The Complex International Migration Network for Top Scientific and Technological Talents

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Abstract

This paper studies international migration for top scientific and technological talents under mathematical and quantitative approach. In the beginning, we give the definition about top scientific and technological talents, and collect information and data of international migration for top talents. Then, with the knowledge of algebraic graph theory, probability and statistics, complex systems and networks, the complex network model of talent's migration is built. After that, the relationship between complex networks and international migration for top talents is investigated, and some concepts and indices of complex networks are employed to study the characteristics of talent's migration, including immigration and emigration. Finally, we analyze the migration for top talents between eleven major and typical countries or regions based on the proposed complex network model of talent's migration, and show the effectiveness of the theoretical results.

Keywords: Top talents; complex network; talent migration; quantitative analysis

1. Introduction

Driven by the desired for more secure environment, better job opportunities, attractive remuneration, sophisticated laboratory conditions, or other things, an increasing number of top talents in science and technology have contributed to unprecedented levels of cross-border flows in the last decades. Although international migration for top scientific and technological talents makes up a small part of international flows of migrants, it may be significant implication for a country's economic performance. In particular, the international migration for top talents may strongly affect innovation systems. Therefore, a great number of researchers and policy makers in all countries, not only in developing or emerging economies, concern the importance of international migration for top talents, so that many literatures in this field are emerging.

The work Choudaha (2017) analysed the changes in international student mobility from the lens of three overlapping waves spread over seven years between 1999 and 2020, and maintained that institutions were under increasing financial and competitive pressure to attract and retain international students by analyzing the underlying drivers and characteristics of the mobility waves. Also, the authors in the paper Ismail et al.(2016) conducted a survey to find the main issues of talent attraction for institutions or companies.

The paper Solimano (2006) reviewed analytical and policy issues related to the international migration of talented individuals and examined the main types of talent who move internationally, their specific traits and characteristics and the implications of this mobility for source and destination countries and for global development. And the paper Kuvik (2015) argued that the "global competition for talent" had come into play in media, policy, and migration research, but more as a catchword rather than as an intricately defined concept or theory that paid attention to both the more "global" changes as well as the particularities of career and country or regional contexts. The work Milio (2012) provided a critical overview of the vast body of literature on migration and mobility of highly-skilled persons, commonly referred to as brain drain. The work Leipziger (2008) outlined the challenges of retaining and attracting high-skilled professionals, briefly assessed both the "brain gain" and the "brain drain" in the health sector, and examined some of the existing programs that encouraged return. Moreover, the most famous reference about talent mobility in recent years is Basri (2008), which answered several questions about the characteristics of mobile talents, the implications of increased mobility of talents and so on.

Although there exist a lot of works discussing international migration, such as the mentioned above, most of results are obtained from experience of scholars with qualitative analysis. The most significant limitation of this approach is the quality of the research depends too greatly on the individual researcher, and researchers' bias is built in and unavoidable. Moreover, the rigor of qualitative research is harder to demonstrate because it often does not involve quantitative data. Therefore, many scholars focus on quantitative analysis for international migration to deal with these disadvantages of quantitative method. The authors in Lu and Zhang (2015) compared the performance of overseas returnees and local scholars in academic and innovation by quantitative analysis and found that overseas returnees performed better. And the work Harrison and Cameron (2013) used logistic regression analysis to study the technological migration in the Australian context, as well as the factors that explained use of Australian 457 visa scheme by organizations for attracting and recruiting talent. In Lanvin and Evans (2016), a kind of Global Talent Competitiveness Index (GTCI) was established, and the corresponding report about the GTCI focused the attention of readers on key dimensions of talent competitiveness that were critical for the ability of countries to chart a sustainable course between economic, social and political imperatives. Moreover, the report OECD (2016) presented the first broad international comparison across all EU and OECD countries of the outcomes for immigrants and their children, through 27 indicators organized around five areas: Employment, education and skills, social inclusion, civic engagement and social cohesion, and also presented detailed contextual information (demographic and immigrant-specific) for immigrants and immigrant households. Another quantitative analysis for migration is Kim and Cohen (2010), which quantified determinants of international migration inflows and constructed a mathematical migration mode with the logarithm of the number of migrants (inflows and outflows separately).

This study in our paper draws on analytical literatures, the most recent available data inventories and the tools of complex networks to investigate the dimensions of international migration for top talents at the present time. For this object, we first define the top talents as the authors of the highest cited papers and the inventors of the strongest patents with the approach of bibliometrics. Also, we propose a way to search the international migration information of these talents. Next, the complex network model of international migration is built. In advance, we introduce some concepts of complex network and analyze the relationship between these concepts and top talents' migration. Finally, we collect the migration information of top talents in some typical countries and regions according to the proposed method, explicit the quantitative approach with the knowledge of complex networks to investigate the migration problem between these countries and regions, and obtain some interesting results. The first major contribution of this paper is that the theoretical results are obtained based on quantitative analysis totally, so that some parts of the results maybe not mentioned by previous investigations through qualitative approach. The second major contribution of this paper is that we propose a new quantitative way, employing complex networks, to analysis international migration, so that this approach draws a more complete picture of international migration for top talents, not only limits in a single original or destination country.

The rest of the paper is organized as follows. Section 2 gives the definition of top talents, and presents how to collect and process data and information about the migration of top talents. In Section 3, the migration for top talents is modeled as a kind of complex networks. Section 4 analyses the network of the international migration for top talents consist of eleven typical and major countries and regions. The last section states the conclusion.

2. Data collection and processing

The absence of detailed and high quality data is the main base to study the international migration for talents quantitatively. In this paper, we define top talents as the authors of the top thirty highest cited papers according to Web of Sciences, and the inventors of the top thirty strongest patents according to the tool Innography developed by Dialog in ten frontiers of sciences and technologies, these are "Frontier and basic science", "New energy technology", "New information technology", "Advanced material research", "Development of ocean, space and earth", "Advanced equipment manufacturing", "Agriculture and food security", "Resource and environment", "Modern medicine and frontier biotechnological research" and "Smart city and digital society". These fields are obtained from a lot of discussions by many famous scholars based on the trend of science and technology and the development demand of countries all over the world. More details about the strongest patent and patent strength have been introduced in Narin et al. (1987). Then, the migration information of these selected top talents is obtained from CV analysis, the locations of published papers and public patents. According to the above method, we get the number of top migration talents from country j to country i and denote it as m_{ij} .

3. Modeling the complex international migration network for top scientific and technological talents

In this section, the complex network model of international migration for top scientific and technological talents is introduced by employing algebraic graph theory, probability and statistics, complex systems and networks, and we also show how to represent the proposed international migration model in matrix. Some preliminaries about algebraic graph theory, probability and statistics, complex networks are introduced in Godsil et al. (2001); Degroot (2011); Chen et al. (2012); Boccaletti et al. (2006).

Complex network is a graph (network) with non-trivial topological features which do not occur in simple networks such as lattices or random graphs but often occur in graphs modeling of real systems. The complexity of network performance may be viewed from different perspectives, including structural complexity, node-dynamic complexity and mutual interaction among various complex factors. The recent study of complex networks has directed most interests to modeling and understanding of various complex systems, such as computer networks, technological networks, brain networks and social networks.

Migration for top talents can be considered as a bridge of information between the host country and the original country. And our thought in this paper is that representing the migration by a complex network and then investigating it through mathematical analysis and computation. Based on this idea, if countries of the world are viewed as nodes, migration flows are viewed as directed edges, and the migration weights are denoted as edge weights for corresponding edges, the international migration for top talents is associated to a complex network. In detail, for the complex international migration network, node i represents country i , the directed edge (j,i) represents the migration flow from original country j to host country i , also its corresponding weight $a_{ij} > 0$, which will be given clearly in the latter, is used to represent the amount of migration along this flow. Otherwise, if there exists no top talent moving from country j to country i , the directed edge does not exist, and it is straightforward that the weight a_{ij} is zero. Moreover, we also set the self-weight $a_{ii} = 0$ for country i . E is denoted as the set of directed edges whose weights are nonzero. Next, we define a directed path (directed migration flow) is a sequence of successive nodes starting at node j and ending at node i such that successive nodes are adjacent. Then, normalization for the number of top migration talents is needed because weights of edges are in the range $[0,1]$ for complex networks generally. In this paper, linear function is employed for data normalization, so that for m_{ij} , its normalization value a_{ij} is given by

$$a_{ij} = \frac{m_{ij} - Minvalue}{Maxvalue - Minvalue}$$

Where $Maxvalue$ is the maximum value, and $Minvalue$ is the minimum value for all m_{ij} .

After that, the adjacent matrix of the complex network consist of n nodes is given by $A=[a_{ij}]\in R^{n\times n}$, and the corresponding Laplacian matrix $L=[l_{ij}]\in R^{n\times n}$ is

$$l_{ij}=\begin{cases}\sum_{j=1}^{n}a_{ij}, & i=j\\ -a_{ij}. & i\neq j\end{cases}$$

It is obvious that for L, the vector $\mathbf{1}=[1,\ldots,1]^{\mathrm{T}}$ is an eigenvector associated with eigenvalue 0. Considering that migration flow is usually directed, it follows that the matrices A and L are asymmetric. Based on the above discussion, the international migration is modeled mathematically, and can be represented by a graph and matrices. It follows that it is possible for international migration to be analyzed by employing the tool of complex networks quantitatively.

4. Properties of the complex international migration network for top scientific and technological talents

This section introduces some concepts, indices, properties of complex networks, and discusses the meaning of these items for international migration. We focus on how to explicit these tools to study international migration for top talents with the proposed model of complex networks. Considering the characteristics and realities of migration for top talents, the following statements about topologies and complex networks may be different from their general concepts. The concept of degree, including in-degree and out-degree, is the most fundamental character and measure of a node in a network. In a directed complex network, in-degree is defined as the sum of weights associated with inflow edges for node i, that is

$$b_i=\sum_{j=1}^{n}a_{ij},$$

And for migration, this concept describes the total amount of top talents immigrating into country i from other countries. And out-degree for node i is defined as the sum of weights associated with outflow edges, that is

$$c_i=\sum_{j=1}^{n}a_{ji},$$

and for migration, this concept describes the total amount of top talents emigrating from country i to other countries. Denoting the matrix $D=\mathrm{diag}(b_1,\ldots,b_n)$, it is always true that $L=D\text{-}A$. Next, the overall degree is denoted by $u_i=b_i+c_i$, reflecting the total amount of top migration talents, including emigrating and immigrating. Besides the overall degree, the ratio of in-degree to out-degree is denoted as $r_i=b_i/c_i$, which is used to determine whether a given country is in the state of brain drain or brain gain. The distance between any two nodes, labeled j and i, denoted as d_{ij}, is equal to the sum of weights associated with the directed shortest path $(j,v_1),\ldots,(v_{k-1},i)$ from node j to node i. Hence, it is denoted as

$$d_{ij}=Min[\sum(a_{v_1 j}+\ldots+a_{iv_{k-1}})].$$

In the field of migration, the distance is viewed to measure the convenience and frequency for top talents moving from country j to country i. The concepts mentioned above are basic for studying complex network and migration, and in the following, we will introduce another mathematical tools originated from them. The first one is the connectedness for complex networks, including strong connectedness and weak connectedness. A directed network is strongly connected if and only if there is a directed path from every node to every other node. A directed network is called weakly connected if and only if replacing all of its directed edges by undirected edges produces a connected (undirected) network, which is called the underlying network for the directed network. And the adjacent matrix of underlying network is denoted by $\hat{A}$ whose elements are

$$\hat{a}_{ij}=\frac{a_{ij}+a_{ji}}{2},$$

So that we have $\hat{A} = (A + A^{\mathrm{T}}) / 2$. Hence, the Laplacian matrix of the underlying network is given by $\hat{A} = (A + A^{\mathrm{T}}) / 2$, which is symmetrical and also satisfied .

It has been proved that if the rank of L is $n-1$, that is $rank(L) = n-1$, the network is strongly connected. And if $rank(L) = n-1$, the network is weakly connected. We expand the two items for international migration as follows: for strongly connected migration network, there exists at least one migration flow channel (directed path) from each country to any other country; for weakly connected migration network, there exist top talents emigrating from or immigrating into each country, that is each country participates in the migration for top talents, and also means that the migration network is a unity.

The other important feature of complex networks is their correlation coefficient ρ between in-degree and out-degree satisfying $-1 \le \rho \le 1$, denoted in the following

$$\rho = \frac{n\sum_{i=1}^{n} b_i c_i - \sum_{i=1}^{n} b_i \sum_{i=1}^{n} c_i}{\sqrt{n\sum_{i=1}^{n} b_i^2 - (\sum_{i=1}^{n} b_i)^2}\sqrt{n\sum_{i=1}^{n} c_i^2 - (\sum_{i=1}^{n} c_i)^2}},$$

Which describes the relationship between inflow top talents and outflow top talents for the overall international migration. The value of ρ near to 1 means that countries with large amount of inflow talents also have large amount of outflow talents on average; the value of ρ near to -1 means that countries with large amount of inflow talents have small amount of outflow talents on average; the value of ρ near to zero means the amount of inflow and outflow talents are independent.

Another useful concept for investigating international migration network is associativity. For a network, if nodes with large degrees tend to connect to nodes also with large degrees on average, the network is said to be assortative, and the associativity coefficient will be positive; but if nodes with large degrees tend to connect to nodes with small degree on average, the network is said to be disassortative, and the associativity coefficient will be negative. For undirected network, there just exists one associativity coefficient, but for the directed migration network investigated in this paper, we propose two kinds of associativity coefficients, which are in-out degree associativity coefficient and overall degree associativity coefficient. In-out degree associativity κ_1 is denoted via the Pearson correlation coefficient as

$$\kappa_1 = \frac{M^{-1}\sum_{(j,i)\in E} b_j c_i - [M^{-1}\sum_{(j,i)\in E}\frac{1}{2}(b_j + c_i)]^2}{M^{-1}\sum_{(j,i)\in E}\frac{1}{2}(b_j^2 + c_i^2) - [M^{-1}\sum_{(j,i)\in E}\frac{1}{2}(b_j + c_i)]^2}$$

Where M is the total number of edges, and b_j is the out-degree of node j which is the negative end of directed edge (j,i), and c_i is the in-degree of node i which is the positive end of directed edge (j,i). Overall degree associatively coefficient κ_2 is denoted as

$$\kappa_2 = \frac{M^{-1}\sum_{(j,i)\in F} u_j u_i - [M^{-1}\sum_{(j,i)\in F}\frac{1}{2}(u_j + u_i)]^2}{M^{-1}\sum_{(j,i)\in F}\frac{1}{2}(u_j^2 + u_i^2) - [M^{-1}\sum_{(j,i)\in F}\frac{1}{2}(u_j + u_i)]^2},$$

Where F is the set of undirected edges created by the existing directed edges without directions. For international migration, in-out degree associativity is employed to assess whether top talents from the countries with large outflow amount migrate to the countries with large inflow amount if κ_1 is positive, or not if κ_1 is negative. This index is very useful to estimate migration directions.

And overall degree associativity can be used for finding whether talents are used to migrating between the countries with large inflow and outflow amount if κ_2 is positive, or not if κ_2 is negative. The concept of centrality determines the relative importance of a given node in the network. In other words, a centrality is a measurement of the structural importance of a given node in the network, and the more central node has a stronger influence on the other nodes. The most frequently used tool to evaluate centrality of a node is node-betweenness centrality given by

$$g_i = \frac{2\sum_{j\neq k\neq i} \frac{\alpha_{kj}(i)}{\alpha_{kj}}}{(n-1)(n-2)},$$

Where α_{kj} is the number of all existing shortest paths from node j to node i, and $\alpha_{kj}(i)$ is the number of all existing shortest paths from node j to node i that actually pass through node i. For international migration, the node-betweenness centralities of a country or a group of countries are larger than others means that these countries have a higher place in the migration, and top talents usually though these countries from origin to destination, so that the changes of these countries may have a great influences on the overall migration.

Moreover, to describe the heterogeneity of networks, network structured entropy ò is introduced. If all nodes in a network have the same importance approximately, the network is said to be non-heterogeneous, otherwise the network is heterogeneous. And the network structured entropy is defined by

$$ò = \frac{-2\sum_{i=1}^{n} \eta_i(\mathrm{In}\,\eta_i) - \mathrm{In}[4(n-1)]}{2\mathrm{In}\,n - \mathrm{In}[4(n-1)]},$$

Where $\eta_i = u_i / \sum_{j=1}^{n} u_j$ also evaluates the importance of node i. It is obvious that $0 \leq ò \leq 1$. And if ò is near to 0, the network is heterogeneous; if ò is near to 1, the network is non-heterogenous. This index, network structured entropy, can be used to estimate whether international migration depends on one country or a group of countries.

5. *Analysis international migration for top scientific and technological talents based on complex network model*

In above section, we have introduced some concepts of complex networks and discussed the relationship between complex networks and international migration for top talents. In this section, we explicit the proposed method to analyze the migration between eleven major and typical countries and regions–USA, UK, Russia, France, Germany, China, Japan, India, Eastern Asia, Africa and Oceanaria, and obtain some quantitative results. According to the method proposed in Section 2, the data of international migration from 2011 to 2016 has been collected in the following table.

Table 5-1. The number of migration talents between the selected countries and regions

Origin Host	**USA**	**UK**	**Russia**	**France**	**Germany**	**India**	**China**	**Japan**	**Eastern Asia**	**Africa**	**Oceanaria**
USA	0	12	6	18	21	15	36	24	12	12	12
UK	12	0	3	9	12	18	6	0	6	3	9
Russia	0	0	0	0	0	0	0	0	0	0	0
France	0	6	9	0	18	0	0	0	3	3	0
Germany	6	9	6	21	0	0	0	0	0	0	0
India	18	6	0	3	0	0	0	0	12	0	0
China	15	3	0	6	3	0	0	6	12	0	6
Japan	9	0	0	0	0	9	15	0	3	0	0
Eastern Asia	0	3	0	0	0	0	9	3	0	0	3
Africa	0	0	0	0	0	0	0	0	0	0	0
Oceanaria	6	12	3	9	6	12	24	12	9	0	0

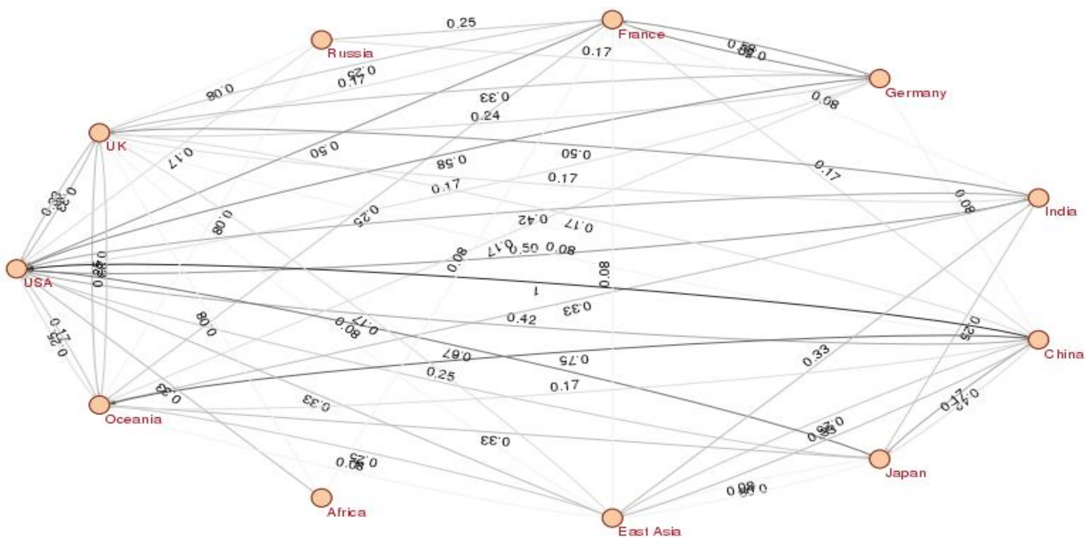
The normalized data-table with in-degrees and out-degrees of these countries and regions is given by

Table 5-2. The normalized data of migration talents between the selected countries and regions

Origin Host	**USA**	**UK**	**Russia**	**France**	**Germany**	**India**	**China**	**Japan**	**Eastern Asia**	**Africa**	**Oceanaria**	**In degree**
USA	0	0.33	0.17	0.5	0.58	0.42	1	0.67	0.33	0.33	0.25	4.58
UK	0.33	0	0.08	0.25	0.33	0.5	0.17	0	0.17	0.08	0.25	2.16
Russia	0	0	0	0	0	0	0	0	0	0	0	0
France	0	0.17	0.25	0	0.5	0	0	0	0.08	0.08	0	1.08
Germany	0.17	0.24	0.17	0.58	0	0	0	0	0	0	0	1.16
India	0.5	0.17	0	0.08	0	0	0	0	0.33	0	0	1.08
China	0.42	0.08	0	0.17	0.08	0	0	0.17	0.33	0	0.17	1.42
Japan	0.25	0	0	0	0	0.25	0.42	0	0.08	0	0	1
Eastern Asia	0	0.08	0	0	0	0	0.25	0.08	0	0	0.08	0.49
Africa	0	0	0	0	0	0	0	0	0	0	0	0
Oceanaria	0.17	0.33	0.08	0.25	0.17	0.33	0.75	0.33	0.25	0	0	2.66
Out degree	1.84	1.4	0.75	1.83	1.66	1.5	2.59	1.25	1.57	0.49	0.75	

Based on Table 5-2, the migration network for the selected eleven countries and regions is plotted as follows.

Figure 5-1. Migration network for the selected eleven countries or regions



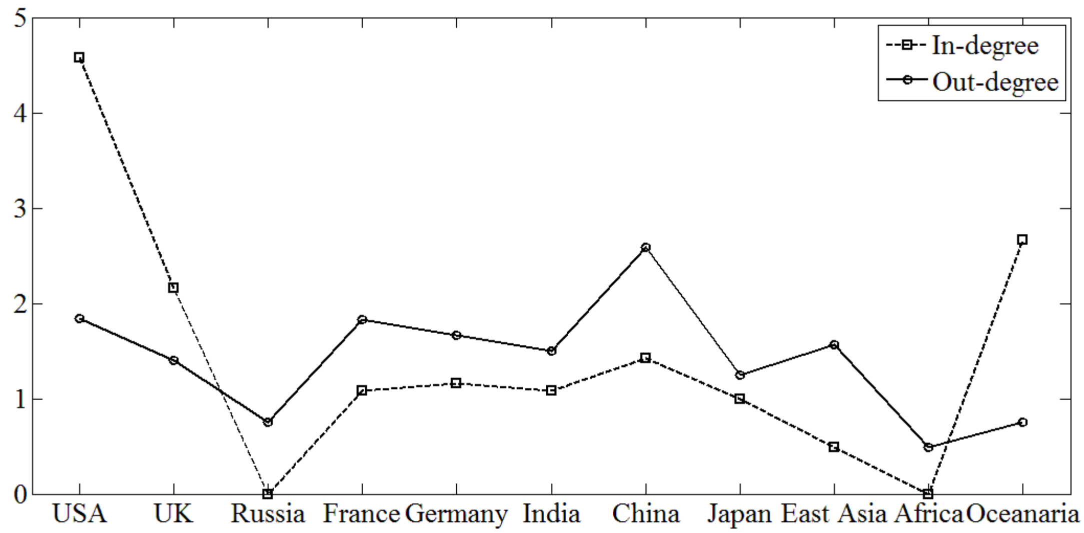
According to the data of top migration talents, and the relationship between complex networks and the international migration for top talents introduced in Section 3, the following results are achieved. We first investigate each country's or region's top talent migration in general. According to the concepts of total degree and the ratio of in-degree and out-degree, we have the following table Moreover, the corresponding Laplacian matrix L can be constructed. And after calculating the rank of L, it is obtained $\text{rank}(L) = 9$. It means that the directed network is not strongly connected. By constructing the migration's underlying network, it is weakly connected, so that all of the selected countries are in the international migration network, and the international migration is a unity, but there exists at least one pair of countries with no bi-directional migration flow. According to the ratios of in-degree and out-degree, we find that except USA and UK, the values of all other countries are less than 1.

Table 5-3. The total degree and ratio of in-degree and out-degree of the selected countries and regions

Country	**USA**	**UK**	**Russia**	**France**	**Germany**	**India**	**China**	**Japan**	**Eastern Asia**	**Africa**	**Oceanaria**
Total Degree	6.42	3.56	0.75	2.91	2.82	2.25	2.58	4.01	2.06	0.49	3.41
Ratio	2.49	1.54	0	0.59	0.70	0.8	0.59	0.55	0.31	0	3.55

If viewing the USA, the UK, France, Germany, Japan and Oceanaria as developed countries or regions, and viewing China, India, Russia, Africa and East Asia as developing countries or regions, it is also known that some most developed countries or regions attract a great number of top talents, other developing and developed countries or regions experience a serious brain drain. In advance, by investigating the relationship between the amount of top immigration talents and top emigration talents, we obtain the correlation coefficient between in-degree and out-degree is $\rho = 0.32$, which is far from −1 or +1, so that it is determined that there exists less relationship between the two groups of values. We also plot a figure to show in-degrees and out-degrees for the nodes in the following.

Figure 5-2. Trajectories of in-degrees and out-degrees



As shown in Figure 5-2, it is seen that the differences between in-degrees and out-degrees seem to be random without any law. Combined these results and the relationship between complex networks and migration, it is obtained that the amount of top immigration talents has less relativity with the amount of top emigration talents. This result also reflects that top talents may swam into the most developed countries, and other countries or regions suffer from brain drain.

According to the associativity of the migration network, we get $\kappa_1 = 0.0122$ and $\kappa_2 = -0.2185$. Because the value of κ_1 is positive, it is obtained that the main migration flows for top talents are from the countries with larger amount of emigration to the countries with larger amount of immigration on average. However, κ_1 is not large, which means this phenomenon is not very clear. Then, from $\kappa_2 = -0.2185$, the countries with larger total degrees link the countries with smaller total degrees on high probability. But considering the absolute value of κ_2 is not large enough, the phenomenon is not very obvious.

Next, according to the calculation of path distances, the top ten shortest paths are: the path from China to the USA, the path from Japan to the USA, the path from China to Oceanaria, the path from Germany to the USA, the path from France to Germany, the path from Germany to France, the path from France to the USA, the path from India to the USA, the path from India to the UK and the path from the USA to India. Therefore, it is seen that most of major migration flows are from developing countries, such as China and India, to the major developed countries, such as the USA and the UK; the talent's migration between developed countries is very easy and with less obstacles; and some countries or regions, such as Africa and Russia, have less channels of top talent's migration with other countries, including inflow and outflow. Hence, it is obtained that few developed countries attract more top talents from the world, and many countries or regions, including developing and developed, suffer from brain drain; the major migration flows are from developing countries to developed countries; and the migration between developed countries is very frequent and facilitated. Furthermore, calculating the node-between's centralities of all nodes, we have

Table 5-4, The node-betweenness centrality of the selected countries and regions

Country	USA	UK	Russia	France	Germany	India	China	Japan	Eastern Asia	Africa	Oceanaria
Node-betweenness	0.11	0.11	0.00	0.03	0.01	0.01	0.01	0.03	0.04	0.00	0.03

From Table 4, it is known that many top migration talents' flows usually through some developed countries or regions, but the centralities of developed countries are not very obvious because the values of this index are not large. To determine whether the international migration is heterogenetic or not, we get the importance for the countries or regions in the following table.

Table 5-5. The importance of the selected countries and regions

Country	USA	UK	Russia	France	Germany	India	China	Japan	Eastern Asia	Africa	Oceanaria
Importance	0.21	0.11	0.02	0.09	0.09	0.13	0.08	0.13	0.07	0.02	0.11

Then, we obtain the network structured entropy ò=0.72 according to its definition. Considering its relationship with talent's migration, it is known that the international migration network seems heterogeneity at some level. Hence, although some developed countries or regions have higher values of total degrees and importance, the overall migration network for top talents does not depend on one country or a group of countries, so that the network has strong robustness, and if internal or external environment of any country or countries changes, the overall migration may not change greatly and its basic situation remains stable. It is in agreement with the truth that all of node-betweenness centralities are not very large.

6. Conclusion

This paper has investigated the international migration for top talents in sciences and technologies based on the tool of complex networks, and obtained some quantitative results. At the beginning, the definition of top talents has been given by bibliometrics, and the way how to find these top talents has also been proposed. Then, some concepts and preliminaries of complex networks have been introduced. Furthermore, the relationship between complex networks and international migration has been discussed, and the migration model with the knowledge of complex networks has been built.

Based on the proposed model with the collected migration information, our paper has analyzed the basic state of international migration for top talents quantitatively in recent years, and maintained that the international migration for top talents is heterogeneity, few of developed countries have attracted more top talents from the world, and lots of countries, including developing and developed, suffer from brain drain; the major migration flows are from developing countries to developed countries; and the migration between developed countries is very frequent and facilitated. In the future, we should focus on analyzing the reasons why the recent phenomenon of migration for top talents happens, and advise some political suggestions to attract global top talents for governments.

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