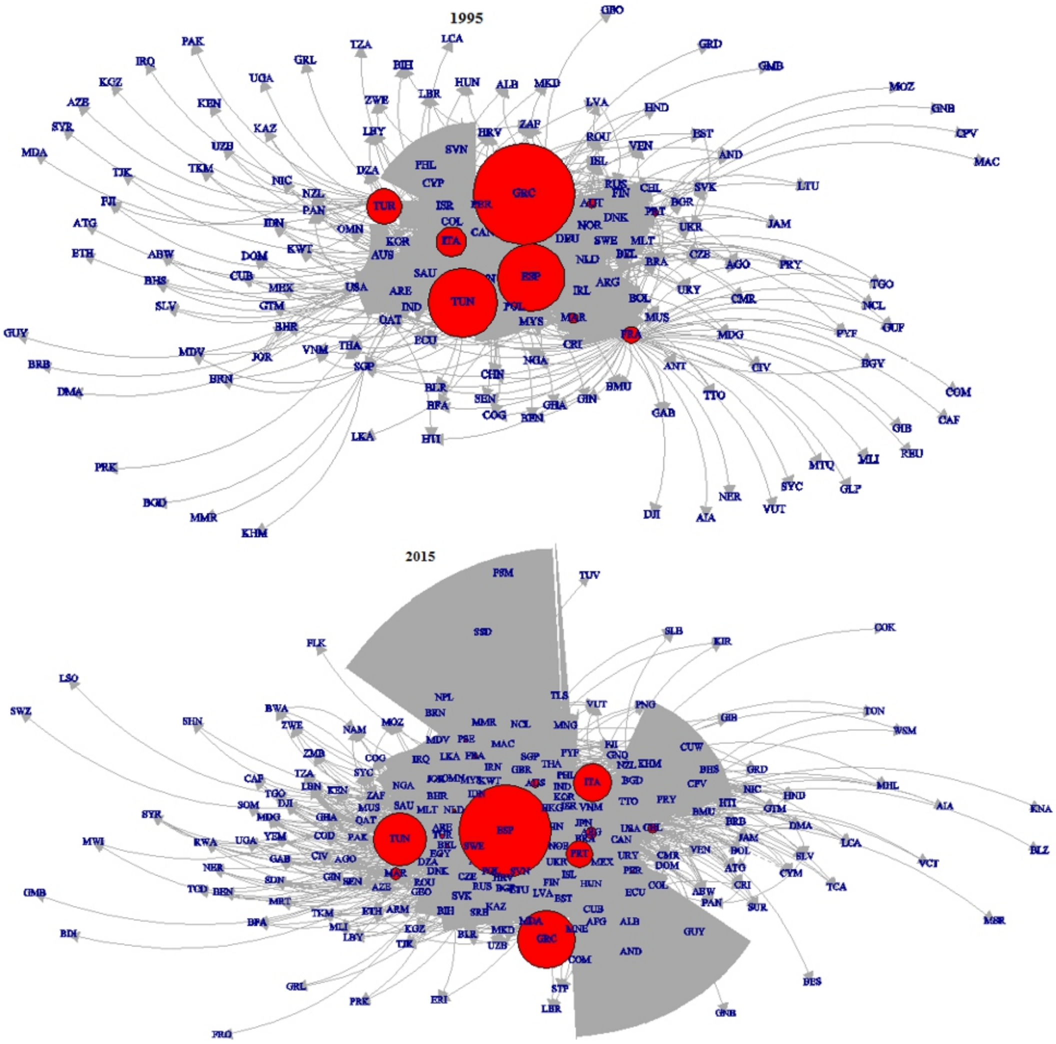



**Figure 3.** Visualization of International Olive Oil Trade Network in terms of Hub Centralities (1995 and 2015)

Investigation of only hub centralities provides only one sided evaluation of this global market. That's why it is also necessary to evaluate authority (import) centralities in order to take demand-side of the market into consideration. Table 7 represents the rank order of import centralities and import shares of first ten countries.

| Ranking according to import centrality | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Rank | 1995 | | 2000 | | 2005 | | 2010 | | 2015 | |
| 1 | ITA | 0.955 | ITA | 0.943 | ITA | 0.930 | ITA | 0.944 | ITA | 0.901 |
| 2 | ESP | 0.238 | FRA | 0.265 | FRA | 0.295 | FRA | 0.199 | FRA | 0.260 |
| 3 | FRA | 0.125 | PRT | 0.126 | USA | 0.130 | USA | 0.192 | USA | 0.236 |
| 4 | PRT | 0.105 | USA | 0.125 | PRT | 0.129 | PRT | 0.126 | PRT | 0.138 |
| 5 | USA | 0.052 | GBR | 0.071 | GBR | 0.063 | GBR | 0.059 | ESP | 0.105 |
| 6 | NLD | 0.023 | DEU | 0.042 | ESP | 0.049 | JPN | 0.051 | JPN | 0.089 |
| 7 | DEU | 0.022 | JPN | 0.034 | KOR | 0.048 | BRA | 0.047 | CHN | 0.087 |
| 8 | GBR | 0.021 | ESP | 0.023 | DEU | 0.041 | AUS | 0.044 | GBR | 0.087 |
| 9 | BEL | 0.008 | AUS | 0.018 | JPN | 0.034 | CHN | 0.041 | DEU | 0.065 |
| 10 | AUS | 0.006 | BEL | 0.017 | BEL | 0.028 | DEU | 0.041 | BRA | 0.046 |
| **Ranking according to import shares** | | | | | | | | | | |
| **Rank** | **1995** | | **2000** | | **2005** | | **2010** | | **2015** | |
| 1 | ITA | 0.411 | ITA | 0.399 | ITA | 0.370 | ITA | 0.310 | ITA | 0.276 |
| 2 | ESP | 0.151 | USA | 0.134 | USA | 0.129 | USA | 0.146 | USA | 0.142 |
| 3 | FRA | 0.132 | FRA | 0.117 | FRA | 0.096 | FRA | 0.083 | ESP | 0.111 |
| 4 | USA | 0.086 | DEU | 0.069 | ESP | 0.088 | DEU | 0.058 | FRA | 0.080 |
| 5 | PRT | 0.067 | GBR | 0.042 | DEU | 0.054 | BRA | 0.043 | DEU | 0.051 |
| 6 | DEU | 0.040 | PRT | 0.038 | PRT | 0.034 | PRT | 0.033 | BRA | 0.035 |
| 7 | GBR | 0.022 | JPN | 0.027 | GBR | 0.031 | JPN | 0.030 | JPN | 0.034 |
| 8 | NLD | 0.013 | ESP | 0.021 | JPN | 0.021 | GBR | 0.029 | PRT | 0.033 |
| 9 | BEL | 0.012 | CAN | 0.020 | CAN | 0.017 | CAN | 0.025 | GBR | 0.028 |
| 10 | CAN | 0.010 | CHE | 0.015 | CHE | 0.016 | ESP | 0.023 | CHN | 0.024 |

In terms of import, Italy ranks first according to both high-degree and first-degree indicators. Second important importer country of this global network differs depending on the indicators. Import share as a first-degree indicator indicates that the US ranks second while import centrality as a high-degree indicator indicates that France ranks second. Thus, although the US has the second highest import share in global olive oil market it can be said that France has higher impact as an importer on this global market since the countries from which France imports olive oil have strong export centralities.

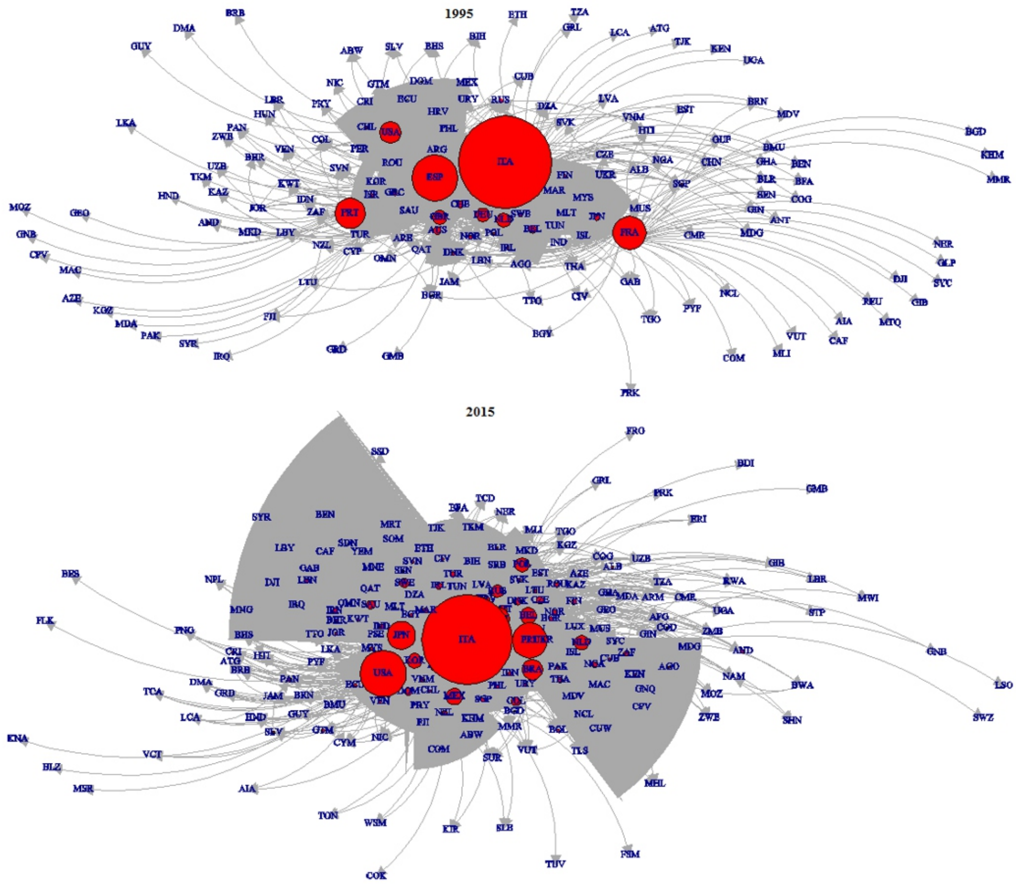



**Figure 4.** Visualization of International Olive Oil Trade Network in terms of Authority Centralities (1995 and 2015)

These visualizations in Figure 4 also summarize the explanations above. In these networks, size of the nodes represents the authority centralities (import impacts) of countries. In other words, they indicate how strong impact countries have as an importer in this international market. Italy is the biggest importer of olive oil for both years. The US, Portugal and Japan also have an increasing impact over the period.

## 5. CONCLUSION

In today's world where healthy nutrition is seen as a precursor to long life, olive oil is much healthier than other oils. World consumption in the olive oil has increased at the rate of 79% from 1990/91 to 2015/16. This increase is an indicator of this consciousness. However, only Mediterranean countries have the comparative advantage of this foodstuff. That's why trade volume of olive oil increases significantly with this increasing consciousness. In this case, it becomes more important to analyze these global trade connections.

In the literature, there is a vast number of qualified studies which use survey method and statistical investigation. There are also some reports which analyze the current situation and problems of the sector and also offer solutions. However, standard tools such as import or export shares of countries in global values may not reflect the real importance of the countries in global context. Because global trade relations have complex structures and the importance of an exporter depends not only the volume of its export but also the importance of the countries it exports to. That's the reason why network analysis has become a popular tool to investigate such complex structures. Network analysis enables us to evaluate the system as a whole since it takes into consideration the second-order relations among trade partners. Thus, it is more probable to determine the real impacts of the importers (as demand-side) and the exporters (as supply-side) in this hierarchical complex trade structure.

In this analysis, we applied network analysis to the global olive oil trade from the year 1995 to the year 2015. The reason for the selection of this period is the data availability. Density coefficient, as an indicator of connectedness in the network, indicates that countries have become more connected to one another over the period. The density coefficient, increases from 0,02 in 1995 to almost 0,05 in 2015, explains this connectedness.

It has also been proved by K-S test that strength distribution of the countries in this global trade network follows power-law distribution, meaning that connectedness of the countries displays a heterogeneous structure. Heterogeneous connectedness also refers to the existence of some hubs in this global network. Another method to prove the existence of the hubs in the network is to investigate disassortativity. The existence of disassortative structure in the network means the existence of core-periphery structure in the network. In our analysis, global olive oil trade network displays disassortative structure for all years, meaning that there is a core-periphery structure in the network. This heterogeneous and core-periphery framework of this network is also an indicator of complexity of the network.

Centrality measures help us to determine these hubs. According to centrality results, Greece loses its position as the most central exporter of 1995 and Spain becomes the most central exporter in the later years. Italy ranks fourth in terms of export centrality although it seems like the second best exporter according to export share indicator. Greece and Tunisia also rank higher place in terms of export centrality when compared to export share. However, Turkey and Tunisia have decreasing trend in their export centrality values. When it comes to import, Italy ranks first for all years according to both high-degree and first-degree indicators. On the other hand, as mentioned in Table 2; Italy is the second country as a producer of both olive and olive oil in the world. Because Italy has a special situation with its olive oil trademark in all over the world. One of the biggest factors in achieving this success is the fiscal incentives that the EU has provided to the olive oil sector. Otherwise, the import centrality of the US, Portugal and Japan also have an increasing trend over the period because of the increasing importance of olive oil for healthy nourishment.

When we evaluate these results in terms of sustainability of agricultural production and export, it can be said that Turkey, Tunisia and Morocco have lost their export impact in this network contrary to the European countries meaning that Europe has become the center of this product. Thus, these countries which have lost their impact should revise and improve their policies for this product to prevent the dependence of world consumption on only one region and also to provide effective use of their potential.

## KAYNAKLAR


*Anania, G., Pupo D'andrea, M. R. 2007. The global market for olive oil. Actors, trends, policies, prospects and research needs, Agricultural Trade Agreement, Working Paper 08/2.*

*Barabasi, A.L., Albert, R. 1999. Emergence of scaling in random networks. Science, 286, 509&512. Doi: 10.1126/Science.286.5439.509.*

*Barrat, A., Barthelemy, M. and Vespignani, A. 2004. Traffic-Driven model of the world wide web graph. algorithms and models for the web-graph, Third International Workshop, Springer Berlin Heidelberg, 56-67. Doi: 10.1007/B101552.*

*Bayramer, G. and Tunalıoğlu, R. 2016. Türkiye'de sofralık zeytin - zeytinyağı ihracatçılarının sorunları ve çözümüne yönelik yaklaşımlar, Journal of Adnan Menderes University Agricultural Faculty 2016; 13(1) : 141 – 150.*

*Blery, E. and Kapsopoulou. K. 2007. Marketing olive oil, Journal of Food Products Marketing, 13:4, 39-55, Doi: 10.1300/J038v13n04_03*

*BM. 2018. Report of the World Commission on Environment and Development: Our Common Future, Available at: http://www.un-documents.net/our-common-future.pdf, (accessed 20 July 2018).*

*Crescimanno, M., Di Marco, S. and Guccione, G. 2002. Production and trade marketing policies regarding organic olive oil in sicily, British Food Journal, Vol. 104, No. 3/4/5, 175-186.*

*Decarlo, L. 1997. On the meaning and the use of kurtosis. Psychological Methods, 2 (3), 292-307. Doi: 10.1037/1082-989x.2.3.292*

*Duran, M. 2006. Zeytin/Zeytinyağı sektör raporu, dış ticaret uygulama servisi, Available at: Retrieved from http://www.ito.org.tr/dokuman/sektor/1-106.pdf (accessed 26 June 2017).*

*Estrada, E. 2015. Introduction to complex networks: structure and dynamics. evolutionary equations with applications in natural sciences. Lecture Notes In Mathematics 2016. J. Banasiak, M. and M. Mokhtar-Kharroubi (Eds.). P. 93-131. Doi 10.1007/978-3-319-11322-*

*Fagiolo, G., Reyes, J. and Schiavo, S. 2010. The evolution of the world trade web: a weighted network analysis. Journal of Evolutionary Economics, 20, 479-514. Doi: 10.1007/S00191-009-0160-X.*

*Harwood, J.L. and Yaqoop, P. 2002. Nutritional and health aspects of olive oil. Eur. J. Lipid Sci. Technol.104, 685-697.*

*Howell, A. 2012. Network statistics and modeling the global trade economy: exponential random graph models and latent space models: Is geography dead?. Unpublished Thesis, University Of California*

*Igraphs 2018. Available at: Retrieved from http://igraph.org/r/doc/fit_power_law.html (accessed 09 January 2018).*

*IOC. 2017. Available at: Retrieved from http://www.internationaloliveoil.org/ (accessed 10 September 2017).*

*Kailis, S. and Harris, D. 2007. Producing table olives, Landlinks Press, Australia.*

*Karabulut C., 2013. Aydın ticaret borsası: zeytin ve zeytinyaği raporu. Aydın Ticaret Borsası, Aydın.*

*Karipidis, P., Tsakiridou, E. and Tabakis, N. 2005. The greek olive oil market structure, Agricultural Economics Review, Vol. 6, No 1, 485-504.*

*Kleinberg, J.M. 1999. Authoritative sources in a hyperlinked environment. (Available at: Retrieved from https://www.cs.cornell.edu/home/kleinber/auth.pdf, 1-34. (accessed 15 December 2017).*

*Kolaczyk, E. 2009. Statistical analysis of network data methods and models. Springer.*

*Leon, C. and Perez, J. 2013. Authority centrality and hub centrality as metrics of systemic importance of financial market infrastructure. Borradores De Economia, 754, 1-24.*

*Leon, C. and Berndsen, R.J. 2014. Rethinking financial stability: challenges arising from financial networks' modular scale-free architecture. 1-37.*

*Leon Rincon, C., Machado, C. and Paipilla, S. 2015. Identifying central bank liquidity super-spreader in interbank funds network, EBC Discussion Paper, Vol. 2015-010, 1-43.*

*Lovric, M. 2010. Skewness. International Encyclopedia of Statistical Science, Springer: New York.*

*Metin İ. and Atli, H. 2016. Zeytinyağı dış pazar araştırması: Edremit, Ayvalık ve Burhaniye ticaret odalarına üye zeytinyağı işletmelerinin ihracat potansiyellerinin geliştirilmesi projesi, Available at: http://www.burhaniyeto.org.tr/uploads/zeytinyagpazararastirma.pdf (accessed 10 September 2017).*

*Mili, S. 2006. Market dynamics and policy reforms in the EU olive oil industry: an exploratory assessment, Paper Prepared For Presentation At The 98th EAAE Seminar 'Marketing Dynamics Within The Global Trading System: New Perspectives', Chania, Crete, Greece As In: 29 June – 2 July, 2006.*

*Mili, S. and Zúñiga M. R. 2001. Exploring future developments in international olive oil trade and marketing: A Spanish perspective. Agribusiness: An International Journal, 17 (3), 397–415.*

*Mitchell, M. 2006. Complex systems: Network thinking. SFI Working Paper, 2006-10-036.*

*Newman, M.E.J. 2010. Networks an introduction. Oxford University Press.*

*Olive Oil Times 2017. Available at: Retrieved from https://www.oliveoiltimes.com (accessed 25 November 2017).*

*Öztürk, F. Yalçın, M. ve Dıraman H. (2009), Türkiye zeytinyağı ekonomisine genel bir bakış, Gıda Teknolojileri Elektronik Dergisi, Cilt: 4, No: 2, 35-51.*

*Pomarici E. and Vecchio R. 2013. The Italian olive oil industry in the global competitive scenario, Agric. Econ. - Czech, 59, 8: 361–372*

*Rabobank International. 2012. World olive oil market overview – new world versus old world olive oil winning in the US market with quality. Report Presented At Confagricoltura, Rome December 11th 2012.*

*Reichardt, J. 2009. Introduction to complex networks. Springer-Verlag, Berlin Heidelberg.*

*Scheidel, A. and Krausmann, F. 2011. Diet, trade and land use: A socio-ecological analysis of the transformation of the olive oil system, Land Use Policy, 28, 47–56.*

*Tunalıoğlu, R. 2010. Türkiye'nin dökme zeytinyağı ihracat tercihi üzerine düşünceler, Akdeniz Kültürü Dergisi, Yıl: 4, Sayı: 20.*

*Tunalıoğlu R., 2012. Türkiye'de zeytin ve zeytinyağı politikaları ve dünya"daki rekabet gücü, GTHB-Ege Tarımsal Araştırma Enstitüsü, Bahçe Bitkileri Grubu, 10-12 Temmuz 2012, İzmir, Bölge Bilgi Alışveriş Toplantısı Bildirileri No. 151:37-39.*

*Tunalıoğlu, R. Çobanoğlu, F. Cankurt, M. ve Armağan, G. (2012). Zeytinyağı tüketici davranışları, 10. Ulusal Tarım Ekonomisi Kongresi. Konya.*