Journal of Business Economics and Management
ISSN 1611-1699/eISSN 2029-4433
2019 Volume 20 Issue 5: 1000–1021
https://doi.org/10.3846/jbem.2019.10455

STUDY ON THE CHARACTERISTICS OF POTASSIUM SALT INTERNATIONAL TRADE BASED ON COMPLEX NETWORK

Mingyue WANG[1], Rui KONG[2*]

[1, 2]School of Economics and Management of China University of Geosciences, Beijing, China
[2]Key Laboratory on Resources and Environment Capacity under Ministry of Land and Resources of People's Republic of China, Beijing, China

Received 13 November 2018; accepted 30 May 2019

Abstract. This paper studies the evolutionary characteristics of international trade of potassium salts. We construct a weighted and directed complex network model of potassium salt trade, analyze the scale and activity, trade relations, trade flow distribution and the importance of trading countries using UN Comtrade 2000–2016 data. Results show that potassium salt trade is more dynamic, resource allocation is more convenient. Some countries have formed trade groups. The relationship between small and major countries is growing. The resource flows of countries with large degrees are conducive to balancing resource's distribution. Besides Canada is a leading trade country, and the US, the Russian Federation, China and Brazil are trade-led countries. China, the Netherlands, the US, France and India are important hubs. Finally, using Porter's national competitive advantage theory, it proposes countermeasures for forming the international competitive advantage of potassium salt enterprises in different countries.

Keywords: potassium salt, complex network, evolutionary characteristics, trade relationship, trade flow distribution, trade scale, trade activity.

JEL Classification: F02, F14, F23.

Introduction

Recently, trade conflicts between major powers have made international trade a global focus, and trade in resource-based products is no exception. Trade and economy are inseparable (Hye & Lau, 2015). Only by accurately grasping the evolutionary characteristics of the international trade of commodities, can we predict in detail the future trend of commodity trade, which is crucial for each country. The purpose of this paper is to take potash as an example to study the evolution characteristics of international trade from trade scale and activity, relations, flow distribution and participation of major countries, and to put forward countermeasures for relevant trading countries to gain competitive advantages in potash market trade.

*Corresponding author. E-mail: *kongrui@cugb.edu.cn*

Potassium salt is also one of the resource-based products, and it is also a national strategic resource and an important commodity to promote the economic development of all countries. It is widely used in industry, including textile, metallurgy, pharmaceutical industry, aviation, etc., especially the main materials for manufacturing aluminum welding powder, occupying an irreplaceable position in national defense. Potassium salt is mainly used as fertilizer and plays a major role in promoting the development of agriculture (S. Sharma, Duveiller, Basnet, Karki, & R. C. Sharma, 2005). According to the US Geological Survey's statistics, the global potassium resources are abundant, but the distribution is uneven, mainly in Canada, Russia, Belarus and Germany, accounting for 90.58% of the global potassium resources. The international trade of potash affects the distribution of potassium resources. Therefore, it is of practical significance to study the characteristics of international trade of potash for the stability of potash market and the development of global economy.

Within this setting, studying the evolution characteristics of potash international trade not only influences the countermeasures of countries to form competitive advantages, but also is very important for global economic development. In this study, we extend the complex network method to the international trade of potash. By selecting more comprehensive research indexes, the theoretical model for systematically analyzing the characteristics of international trade is established for the first time. And combining with Michael porter's diamond model, the competition in the international market of potash is studied. So this study has theoretical application significance.

The paper is structured as follows. Section 1 explains the theoretical background of the research and the reasons for selecting the research method. Section 2 shows the data source, the applicability of the method and the calculation formula of the index. Section 3 constructs the theoretical model and network model of potassium salt trade. Section 4 presents the results. Section 5 shows the countermeasures. The final section concludes the paper.

1. Literature review

Research on international trade is in various fields such as economy, politics, resources and environment. At present, the research mainly focuses on the following three aspects.

Aspect 1 is studying the relationship between international trade and economic, capital, investment and other factors as well as the impact of events on international trade. The openness of international trade is positively correlated with economic growth, and the regional intellectual property index is very unfavorable to the international trade of developing countries (Campi & Dueñas, 2016; Hye & Lau, 2015). There is a systematic relationship between international trade and capital intensity and a balanced relationship with capital accumulation (Alvarez & Fernando, 2017; Dia & Vanhoose, 2016). In addition, there may be one-way or two-way causal relationship between international trade and foreign direct investment (Nyen Wong & Khoon Goh, 2013; Weng, Yang, & Tu, 2010). Major international events such as "One Belt And One Road" and the World Cup football match help to promote the development of international trade (Fang & Ma, 2018; Ge & Li, 2019). They show that international trade has an inseparable relationship with economic growth and capital accumulation etc. Major events have a greater impact on it.

Aspect 2 is studying international trade relations, trade flows, competitiveness, trade policies, trade potential, etc. Trade relations exist in international trade. EU membership affects bilateral trade relations (Ginevičius, Tvaronavičienė, Korsakienė, & Kalaūinskaitė, 2007). Sebestyén and Tamás (2016) proposed that some trade relations have a significant impact on the cost of international trade. After that, the study of multilateral trade relations was carried out with the help of complex network theory (Ge, Wang, Guan, Li, Zhu, & Yao, 2016). Later, the introduction of link predictions in trade relations research provides a new method for building future trade relations (Feng, Li, Qi, Guan, & Wen, 2017). In addition to international trade relations, there are studies on trade flows. It includes the use of water footprint, life cycle, material flow and complex network theory to study the trade flow of agricultural virtual water, copper ore and iron ore (Lamastra, Miglietta, Toma, De Leo, & Massari, 2017; Zhang et al., 2017a; Li et al., 2018; Zhong et al., 2018). They all put forward that the flow and direction of trade affect the distribution structure of international trade and the strategic security of national resources. In 1990, Michael porter proposed the theory of national competitive advantage (Porter, 1998). Based on it, the researchers studied the competitiveness of international trade from the perspective of theoretical tracing and empirical analysis combined with bibliometric and gravitational models (Cheng, Yang, Chi & Xin, 2019; Olczyk, 2016). Besides, trade policy and potential were also studied (Fiorini & Hoekman, 2017; Fang & Ma, 2018).

Aspect 3 is studying the evolutionary characteristics of international trade. Tian, Geng, and Sarkis (2018) proposed that it is necessary to study the evolution characteristics of international trade. The methods used to study the characteristics of international trade mainly include Input-Output (IO) analysis, bibliometric and network analysis (Liu, S. Chen, B. Chen, & Yang, 2016; Tian, Geng, & Sarkis, 2018; Vall-Llosera & Cassey, 2017). Using different methods to study trade characteristics is based on different research indicators. The IO used trade volume to study the international trade characteristics, while the bibliometric used clustering research index. Network analysis has more indicators and is used widely. By constructing the trade network, the characteristics of international trade are studied respectively from clustering, heterogeneity and node centrality (De Andrade & Rêgo, 2017; Zhang et al., 2017b; Zhou, Wu, & Xu, 2016). Then, more detailed indicators from the complex network are introduced. Sun, Gao, Zhong, and Liu (2017) and Du et al. (2017) studied the stability and clustering of oil trade. The former utilized two indicators of trade volume and trade relationship. Based on it, the latter further used clustering coefficient, node degree and node strength to analyze trade clustering and put forward that China, the United States and other major importing countries should be highly valued. After that, richer indicators such as average path length, network diameter and module degree, degree correlation and network density were used (Hou, Liu, Wang, & Wu, 2017; Marko Lovrić, Re, Vidale, Pettenella, & Mavsar, 2018; Wang, Li, & Cheng, 2018).

Therefore, network analysis method is widely used to study the feature of international trade. It can simplify the complex relationship between trading countries. Turning complex trade issues into cyber problem makes the research more targeted. Input-Output is difficult to establish a model to study the characteristics of trade systematically. So, we choose network analysis to study the evolution characteristics of international trade and using diamond model to analyze the result.

Based on complex network, predecessors mainly studied trade volume, trade amount, node degree and intensity, centrality, clustering coefficient, network density, average path length, network diameter and number of communities, etc. The characteristics of trade are analyzed from the perspectives of trade closeness, trade relations, the importance of major countries, clustering and the number of associations. However, the existing studies only select some indicators to analyze one or several aspects, and lack of models to comprehensively analyze the evolution characteristics of international trade. Most research just presents the result, does not put forward the countermeasures systematically. Also the research objects of international trade characteristics are mainly oil, rare earth, coal, wood and other commodities. However, the research on potash focuses on the world production and consumption pattern, international market supply and demand situation, price trend and marketing ideas (Bao & Liu, 2014; Bao, Yuan, & Zhou, 2013; Zhao, 2013). Little research has been done on its evolution characteristic.

Motivated by this gap in the literature, this paper takes potash as the research object and constructs complex network models of unweighted and weighted potash trade network based on international trade theory and complex network theory. A logic model is constructed from four aspects: scale and activity, trade relations, trade flow distribution and the major trading countries to study the characteristics of international trade. Finally, combining with diamond model, this paper puts forward some countermeasures for countries to form competitive advantages in the international market of potash.

2. Methodology and data

2.1. Overview of complex network analysis methods

Networks with some or all characteristics such as small world, cluster and power-law degree distribution are called complex networks. Potash international trade network has the characteristics of small world and cluster. As Figure 1, the degree distribution basically conforms to the power-law distribution. Therefore, it is a complex network system, which can be analyzed by complex network.

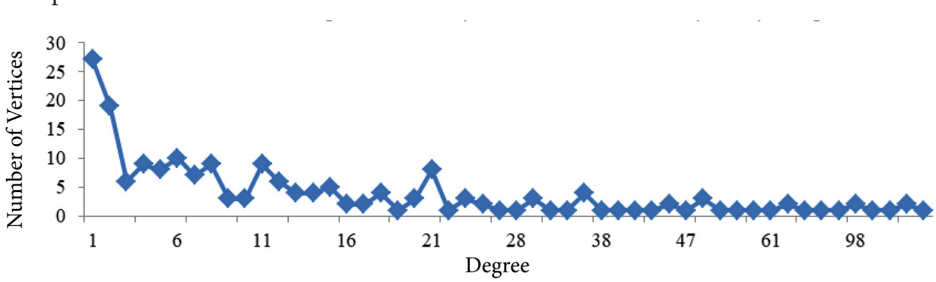


Figure 1. Degree Distribution in 2016

Complex networks can be used to study the geometric properties and evolution of networks (Newman, 2003; Wang, Li, & Chen, 2006). The indicators and its formulas are shown in Table 1.

Table 1. Indicators and formula

Indicators	Formulas
Network diameter and density	$D_{\max} = \max(d_{ij})$ $D = \frac{2M}{N(N-1)}$
Clustering	$C(k) = \frac{\sum_{k_i = K} C_i}{P}$
Degree correlation	$R = \frac{M^{-1}\Sigma_i j_i k_i - [M^{-1}\Sigma_i \frac{1}{2}(j_i + k_i)]^2}{M^{-1}\Sigma_i \frac{1}{2}(j_i^2 + k_i^2) - [M^{-1}\Sigma_i \frac{1}{2}(j_i + k_i)]^2}$
Reciprocity	$\rho = \frac{\sum_{i \neq j}(a_{ij} - \bar{a})(a_{ji} - \bar{a})}{\sum_{i \neq j}(a_{ij} - \bar{a})^2}$
Average path length	$\bar{L} = \frac{1}{N(N-1)} \sum_{i \neq j} d_{ij}$
Standard network strength entropy	$G = -\sum_{i=1}^{N} Q_i \ln Q_i$
Weight difference	$Y(k) = \frac{1}{P} \sum_{k_i = K} Y(i)$
Node degree and node strength	$S_i = \sum_{j \in N_i} W_{ij}$
Betweeness Centrality	$W_k = \sum_{(i,j)} \frac{C_k(i,j)}{C(i,j)}$

2.2. Data selection and processing

This study selects 2000–2016 potassium salt (potassium chloride) international trade data in the United Nations commodity trade statistics database (UN Comtrade; http://comtrade.un.org). In the analysis of each year's potash international trade data, it is found that there are some trade relations between the trade volume and the trade amount are very small or 0 in the data of potash international trade. In order to better reflect the international trade relations of potash, the data weights of the above cases are filled with eps(0) in Matlab, and then the directed and weighted complex network is constructed to ensure the consistency with the topology of the directed unweighted network.

3. Construction of complex network model for potassium salt trade

3.1. Complex network model logic construction

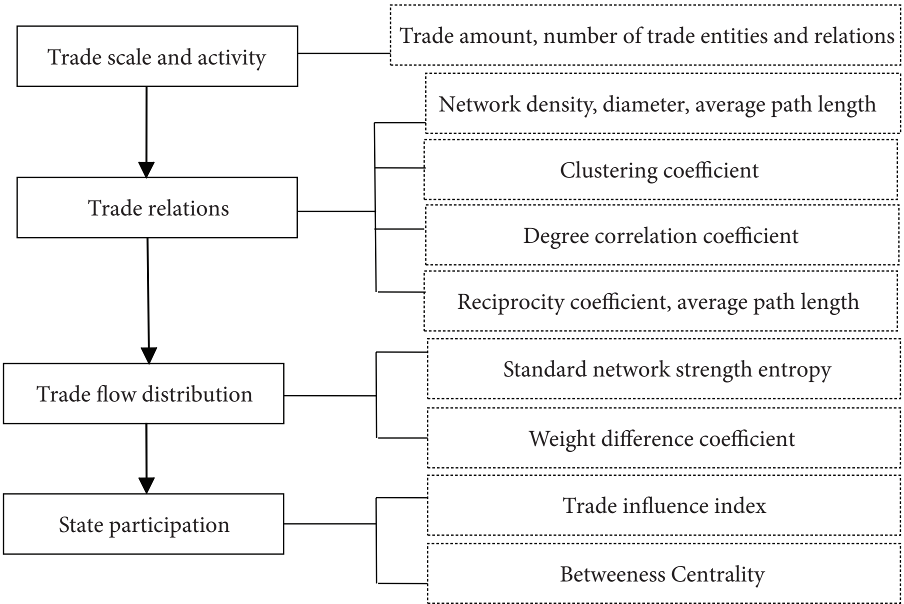


Figure 2. Complex network model logic construction

3.2. International trade network construction

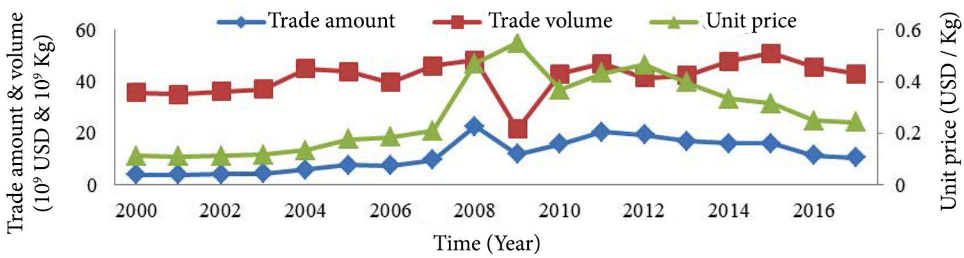
In the global potassium salt trade system, regardless of the geographical location and geographic environment differences, the trade country is abstracted as a node, and the trade relations between countries as edges, constructing a complex network model (Figure 2) of international trade of potassium salt. It constructs a weighted and directed and an unweighted and directed network since trade direction includes imports and exports. The unweighted network mainly reflects the topological structure of the international trade network of potassium salts, in other words, the trade connection relationship between countries, which is represented by the adjacent square matrix. The weighted network mainly reflects the weight structure of the potassium salt international trade network, which can truly illustrate the difference in trade intensity between countries. As can be seen from Figure 3, although trade volume is affected by price and exchange rate difference, the trade volume is positively correlated with the quantity.

For the purpose of showing the characteristics of international trade of potassium salt in the economy, the trade volume between countries is set as the weight of the edge by means of the weighted adjacency matrix. If i exports potassium salt to j, and the amount of trade is V. Then the corresponding adjacency matrix is $w_{ij}(t) = v$, otherwise $w_{ij}(t) = 0$.

4. Results

4.1. Analysis of trade scale and activity of potassium salt

Analysis of total trade volume of potassium salt: A total of 2000–2017 Potash international market trade was obtained by analyzing. It can be seen from Figure 4 that the global trade volume of potassium salt has fluctuated before 2008, reaching the highest level of potassium salt trade amount in 2008.The highest level of potassium trade volume was reached in 2015. After the financial crisis, the rate of change in the trade amount of potassium salt declined sharply. After the rest of 2009, it began to rise in 2010 and then gradually stabilized. From this can be concluded that the scale of potassium trade in 2000–2017 is fluctuating. The trade scale has changed greatly in 2006–2009. In 2008, the trade volume of potassium salt reached the largest in history. It can also be seen from Figure 3 that except for 2008, the scale of potassium salt trade in other years fluctuated little, but the scale has shown a downward trend in general.



Data source: United Nations Commodity Trade Statistics Database

Figure 3. Changes in potassium salt trade from 2000 to 2017

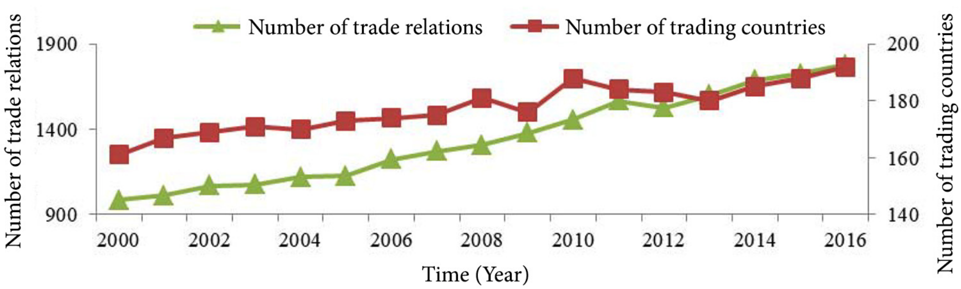


Figure 4. Trends in the total international trade of potassium salt

Analysis on the Subject and Relations of Trade: With the demand of economic development and the improvement of the level of resource exploration and mining technology, some countries with large demand for potassium salt and rich potassium resources have gradually joined the international trade of potassium salt.

From Figure 5, the number of countries and trade relations within the range of 2000 to 2017 has increased in addition to small fluctuations, indicating that more and more countries are joining the potassium salt trade, while potassium salts trade among countries is also increasing. For one thing potassium salt international trading system is more complex. For another, potash market trade more and more active.

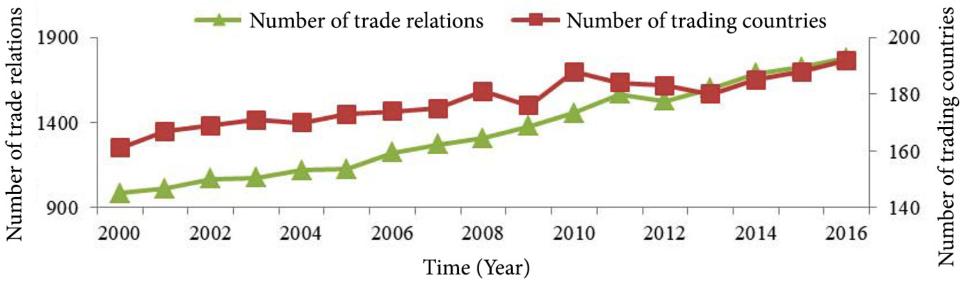


Figure 5. Evolution of the number of trade countries and relations

4.2. Evolution of trade relations of potassium salt

It is found that potassium salt is becoming more and more important, and the trade relations are gradually increasing, and the trading system is more complicated after analyzing the scale and activity of the trade. Hence, the evolution characteristics of the potassium salt trade are further analyzed from the perspective of trade relations.

Evolution of the closeness of trade links: The closeness of the overall trade links of potassium salt is measured by the evolutionary analysis of the density and diameter of the trading network from 2000 to 2016 on the basis of the unweighted and directed network.

Table 2. 2000–2017 International trade indicators for potassium salt

Year	Network density	Network diameter	Average path length
2000	0.038	8	2.896
2001	0.037	8	3.199
2002	0.038	8	2.948
2003	0.037	7	2.878
2004	0.039	7	3.164
2005	0.038	7	2.873
2006	0.041	6	2.754
2007	0.042	7	2.771
2008	0.040	8	2.852
2009	0.045	6	2.804
2010	0.041	7	2.946
2011	0.047	7	2.798
2012	0.046	7	2.756
2013	0.050	6	2.67
2014	0.050	6	2.562
2015	0.049	4	2.362
2016	0.048	5	2.268

From Table 2, the network diameter is decreasing and the network density is increasing generally. The network diameter was greater than 7 from 2000 to 2002, which shows that the risk of potassium trade was high. Besides, the diameter of the potassium salt trade network also rose to 8 in 2008, indicating that the financial crisis has made the trade risk to the highest level. From the evolution of trade closeness, it can be seen that the international trade of potassium salt is getting closer and closer, but the outbreak of the financial crisis has reduced it to the level of six years ago, which is not conducive to the stability of the trade of potassium salt.

Evolution of the degree of trade association: The study calculated the variation of the clustering coefficient in the potassium salt trade network in 2001, 2006, 2008, 2011 and 2016. The distribution is analyzed from four angles: the degree's distribution, the difference of the clustering coefficient of the same degree of time, the variation of the clustering coefficient of the same year, and the clustering coefficient's distribution. From Figure 6, it can be seen that the distribution of degrees is more scattered, especially in 2016, where the value exceeds 250. As time changes, the node degree in the network increases, indicating that the trade network is more complicated. The clustering coefficient of the same value increases with time, showing that the degree of clustering of the potassium salt trading network is increasing. In the same year, the clustering coefficient of countries with smaller degree is larger. Combined with Table 3, it is concluded that the number of countries that trade with these is small, and the in-degree of these countries is basically greater than the out-degree, and the trade volume is small, indicating that most of these countries do not have high demand for potassium salt**.** The constraints of the economic level, resource demand and traffic conditions make these countries trade only with several countries, thus have a high degree of association. Countries with large degree, because of more trade partners, as well as the economic development level and geographical distribution of these countries are also different, and the possibility of trade is also small. So they are less clustered. From the distribution of clustering coefficient, the distribution in 2001 is the most chaotic. By 2016, it is gradually ordered except for a few

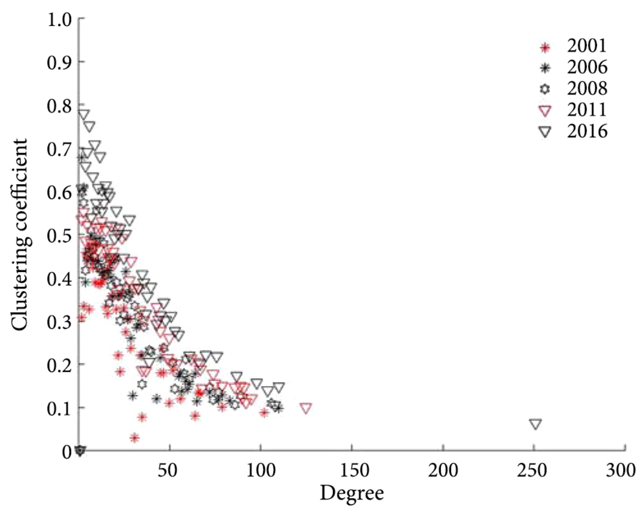


Figure 6. 2001, 2006, 2008, 2011 and 2016 cluster coefficient evolution

special points, which indicates that the early international trade relationship of potassium salt is not obvious, and the clustering is obvious with the time lapse. The small trade group appears, and there are differences in the degree of clustering among them.

Evolution of the relevance of trade countries: In order to determine whether the participating countries of the potassium trade tend to trade with countries with comparable degree, the degree correlation coefficient from 2000 to 2016 is calculated. The degree value of each node in Figure 8 is weighted to reflect the trade volume with a country.

It can be seen from Figure 7 that the correlation coefficient of node degree of potassium trade is less than 0, which is a typical heterogeneous mixture. In terms of time, the correlation coefficient of node degree is declining, revealing that countries with less degree tend to trade with countries with larger degree in the potassium salt trade network. The big trading countries have more "customers" than the small, and can provide more stable quantities and

Table 3. Top ten countries with higher clustering degree in 2016

Country	Number of import countries	Number of export countries	Trade amount	Clustering coefficient
Malta	5	1	17.46	0.95
Belize	4	1	635.87	0.92
Cyprus	4	7	2294.57	0.89
Cameroon	7	1	5517.33	0.88
Armenia	6	0	288.92	0.87
Venezuela	6	0	13232.89	0.87
Azerbaijan	4	1	1481.43	0.83
Ethiopia	6	1	129.34	0.83
Guinea	3	0	30.95	0.83

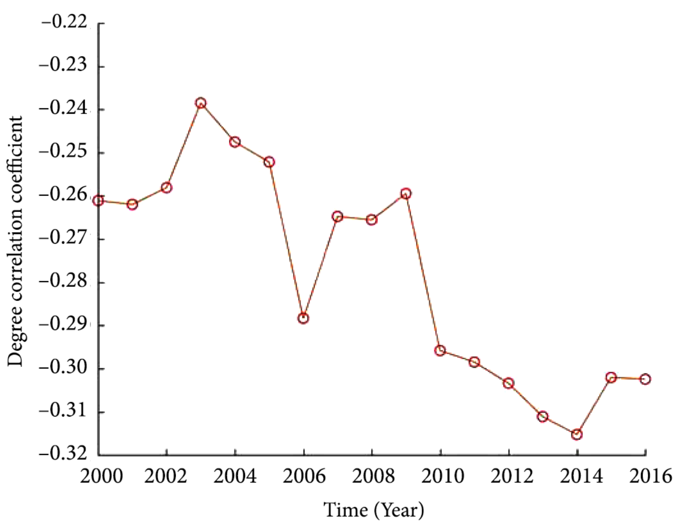


Figure 7. Evolution of node degree correlation coefficient from 2000 to 2016

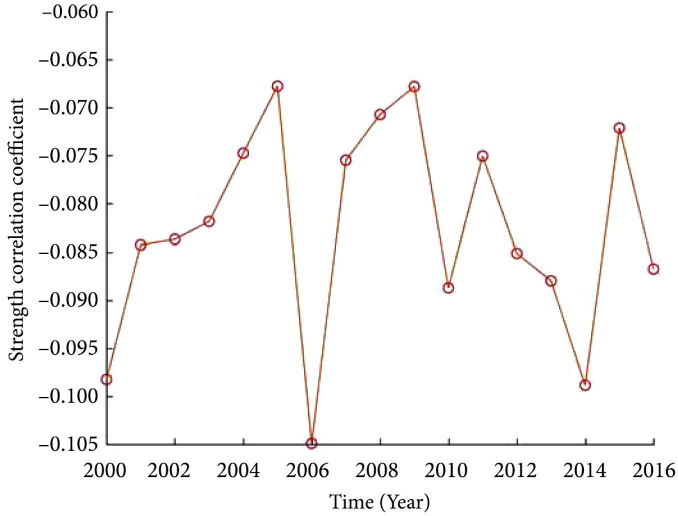


Figure 8. Evolution of node strength correlation coefficient from 2000 to 2016

higher quality potash commodities. In addition, large degrees countries whose geographical location is more dispersed are more connected to the international trade market. The information spread smoothly, which makes them a high reputation. Countries with smaller degree have fewer trade links, and information is more blocked and less popular. Under the same circumstances, countries are more likely to receive information on major countries, so they are more inclined to trade with them, and this trend is increasing.

It can be found out from Figure 8 that the strength correlation coefficients of potassium international trade network are all less than 0, the same as the results in Figure 6. Overall, the strength correlation coefficient of potassium trade network shows a cyclical fluctuation trend. It first rises and then decreases from 2000 to 2006, then rises and then decreases from 2006 to 2010. The trend of 2010–2014 and 2014–2016 is the same as that of 2006–2010, but the fluctuation cycle is decreasing. Before 2006, the strength correlation coefficient showed a trend of growth, indicating that some countries with similar strength have continuously carried out potassium salt trading activities. In 2006, the strength correlation coefficient of the network showed a significant decline trend, reaching the minimum, indicating that the regional trade in the potassium-salt trade network in 2006 was the most obvious. It is basically considered that the strength correlation distribution in the potassium salt trade network is in a stable state from the distribution interval of the degree correlation coefficient, which is between −0.15 and −0.065.

Evolution of market trade's order: The evolution of the international trade order of potassium salt is analyzed from the convenience and order of trade. Judging from the average path length in Table 1, it is below 3 except 2001 and 2004, with a minimum of 2.268 in 2016, indicating that the links between the two countries are more convenient as the global potash trade deepens.

Figure 9 shows that the reciprocal coefficient of the potassium salt trade is between 0.12 and 0.32, which is lower than 0.5, indicating that the degree of ordering of the network is

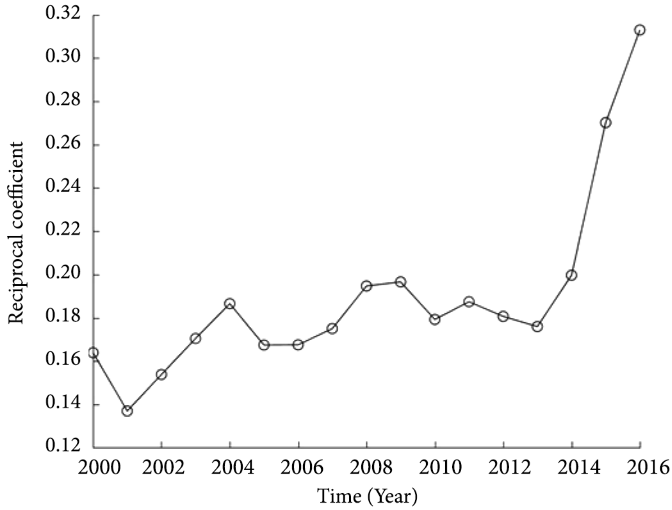


Figure 9. Reciprocal coefficient curve from 2000 to 2016

not high, and the two-way trade between countries is less. Most countries are in an export or import advantage. However, in terms of time, it has shown an upward trend, and the rise is most distinct between 2014 and 2016. It shows that with the increasing number of countries in the two-way trade, the potassium salt trade network has gradually transformed from disorderly to orderly. The complementarity of trade between countries is increasing, as well as the trend of globalization is clearer.

4.3. Evolution of trade flows of potassium salt

Trade relations analyze the characteristics of trade networks from the perspective of the connectivity of vertices in the international trade network. In the international trade of potassium salt, the difference in trade volume between countries may be large, and the analysis of topological structure ignores it. Therefore, the evolution of the distribution of potassium salt trade flows is continued after analyzing the evolution of trade relations, which is mainly measured by standard network strength entropy and weight difference.

Evolution of the overall trade balance of potassium salt: Figure 10 indicates that the standard network strength entropy of the potassium salt trading network is above 0.57, revealing that the trade volume between countries in the potassium salt trading network is relatively balanced. But it shows a downward trend as time goes by, indicating that the heterogeneity of the network is rising. The gap in trade between countries is increasing, beginning with the fact that a small number of countries have a large trade volume and most countries occupy less trade volume. First, the external demand for potassium in small countries increases as the economy developing and information blocked, and it is more inclined to increase trade with major trading countries. Second, some countries have reduced their external demand for potash due to local resource, environmental and economic development constraints, thereby reducing trade with neighboring trading countries, which has shifted the distribution of trade to an uneven situation. What's more some countries have consumed more local potassium resources in the process of potassium salt trade and their own production and development, from adequate resources to insufficient. Promoting economic development and maintaining trade through trade with major potash trading countries has increased the heterogeneity.

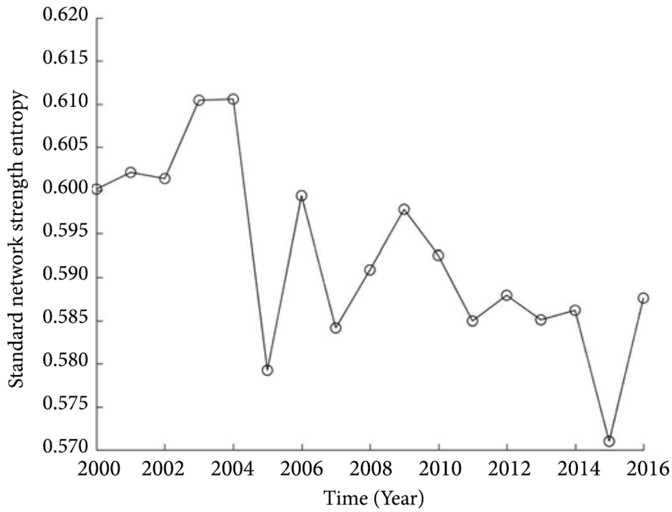


Figure 10. Standard network strength entropy change from 2000 to 2016

Evolution of local trade equilibrium: The partial trade balance of potassium salt refers to the degree of balance of trade volume with other countries that generate trade with a country, and is calculated by using weight difference. Weight difference is an important index to analyze the local heterogeneity of the network and can also reflect the equilibrium of the local trade. In this study, it analyzed the evolution of the weight difference from 2000 to 2016, and selected 2001 and 2016 for comparative analysis.

Figure 11 shows that as the degree increasing, the weight difference coefficient is closer to $y=\frac{1}{k}$ except for the point with degree of 1, indicating that the less trade relations, the greater the difference of trade distribution, and the more balanced the trade flow distribution, the countries with more trade relations. The weight difference curves of 2001 and 2016 are not much different from $y=\frac{1}{k}$. By calculating the points with same degree in 2001 and 2016, 59.26% of the points in 2001 are closer to $y=\frac{1}{k}$, manifesting that the local trade difference is increasing with time. With the deepening of the trade in potassium salts, the potassium resources of various countries are gradually being consumed, and the supply of potash is reduced. Some big supply countries have evolved into small supply countries, and these small countries have begun to seek trading partners and increase the volume of foreign trade in order to meet the needs of production and life. With the number of these countries increasing over time, the number of countries that can supply larger amounts of potassium is becoming less and less. The difference in the amount of potassium salt supplied by each country is also expanding, so as to larger weight difference of the local trade, which is extremely unfavorable for small trading countries.

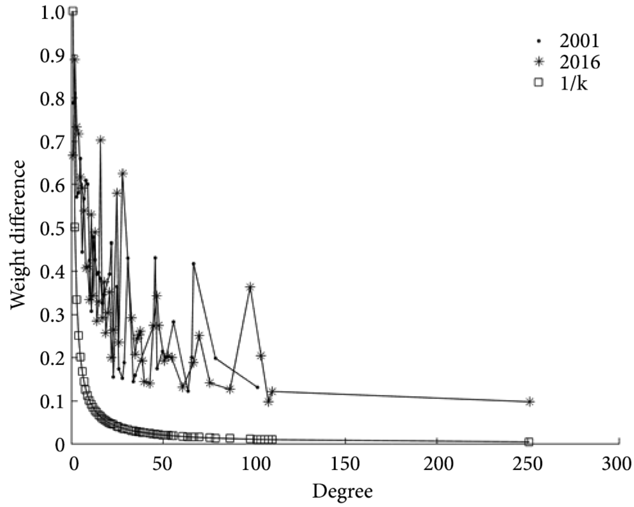


Figure 11. Evolution of weight difference coefficients in 2001 and 2016

4.4. Evolution of state participation

Evolution of trade influence in major countries: The national trade influence is reflected in the international trade of potassium salt as the total trade involved in trade with the country, that is, the strength of the nodes in the trade network, measured by the trade influence index. The potassium salt trade network is a directed network, so the node strength is divided into the input strength s^{in} and the output strength s^{out} according to the direction of trade, and the node strength is the sum of s^{in} and s^{out}. First, the trade influence index for the first country is assigned 100. The trade influence index of other countries is calculated in line with the ratio of the strength of the node in the country to the strength of the node in the first country, and the trade influence of each country is obtained every year. The processing way can not only eliminate the difference in the order of magnitude of node strength in different years, but also normalize the data and process the data to between 0 and 100. At the same time, it can also reflect the relationship between the node strength and the maximum node strength of each country in the current year, which is convenient for inductive analysis. Table 3 shows the top 15 countries of the 2000–2016 trade influence Index.

Table 4 demonstrates that Canada has been the country with the largest trade influence index since 2000, and it has a big difference with the second. Mainly because of the world's largest potassium deposit in the Elk Point Basin in Saskatchewan, Canada, the unique geographical advantages make Canada have sufficient potassium supply in the past 17 years, and the potassium salt trade has been in a leading position. However, Canada's in-degree and out-degree are small, and the out-degree is greater than the in-degree. The weighted out-degree is much larger than the weighted in-degree. It can be concluded that Canada's potassium trade is mainly exported, and the number of countries that export is small. The trade volume of these countries with Canada is basically larger. Despite the product advantages, there are still certain risks that are easily controlled by the exporting country. Secondly the United States and the Russian Federation have an average trade influence index of more than 50. China's and Brazil's are above 40. Figure 10 shows that there is a large gap in the mean distribution of trade influence indices. The trade influence index of other countries is below 70 except for Canada, and the number of countries with less than 40 is more. Using the ABC classification method, the trade influence index is above 70 for trade leading countries, 40 to 70 for trade dominant countries, and other countries for trade-related countries. Therefore, Canada is the leading country, while the United States, Russian Federation, China and Brazil are the dominant countries, and the rest are trade-related countries. As can be seen from Figure 13, Canada's trade influence has always been the largest, and there will be no large fluctuations in the short term. The trade influence of US is in a fluctuating form, with little fluctuation, and is basically not affected by the financial crisis, ranking second. The trade influence of the Russian Federation fluctuated greatly. 3 years in the past 17 years, it surpassed the US in the second place, but it was ranked third after being affected by the financial crisis. Before 2008, China's trade influence index showed a volatility trend, and in 2007 surpassed the United States and the Russian Federation, becoming the second largest country. However, since 2008, the influence of trade has continued to decline. In 2010, it fell to the lowest level, and then rose volatility, but the increase was small. Brazil's trade influence is a trend of rising, less affected by the financial crisis, the future trade influence is likely to surpass the Russian Federation.

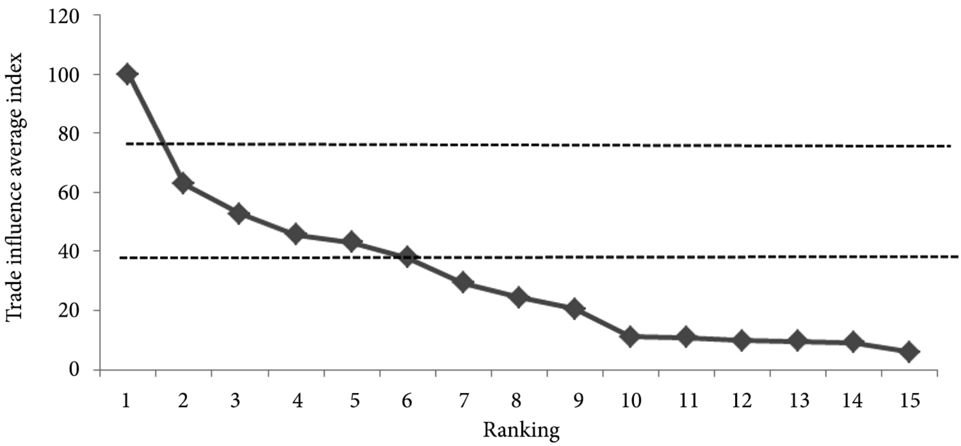


Figure 12. Mean trade influence of the top 15 countries

Evolution of the ranking of trade hub: Based on the 2000–2016 potassium international trade data, it can be reached that 224 countries involved in potassium salt trade. According to the ranking of trade hub capacity, the Netherlands, the US, India, France and China are the top 5. Namely, these 5 are the main transit trade countries (Figure 12).

As can be seen from Figure 14, the trade transfer capacity of the Netherlands and China has shown an increasing trend over time. Before 2015, the Netherlands had a lower ranking except for 2010, but ranked first in the second consecutive year after 2015, and the Netherlands ranked first in terms of total trade transfer capacity in 17 years. From the specific data point of view, the Netherlands' betweeness centrality is 12 times that of the second-ranking country in 2015, while other countries have a small difference in rankings, but the gap between the centers is not large. Hence, the Netherlands' potassium salt trade in 2015 laid the foundation for becoming an important hub. Before 2008, China's trade transfer capacity has been improving, ranked first in 2007. However, after being affected by the financial crisis, it showed a downward trend for two consecutive years. After that, it began to increase year by year and was basically stable in 2011. Compared with other countries, the transfer capacity of China was affected badly by the financial crisis. The United States, France, and India are basically in the top ten in the 17-year rankings, indicating that the three have sufficient key information and a stable and critical transit position in the potassium trade.

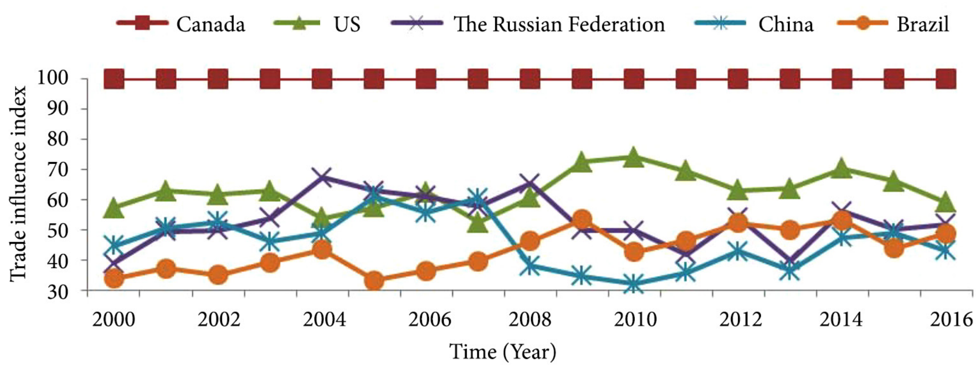


Figure 13. Evolution of trade influence index of trade leading countries and dominant countries

Table 4. Trade influence index 2000–2016

Country	2000	2002	2004	2006	2008	2010	2012	2014	2016	均值
Canada	100	100	100	100	100	100	100	100	100	100
US	57.1	61.5	53.7	62.4	60.5	73.9	63.0	70.2	58.9	62.4
The Russian Federation	38.7	49.7	67.2	61.0	65.1	49.6	54.0	55.9	51.8	54.8
China	44.6	52.5	48.8	55.6	38.0	32.0	42.7	47.4	42.9	44.9
Brazil	33.8	34.9	43.3	36.3	46.2	42.5	52.2	53.2	48.8	43.5
Belarus	21.7	24.2	36.4	40.5	42.8	38.5	40.6	49.8	48.5	38.1
Germany	26.7	32.9	33.4	35.8	27.5	27.3	28.6	24.7	24.5	29.0
India	18.0	18.5	19.6	25.4	33.0	33.4	18.1	23.6	24.0	23.7
Israel	18.2	24.9	26.2	15.9	22.2	23.2	19.7	21.3	17.8	21.0
Indonesia	3.9	5.3	8.1	8.9	14.8	13.0	18.0	16.5	16.1	11.6
Malaysia	10.6	10.6	12.8	11.8	12.0	11.6	10.3	10.8	10.9	11.3
Belgium	7.6	10.2	9.3	11.2	9.7	13.3	10.3	8.8	9.7	10.0
France	12.5	12.0	14.7	10.7	9.1	9.6	6.8	7.0	6.5	9.9
Jordan	12.7	13.6	10.4	11.1	9.7	6.4	8.3	7.2	6.7	9.6
Spain	5.9	4.8	6.8	6.1	4.8	6.0	6.8	7.1	6.7	6.1

Note: Table 4 only shows data for even years, and the mean is for all years.

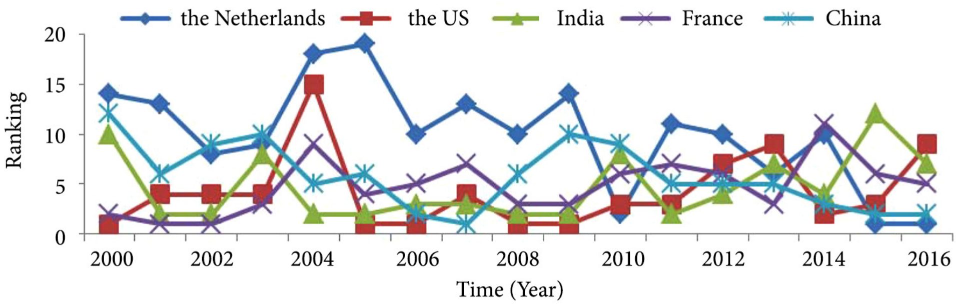


Figure 14. Evolution of the ranking of major trading hubs

5. Countermeasures

Michael porter's theory of national competitive advantage analyzes the factors that influence the formation of a country's competitive advantage in international trade macroscopically. The differences and changes of these factors make international trade more complicated and affect its stability. The theory provides an analytical framework for countries to create and maintain international competitiveness. The trade competitiveness of each country is closely linked with the prosperity and stability of the international trade market. In order to maintain the stability of the international trade of potash, this paper puts forward the countermeasures for each country to gain the competitive advantage according to Michael porter's theory of relative competitive advantage.

Between 2000 and 2016, the scale of international trade in potash did not change much, but the activity of the transaction was increasing, showing that limited by resources and environment, the scale of potassium trade has not expanded indefinitely. Potash trade is becoming more and more important. Whether countries can form competitive advantages in the international market of potassium salt is crucial to the stability of national strategic security of resources and economic development. According to Michael porter, for the formation of national competitive advantage, related and supporting industries are closely related to competitive industries. Based on the existing potash industry, from the perspective of the industrial chain, the upstream and downstream enterprises of potash are developed to form industrial clusters, which is conducive to the formation of national competitive advantages under the background of the stable scale of potash trade. China's potash industry has formed an industrial chain of "ore-based products/bulk products-downstream products", and should further upgrade related and supportive industries (Li, 2012; Rawashdeh & Maxwell, 2014). Countries should base themselves on the production of potash products, and should broaden their horizons to focus on the development of related and supportive industries. As long as you are bigger and better in one part of the industry chain, form competitive advantages will be just around the corner.

From the evolution of trade relations, the overall trend of trade development is stable. However, from the perspective of the clustering, trade has gradually evolved with time and has evolved toward the formation of trade groups. Countries should conform to the trend of trade evolution and join solid trade groups in time. It is better to form a trade group with native country at the core Michael Porter pointed out that domestic demand is the driving force for industrial development, so countries should consolidate their position in the trade group by stimulating domestic demand. The major potassium demand countries are China, the United States, Brazil and India. They should pay attention to the "big customers" in the domestic market and apply survey to discover expected needs as the basis for the improvement and marketing of potash products. China should consolidate its relations with countries by increasing political, economic and cultural exchanges with various countries. In addition, China has a large demand for potash and is the main importer of potash, but China's exporting countries are four times the number of importing countries. China should not only reduce the dependence on potassium salt self-sufficiency in terms of potassium exploration and development technologies, but also pay attention to the proportion of importing countries, and stabilize import sources by signing agreements with major importing countries to reduce the risk of potassium supply. Countries should focus on the export countries, sum up the demand differences of different countries from the needs of customers, and improve products according to the most complicated importing countries.

Trade flows spread toward an unbalanced direction with time. From the local trade network, the greater the difference in the distribution of trade flows between countries with less trade relations, the smaller the distribution of trade flows in countries with more trade relations. The distribution of trade flows over time trade has become more and more different. The essence of trade flow is the flow of factors of production. Unbalanced distribution of trade flow is equal to unbalanced distribution of factors of production. Porter divides the factors of production into primary and advanced ones and points out that the advanced are more important for the country to obtain competitive advantages. Canada is a leading country in the potash trade, which has obvious natural resource advantages and is the world's largest and best quality potash resource. In addition, Canada has a high level of economic development and has a financial advantage. Therefore, Canada should pay attention to the expansion of advanced production factors, increase the construction of technical facilities, increase the number of research institutions, and cultivate professional talents such as potassium salt development and production. Data on the trade in potash should also be collected to form an information advantage in case of insufficient resources in the future. The US, the Netherlands and India are the main drivers of trade flow, which have the greatest impact on the distribution of trade flow. The United States has both resource advantages and information advantages, but information advantages are decreasing. The United States should be more involved in the potash trade, further expanding the information it has in the past, and thus forming a competitive advantage in information superiority. Then there is the Netherlands. Although the Dutch resource advantage is not obvious, the number of importing countries and exporting countries is far ahead. The countries that generate trade are distributed on all continents except Antarctica. It has obvious advantages of modern communication and information. Form a competitive advantage in the coexistence of information and resources. The Netherlands should also pay attention to the production technology of potassium products. The advantages of resources and information are not enough to for competitive advantage. If it can have the advantage of production technology on this basis, the competitive advantage will not be easily replaced in a short time. Finally, India has certain information advantages. India, as the world's second most populous country, has obvious advantages in low-cost human resources. This has the effect of reducing costs by mining potassium and producing potassium products.

From the evolution of the participation of major countries in the potassium salt trade, the trade influence of China and the Russian Federation is relatively large due to the financial crisis, and smaller in Canada, the United States and Brazil. Michael porter believes that opportunities are uncontrollable and the impact of government policies cannot be ignored. They impact the four elements. China is most affected by the financial crisis in the potash trade. In order to turn better, China can appropriately increase its trade with small countries, thereby increasing the understanding of the information and obtain timely opportunities in the international market. At the same time, China can increase the visibility in the international market by increasing the number of trading countries. As an important hub, it is also necessary to use the "Belt and Road" to tap into countries with more potassium demand, and to act extensively as a trading medium to form a "hub" advantage. Promote trade cooperation between China and African countries through the "China-Africa Cooperation Forum" and reduce trade barriers. Finally, China has increased its trade influence by increasing its trade with countries and fostering global agency advantages. Countries should make full use of the development of the Internet to collect, process and analyze information disseminated in the international potash network. In addition, attention is paid to changes in exchange rates in the financial industry, price fluctuations in the energy industry, and further development of potash marketing strategies and market entry points. The most important role of the government in industrial development is to ensure that the domestic market is in a lively competitive state, to develop competition norms, and to avoid the state of "Trust".

Conclusions

Through the study of the evolution characteristics of the international trade of potassium salts, the scale, trade links and trade equilibrium of the international market of potassium salts have been clearly understood, and the total evolution characteristics of trade have also been analyzed. Secondly, it also understands the degree of clustering and equilibrium of local trade. Then, by analyzing the participation of major countries, the status of countries with vital influence in trade and pivotal hub in the future international market is speculated and analyzed. Finally, combined with the diamond model, it puts forward the suggestions of countries to form competitive advantage from the perspectives of related and supporting industries, demand conditions, production factors, opportunities and government. Countries should pay attention to the development of their own potash industry clusters. At the same time, all trading countries should focus on countries with rising potassium reserves, major importing countries and countries with large import and export gaps, and should also pay attention to changes in the international trade environment. All countries should enhance the spirit of mutual benefit and strengthen international cooperation. China should use the China-Africa Cooperation Forum and the "Belt and Road Initiative" to maintain the stability of the international potash trade. The complex network method simplifies the relationship between trade countries. Limited by the method used, the factors considered in the study are still not comprehensive enough. More factors such as policy, transportation, geographic location should be studied. The dynamic evolution of trade between countries should continue to be studied in depth.

Acknowledgements

We appreciate the support provided by the development strategy of important and mineral resources in Qinghai Province (China Geological Survey, Grant No. 12120113033031).

Funding

This work was supported by the < the development strategy of important and mineral resources in Qinghai Province (China Geological Survey) > under Grant [number 12120113033031].

Author contributions

Both authors initiated this research and a manuscript. Mingyue Wang and Rui Kong proposed the study goal, conducted literature search. Mingyue Wang was responsible for data analysis and both participated in the analysis of data and result.

Disclosure statement

Both authors don't have any competing financial, professional, or personal interests with other parties.

References

Alvarez, & Fernando. (2017). Capital accumulation and international trade. *Journal of Monetary Economics*, *91*, 1-18. https://doi.org/10.1016/j.jmoneco.2017.09.005

Bao, R., & Liu, W. (2014). World potash production and consumption pattern and its changes. *Land and Resources Intelligence,* (8), 18-21.

Bao, R., Yuan, Z., & Zhou, D. (2013). Potash resources and potash supply and demand situation analysis and prediction. *Journal of Phosphate Fertilizer and Compound Fertilizers, 28*(2), 4-8+14.

Campi, M., & Dueñas, M. (2016). Intellectual property rights and international trade of agricultural products. *World Development, 80*, 1-18. https://doi.org/10.1016/j.worlddev.2015.11.014

Cheng, M., Yang, G., Chi, X., & Xin, M. (2019). International trade competitiveness of traditional Chinese medicine (TCM) based on the theory of the diamond industry research. *China Journal of Chinese Materia Medica*, *44*(01), 207-211.

De Andrade, R. L., & Rêgo, L. Ch. (2017). The use of nodes attributes in social network analysis with an application to an international trade network. *Physica A: Statistical Mechanics and its Applications*, *491*, 249-270. https://doi.org/10.1016/j.physa.2017.08.126

Dia, E., & Vanhoose, D. (2016). Capital intensities and international trade in banking services. *Journal of International Financial Markets, Institutions and Money*. https://doi.org/10.1016/j.intfin.2016.08.007

Du, R., Wang, Y., Dong, G., Tian, L., Liu, Y., & Wang, M., et al. (2017). A complex network perspective on interrelations and evolution features of international oil trade, 2002–2013. *Applied Energy, 196*, 142-151. https://doi.org/10.1016/j.apenergy.2016.12.042

Fang, Y., & Ma, R. (2018). *Potential and influencing factors of cultural trade between China and countries along "One Belt And One Road": an empirical study based on stochastic frontier gravity model.* World economic research.

Feng, S., Li, H., Qi, Y., Guan, Q., & Wen, S. (2017). Who will build new trade relations? Finding potential relations in international gas trade. *Energy, 141*, 1226-1238. https://doi.org/10.1016/j.energy.2017.09.030

Fiorini, M., & Hoekman, B. (2017). Services trade policy and sustainable development. *SSRN Electronic Journal, 112*. https://doi.org/10.2139/ssrn.3033851

Ge, Y., & Li, B. (2019). Football is a game? – based on the breakpoint regression design to study the effect of the World Cup on international trade. *Journal of Economic Review,* (1), 91-105.

Ge, J., Wang, X., Guan, Q., Li, W., Zhu, H., & Yao, M. (2016). World rare earths trade network: patterns, relations and role characteristics. *Resources Policy, 50*, 119-130. https://doi.org/10.1016/j.resourpol.2016.09.002

Hou, W., Liu, H., Wang, H., & Wu, F. (2017). Structure and patterns of the international rare earths trade: a complex network analysis. *Resources Policy*, *55*, 133-142. https://doi.org/10.1016/j.resourpol.2017.11.008

Hye, Q. M. A., & Lau, W. Y. (2015). Trade openness and economic growth: empirical evidence from India. *Journal of Business Economics and Management, 16*(1), 188-205. https://doi.org/10.3846/16111699.2012.720587

Lamastra, L., Miglietta, P. P., Toma, P., De Leo, F., & Massari, S. (2017). Virtual water trade of agri-food products: evidence from Italian-Chinese relations. *Science of the Total Environment, 599–600*, 474-482.

Li, G. (2012). Status quo, development opportunities and challenges of China's potash industry. *Inorganic Salt Industry*, *44*(5), 1-3.

Li, Q., Zhong, W., Wang, G., Cheng, J., Dai, T., & Wen, B., et al. (2018). Material and value flows of iron in Chinese international trade from 2010 to 2016. *Resources Policy, 59, 139-147*. https://doi.org/10.1016/ j.resourpol.2018.06.011

Liu, Y., Chen, S., Chen, B., & Yang, W. (2016). Analysis of CO2 emissions embodied in China's bilateral trade: a non-competitive import input–output approach. *Journal of Cleaner Production*.

Marko Lovrić, Re, R. D., Vidale, E., Pettenella, D., & Mavsar, R. (2018). Social network analysis as a tool for the analysis of international trade of wood and non-wood forest products. *Forest Policy and Economics, 86*, 45-66. https://doi.org/10.1016/j.forpol.2017.10.006

Newman, M. E. J. (2003). The structure and function of complex networks. *SIAM Review, 45*(2), 167-256. https://doi.org/10.1137/S003614450342480

Nyen Wong, K., & Khoon Goh, S. (2013). Outward FDI, merchandise and services trade: evidence from Singapore. *Journal of Business Economics and Management, 14*(2), 276-291. https://doi.org/10.3846/16111699.2012.703964

Olczyk, M. (2016). Bibliometric approach to tracking the concept of international competitiveness. *Journal of Business Economics and Management, 17*(6), 945-959. https://doi.org/10.3846/16111699.2016.1236035

Porter, M. E. (1998). *The competitive advantage of nations*. Free press. https://doi.org/10.1007/978-1-349-14865-3

Rawashdeh, R. A., & Maxwell, P. (2014). Analysing the world potash industry. *Resources Policy, 41*(41), 143-151. https://doi.org/10.1016/j.resourpol.2014.05.004

Ginevičius, R., Tvaronavičienė, M., Korsakienė, R., & Kalaūinskaitė, K. (2007). Lithuania - Belarus economic relations: how the EU accession impacted bilateral trade. *Journal of Business Economics and Management, 8*(2), 137-144. https://doi.org/10.3846/16111699.2007.9636161

Sebestyén, & Tamás. (2016). Moving beyond the iceberg model: the role of trade relations in endogenizing transportation costs in computable general equilibrium models. *Economic Modelling*, *67*, 159-174. https://doi.org/10.1016/j.econmod.2016.11.015

Sharma, S., Duveiller, E., Basnet, R., Karki, C. B., & Sharma, R. C. (2005). Effect of potash fertilization on helminthosporium leaf blight severity in wheat, and associated increases in grain yield and kernel weight. *Field Crops Research, 93*(2-3), 0-150. https://doi.org/10.1016/j.fcr.2004.09.016

Sun, Q., Gao, X., Zhong, W., & Liu, N. (2017). The stability of the international oil trade network from short-term and long-term perspectives. *Physica A: Statistical Mechanics and its Applications*, *482*, 345-356. https://doi.org/10.1016/j.physa.2017.04.047

Tian, X., Geng Y., & Sarkis, J. (2018). Trends and features of embodied flows associated with international trade based on bibliometric analysis. *Resources Conservation* & *Recycling, 131*, 148-157. https://doi.org/10.1016/j.resconrec.2018.01.002

Vall-Llosera, M., & Cassey, P. (2017). "Do you come from a land down under?" characteristics of the international trade in Australian endemic parrots. *Biological Conservation, 207*, 38-46. https://doi.org/10.1016/j.biocon.2017.01.015

Wang, W., Li, Z., & Cheng, X. (2018). Evolution of the global coal trade network: A complex network analysis. *Resources Policy*, 1-11. https://doi.org/10.1016/j.resourpol.2018.10.005

Wang, X., Li, X., & Chen, G. (2006). *Complex network theory and its application.* Tsinghua university press.

Weng, Y., Yang, C., & Tu, F. (2010). Outward foreign direct investment and product quality of domestic productions: an empirical investigation. *Journal of Business Economics and Management, 11*(3), 396-414. https://doi.org/10.3846/jbem.2010.19

Zhang, L., Chen, T., Yang, J., Cai, Z., Sheng, H., & Yuan, Z., et al. (2017a). Characterizing copper flows in international trade of China, 1975–2015. *Science of The Total Environment, 601-602*, 1238-1246. https://doi.org/10.1016/j.scitotenv.2017.05.216

Zhang, X., Cui, H., Zhu, J., Du, Y., Wang, Q., & Shi, W. (2017b). Measuring the dissimilarity of multiplex networks: an empirical study of international trade networks. *Physica A: Statistical Mechanics and its Applications, 467*, 380-394. https://doi.org/10.1016/j.physa.2016.10.024

Zhao, Z. (2013). Global potash resource supply and demand pattern and potash market price trend. *China Economic* & *Trade Journal*, *35*, 11-13. https://doi.org/10.3969/j.issn.1007-9777.2013.35.004

Zhong, W., Dai, T., Wang, G., Li, Q., Li, D., & Liang, L., et al. (2018). Structure of international iron flow: based on substance flow analysis and complex network. *Resources Conservation* & *Recycling, 136*, 345-354.

Zhou, M., Wu, G., & Xu, H. (2016). Structure and formation of top networks in international trade, 2001-2010. *Social Networks, 44*, 9-21. https://doi.org/10.1016/j.socnet.2015.07.006