УДК 339
JEL F17, N75

EVOLUTION OF THE INTERNATIONAL TRADE NETWORK STRUCTURE IN CHINA'S BIOPHARMACEUTICAL INDUSTRY

Wang Kexin[1], graduate student
Solovieva Yuliana Vladimirovna[2], Cand. Sci. (Econ.), Assoc. Prof.

[1,2] Peoples' Friendship University of Russia named after Patrice Lumumba (RUDN University), Miklukho-Maklaya Str., 6, Moscow, Russia, 117198; e-mail: solovyeva-yuv@rudn.ru

Importance: the paper explores the biopharmaceutical industry in China and a number of foreign countries that are key in its trade in biopharmaceutical products (USA, Germany, Belgium, Switzerland, Ireland, UK). Based on data from the past decade on the import and export of biopharmaceutical trade partner countries, the authors calculate the performance of each country in the international trade network based on the Social Network Analysis Method, in order to develop and increase the trade status of the biopharmaceutical industry in China. *Purpose*: using the Social Network Analysis Method, data from the International Trade in goods of the biopharmaceutical industry from 2010 to 2019, including such indicators as global trade network density, overall trade network density of the biopharmaceutical industry and industrial structure, are analyzed. The calculation of the International Biopharmaceutical Industry Trade Agglomeration Coefficient reveals the expansion and deepening of the cross-country trade exchange of goods of the biopharmaceutical industry. *Research Design*: using bilateral trade data from the United Nations Commodity Trade Statistics Database to explain trade relations between countries, the authors apply a method of maximizing each weight matrix to level differences in statistical levels between different countries and regions. This article summarizes the experience of core powers in the traditional biopharmaceutical industry and proposes effective suggestions to promote the accelerated development of trade in China's biopharmaceutical industry. *Results*: based on the results of the study with in the context of the development of the global biopharmaceutical industry, the authors propose measures to increase the trading status of the biopharmaceutical industry in China and strengthen its potential in the field of technological innovation.

Keyword: international Trade Network, Social Network Analysis Method, Biopharmaceutical industry, technology innovation.

DOI: 10.17308/meps/2078-9017/2024/11/146-160

Introduction

In recent years, when the COVID-19 has ravaged the world, most entities in China have temporarily stopped production, which has had a great impact on the economies of various countries. The international trade network structure has been impacted to a certain extent, which has also made countries pay more attention to research and development investment and technological innovation in the biopharmaceutical industry. The point strength of each country in the world trade network is the strength of trade between that country and other countries. With the continuous acceleration of economic globalization, global economic and trade relations have shown a complex trend of networked development, and the behavior of countries in the international trade network is increasingly related to other countries in the network.

Based on the analysis of the core, semi marginal, and marginal countries (regions) in international biopharmaceutical industry trade, the authors identify the growth of core countries in this area. This demonstrates the steady progress and expansion of international trade in the biopharmaceutical sector. At the same time, the number of semi marginal countries (regions) is gradually increasing, while the number of marginal countries (regions) shows a downward trend.

Taking into account the current international situation and international trade structure, in-depth analysis of countries in different positions and empirical testing of the impact of trade network status on a country's biopharmaceutical industry undoubtedly have important theoretical and practical significance. The current world economic environment, especially under the influence of the COVID-19, has created new opportunities for China's foreign trade development. Therefore, this article selects the import and export trade data of major global biopharmaceutical industry trading countries from 2010 to 2019, constructs relevant trade networks, analyzes its structural characteristics and evolution process, and deeply understands the situation and forms of biopharmaceutical industry trade. Based on the research results, the authors proposed recommendations for China aimed to enhance its technological innovation capability and trade position in the biopharmaceutical industry.

In addition, this article summarizes the experience of core powers in the traditional biopharmaceutical industry and proposes effective suggestions to promote the accelerated development of trade in China's biopharmaceutical industry.

Literature review

Snijders [19] explains that the basic idea of social network evolution is that the actors in the network evaluate the network structure and obtain a pleasant configuration of relations. By studying international trade networks, most existing

literature has analyzed the impact of various factors on the structural characteristics of international trade networks [20]. Cai [5] and other scholars [1; 2; 3] used complex network analysis methods to confirm that international trade networks have the characteristics of scale-free distribution, small world attributes, and high cohesion coefficients. Fagiolo et al. [8; 9; 11; 22] discovered the difference between global weighted and unweighted trade networks. Chinese scholars tend to use social network analysis methods to study the evolution and influencing factors of specific industries. Li and Liu [15] established and analyzed the global value-added trade network based on the global input-output table from 1995 to 2018, and conducted empirical tests on the impact of manufacturing services on the global value-added trade network. Some scholars [7; 12; 16; 18; 24] have conducted in-depth research on the characteristics of global trade networks such as high-end manufacturing, service, and energy industries, but there is not much research on the biopharmaceutical industry. However, the pharmaceutical industry, its competitiveness in the national and world markets is one of the most important areas of technological sovereignty in many countries, including China [13]. This article examines the dynamic changes in the world biopharmaceutical industry trade network from 2010 to 2019, and analyzes and explores the following issues: what role have major biopharmaceutical industry import and export trading countries played in the trade network this year, whether the status of each country in the biopharmaceutical industry trade network has changed over time, and what is China's current position in the global biopharmaceutical industry trade network, How to improve its position in the trade network.

Research Methods and Data Explanation

The social network analysis method analyzes the network structure and attribute characteristics by analyzing the relationships between different individuals in the network. Social network analysis constructs the structure of a network composed of nodes that are linked to each other by specific types of connections. Recognizing countries as nodes in the network and the ties. These relationships not only include the individual attributes of the network, but also the overall attributes of the network. Social network is a social organization based on a "network", where nodes are connected to each other rather than a "group" with clear boundaries and order. It refers to a relatively stable relationship system formed by the interaction between individual members of society.

In this article, vector V_i represents the exporting country and vector V_j represents the importing country:

$$V_i = [v_i](i = 1,2, \dots, n),$$
$$V_j = [v_j](j = 1,2, \dots, n).$$

Establish adjacency matrix representing the trade relationship between the two countries. If there is trade between the two countries, $a_{ij} = 1$, otherwise $a_{ij} = 0$, and $a_{ij} = a_{ji}$.

Establish a weight matrix to represent the trade volume between the two countries, and $W_{ij} = W_{ji}$. The trade volume between countries is calculated by

calculating the average value of their import and export trade. These matrices together constitute the international trade network of the biopharmaceutical industry.

This article selects bilateral trade data from the United Nations Commodity Trade Statistics Database to explain trade relations between countries. According to the standard definition of the OECD, 68 countries and regions were selected for the 2010-2019 biopharmaceutical industry, namely products with HS codes 29 and 30. In addition, the trade transaction data with import and export amounts exceeding 100 million US dollars was taken for analysis. These data were arranged into adjacency matrices and weight matrices, without affecting the network of world trade analysis results, Divide all values of the weight matrix by the maximum value of the matrix. In addition, due to differences in statistical levels among different countries and regions (US, Germany, Belgium, Switzerland, Ireland, China, UK et al.), this article symmetrically processed each weight matrix using the maximum method. The International Biopharmaceutical Industry Trading Network analysis considered its density, primary and secondary centrality, and core marginal structure. Since the unweighted average agglomeration coefficient in the international trading network of the biopharmaceutical sector significantly exceeds the weighted average coefficient, this indicates the importance of the country's total trade volume and its distribution have a significant impact on the connectivity and tightness of the network.

Analysis of International Biopharmaceutical Industry Trade Network

1. Density

Density is used to describe the degree of interconnectivity among nodes in a network. The higher the density, the closer the relationship between individual network members, and the greater the impact of the network on individual members. A network with *N* nodes and *M* actual connections, with a network density is:

$$\frac{2M}{N(N-1)}. \quad (1)$$

The results are shown in Tab. 1.

Table 1

International Biopharmaceutical Industry Trade Network Density, 2010-2019

Year	Density	Year	Density
2010	0.9438	2015	0.9319
2011	0.9403	2016	0.9425
2012	0.9390	2017	0.9438
2013	0.9419	2018	0.9456
2014	0.9467	2019	0.9479

Source: complete by authors.

From Tab. 1, it can be seen that the density of the international biopharmaceutical industry trade network fluctuated between the two values of 0.9300-0.9500 from 2010 to 2019, indicating a tight global biopharmaceutical industry trade network. From 2010 to 2012, network density showed a decreasing trend and increased in 2012 to 2014, indicating that the trade network of the biopharmaceutical industry among countries is gradually becoming closer. The value decreased again in 2015 and rebounded in 2016, possibly due to frequent fluctuations in the international market prices of biopharmaceutical products and the negative impact of frequent economic and political competition among countries on international trade in the biopharmaceutical industry. Since then, the density has been steadily increasing, indicating that the international biopharmaceutical industry has a high ability to restore trade relations.

2. Centrality

Primary centrality

Point degree, also known as correlation degree, represents the number of edges associated with a node. In the world trade network, the number of points per country is the number of countries that have trade relations with it. The higher the degree of a node, the greater its position and influence in the network. The calculation formula for absolute point degrees is:

$$c_i = \sum_j a_{ij} \,. \tag{2}$$

In networks of different scales, the absolute degree of points cannot be compared. Therefore, this article chooses the relative degree of points, which is the ratio of the absolute degree of points to the maximum possible degree *(N – 1)* in the network. The results are shown in Tab. 2.

Table 2

Degree of International Biopharmaceutical Industry Trade Points, 2010-2019

Year	Absolute point degree average	Relative point degree average
2010	2.352	1.196
2011	2.474	1.191
2012	2.454	1.278
2013	2.606	1.276
2014	2.678	1.301
2015	2.274	1.268
2016	2.302	1.367
2017	2.426	1.374
2018	2.667	1.382
2019	2.683	1.386

Source: complete by authors.

From Tab. 2, it can be seen that the relative degree of trade in the biopharmaceutical industry has not changed much, indicating that the exporting countries of the biopharmaceutical industry are relatively concentrated, mainly

related to the technological level of the biopharmaceutical industry in various countries. Developed countries such as the United States and Germany have the vast majority of production patent technologies, and their exports are among the top in the world. However, emerging developing countries such as China and India have a large population and a wide market, and in recent years, their technological innovation capabilities have gradually improved, becoming important export countries for the biopharmaceutical industry [21; 23]. In 2015, due to the impact of the unstable economic situation in the world, the relative point degree was the smallest. In 2019, due to the continuous growth of patent numbers and the steady improvement of technological innovation ability, the relative point degree was the largest.

Point strength refers to the weight of nodes. The point strength of each country in the world trade network is the strength of trade between that country and other countries. The higher the point strength, the higher the weight that the node is connected to other nodes. The calculation formula is:

$$w_i = \sum_j Q_{ij} . \quad (3)$$

The results are shown in Tab. 3.

Table 3

International Biopharmaceutical Industry Trade Point Strength, 2010-2019

Year	Average point strength	Year	Average point strength
2010	1.176	2015	1.245
2011	1.178	2016	1.288
2012	1.212	2017	1.375
2013	1.273	2018	1.382
2014	1.278	2019	1.387

Source: complete by authors.

From Tab. 3, it can be seen that the average point intensity of trade in the biopharmaceutical industry has shown an upward trend since 2010, with a more significant increase from 2015 to 2019. This indicates that the biopharmaceutical industry is increasingly valued by countries and has become a very important strategic resource. The total amount of trade is gradually increasing, and the scale of trade is gradually expanding.

Secondary centrality

The agglomeration coefficient is used to describe the clustering of nodes in a network, that is, the degree of correlation between nodes and adjacent nodes. The overall agglomeration coefficient can measure the aggregation degree of the entire network, while the local agglomeration coefficient can measure the embedding degree of a single node. In the trade network of the biopharmaceutical industry, nodes have a strong clustering trend, characterized by relatively close connections.

The unweighted average agglomeration coefficient of the international biopharmaceutical industry trade network is much greater than the weighted average agglomeration coefficient, indicating that a country's total trade volume and its distribution have a significant impact on the connectivity and tightness of the network. As shown in Figure 1, overall, the average agglomeration coefficient is increasing, indicating that as trade exchanges between countries become closer and wider, the biopharmaceutical industry is also constantly developing and receiving attention from various countries. The unweighted average agglomeration coefficients are all between 0.85 and 1, indicating that the international biopharmaceutical industry trade network maintains good relations.

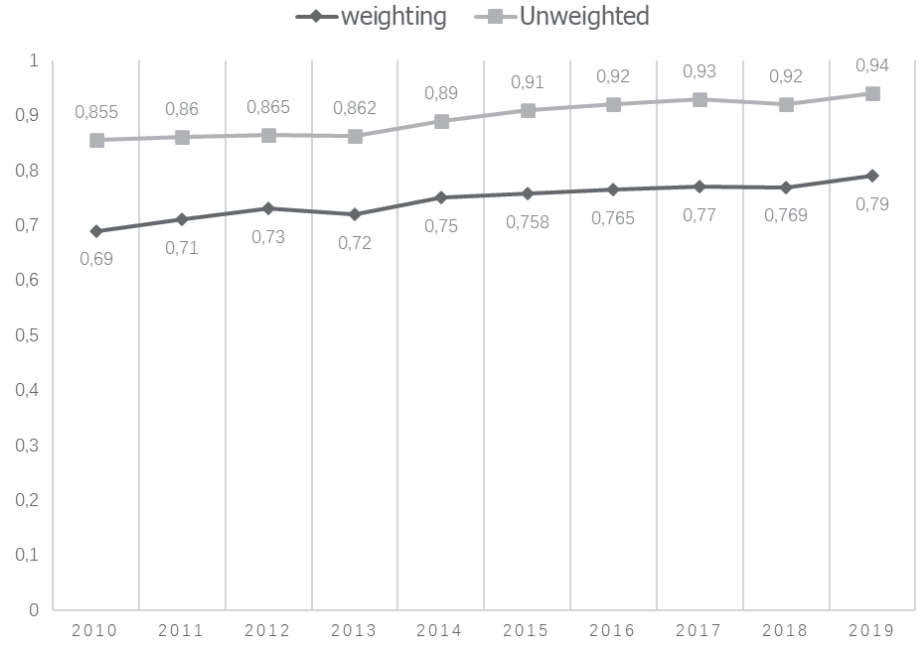


Fig. 1. International Biopharmaceutical Industry Trade Agglomeration Coefficient, 2010-2019.

Source: complete by authors

3. Core – Marginal Structure Analysis

The core – marginal structure is an indicator for determining the status of nodes in a social network. This study estimates the core competitiveness of each country each year and provides a quantitative assessment and understanding of the trade status of countries around the world in the biopharmaceutical industry network. Countries with a core degree more than 0.3 are classified as core regions, countries with a core degree between 0.1 and 0.3 are classified as semi marginal regions, and countries with a core degree less than 0.1 are classified as marginal regions. The results are shown in Tab. 4.

Table 4

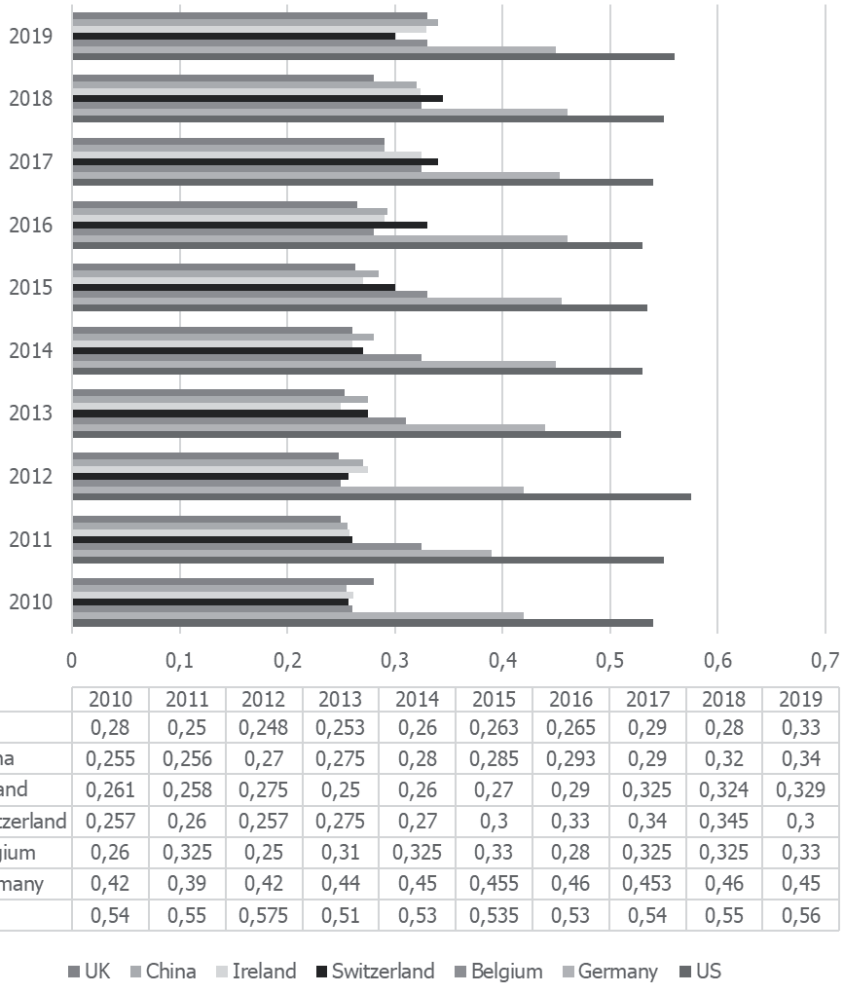
Core, semi marginal, and marginal countries (regions) in international biopharmaceutical industry trade from 2010 to 2019

Year	Core countries (regions)	Number of core countries (regions)	Number of semi marginal countries (regions)	Number of marginal countries (regions)
2010	US, Germany	2	11	55
2011	US, Germany	2	10	56
2012	US, Germany	2	10	56
2013	US, Germany, Belgium	3	10	55
2014	US, Germany, Belgium	3	10	55
2015	US, Germany, Belgium, Switzerland	4	13	51
2016	US, Germany, Switzerland, Ireland	4	13	51
2017	US, Germany, Belgium, Switzerland, Ireland, China	5	15	48
2018	US, Germany, Belgium, Switzerland, Ireland, China	5	16	47
2019	US, Germany, Belgium, Switzerland, Ireland, China, UK	6	18	44

Source: complete by authors.

From Tab. 4, it can be seen that the overall number of core countries in the international biopharmaceutical industry's trade is increasing. The United States and Germany have been core countries in the biopharmaceutical industry for 10 years. Belgium became the core country in 2013, Switzerland became the core country in 2015, Ireland became the core country in 2016, China became the core country in 2017, and the United Kingdom became the core country in 2019; In 2019, the number of core countries has increased from 2 in 2010 to 7, indicating the continuous development and expansion of international trade in the biopharmaceutical industry, and the number of semi marginal countries (regions) is gradually increasing, while the number of marginal countries (regions) is gradually decreasing.

The core values of major trading countries in the biopharmaceutical industry (US, Germany, Belgium, Switzerland, Ireland, China, and the United Kingdom) with core values greater than 0.25 from 2010 to 2019 are shown in Fig. 2. These countries are showing an upward trend in their core competencies and are relatively stable. The United States and Germany have consistently ranked in the top two, indicating that they lead international trade cooperation in the biopharmaceutical industry. It is worth noting that until 2019, China became the third largest core country, indicating significant development in international trade cooperation in the biopharmaceutical industry, and its position in the trade network continues to rise.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
UK	0,28	0,25	0,248	0,253	0,26	0,263	0,265	0,29	0,28	0,33
China	0,255	0,256	0,27	0,275	0,28	0,285	0,293	0,29	0,32	0,34
Ireland	0,261	0,258	0,275	0,25	0,26	0,27	0,29	0,325	0,324	0,329
Switzerland	0,257	0,26	0,257	0,275	0,27	0,3	0,33	0,34	0,345	0,3
Belgium	0,26	0,325	0,25	0,31	0,325	0,33	0,28	0,325	0,325	0,33
Germany	0,42	0,39	0,42	0,44	0,45	0,455	0,46	0,453	0,46	0,45
US	0,54	0,55	0,575	0,51	0,53	0,535	0,53	0,54	0,55	0,56

Fig. 2. Core Degree of Major Biopharmaceutical Industry Trading Countries, 2010 – 2019

Source: complete by authors.

Conclusions

The social network analysis method was used to analyze the international biopharmaceutical industry trade data from 2010 to 2019, and the following conclusions were drawn.

From the perspective of the global trade network density of the biopharmaceutical industry, the overall trade network density of the biopharmaceutical industry was relatively tight from 2010 to 2019. From 2010 to 2012, the density of the international biopharmaceutical industry trade relationship network showed a decreasing trend. After 2012, the density increased, decreased in 2015, and rebounded in 2016. Since then, it has been increasing, indicating a high recovery ability of the international biopharmaceutical industry trade relationship.

From the centrality of the global biopharmaceutical industry trade network, old capitalist powers such as the United States and Germany still play an important role, indicating that developed countries have always played an important role in the global biopharmaceutical industry trade network. However, the number of emerging developing countries such as China and India is increasing and playing an increasingly important role in the network.

From the perspective of the core – marginal structure of the global biopharmaceutical industry trade network, in the past decade, the United States and Germany have always maintained a core position, while the core positions of countries such as Belgium, Switzerland, Ireland, and China have all increased, with China being particularly prominent. This indicates that more countries have the opportunity to participate in global trade in the biopharmaceutical industry.

Based on the above research results, the following suggestions are proposed for China to enhance its technological innovation capability and trade status in the biopharmaceutical industry.

To continue to maintain China's key position in the international biopharmaceutical industry trade network, we can actively explore and expand trade channels in the biopharmaceutical industry, carry out trade cooperation with more countries in the biopharmaceutical industry, achieve mutual benefit and win-win results, meet China's demand for the biopharmaceutical industry, consolidate China's position in the global market, and actively guide and promote Chinese biopharmaceutical enterprises to go abroad and carry out foreign trade, Improve the trading system. This not only enables China to play an important role in the international biopharmaceutical industry trade network, but also enables China to develop biopharmaceutical industry trade, promote economic development, and promote employment, achieving a win-win situation.

Based on the actual situation in China, we should learn from the experience of traditional biopharmaceutical industry trade powers. Traditional biopharmaceutical industry trade giants such as the United States and Germany have rich experience in biopharmaceutical industry trade, which is worth learning from and learning from.

Efforts should be made to diversify the biopharmaceutical industry, improve the industrial system, optimize the industrial structure, develop core technologies in the biopharmaceutical industry, improve research and development levels, and apply for more patented products to provide more security for China's biopharmaceutical industry.

China needs to actively develop key core technologies in the biopharmaceutical industry. At present, although China plays an important role in the international trade network of the biopharmaceutical industry, its technological level and innovation ability are still insufficient, and its core technology still relies on foreign imports. Once technology exporting countries refuse to export these technologies to China, it will have a huge negative impact on China and be detrimental to the development of China's biopharmaceutical industry.

References

1. Backer K.D., Lombaerde P.D., Iapadre L. Analyzing Global and Regional Value Chains. *International Economics*, 2018, no. 153(5), pp. 3-10.

2. Barthélemy M., Barrat A., Pastor-Satorras R., Vespignani A. Characterization and modeling of weighted networks. *Physica A: Statistical Mechanics and its Applications*, 2007, no. 346(1), pp. 34-43.

3. Borgatti S.P. Centrality and network flow. *Social Networks*, 2002, no. 27(1), pp. 55-71.

4. Buesa M., Heijs J., Baumert T. The determinants of regional innovation in Europe: A combined factorial and regression knowledge production function approach. *Research Policy*, 2010, no. 39(6), pp. 722-735.

5. Cai X., Liu C., Zheng S., Hu H. Analysis on the evolution characteristics of barite international trade pattern based on complex networks. *Resources Policy*, 2023, no. 83(6), pp. 103593.

6. Cen L.J. China's Division of Labor and Trade Status in Global Production Networks: A Study Based on TiVA Data and GVC Index. *International trade issues,* 2015, no. 1, pp. 13-31.

7. Chen Y.F. Social Network Analysis of the World Trade Pattern from 2000 to 2009. *International trade issues*, 2011, no. 11, pp. 31-42.

8. Fagiolo G., Reyes J., Schiavo S. On the topological properties of the world trade web: A weighted network analysis. *Physica A: Statistical Mechanics and its Applications*, 2008, no. 387(15), pp. 3868-3873.

9. Garlaschelli D., Loffredo M.I. Structure and evolution of the world trade network. *Physica A: Statistical Mechanics and its Applications*, 2005, no. 355(1), pp. 138-144.

10. Gereffi G. International trade and industrial upgrading in the apparel commodity chain. *Journal of International Economics*, 1999, no. 48(1), pp. 37-70.

11. Hong J.J., Shang H. A Study on the Mechanism of Determining the Hub Status of International Trade Networks. *International trade issues*, 2019, no. 10, pp. 1-16.

12. Htwe N.N., Lim S.H., Kakinaka M. The coevolution of trade agreements and investment treaties: Some evidence from network analysis. *Social Networks*, 2019, no. 61(5), pp. 34-52.

13. Khalizeva D.I. [Pharmaceutical industry of the Russian Federation: status, problems and prospects]. *Rossiya i Asiya*, 2023, no. 4(26), pp. 50-59. (In Russ.). Available at: https://russia-asia.org/file/2024/03/RA_4_26_2023.pdf (accessed: 22.06.2024)

14. Lelio I., Tajoli L. Emerging countries and trade regionalization. A network analysis. *Journal of Policy Modeling*, 2013, no. 36(1), pp. 89-110.

15. Li X., Liu B.Q. Evolution of the International Trade Network in Manufacturing Sector 1995-2018: An Analysis Based on STERGM. *International Economics and Trade Research*, 2023, no. 39(12), pp. 4-20.

16. Lin J.Y. Will China continue to be the engine of growth in the world. *Journal of Policy Modeling*, 2016, no. 38(4), pp. 683-692.

17. Liu L., Shen M., Sun D., Yan X., Hu S. Preferential attachment, R&D expenditure and the evolution of international trade networks from the perspective of complex networks. *Physica A: Statistical Mechanics and its Applications,* 2022, no. 603(1), p. 127579.

18. Smith M., Gorgoni S., Cronin B. (2019). International production and trade in a high-tech industry: A multilevel network analysis. *Social Networks*, 2019, no. 59(10), pp. 50-60.

19. Snijders T. A. B. Introduction to the special issue on Network Dynamics (Part 2). *Social Networks,* 2012, no. 34(3), pp. 289-290.

20. Solovieva Y.V., He M. China-EU Trade: Dynamics and Current Trends. *Modern Global Economic System: Evolutional Development vs. Revolutionary Leap: Institute of Scientific Communications Conference*, Vol. 198, Cham: Springer Nature, 2021, pp. 1907-1913.

21. Solovieva Yu., He M. National innovation systems and technology transfer of SCO countries. *Asia and Africa Today,* 2022, no. 4, pp. 51-58.

22. Wen L., Cai H. B., Wu Z.N. International Trade Network: Comparison between Value Added Trade and Total Trade. *International Business Research*, 2018, no. 39(5), pp. 49-58.

23. Xie Y. Empirical Analysis of the Impact of International Technology Trade on China's Technological Progress. *Beijing: University of International Business and Economics*, 2018.

24. Xu H.L., Sun T.Y., Wu G. Trade Network Status, R&D Investment, and Technology Diffusion: An Empirical Study Based on Global High end Manufacturing Trade Data. *China Soft Science*, 2015, no. 9, pp. 55-69.

25. Zhou J., Latorre M. FDI in China and global production networks: Assessing the role of and impact on big world players. *Journal of Policy Modeling*, 2021, no. 43(6), pp. 1225-1240.

26. Zhu N., Huang S. Impact of the tariff concessions of the RCEP agreement on the structure and evolution mechanism of manufacturing trade networks. *Social Networks*, 2023, no. 74(7), pp. 78-101.

ЭВОЛЮЦИЯ СТРУКТУРЫ МЕЖДУНАРОДНОЙ ТОРГОВОЙ СЕТИ В БИОФАРМАЦЕВТИЧЕСКОЙ ПРОМЫШЛЕННОСТИ КИТАЯ

Ван Кэсинь[1], асп.
Соловьева Юлиана Владимировна[2], канд. экон. наук, доц.

[1,2] Российский университет дружбы народов им. Патриса Лумумбы (РУДН), ул. Миклухо-Маклая, 6, Москва, Россия, 117198; e-mail: solovyeva-yuv@rudn.ru

Предмет: в статье исследуется биофармацевтическая промышленность Китая и ряда зарубежных стран, являющихся ключевыми в ее торговле товарами биофармацевтической промышленности (США, Германия, Бельгия, Швейцария, Ирландия, Великобритания). На основе данных за последнее десятилетие об импорте и экспорте стран-партнеров по торговле товарами биофармацевтической промышленности авторы рассчитывают показатели каждой страны в международной торговой сети на основе метода анализа социальных сетей, с целью развития и повышения торгового статуса биофармацевтической промышленности Китая. *Цель*: применяя метод анализа социальных сетей, анализируются данные международной торговли товарами биофармацевтической промышленности с 2010 по 2019 год (до пандемии COVID-19), в том числе такие ее показатели, как глобальная и общая плотность торговой сети биофармацевтической промышленности и промышленная структура. При расчете коэффициента агломерации международной торговли биофармацевтической промышленностью выявляется расширение и углубление межстранового торгового обмена товарами биофармацевтической промышленности. *Дизайн исследования*: используя данные о двусторонней торговле Базы данных Организации Объединенных Наций по статистике торговли сырьевыми товарами для разъяснения торговых отношений между странами, авторы применяют метод максимизации каждой весовой матрицы для нивелирования различий в статистических уровнях между различными странами и регионами. В статье обобщается опыт основных держав в традиционной биофармацевтической промышленности и предлагаются эффективные предложения по содействию ускоренному развитию торговли в биофармацевтической промышленности Китая. *Результаты*: на основе полученных результатов исследования в контексте развития глобальной биофармацевтической промышленности авторами предлагаются меры по повышению торгового статуса биофармацевтической промышленности Китая и укреплению его потенциала в области технологических инноваций.

Ключевые слова: международная торговая сеть, метод анализа со-

циальных сетей, биофармацевтическая промышленность, технологические инновации.

Список источников

1. Backer K.D., Lombaerde P.D., Iapadre L. Analyzing Global and Regional Value Chains. *International Economics*, 2018, no. 153(5), pp. 3-10. (In Eng.)

2. Barthélemy M., Barrat A., Pastor-Satorras R., Vespignani A. Characterization and modeling of weighted networks. *Physica A: Statistical Mechanics and its Applications*, 2007, no. 346(1), pp. 34-43.

3. Borgatti S.P. Centrality and network flow. *Social Networks*, 2002, no. 27(1), pp. 55-71. (In Eng.)

4. Buesa M., Heijs J., Baumert T. The determinants of regional innovation in Europe: A combined factorial and regression knowledge production function approach. *Research Policy*, 2010, no. 39(6), pp. 722-735. (In Eng.)

5. Cai X., Liu C., Zheng S., Hu H. Analysis on the evolution characteristics of barite international trade pattern based on complex networks. *Resources Policy,* 2023, no. 83(6), pp. 103593. (In Eng.)

6. Cen L.J. China's Division of Labor and Trade Status in Global Production Networks: A Study Based on TiVA Data and GVC Index. *International trade issues,* 2015, no. 1, pp. 13-31. (In Eng.)

7. Chen Y.F. Social Network Analysis of the World Trade Pattern from 2000 to 2009. *International trade issues*, 2011, no. 11, pp. 31-42. (In Eng.)

8. Fagiolo G., Reyes J., Schiavo S. On the topological properties of the world trade web: A weighted network analysis. *Physica A: Statistical Mechanics and its Applications*, 2008, no. 387(15), pp. 3868-3873. (In Eng.)

9. Garlaschelli D., Loffredo M.I. Structure and evolution of the world trade network. *Physica A: Statistical Mechanics and its Applications,* 2005, no. 355(1), pp. 138-144. (In Eng.)

10. Gereffi G. International trade and industrial upgrading in the apparel commodity chain. *Journal of International Economics,* 1999, no. 48(1), pp. 37-70. (In Eng.)

11. Hong J.J., Shang H. A Study on the Mechanism of Determining the Hub Status of International Trade Networks. *International trade issues*, 2019, no. 10, pp. 1-16. (In Eng.)

12. Htwe N.N., Lim S.H., Kakinaka M. The coevolution of trade agreements and investment treaties: Some evidence from network analysis. *Social Networks*, 2019, no. 61(5), pp. 34-52. (In Eng.)

13. Khalizeva D.I. [Pharmaceutical industry of the Russian Federation: status, problems and prospects]. *Rossiya i Asiya*, 2023, no. 4(26), pp. 50-59. (In Russ.). Available at: https://russia-asia.org/file/2024/03/RA_4_26_2023.pdf (accessed: 22.06.2024).

14. Lelio I., Tajoli L. Emerging countries and trade regionalization. A network analysis. *Journal of Policy Modeling,* 2013, no. 36(1), pp. 89-110.

15. Li X., Liu B.Q. Evolution of the International Trade Network in Manufacturing Sector 1995-2018: An Analysis Based on STERGM. *International Economics and Trade Research,* 2023, no. 39(12), pp. 4-20.

16. Lin J.Y. Will China continue to be the engine of growth in the world. *Journal of Policy Modeling*, 2016, no. 38(4), pp. 683-692.

17. Liu L., Shen M., Sun D., Yan X., Hu S. Preferential attachment, R&D expenditure and the evolution of international trade networks from the perspective of complex networks. *Physica A: Statistical Mechanics and its Applications*, 2022, No. 603(1), p. 127579.

18. Smith M., Gorgoni S., Cronin B. (2019). International production and trade in a high-tech industry: A multilevel network analysis. *Social Networks,* 2019, no. 59(10), pp. 50-60.

19. Snijders T.A.B. Introduction to the special issue on Network Dynamics (Part 2). *Social Networks,* 2012, no. 34(3), pp. 289-290.

20. Solovieva Y.V., He M. China-EU Trade: Dynamics and Current Trends. *Modern Global Economic System: Evolutional*

Development vs. Revolutionary Leap: Institute of Scientific Communications Conference, Vol. 198, Cham: Springer Nature, 2021, pp. 1907-1913.

21. Solovieva Yu., He M. National innovation systems and technology transfer of SCO countries. *Asia and Africa Today*, 2022, no. 4, pp. 51-58.

22. Wen L., Cai H. B., Wu Z.N. International Trade Network: Comparison between Value Added Trade and Total Trade. *International Business Research*, 2018, no. 39(5), pp. 49-58.

23. Xie Y. Empirical Analysis of the Impact of International Technology Trade on China's Technological Progress. Beijing: *University of International Business and Economics,* 2018.

24. Xu H.L., Sun T.Y., Wu G. Trade Network Status, R&D Investment, and Technology Diffusion: An Empirical Study Based on Global High end Manufacturing Trade Data. *China Soft Science*, 2015, no. 9, pp. 55-69.

25. Zhou J., Latorre M. FDI in China and global production networks: Assessing the role of and impact on big world players. *Journal of Policy Modeling*, 2021, no. 43(6), pp. 1225-1240.

26. Zhu N., Huang S. Impact of the tariff concessions of the RCEP agreement on the structure and evolution mechanism of manufacturing trade networks. *Social Networks*, 2023, no. 74(7), pp. 78-101.