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Evolution of Spatial Pattern of Crude Oil Trade

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Abstract
In these years, diversification of import channels has been a important strategy to get the security of petroleum import. However, diversification premises a thorough analysis and understanding of the importing strategy of other countries in advance. Ignorance of other crude oil importing countries' strategic decisions and their interactions and integrations will inevitably lead to the failure of the diversification strategy.
This paper analyses the world's network of crude oil import and shows the evolving of the structure. Analysis of a regional comparison is also carried out to highlight the difference between the states and the homogeneity of world crude oil trade networks. Finally, the spatial structure of world crude oil trade has been simulated. In conclusion, diversification does necessarily not mean homogeneity. The resource reserve in each region varies and the economic and political relationships among regions are also diverse, which determine that diversification of import channels depends on the objective situation and relationship with our partners.

Key words: Importing strategy; Diversification strategy; Petroleum import

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INTRODUCTION
With the mounting up of the Chinese crude petroleum import year by year, the security of the petroleum import has become more and more striking. The strategy of import diversification has obviously become the primary strategy to efficiently solve the problem of security of the petroleum import in China. However, the adoption of import diversification strategy is premised with the command of formation and evolutionary law of the world crude trade spatial pattern and clarification of the role of other crude oil import countries in it. The ignorance of other members' strategetic option in the formation of regional structures and the interaction and integration of other mainstays will ultimately lead to the failure of the diversification strategy.

This work makes out an outline of the world crude oil trade spatial structure according to the world crude oil trade data, by means of complicated network analysis and on the basis of regional analysis in geography. The functions of different regions in the world crude oil trade pattern have been shown by comparison of nodes, degree, and edge weight. The homogeneity of world crude oil trade spatial pattern has been analyzed and the world crude oil trade spatial structure has been simulated. The research reveals that the space and effects of world crude oil trade is gradually expanding with time; the spatial pattern of world crude oil is non-homogeneity, and the structure entropy and weight entropy also match with the ordering of world crude oil trade. The world crude oil trade spatial pattern is meanwhile characterized with significant, also stable modularity. The analysis finds that

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diversification does not mean homogeneity. The trade mainstays should choose partners in appropriate regions in accordance with the objective environment so as to carry out diversified import strategy and settle potential crisis for petroleum supplement to the essence.

With the rapid development of Chinese economy, the crude oil import is rising up. In 2009, 50% of Chinese crude oil relied on import of foreign crude oil, exceeding internationally acknowledged alarm level. As was predicted by SDPC (State Development Planning Commission), the crude oil import will be further increased in the near future (Rosvall, Trusina, Minnhagen, & Sneppen, 2005). With the mounting up of the crude petroleum import, the security of the petroleum import has become more and more striking. It reaches a consensus to establish the diversified crude oil import pattern with the Middle East as the center. The transportation pipelines are also the focus of the scholars. The transportation diversification of Chinese import security is discussed from different perspectives. The strategy of import diversification has obviously become the primary strategy to solve problem of security of-petroleum import in China efficiently. However, the import diversification requires the clarification of the evolutionary law and trend of the world crude oil trade spatial pattern and the strategetic option of other crude oil import regions. Otherwise, "One cannot see the forest for the trees" in research of Chinese crude oil import spatial pattern. The ignorance of other members' strategetic option in the formation of regional structures and the interaction and integration of other mainstays will ultimately lead to the failure of the diversification strategy.

The traditional analysis of world crude oil trade is based on the micro mainstays, with the focus on trade relationship of individual country or countries in particular regions. However, with the intensification of crude oil trade among countries, the complex network of the world crude oil trade has become more and more clarified. The complex network results from abstraction of large amount of real and complicated topology. Complicated network has been developed rapidly since the Small World Network model was put forward in 1998. It has been adopted by the scholars in the research on social relationship, transportation network, and virus-infection network. While these researches mainly focused on the basic data characteristics of the complicated network, which was abstracted from the actual world: Small World, Scale Free and Clustering (Rosvallm, et al., 2005; Gastner, 2006), and the geographic location of the network has been ignored. However, the relationship among the nodes of international trade spatial structure has been less valued in comparison with the influence of spatial distance, thus the state trade spatial structure is of great geographic features. Based on the statistics of ITC (International Trade Centre), this paper studies the real petroleum trade spatial structure with the combination of the principle of complicated network and space analysis in geography. Crude oil spatial structure is investigated by means of network approach, which requires high integrity of international crude oil trade statistics. Consequently, the real petroleum trade spatial structure is studied so as to provide new insight and reference for world petroleum trade.

1. GRAPH THEORY DESCRIPTION OF CRUDE OIL TRADE SPATIAL STRUCTURE

Assuming V is a cluster of crude oil exporting countries composed of n countries v_i (i=1, 2, ….,n). i.e. V={v_1, v_2, ..., v_n}, W is a cluster of crude oil importing countries composed of m countries w_j (j=1, 2, ….,m). Adjacency matrix A is used to express the trade relationship between importing and exporting countries, A is composed of directed line segments a_{ij} (i=1, 2,…,n; j=1, 2, ….,m). a_{ij} is 0 or 1, when a_{ii}=0, it means that there is no relationship between importing countries and exporting countries; When a_{ii}=1, it signifies that there is trade between the two parties. Any a_{ii} of A is made with importing countries and exporting countries as two ends. There is no other joint on any line except the two ends. The relative intensity between two nodes is then expressed through weight. Each line a_{ii} is correspondingly given one weight $r_{ij,}$ i.e., trade volume. The weight matrix R then goes like this: R=[r_{ij}] (i=1, 2,…,n; j=1, 2, ….,m) . As a result, the crude oil import trade spatial structure graph of a country at a specific time is then composed of V, W, A and R, which is recorded G=(V, W,A,R).

1.1 Node

Node refers to the regions or countries with roles in the world crude oil trade spatial structure. The identification of the trade trend of the nodes in the spatial structure is to divide into the functional regions, and define the division of role in the crude oil trade. The flow trend of the crude oil volume will then determine the difference of the capacity and consumption of the regional crude oil. The difference of the two is then defined as Δi, $\Delta i = P_i - C_i$.

In which: Δi refers to the exporting volume of crude oil in a certain period of time in region i, P_i signifies the crude oil capacity, C_i means the consumption volume. The flow trend of crude oil will then be determined according to the regional exporting availability. Theoretically,

When $\Delta i \approx 0$, i.e., $P_i \approx C_i$, region i is then considered the self –sufficient region;

When $\Delta i < 0$, i.e., $P_i < C_i$, region i is then considered the importing region;

When $\Delta i > 0$, i.e., $P_i > C_i$, region i is then considered the exporting region; Different regions can be defined as self-sufficient regions, importing node regions and exporting node regions (they are the functional regions in the crude oil trade spatial structure) according to

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the regional functions each country assumes in the international crude oil trade.

1.2 Export and Import Degree

The crude oil interaction between importing countries and exporting countries create the trade relation, which is directly indicated through export or import quotas. The research on quota is helpful for better understanding of trade relation among nodes in the crude oil spatial structure, and the evolution of the trade relation can be learnt through the description of time series.

Export quotas means $N_i^{out}(t)$, the value of directed line segment a_{ii} which is conjoined by year t and exporting country i and, signifying exporting to $N^{out}(t)$ countries in t years. It is expressed like this:

$$N_i^{out}(t) = \sum_{j=1}^{m} a_{ij} (a_{ij} = 0, \text{or } 1) \quad (1)$$

Import quotas means the $N_i^{out}(t)$, value of directed line segment a_{ii} which is conjoined by year t and importing country i and, signifying exporting to $N^{out}(t)$ countries in t years. It is expressed like this:

$$N_j^{in}(t) = \sum_{i=1}^{n} a_{ij} (a_{ij} = 0, or 1) \quad (2)$$

1.3 Weight (Intensity of Trade Relations)

The scale of the international crude oil trade volume at present is extremely imbalanced; few trade relations have great trade volume while most trade relations have a small amount of volume. Therefore, it is impossible to describe the structure features of crude oil importing trade spatial pattern through quotas, the research of trade intensity is then introduced.

1.4 Homogeneity of Crude Oil Trade Structure

Another importing indicator for description of crude oil trade spatial structure is homogeneity of the network, besides the three indicators mentioned above. The structure entropy and the intensity entropy which are used to research the non-homogeneity of complicated network are introduced in this paper in order to show the evolutionary law of the homogeneity of international trade network. The non-homogeneity of the complicated network refers to the condition when few core ends have lots of joints while most ends share less joints (Liu, 2007). The entropy of the system reflects the uniformity of the condition. The smaller the entropy is, the more systematic the system is and the less even it is; otherwise, the less the systematic system is, the more even it is.

1.4.1 Structure Entropy

According to the connotation of entropy, the structure entropy is:

$$E = -\sum_{i=1}^{n} I_i \ln I_i \quad (4)$$

In which, I_i is the significance of the No. i end, $I_i = \sum_{j=i}^{m} a_{ij} \Big/ \sum_{i=1, j=i}^{i=n, j=m} a_{ij}$. When the system is complete homogeneous, i.e., $I_i = 1/m$, the structure entropy is the largest, i.e.,: E_{max}=1n m; when the trading country has trade relation with only one country, the spatial structure is the least even, I_1=1, I_i=0(i≠1), the structure entropy is the least $E_{\min} = \frac{1}{2}\ln 4(n-1)$.

The structure entropy is then normalized in order to eliminate the effect of different importing origins on the comparison of entropy and obtain the standard structure entropy E_S, that is:

$$E_S = (E - E_{\min}) / (E_{\max} - E_{\min}) \quad (5)$$

1.4.2 Intensity Entropy

Assuming the weight vector r_{ij} is the weight value of relativity between No. i country and No. j country, K_i is the significance of weight, i.e., the significance of trade volume in the crude oil trade spatial structure. $K_i = \sum_{j=1}^{m} r_{ij} \Big/ \sum_{i=1, j=i}^{i=n, j=m} r_{ij}$. The intensity entropy then goes like this:

$$J = -\sum_{i=1}^{n} K_i \ln K_i \quad (6)$$

When the system is completely homogeneous, i.e., $K_i = 1/m$, the intensity entropy is the largest, i.e.,: J_{max}=1nm; when the intensity of trade spatial structure is concentrated on one country, the spatial structure is the most uneven, K_1=1, K_i=0(i≠1), the intensity entropy is the minimum, the standard entropy is J_S , i.e.,:

$$J_S = (J - J_{\min}) / (J_{\max} - J_{\min})$$

2. EVOLUTION OF NODES AND QUOTAS OF THE WORLD CRUDE OIL TRADE SPATIAL STRUCTURE

2.1 Total Volume Variation of the Modes and Quotas of the World Crude Oil Trade Spatial Structure

The mainstay of the exporting modes network is an important dimensionality of the network. The simplification of nodes seems to be especially crucial when more common production factors flowing network is researched. Since there are relatively less exporting-oriented countries and the volume of importing–oriented countries is not enough to have influence on the basic structure of the world petroleum trade structure.

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Therefore, the present work does not target on all the countries. Exporting research focuses on the exporting–oriented countries, and so does importing research. Meanwhile, the countries whose annual trade volumes are below 50,000 ton are not studied. The amount of input and output nodes are shown in the table. It can be seen that the input nodes are more than the output nodes (remaining 43-45) when the output nodes are between 37-29. There is little variation of nodes between 2001 and 2012.

Table 1
Evolution of Total Volume of World Crude Oil Trade Topological Structure From 2001 to 2012

	2001	2003	2005	2007	2009	2012
Output nodes	39	39	38	37	37	36
Input nodes	43	43	44	45	45	46
Output	655	684	722	776	778	785
Input	683	728	734	795	789	892

The output and input table can be obtained by establishment of incidence matrix of input and output nodes. It shows the general rising trend of the world crude oil trade. Since the research of this paper does not target on all the trade countries, the output and input is not equal. The input slightly surpasses the output all the time, which reveals the importing countries tend to establish more trade relations.

2.2 Geographical Distribution of the Input Nodes and Input

In graph theory, the qualities of the network represented without relying on the specific position of nodes and the specific shape of lines are called topological features of network, while research on topological quality of network is not only the abstraction of the complicated petroleum trade system, but also in combination with the research of the geographical spatial structure.

From the input data of the sub-regions, W. & Cent Europe and Asia Pacific have the highest input, which is about 300 annually, and both of the imports in the two regions tend to increase. The import of W. Cent. Europe is relatively less than that of Asia Pacific. The following regions are S. & Cent. America and North America successively; the former, which remains between 54 and 64, is slightly higher than the latter one, which is almost 36-47. Africa has the smallest import, with relatively small variation. The North America has the largest regional average import, which is different from regional import and ranking. Though it has relatively small sum of regional import, it enjoys the highest average import within the region since America is the only importing node (country). It presents that America is one of the countries which have established the greatest crude oil trade relations, much higher than the average level of other regions; Asia Pacific is the next; the second from the last is W. & Cent. Europe. Though the regional import sum of the W. & Cent. Europe ranks the first two places; it has relatively low average import since the import nodes in the world petroleum trade spatial structure is far ahead from the corresponding values of other regions. Africa has the smallest average import, which is between 6 and 13. Africa is the least inactive regions, seen from sum of import, average import and regional import nodes.

Table 2
Regional Input Nodes and Input T From 2001 to 2012

Regional input nodes						
	2001	2003	2005	2007	2009	2012
North American	1	1	1	1	1	1
S. & Cent. America	3	3	3	2	2	2
Asia Pacific	14	14	14	15	16	16
Europe	21	22	23	23	23	24
Africa	4	3	3	4	3	3
Regional input						
	2001	2003	2005	2007	2009	2012
North American	36	40	41	46	44	46
S. & Cent American	64	58	54	61	58	57
Asia Pacific	263	279	319	335	336	338
Europe	296	307	311	337	325	326
Africa	24	24	28	24	27	26

2.3 Distribution of Exporting Nodes and Exporting Quotas

The Middle East has the highest export quotas. Though the importing countries hope to avoid the risk of importing petroleum from turbulent Middle East, it is inevitable to import from Middle East; Former Soviet Union is another region of high exporting quota, with the basic export between 118 and 158. Compared with stability of Middle East, former Soviet Union has striking rising trend. As for the average exporting quotas, former Soviet Union has the largest exporting quotas. The primary exporting target of former Soviet Union is W. & Cent. Europe, which is a region with intensified countries. That is exactly the main reason for great exporting countries; Western Africa and Europe rank the third and fourth in the regional exporting quotas. The abundant petroleum resource in Western Africa and the development of petroleum exploration in recent years contribute a lot for its exporting to the world

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and then extensive crude oil trade relations have been established in the world. Though there are few exporting countries in Western Europe, it has the relatively high exporting quota since the main market is Western Europe which is country-intensified. As for the rank of exporting quotas, North Africa and Southeast Asia are similar. What is unlike is that the exporting quota has the rising trend in North Africa; in contrast, the corresponding value is decreasing in Southeast Asia. Southeast Africa has the smallest exporting quota since it is deficient in petroleum. The petroleum consumed in other countries is mainly exported. North America and S. & Cent. America have the smallest average exporting quota, remaining 9-15 because it is the relatively inactive exporting region in the world crude oil trade pattern.

Table 3
Distribution of Exporting Nodes and Exporting Quotas

Exporting nodes						
	2001	2003	2005	2007	2009	2012
South Africa	1	1	1	1	1	1
West Africa	6	6	6	6	6	6
North Africa	4	4	4	4	4	4
S. & Cent American	5	5	5	5	5	5
North American	2	2	2	2	2	2
Asia Pacific	4	4	4	4	4	4
Former Soviet Union	4	4	4	4	4	4
Europe	3	3	3	3	3	2
Middle East	9	9	9	9	9	9
Output quotas						
	2001	2003	2005	2007	2009	2012
South Africa	26	23	26	34	32	34
West Africa	83	79	76	87	84	84
North Africa	52	63	71	82	88	83
S. & Cent American	47	46	67	72	75	78
North American	24	25	20	23	27	28
Asia Pacific	70	43	53	56	50	46
Former Soviet Union	118	139	148	154	160	162
Europe	71	75	72	70	65	62
Middle East	164	191	189	195	193	197

3. INTENSITY OF WORLD CRUDE OIL TRADE RELATION

3.1 Evolutionary Trend of Trade Volume and Average Weight

As is seen from trade spatial structure table and intensity table, both average exporting intensity and importing intensity are increasing slowly, which presents the strengthening of international crude oil flow. Consequently, the leading position of petroleum and the industrial raw material has not been changed though every country is constantly seeking the substitutable energy under the influence of petroleum crisis. Moreover, with the expansion of social production and the increasing consumption of petroleum, the scale and effect of crude oil trade flow will increase.

3.2 Geographical Distribution of Intensity

The total amount of Asia-Pacific has been ranking first in the regional import between 2001-2012 and the import of crude oil in the region is increasing from 768.9 MT in 2001 to 1051.6 MT in 2012, which has obviously played an important role in world crude oil import spatial pattern; Asia-Pacific follows North America, as is seen from the weight of line. Though the total amount of import in North America is next to that of Asia-Pacific, the weight of crude oil importing trade in North America is far ahead Asia-Pacific which ranks the second since the quota is farther below Asia-Pacific. The W. & Cent. Europe ranks the third place. The total import amount in the region is slightly higher than North America. However, the weight of this region is much the same as Africa since there are more importing countries and high importing quotas. The total amount of import is S. & Cent. America is higher than Africa, but the weight is 1/2 that of Africa, which indicates that the import trade relation in S. & Cent. America is more than that of Africa.

Table 4
Distribution of Importing Intensity

Regional import trade volume						
	2001	2003	2005	2007	2009	2012
North American	455.40	480.30	500.70	501.57	485.4	449.7
S. & Cent American	42.52	36.58	32.70	41.50	20.9	19.6
Asia Pacific	621.76	661.89	731.30	800.62	875.8	948.5
Europe	454.63	479.25	524.70	536.68	465.1	974.9
Africa	34.24	35.92	38.10	35.76	28.7	20.40
Regional import trade average volume						
	2001	2003	2005	2007	2009	2012
North American	12.65	12.01	12.21	10.90	11.03	9.78
S. & Cent American	0.66	0.63	0.61	0.68	0.36	0.34
Asia Pacific	2.36	2.37	2.29	2.39	2.61	2.81
Europe	1.54	1.56	1.69	1.59	1.43	2.99
Africa	1.43	1.50	1.36	1.49	1.06	0.78

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3.3 Homogeneity of World Crude Oil Trade Space

The international flow of crude oil is the basis of crude oil trade structure. However, the flow of crude oil cannot completely present the potential difference resulted from production and consumption, i.e., the flow trend of international crude oil is of great selectivity. Therefore, the crude oil space structure is of non-homogeneity. The non-homogeneity of crude oil trade spatial pattern is the same as heterogeneity of complicated network. The average trade weight merely expresses the trend of variation of the average values in the whole trade relations. The nodes in the topography of the real world are of great heterogeneity and the relation intensity of nodes is various. If the information of the relation difference is omitted, it is difficult to solve the practical problem.

3.3.1 Structure Entropy of the World Crude Oil Trade Space

Entropy of quotas and weight has been introduced in this paper to reflect the homogeneity of the trade relations in the space pattern. The value of entropy which is close to 1 signifies that the spatial pattern is nearly a random network; the homogeneous trade relation in the spatial pattern indicates a disordered network. The entropies of quotas and weight of the import and export trade spatial structure are calculated and normalized for the convenience of comparison. The standard entropy of the spatial structure is then obtained as follows.

Either the entropy of quotas or entropy of weight shows that the international crude oil trade spatial structure is not random network, but in order. The standard entropy of import is relatively larger than that of export by comparison. Therefore, the ordering of import spatial pattern is inferior to export, which is nearly random. Multiple trade relations are helpful to reduce the risk. There are similarity between the difference of weight entropy and quota entropy. The weight entropy of export is lower than that of import, i.e., the homogeneity of export spatial pattern is lower than that of import. As for the standard entropy of quotas and export entropy of weight, the latter is higher than the former, i.e., quota is more homogeneous compared with quotas

3.3.2 Modularity of World Crude Oil Trade Spatial Structure

Modularity is an important representation of non-proportionality of spatial structure. Ravasz & Barabasi discovered that many networks in the world are characterized with striking modularity, with nodes connected in the module. While there are few or even no connection between modules and there are distinct clarification between modules and non-modules.

In order to present the significance of the main exporting region in the world crude oil trade spatial structure, without outshining the important trade relation of the exporting sub-regions, the uniformed trade volume standard is not adopted in research of modularity of world crude oil trade spatial pattern in this paper. The world can be divided into six crude oil exporting regions: Middle East, North Africa, Western Africa, Former Soviet Union, S. & Cent America, and Mexico and Canada in North America. The modularity of the ordering network is adopted, i.e., the nodes within the module are highly connected, while there is few or no connected formation accumulative program among modules. If the trade volume of the relations in the first selected n regions is less than 80%, and the import volume of No. n country amounts to 5% of the export volume in the selected region, accumulation should go on until the accumulation is over 80% or the import volume of No. n country doesn't reach 5% of the export volume in the selected region. The selected module is then formed by the first n countries and the exporting region.

The division of importing region should be in line with the division as the traditional analysis of world petroleum. The crude oil trade territory of importing countries can be divided into ten importing regions: US, S. & Cent America, Africa, Western Europe, China, Japan, Korea, Singapore, Thailand and the rest of the world.

After the accumulative program is carried out, the main module of the world crude oil trade spatial pattern is as follows:

The data in the table are the proportion of exporting volume of each module in the overall exporting volume. As is seen from the table, the selected six trade modules, as the largest crude oil exporting regions in the world and the regions with most selective modules take 72.98%, with the rest of the world taking 27.02%, while there is no country surpassing 5%. Western Africa takes the second place in selected modules, with the total trade volume of the four modules less than 80% of the total exporting volume. There are only two modules in North Africa, Former Soviet Union and S. & Cent. America, with the trade volume surpassing 80% of the overall exporting volume. Export is concentrated in Canada and Mexico in North America, with over 90% of the exporting volume into US, which makes it the most concentrated exporting region in the world.

According to the trade module, the world crude oil trade pattern is relatively stable. Three new modules are created during 2001-2012. The first one is Middle East-China, whose trade volume in 2003 surpassed 5% of the overall volume in the Western Africa and is mounting up year by year; the second module is Western Africa-China, whose trade volume in 2002 reached over 6.1% , is increasing gradually thereafter, peaked 15.8% in 2006 and has been decreasing in recent years, but remains over 12% of the export in Western Africa; the third module is Former Soviet Union-America, 6.6% of export from Former Soviet Union are transported to US, which has been 5%-6% thereafter.

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CONCLUSION

The present work has studied the world crude oil trade spatial pattern and makes an analysis of its main features, by means of complicated network analysis, with the combination of regional analysis in geography. The main conclusions are drawn:

• There is little variation of importing nodes and exporting nodes in the world crude oil trade spatial pattern between 2001 and 2012. It reveals that the role of the state in trade is relatively stable.

• As is seen from the exporting and importing quotas, the world crude oil trade relation is generally increasing and the flowing scale and effect is up. As the importing quota, exporting quota and the average, the trade relation and its variation is uneven.

• The spatial structure of the world petroleum trade is heterogeneity. Either the structure entropy or weight entropy indicates the spatial structure is not random network, rather in order. The ordering of the importing spatial pattern is lower than that of the exporting. The crude oil importing countries tend to be multiple; the homogeneity of the exporting pattern is lower than that of importing space pattern. Quota is more homogeneous compared with weight.

• The world crude oil trade spatial pattern is characterized with striking modularity. With nodes within the module highly connected, few and even no connection among different modules. The world crude trade spatial pattern is relatively stable according to the trade module. The heterogeneity of the spatial structure and the high interaction within the model can be learnt through network model.

It can tell from the world crude oil trade spatial structure that diversification has become the basic strategy for the importing countries to avert the risk. However, diversification does not mean homogeneity. The natural source in the actual world is in order. Political and economic relations of different mainstays also have certain orders. Diversification is not homogeneity-oriented. Different mainstays should choose the appropriate regional partners according to their individual objective surroundings, so as to carry out the diversified importing strategy and virtually settle the potential supplement risk of petroleum.

REFERENCES

Gastner, M. T., & Newman, M. E. J. (2006). The spatial structure of networks. *Eur. Phvs. J. B.* (49), 247-252.

Isard. W. A. (1949). General theory of location and space economy. *Quarterly Journal of Economics, 13*, 490.

Liu B. Q. (2007). *Research on measurement and evolution of world trade network* (Doctoral dissertation). Shanghai Jiao Tong University, Shanghai.

Newman M. E. J., & Watts D. J. (1999). Renormalization group analysis of the small-world network model. *Physics Letters A., 263*, 341-346.

Portes, R., & Rey. H. (2005). The determinants of cross-border equity flows. *Journal of International Economics, 65*(2), 269-296.

Rosvall, M., Trusina, A., Minnhagen, P., & Sneppen, K. (2005). Networks and cities: An information perspective. *Physical Review Letters*, (94), 028701.

Zhang, Y. Y. (2006). *Study on industrial integration and its countermeasure based on the nuclear region of Jilin Province* (Doctoral dissertation). Northeast Normal University, Changchun.

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