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Network Analysis of Crude Oil and Oil Products Trade

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Abstract:
The study analyzes export/import flows of a range of countries from the perspective of network analysis. The motivation for performing this analysis is based on the supposition that markets are a system of relations. The analysis is followed by the demonstration of the networks comprising the international trade of crude oil (HS 2709) and oil products (HS2710) at the following points of time: 2001, 2007, 2014, and 2018. For this study, a set of countries was selected that includes 25 countries (base countries) and their export/import partners for the observed points in time. The study provides the calculation of main network parameters offers comparisons between them and researches the similarities in the network parameters between the analyzed base countries. The results of the study show that there are similarities in the centralities between the 25 observed countries (base countries). According to the analysis, countries that have the same level of centralities in one network also show similarities in another network.

Key Word: network, centralities, crude oil, oil products.

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I. Introduction

Over the last 70 years, most of the countries demonstrate a strong and steady increase of international trade. Current international trade shows that countries sell and buy a wide range of commodities, and trade between countries usually includes hundreds or thousands of positions. Trade liberalization is the mainstream movement in trade policies of the majority of countries. Countries tend to increase the volume of trade, and to that end they participate in various types of trade agreements; most of them are members of World Trade Organization (WTO), resource exporting countries participate in various types of institutions that help them to improve their export position (one of these institutions is the OPEC). Current international trade can be presented as a complex network, with a large number of actors, i. e. countries, international and national institutions, and a number of private businesses that interact with each other. Crude oil and oil products hold a prominent place in the trade relations between the countries. According to the international statistics, crude oil still remains the main source of energy. Crude oil and oil products are among the most traded international commodities. These commodities are to be found in the trade balance of all countries. Some countries are importers, and others are exporters of crude oil and oil products, while some countries are both exporters and importers of crude oil and oil products. Export/import relations between countries can be described from the perspective of network methodology, while international trade of oil (crude oil and oil products) also can be presented as the network. Analysis of the network that depicts the trade relations in the area of oil is instrumental for the understanding of the evolution of trade relations between countries in the area of such important products as the crude oil and oil products; besides, network analysis helps to identify the main actors in the network presented by countries. Besides, network analysis helps to identify the countries that have similar positions in the network of oil trade. The results of analysis and identification of the countries' positions, as well as of the possible similarities of their network parameters, are useful for chartering new ways of improvement of oil trade for both parties in the trade relations, i. e. for exporters and importers. This study is structured as follows: first it provides the literature review in the area of network analysis of oil trade, the next part presents the description of methodology and data, after that the results of the analysis of networks of oil trade are presented, and the final part is the Conclusion. The analyzed network of oil trade features a set of 25 countries, and at each point of time under analysis (2001, 2007,2014, 2018) those countries with which the analyzed ones have export/import relations in the products presented by HS2709 and HS 2710 are added.

II. Literature Review

International trade in general, and trade of crude oil and oil products in particular are analyzed from the viewpoint of network theory in a range of studies.

De Benedictis and Tajoli (2011) has mentioned that application of network methodology for international trade analysis have started from Hilgert (1943). (De Benedictis et al. (2014)) apply network analysis to 178 countries for the period of 1995-2010, the bilateral trade flows are analyzed at a highly detailed level (HS 6 digits) for a wide range of commodities. Their results postulate the applicability of this methodology for the analysis of the countries' economy and of their position in the global trade network through the application of series of centralities. Concerning oil trade, a series of studies analyzes it from the position of network theory, the most recent ones are shown below.

Ji et al. (2014) applied network theory analysis for the study and identification of global oil trade patterns. Applying the provisions of complex network theory, they show that the main oil-exporting countries differ in their influence in oil trade network. According to the results of their modeling, the most important influencers in oil trade network, in the case of oil exporting countries, are Russia and Saudi Arabia. Main influencers in oil trade network are the main actors in maintaining the stability of oil trade. Currently, oil trade network, that is formed within the framework of the current geopolitics and diplomatic relations, can be presented as a structure that includes three trading blocs: 'South America–West Africa–North America', 'Middle East–Asian–Pacific region' and 'the former Soviet Union–North Africa–Europe'.

Zhong et al. (2014) detect and analyze the communities in international oil trade network. By the application of complex network theory for the analysis of oil trade for the period of 2002-2011, they study the evolution of these communities. The results of their analysis helped to identify the two important moments in time that influence the development of communities and their stability in the international oil trade network: the first instance (2004-2005) is presented by the changes in the oil market due to the Iraq War, and the second instance (2008-2009) is presented by the post-effects of the global financial crisis in 2008.

Applying the complex network theory, Zhong et al. (2017) study four countries in the world fossil fuel trade network: USA, China, Russia and Saudi Arabia. Analyzing series of centralities that define each country's position in the fossil fuel trade network, they prove that these countries play the paramount role in the fossil fuel international trade network. USA, Russia and China are more focused on the trade relations with their close neighbors. Besides, the results of their study show that geographic position plays an important part in transportation costs.

An et al. (2014) analyze the international crude oil trade by offering the model that uses two types of networks, the first one based on import relations and the second one on export relations. 81 countries' oil trade for the time period of 1993-2012 is analyzed. According to the results of the modeling, international crude oil trade is under the influence of various factors that account for a range of influences and outcomes for both importer and exporter countries. Besides, the results of their modeling show that international crude oil trade is evolving into a stable system, orderly and integrated.

Yang et al. (2015) applied complex network analysis to the studying of the evolution and geography of global crude oil flows for the period of 1988 to 2013. Their results show that global crude oil trade is under the domination of fifteen oil hubs, that play the leading role in the network. According to their results, the most important hubs are Russia, Saudi Arabia, USA, China and UK. The characterization of global crude oil is based on network specifications that cover a wide range of market properties. Jia et al. (2017) explored two bigger steady homogeneous groups of regional oil markets and the dominant regional markets in the process of the market evolution.

Fracasso et al. (2018) analyze the global oil trade network properties for the period of 1995 to 2014. According to their results, within this period of time global crude oil trade went through significant changes, represented by the diminishing role of OPEC and growing role of China in the global oil trade. Besides, their results show that the position and role of the countries in oil trade network is not necessarily directly related to to their market share presented by demand and supply.

III. Methodology

In the study, a network is described as a set of nodes (countries) and edges (export/import relationships). We generate an adjacency matrix that represents nodes and their connections. To create an adjacency matrix, we used data on the presence/ absence of trade relations between countries. Unweighted network analysis was used for network analysis.

The series of centralities are applied for the analysis of network: degree centrality, betweenness centrality, closeness centrality and eigenvector centrality. These centralities let to determine the importance of the node in the network Freeman (1978), Bonacich (1972).

Degree centrality

The degree of a node is the number of edges connected to that node. In this study, degree centralities are calculated using the following formulas:

In-degree centrality of country i: $D_i^{in} = \sum_{j=1}^{N} dc_{ji}$ (1.1)

Out-degree centrality of country i: $D_i^{out} = \sum_{j=1}^{N} dc_{ij}$ (1.2)

Total centrality of country i: $D_i^{total} = D_i^{in} + D_i^{out}$ (1.3)

Where: N is the number of nodes; dc_{ji}, dc_{ij} are the variables that show the presence of trade relations between countries i and j (dc_{ji}- presents import dc_{ij}- presents export), (1 in the case of presence of trade relations, and 0 in the case of absence of trade relations).

Closeness centrality

Closeness centrality represents the distance of a node from the other nodes. This centrality is determined by calculating the sum of the length of the shortest paths between the node and all the other nodes in the network. Closeness centrality Cc(i) indicates how close a node is to all the other nodes in the network.

$$Cc(i) = \frac{1}{\sum_j d(i,j)} \quad (1.4)$$

Where d(i,j) is the number of edges between node i and j in the case of the shortest way.

Betweenness centrality

Betweenness centrality represents the node's ability to control the connection between other nodes. To analyze the importance of a node in the network as the shortest path throughout the network, betweenness centrality is applied. For the calculation of this centrality, the following data are taken into account: the number of shortcuts between the two nodes (node 1 and node 2), SC_{12}; SC_3 that shows the number of shortcuts between node 1 and node 2, traced through the transit node (node 3):

$$BC = \frac{SC_3}{SC_{12}} \quad (1.5)$$

Eigenvector centrality

Eigenvector centrality measures a node's importance while taking into the account the importance of its neighbors. It is used to measure a node's influence in the network. For the calculation of eigenvector centrality methodology based on Bonacich (1972). According to this methodology, eigenvector centrality defines the eigenvector centrality of country i (EVi) as the sum of the eigenvector centralities of its neighbors (EV1, EV2,..,EVk).

$$EV_i = A_{i1}EV_1 + A_{i2}EV_2 + A_{i3}EV_3 \dots\dots\dots + A_{ik}EV_{1k} \quad (1.6)$$

Where A_{ik} is the trade adjacency matrix of country.

IV. Data for Network Analysis

We will analyze the networks of trade of the following products: HS2709, HS 2710. The trade network for every product is constructed by tracing the export/import relations for the set of 25 countries (base countries), plus the countries that export crude oil and oil products to these 25 countries in each of the period are added to the analysis. The set of base countries includes: Belarus, Bulgaria, China, Croatia, Czech Republic, Finland, France, Germany, Greece, Hungary, India, Italy, Japan, Republic of Korea, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden, Turkey, United Kingdom, United States of America. The following points of time have been selected: 2001, 2007, 2014, and 2018. The data source on export/import relations is COMTRADE database; we use it for the construction of export/import networks and for further analysis.

V. Analysis of Networks

The first point of time used in the analysis is 2001. This year is of interest because that was when crude oil prices started to grow. The next point of time is 2007. This year was the year of global financial crisis, and for our purposes it is important to understand what happened to the export network before and after 2007. The next point is 2014. This year was characterized by a drop of oil prices, and the start of wide-ranging exploration of shale oil in the USA. As a result, at the end of 2014, all prices dropped. The last point of analysis is 2018. In this year, the current situation in the oil network was achieved, and it is helpful to compare it with the earlier periods. Thus, three timeframes are used for the analysis: 2001-2007, 2008-2014, and 2014-2018.

V.I Case of export network for product group HS 2710

First, we present the results that elucidate the dynamics of the following network elements: the number of edges and the number of nodes (Table 1).

Table no 1 Parameters of network for HS 2709

	Year 2001	Year 2007	Year 2014	Year 2018
Nodes	95	98	101	106
Edges	393	464	491	522

The present network contains the 25 base countries and the additional countries that were also exporting crude oil to these countries during the analyzed period, and it indicates relatively stable nodes. The number of edges has increased during this period. From the total number of connections, the analysis is diverted to the number of individual connections of nodes. The parameters of degree centrality are observed. The results of calculations of this centrality are displayed in the (Table 2) below.

Table no 2 Degree centrality for HS 2709

Country	Year 2001	Year 2007	Year 2014	Year 2018
Belarus	1	5	1	1
Bulgaria	1	5	10	8
China	34	47	46	46
Croatia	12	4	6	11
Czech Republic	8	12	11	14
Finland	41	8	10	7
France	31	42	39	38
Germany	13	38	39	35
Greece	1	14	13	13
Hungary	2	7	6	12
India	31	29	41	44
Italy	27	36	44	40
Japan	33	29	29	28
Korea, Republic of	5	31	33	36
Lithuania	27	5	7	8
Netherlands	12	33	40	58
Poland	19	14	15	21
Portugal	8	15	16	18
Romania	21	15	7	11
Slovakia	4	3	6	8
Spain	30	34	38	36
Sweden	15	14	12	23
Turkey	11	12	3	6
United Kingdom	29	39	40	35
United States of America	50	52	54	60

In 2001, the analyzed countries had a wide range of degree centrality. Some countries, e. g. Belarus, Bulgaria, Greece and Hungary, had a relatively low degree centrality, between 1 and 5. At the other side of this range during that period was the group of countries that had the degree centrality ranging between 29 and 50. In 2007, the group of countries with the degree centrality higher than 30 (India, Japan, Korea, the Netherlands, Spain, Italy, Germany, UK, France, China, and USA) created a stable group of countries with the highest level of this centrality in the next period. The countries with a relatively low level of degree centrality (between 1 and 10) also featured a relatively steady behavior of this centrality. Among these countries were Belarus, Turkey, Finland, Slovakia, and Lithuania. During the analyzed period, the countries like Czech Republic, Portugal, Poland, and Sweden had a stable position between the low-level degree centrality and the high level of degree centrality. For most countries, the degree centrality had a tendency for growth.

For closeness centrality, the results of calculations are displayed in Table 3. Initially, 2001 was analyzed. The 25 countries in question had a relatively wide range of the closeness centrality, from 1.61 to 3.5. This centrality was never stable, for either a period or a country. In 2001 and other periods, USA, the Netherlands, UK, China, Italy, Germany, and Japan featured the closeness centrality in the range between 1.5 to 2.0. The countries with the high closeness centrality throughout all the periods were Belarus, Lithuania, Slovakia, Bulgaria, and Greece. They had closeness centralities between 2.76 and 3.7. The closeness centrality was relatively stable throughout the analyzed period. Therefore, as far as the closeness centrality is concerned, there were certain similarities between markets.

Table no 3 Closeness centrality for HS 2709

Country	Year 2001	Year 2007	Year 2014	Year 2018
United States of America	1.61	1.54	1.54	1.5
Netherlands	1.93	1.81	1.73	1.68
United Kingdom	1.83	1.68	1.67	1.75
China	1.78	1.64	1.73	1.78
Italy	1.82	1.76	1.72	1.83
Germany	1.93	1.92	1.78	1.84
India	2.76	2.01	1.88	1.85
Spain	1.84	1.79	1.72	1.88
France	1.7	1.75	1.81	1.88
Republic of Korea	1.95	1.95	1.86	1.9
Sweden	2.05	2.04	2.13	1.9
Japan	1.85	1.86	2.01	2
Poland	2.36	2.22	2.02	2.03
Hungary	3.24	2.34	2.61	2.14
Portugal	2.28	2.27	2.21	2.18
Turkey	2.19	2.08	2.4	2.18
Romania	2.6	2.14	2.44	2.18
Finland	2.46	2.41	2.2	2.19
Czech Republic	2.26	2.06	2.11	2.22
Greece	2.3	2.24	2.23	2.23
Bulgaria	2.46	2.36	2.32	2.28
Croatia	2.65	2.25	2.65	2.42
Slovakia	2.7	2.67	2.33	2.46
Lithuania	2.36	2.45	2.27	2.61
Belarus	2.85	2.44	2.75	2.76

The next centrality is the betweenness centrality. It helps to understand the ability of a country to influence trade relations between other countries. The results of calculations are presented in Table 4. The high level of betweenness centrality for a country testifies to its considerable influence on the network. Among the analyzed countries, USA was the most powerful one in its ability to control the market in each period, with the centrality higher than 1000. For the USA, betweenness centrality was relatively stable. As far as China and the Netherlands are concerned, for China the steady dynamics of betweenness centrality increased from 444 in 2001 to 731.08 in 2018. For the Netherlands, betweenness centrality increased from 253.38 to 933.0. Throughout the period, there were groups of countries, which are divided by the level of betweenness centrality. The first group of countries had a relatively low level of betweenness centrality. In our network, among them were Belarus, Croatia, Finland, Turkey, Greece, Czech Republic, and Hungary. These countries were similar in their low influence on the crude oil markets. Another group included USA, the Netherlands, China, Japan, Germany, and UK, with their betweenness centrality above 16.4. These countries (USA, the Netherlands, China, Japan, Germany, and UK) have demonstrated their importance for the network via the closeness centrality, where the same set of countries played the most central role in the network, and via the betweenness centrality where the same set of countries exerted the most powerful influence on the other countries in our network. Among these countries, the biggest influencer was USA. The other most important countries were the Netherlands and China.

The importance of countries was also tested by eigenvector centrality, which highlights the importance of the countries' connections and its importance for the neighboring countries. The results of the calculations of eigenvector centrality are displayed in Table 5. The results for USA show that the country still holds a unique position on the market. Eigenvector centrality for this country during the entire period was 1. In 2001, China, Spain, and UK featured the eigenvector centrality of ca. 0.8. In 2018, these countries still had the highest eigenvector centrality within our set. All of them, however, featured an insignificant decrease of eigenvector centrality. Within the scope of our observations, these countries, such as Finland, Greece, Hungary, and Belarus, were similar to each other in the low eigenvector centrality throughout the whole analyzed period. There were two groups of countries: on the one hand, countries with a high eigenvector centrality and on the other hand, countries with low eigenvector centrality. Certain similarities of the eigenvector centrality level might be observed among these countries.

Table no 4 Betweenness centrality for HS 2709

Country	Year 2001	Year 2007	Year 2014	Year 2018
Belarus	2.79	2.79	2.79	2.79
Croatia	105.92	13.44	1.51	3.99
Finland	11.54	6.15	3.55	5.33
Turkey	118.83	20.78	4.28	5.77
Greece	37.50	113.21	206.24	7.79
Czech Republic	203.73	50.00	19.76	10.88
Portugal	44.14	11.48	15.6	16.27
Hungary	24.19	24.19	8.33	22.23
Poland	127.98	89.65	63.93	54.24
Germany	240.17	150.49	387.00	88.42
Slovakia	0.23	96.00	99.24	105.24
Lithuania	4.84	4.60	127.60	114.79
Romania	100.68	48.68	4.59	116.92
Bulgaria	11.30	12.31	119.92	122.90
Sweden	92.37	53.1	19.14	134.44
France	510.87	342.93	161.83	164.25
Spain	283.58	344.08	438.54	240.48
United Kingdom	259.67	521.01	287.12	250.17
Italy	175.47	333.62	492.23	316.59
Japan	257.49	326.42	181.69	435.27
Republic of Korea	525.23	274.79	413.54	506.48
India	0.59	210.34	485.69	625.69
China	444.48	782.49	665.09	731.06
Netherlands	253.38	235.37	278.23	955.82
United States of America	1360.66	1096.88	1077.96	1206.29

Table no 5 Eigenvector centrality for HS 2709

Country	Year 2001	Year 2007	Year 2014	Year 2018
Belarus	0.04	0.13	0.03	0.03
Lithuania	0.15	0.13	0.14	0.13
Slovakia	0.1	0.06	0.16	0.18
Turkey	0.32	0.39	0.09	0.2
Finland	0.21	0.2	0.28	0.21
Romania	0.17	0.47	0.19	0.24
Croatia	0.13	0.13	0.16	0.29
Hungary	0.02	0.15	0.12	0.3
Greece	0.4	0.42	0.3	0.35
Czech Republic	0.3	0.37	0.33	0.35
Portugal	0.56	0.44	0.43	0.39
Japan	0.66	0.62	0.51	0.42
Poland	0.23	0.34	0.38	0.46
Sweden	0.41	0.42	0.32	0.54
Republic of Korea	0.64	0.57	0.62	0.56
India	0.06	0.61	0.66	0.63
China	0.83	0.85	0.77	0.69
Spain	0.82	0.85	0.86	0.72
Germany	0.81	0.9	0.83	0.75
France	0.99	0.99	0.85	0.75
Italy	0.87	0.9	0.89	0.77
United Kingdom	0.84	0.92	0.91	0.78
Netherlands	0.65	0.84	0.85	0.89
United States of America	1.00	1.00	1.00	1.00

Bulgaria	0.17	0.17	0.23	0.16

V.II CASE OF EXPORT NETWORK FOR PRODUCT GROUP HS 2710

Table 6 presents the sum-total of data concerning the number of countries and their connections for the product trade at the four points of time.

Table no 6 Parameters of network for HS 2710

	Year 2001	Year 2007	Year 2014	Year 2018
Nodes	145	153	167	164
Edges	1131	1389	1516	1524

The above shows that during the time the network featured a relatively stable number of nodes, with an insignificant increase, and the same is true for the number of edges. The results of degree centrality calculations are presented in Table 7. In 2001-2018, all the countries featured the tendency for growth of degree centrality. The lowest degree centrality was 34 for Lithuania, while the highest was 113 for USA. Based on the degree centralities, we can identify the groups of countries with the relatively close values of this centrality. In 2001, Japan, Germany, Korea, UK, Spain, Italy, the Netherland, France, and USA form the group of countries with relatively the same high level of degree centrality (around 80). In 2007, China and India joined this group of countries with the highest degree centrality, and from this point of time and until the current moment (2018), this group of countries remained intact. Among these countries, China and the Netherland had the above average degree centrality.

Table no 7 Degree centrality for HS 2710

Country	Year 2001	Year 2007	Year 2014	Year 2018
Belarus	36	51	57	59
Bulgaria	47	58	58	66
China	62	85	94	93
Croatia	52	49	49	47
Czech Republic	46	64	75	78
Finland	50	55	69	66
France	108	114	118	116
Germany	83	85	93	87
Greece	61	71	76	78
Hungary	43	56	57	67
India	12	88	109	111
Italy	82	94	99	90
Japan	76	79	79	80
Republic of Korea	73	88	102	104
Lithuania	34	50	55	57
Netherlands	86	97	118	109
Poland	39	66	73	84
Portugal	42	48	52	60
Romania	55	55	63	64
Slovakia	39	53	60	63
Spain	83	91	93	88
Sweden	60	67	74	70
Turkey	57	81	87	90
United Kingdom	85	91	90	83
United States of America	113	124	118	122

The next centrality is closeness centrality. The analyzed countries showed a relatively stable level of this centrality, with the fluctuations of 5%. The results of the calculation of this centrality are presented in Table 8.

Countries with the lowest level of closeness centrality were USA, France, the Netherlands, and Korea, with their closeness centrality ranging between 1.36 and 1.57. It should be underlined that these countries were among the ones with the highest degree centrality for the present product group. After 2007, USA, France, the

Netherlands, Republic of Korea, China, India and Italy have formed group of countries with similar degrees and closeness centrality. For both cases of centralities (degree and closeness), the importance in the group of countries (China, India, and the Netherlands) provided the biggest outcome for the network after 2007. It may be supposed that this testifies to the growing role of India and China in the world economy. The countries that were the top influencers in the network according to the present closeness centrality were Japan and UK, but they showed the marginal position in 2018, which testifies to their decreasing role in the world economy. Among the countries with high closeness centrality were Belarus, Lithuania and Croatia. Other countries had closeness centrality between 1.6 and 1.7 for each point of time.

Table no 8 Closeness centrality for HS 2710

Country	Year 2001	Year 2007	Year 2014	Year 2018
Belarus	1.86	1.78	1.80	1.72
Bulgaria	1.74	1.70	1.76	1.72
China	1.65	1.57	1.57	1.58
Croatia	1.71	1.76	1.83	1.85
Czech Republic	1.78	1.72	1.68	1.66
Finland	1.76	1.75	1.72	1.73
France	1.43	1.43	1.45	1.44
Germany	1.58	1.60	1.59	1.61
Greece	1.67	1.66	1.65	1.63
Hungary	1.79	1.76	1.78	1.72
India	1.97	1.53	1.47	1.45
Italy	1.58	1.54	1.57	1.60
Japan	1.56	1.58	1.63	1.63
Republic of Korea	1.57	1.53	1.51	1.49
Lithuania	1.97	1.77	1.83	1.80
Netherlands	1.56	1.52	1.43	1.48
Poland	1.83	1.67	1.70	1.64
Portugal	1.81	1.84	1.78	1.72
Romania	1.70	1.72	1.73	1.74
Slovakia	1.85	1.74	1.76	1.72
Spain	1.56	1.56	1.58	1.61
Sweden	1.69	1.69	1.67	1.69
Turkey	1.69	1.62	1.61	1.60
United Kingdom	1.53	1.56	1.60	1.64
United States of America	1.36	1.34	1.43	1.40

The betweenness centrality for most of the countries in the observed set ranges between 140 and 450. The results of calculations of betweenness centrality are displayed in Table 9. Thus, among the analyzed countries were those with stable high betweenness centrality at every point of time. These countries were the Netherlands, France, Korea, and USA. They featured the betweenness centrality between 765 and 2478. After 2007, China and India ranked amid the countries with high betweenness centrality. UK, Italy, and Japan had a high level of this centrality in 2001 and 2007, yet they were ousted from the set of countries with the highest betweenness centrality at the other points of time. Betweenness centrality also depicts the rise of China and India and describes the role of some countries. In comparison to the previous centralities for the analyzed product set, USA, Korea, France, the Netherland, China, and India still played the main role in the network, as far as the betweenness centrality was concerned. As for the similarity between countries, it is observed only for the countries with the highest betweennness centrality. The results of calculations of eigenvector centrality are displayed in Table 10. There is a group of countries that had a level of eigenvector centrality between 0.88 and 1. These countries had a relatively stable level of this centrality throughout the entire analyzed period. For the point of time that marked the global financial crisis, there were no significant changes except for the inclusion of new countries, such as China and India. Compared to the other types of centralities, 2007 was the point when China and India turned into the main actors in the network. Among the countries with the lowest level of eigenvector centrality, Croatia, Lithuania, Portugal, and Belarus consistently held a relatively similar position in the network beginning with 2007. Moreover, for eigenvector centrality, certain countries had it at relatively the

same level between 0.73 and 0.88, and for most of the countries the eigenvector centrality with the present range remained relatively stable between 2007 and 2018. In short, we have discovered certain similarities between the analyzed countries in relation to these centralities.

We summarize the results and discussions in Table 11, which presents the results of grouping the countries according to their similarities at most points of time, via the centralities calculated for various product groups.

Table no 9 Betweenness centrality for HS 2710

Country	Year 2001	Year 2007	Year 2014	Year 2018
Belarus	7	26	233	319
Bulgaria	207	223	181	270
China	254	676	1286	591
Croatia	383	105	61	24
Czech Republic	113	91	521	505
Finland	37	41	89	88
France	1585	1529	2274	1668
Germany	435	191	271	290
Greece	367	355	236	344
Hungary	60	95	31	61
India	2	925	2227	1963
Italy	468	583	408	379
Japan	1307	514	284	315
Republic of Korea	903	1283	1233	1857
Lithuania	11	35	94	221
Netherlands	766	797	1506	1293
Poland	39	328	100	238
Portugal	32	25	393	510
Romania	256	282	310	42
Slovakia	7	460	178	144
Spain	663	844	501	455
Sweden	230	109	196	95
Turkey	215	270	789	722
United Kingdom	807	353	307	171
United States of America	2614	2670	2213	2475

Table no 10 Eigenvector centrality for HS 2710

Country	Year 2001	Year 2007	Year 2014	Year 2018
Belarus	0.59	0.64	0.63	0.73
Bulgaria	0.7	0.71	0.68	0.73
China	0.8	0.86	0.9	0.91
Croatia	0.73	0.63	0.6	0.61
Czech Republic	0.63	0.73	0.78	0.82
Finland	0.69	0.69	0.76	0.75
France	1.00	1.00	0.98	1.00
Germany	0.89	0.88	0.9	0.88
Greece	0.74	0.78	0.83	0.85
Hungary	0.64	0.67	0.67	0.75
India	0.3	0.88	0.91	0.94
Italy	0.89	0.91	0.96	0.89
Japan	0.84	0.86	0.83	0.84
Republic of Korea	0.78	0.86	0.94	0.9
Lithuania	0.44	0.65	0.65	0.66
Netherlands	0.90	0.90	1.00	0.97
Poland	0.55	0.78	0.79	0.85
Portugal	0.61	0.6	0.61	0.73

Romania	0.72	0.69	0.72	0.74
Slovakia	0.56	0.63	0.7	0.74
Spain	0.89	0.88	0.9	0.89
Sweden	0.78	0.77	0.79	0.80
Turkey	0.74	0.85	0.86	0.88
United Kingdom	0.94	0.92	0.91	0.89
United States of America	0.99	1.00	0.97	0.98

Table no 11 Grouping of countries based on centralities

Centrality	Similarities	Product group HS2709	Product group HS2710
Degree centrality	Countries similar due to low level	Bulgaria, Belarus, Turkey, Finland, Slovakia and Lithuania	Belarus, Croatia, Bulgaria, Portugal
	Countries similar due to high level	India, Japan, Korea, Netherlands, Spain, Italy, Germany, UK, France, China, and USA	Japan, Germany, Korea, UK, Spain, Italy, Netherland, France, China, India and USA
Closeness centrality	Countries similar due to low level	Belarus, Lithuania, Slovakia, Bulgaria, and Greece	Belarus, Lithuania and Croatia
	Countries similar due to high level	USA, Netherlands, UK, China, Italy, Germany, and Japan	USA, France, Netherlands, China, India, Italy and Korea
Betweenness centrality	Countries similar due to low level	Belarus, Croatia, Finland, Turkey, Greece, Czech Republic, and Hungary	Belarus, Croatia, Finland
	Countries similar due to high level	USA, Netherlands, China, Japan, Germany, and UK	Netherlands, France, Korea, and USA, China and India
Eigenvector vector centrality	Countries similar due to low level	Finland, Greece, Hungary, and Belarus	Croatia, Lithuania, Portugal, Belarus
	Countries similar due to high level	USA China, Spain, and United Kingdom	China, Netherland, India, Italy, UK, Korea, and USA

VI. Conclusion

The study elucidates the trade in product group HS 2709, HS 2710 from the perspective of network theory, and identifies similarities between markets based on their network parameters, such as centralities. A network was constructed that includes 25 countries (base countries), with the added set of countries that export crude oil and oil products to the base countries under analysis. The two networks were analyzed for the case of trade of product groups HS 2709, HS 2710 at the points of time 2001, 2007, 2008, 2014, and 2018.

Based on the results of our analysis for the base countries, we can suggest that these countries (base countries) feature certain similarities of network parameters. Countries with the most important position in one network tended to occupy the same important position in the other product network. The same is true for the countries with the low influence on the network. For our product cases, the network parameters remained at a relatively stable level. Our analysis for the respective points of time hasn't identified any critical changes in the network parameters for any of the product sets. After 2007, the increasing role of China and India can be witnessed. The principal countries in the world market, presented by G7, are the main actors in the network we have analyzed.

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