The Geotemporal Demographics of Academic Journals from 1950 to 2013 according to Ulrich's Database

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Abstract: Academic journals play a critical role in recording and transferring knowledge. However, the geographic evolution and spatial autocorrelation of the distribution of academic journals have yet to be fully investigated. Inspired by this gap, we used descriptive analysis and exploratory spatial data analysis to reveal the cross-country inequality, globalization process and spatial autocorrelation of academic journals from 1950 to 2013 based on the Ulrichsweb database. We found that: (1) there was a tremendous disparity in the distribution of academic journals at the country level; (2) both the cross-country inequality of academic journals and the differences in academic publishing between the top three publishing countries witnessed a wavy trend; (3) the US, Eastern Asia and Europe were the central regions while Africa and Central Asia were lagging behind; (4) most of the academic journals in the top ten publishing countries were technology-based, and the proportion of academic journals in the field of Social Sciences and Technology went up; (5) most of the top ten publishing countries have experienced a rising-decreasing-stabilizing pattern of academic journals' growth before 2000; (6) the temporal and spatial variation of the distribution of academic journals may be attributed to political and economic factors; (7) the spatial autocorrelation of the distribution of academic journal was firstly strengthened and mitigated; (8) the European cluster has been the hot-spot area in academic journal publishing since 1950.

Keywords: Academic Journals; Exploratory Spatial Data Analysis; Geographic Evolution

1. Introduction

Depicting an entirely temporal and spatial landscape of academic journals is crucial for revealing the global inequities in scientific journal publishing, which facilitates the scientific development of countries, especially nations at a disadvantage. The inequalities across countries in scholarly journal publishing represent a part of world's inequities in science that were normally mirrored by the cross-country differences in the number of scientific papers (May, 1997; Xie, 2014), citations (King, 2004), high-quality research (King, 2004) and academic collaboration (Salager-Meyer, 2008). The global inequalities in science strengthened the advantages for developed countries because of intellectual migration to themselves, and in turn resulted in brain drain in developing countries (King, 2004; Mullan, 2005). This imbalance exists between not only the haves and the have-not's countries but also anglophone and non-English-speaking countries (Cope & Kalantzis, 2014). The traditional scientific superpowers still dominate the scientific world despite the emergence of new players, e.g., Brazil, Russia, India and China (Wilsdon, 2011). The world's disparity in academic journals publishing is even worse compared with that of scientific output. According to Nature index[1], China has been the world's second largest contributor to high-quality scientific research articles in 2016 while academic journals published in China have yet to catch too much world's attention. According to Mongeon and Paul-Hus's recent calculation (2016), the top 11 developed countries in terms of the number of scientific papers indexed in WoS produced nearly 65% of scientific articles, while they published more than 77% of scientific journals indexed in this database. As a significant medium of knowledge, scientific journals have played a vital role in the promotion and advancement of science. Therefore, probing the geographic demographics of global academic journals is an essential step to understand and mitigate the world's inequality in scientific journal publishing and even that in science, benefiting countries being disadvantaged where science matters survival.

Meanwhile, whether there is spatial autocorrelation of the distribution of academic journals matters when exploring external factors that affect academic journal publishing. Researchers found a direct correlation between the number of researchers, journals and articles (Derek, 1963; Mabe, 2003). However, to our knowledge, few studies investigated the impact of external factors, e.g. the neighbors of countries on academic journal publishing in a country. The spatial autocorrelation indicates that regions close to each other display more similar values than those further apart (F Dormann et al., 2007). Geographic proximity is proved to promote the knowledge spillover. Regional knowledge spillover can occur in business, innovation and scientific activities, which refers to the process through which actors benefit from the knowledge and experiences of other actors. It is possible that knowledge spillover exists between countries in academic journal publishing which has a commercial and

[1] http://www.natureindex.com/faq

academic nature. The geographical concentration of knowledge spillover can bring about imbalance and thus aggravate disparities between countries (Bottazzi & Peri, 2003; Crescenzi & Rodríguez-Pose, 2011). In this sense, a question arises: "is there a spatial autocorrelation of academic journal publishing?", which is significant to disclose the reason why academic journals are distributed unevenly.

Ulrich's Periodical Directory which is recognized as the most comprehensive and consistent database of global academic journals provides information to investigate the portrait of academic publishing in countries and its historical change. Analyses based on leading indexing databases, like WoS and Scopus, reflected the global differences of academic publishing in the range of "mainstream" science (Marušiæ & Marušiæ, 1999). However, a large body of domestic peripheral journals report information of practical significance or of local interest, which manifests scientific research strength of countries to some degree (Meneghini, 2012).

However, few studies have explored the geotemporal evolution of academic journals at the global scale, as well as the dynamic change of world's inequality and the spatial autocorrelation in scholarly publishing. The current literature focuses on the overall growth of academic journals including non-systematic geographic analysis, the worlds' inequality in scientific papers and citations. The geotemporal demographics of academic journals, as well as the cross-country inequality in academic journal publishing and the spatial autocorrelation of the distribution of academic journals, remained to be explored.

Based on Ulrich's periodical directory, and using descriptive statistical analysis and exploratory spatial data analysis (ESDA), our dominant aim is to provide a fundamentally and comprehensively geographic picture of academic journals from 1950 to 2013 to understand world's inequality and spatial autocorrelation in scholarly publishing. Firstly, we review the prior studies on the history of academic journals' growth, the geographic analysis of academic journals, global inequality in science and spatial autocorrelation of scientific activities. Secondly, the specification of data sources and data processing are presented, as well as the methodology. Then, we reveal the distribution, evolutionary process and spatial autocorrelation of academic journals. Lastly, we list our most important findings and the study's limitations.

2. Literature review

The full picture of academic journals has not been fully investigated. The extant literature discussed the history of studies on academic journals' growth, and some non-systematic geographic analysis of academic journals. Furthermore, although previous researchers explored the scientific inequality across countries typically based on scientific papers, and spatial autocorrelation of scientific activities, the between-countries disparities in academic journal publishing and spatial autocorrelation of it still remained to be probed.

2.1 The history of studies on academic journals' growth

The growth of academic journals is a fully-discussed topic while current literature does not provide a detailed and complete picture of the geotemporal demographics of global academic journals.

The number and the growth features of academic journals have been controversial issues for a long time. In the early stage, by estimation, researchers demonstrated an increasingly growing number of academic journals while they did not reach a consensus on the size of the growth. Dating back to the early 1960s, Price found that the body of journals has been growing exponentially and predicted that 50,000 scientific periodicals had been created in 1963 and there would be 1 million scholarly periodical titles by 2000, which exerted a far-reaching influence on the latter studies, even on par with the law (Derek, 1963). Some criticisms that Price's estimation was overwhelmed have been proposed. In the 1990s, Meadow estimated that the number of journals in 1951 had reached 10,000 and increased to 71,000 in 1987 (Meadows, 1997). Other than estimation worldwide, researchers reported that in 1995 there were estimated 6,771 scientific scholarly journals published by the US publishers in nine fields of science (Tenopir & King, 1997).

The introduction and improvement of online data sources allowed for more realistic estimates of global academic journals and deeper analyses. Because the definition of a scientific journal was too broad and researchers were unable to differentiate active titles from those which had been ceased, the estimations in early studies seem too large (Jinha, 2010; Mabe & Amin, 2001). However, more recent research reported far more modest numbers of academic journals. Based on a sample of journals, Archibald and Line (1991) did an early study in which Ulrich's was utilized to improve their estimates on the growth of academic journals. With the improvement of Ulrich's, an increasing number of authors used it to analyze the overall growth of academic journals. Taking advantage of Ulrich's, Mabe and Amin (2001) reported that approximately 10,800 refereed academic journals being published had been created before 1997. Moreover, they plotted three episodes (from 1900 to 1944, from 1944 to 1978, and from 1978 to 1996) of academic journals with 3.30%, 4.68% and 3.31% annual growth rates for each episode respectively. Contrary to Price's estimation, Mabe (2003) pointed out the growth rate of academic journals has been steady at 3.46% per annum rather than exponential growth over the last three centuries. Table 1 presents the published data of academic journals in Ulrich's.

With the increasing number of academic journals covered in Ulrich's, researchers shifted their attention to more specific characteristics of academic journals' growth. The landscape of academic journals was mapped, including publishers, journal launches and closures, technology, geographic locations and quality. More than 50% of referred journals in Ulrich's has been published by or on behalf of/in association with commercial publishers(Morris, 2007). The author also found that non-profitable publishers have less possibility to close journals and predominate among journals with high citations, although they launch fewer new journals than commercial counterparts.

Table 1. Reported data of academic journals in Ulrich's

Year	Number	Journal	Author
1900-1996	Nearly 11,000	Active refereed academic journals	Mabe and Amin (2001)
1665-2001	14,964	Active refereed academic journals	Mabe (2003)
1665-2005	29,572	Refereed academic journals	de Moya-Anegón et al. (2007)
1665-2007	64,628	Academic journals	Morris (2007)
1665-2007	23,588	Active refereed academic journals	Morris (2007)
1726- 2009	26,406	Active refereed academic journals	Jinha (2010)
1665-2015	36,442	Academic referred journals	Gu and Blackmore (2016)

2.2 Geographic analysis of academic journals

Current literature does not include systematically geographic investigation of academic journals, most of which only mentioned a rough calculation of academic journals across countries based on the location of their publishers. In the early time, researchers were cautious about the analysis by countries of publication because of small numbers of academic journals for most countries and at that time no available data sources(Archibald & Line, 1991).

The diversity of countries in academic journal publishing is evident. It is well-acknowledged that the US and the UK are the most productive countries in terms of academic journals' publishing. In Ulrich's, 33.54% and 18.55% of referred academic journals were published by the publishers in the US and the UK respectively (Morris, 2007). The remaining 23% were published by the publishers in Netherlands, Germany, Australia, Japan, Canada and China. Though Netherlands has a small geographical size, due to its immense publishing industry, it is among the largest publishing countries (de Moya-Anegón et al., 2007). It is observed that Scopus's geographical coverage is similar to Ulrich's except in the UK, Netherlands and Germany (de Moya-Anegón et al., 2007).

2.3 Scientific inequality across countries

Significant inequalities across countries in scientific activities have been noticed for a long time. Most of the relevant literature have been preoccupied with the disparity of countries in scientific articles and citations. However, authors failed to take global academic journals' publishing into consideration, which is the most significant platform for scientific communication. Besides, whether the global inequality in scientific journal publishing is widening or narrowing remained unknown, as well as its historical evolution.

The scientific world is considerably unequal. The tremendous disparity in the distribution of science is not only between the industrialized world and the developing world but also within developing countries (Salager-Meyer, 2008). Only two developing countries, i.e. India and China were listed in the top 15 countries in terms of the share scientific papers and citations from 1981 to 1994 (May, 1997). The other 13 top countries (developed countries) accounted for 78% and 90.80% of the world's scientific articles and citations. The world's inequality is worse in the high-quality scientific output. King (2004) further found that the top eight countries[2] produced more than 84% of the top 1% highly cited publications between 1993 and 2001. In this list based on top 1% cited publications, only two developing countries, i.e., Russia and China were ranked as the top 20 countries. Researchers claimed that there are striking inequalities in scientific publications and citations across countries, which even exceed income inequalities (Carillo & Papagni, 2014). In addition, there is a strong relationship between economics (or money spent on research and development) and the scientific output (May, 1997).

The world's inequality was also highlighted by the inadequate coverage of academic journals published in developing countries in the core international databases. The academic journals published by publishers in 11 developed countries presented 77.2% and 70.5% of the total indexed in WoS and Scopus respectively (Mongeon & Paul-Hus, 2016). The total share of China, India, Brazil and Russia only reached 6.2% and 7.3%, while these countries produced more than 20 % of scientific articles indexed in these databases. The peripheral publishing faced some problems, such as the low-quality of articles published in journals, usage of local languages, small readership and financial restrictions (Salager-Meyer, 2008).

Some researchers hold the view that between-country inequality in the number of scientific articles has narrowed. The countries that have been leaders in science tended to show lower growth of both absolute and relative number of scientific articles while emerging countries exhibited dramatic growth rates (May, 1997; Xie, 2014). Even they are losing their shares of published articles (Wilsdon, 2011). This trend points towards the narrowing of country inequality in scientific papers, which is mainly attributed to the rise of emerging nations, e.g., China. At the macro level, inequalities in scientific articles have been influenced by globalization, the expansion of science, and the widespread use of internet technology (Xie, 2014).

2.4 Spatial correlation of scientific activities

It is claimed that international knowledge flows are a major factor in global growth (Di Cagno, Fabrizi, Meliciani, & Wanzenböck, 2016; Hall, Mairesse, & Mohnen, 2010). Knowledge spillover[3] was frequently observed in many aspects of the business world and the scientific world (Gedik, 2012; Martín-de Castro et al.,

[2] The top eight countries consist of the US, the UK, Germany, Japan, France, Canada, Italy, Switzerland.

[3] Knowledge diffusion, knowledge transfer and knowledge spillover are frequently analogous to each other when they refer to a process through which network members are influenced by the knowledge and experience of another members(Inkpen & Tsang, 2005; Tang & Hu, 2013).

2011; Tang & Hu, 2013). Most of the studies found that knowledge spillover is geographically concentrated, which implies that business activities or scientific activities which benefit from knowledge spillover are influenced by the geographic distance between participants involved in these activities. The transfer of tacit knowledge was proved to be favored by geographic proximity since the short geographical distance strengthens interpersonal relationships and face-to-face contacts (Breschi & Lissoni, 2003; Mairesse & Turner, 2005; Zucker, Darby, & Armstrong, 1994). When starting a collaboration, geographical proximity plays a crucial role. However, once the collaborative relationship has been established, organizational, social, and ethnic links may become more important than physical proximity (Crescenzi & Rodríguez-Pose, 2011).

The academic journal is closely linked to knowledge creation and scientific activities for its irreplaceable role as a formal platform to present the original research and facilitate scientific communications. Limited research probe whether there is spatial autocorrelation of the distribution of academic journal. This research question is particularly important because it reveals whether academic journals published in one country is not only affected by intrinsic factors, e.g. the number of researchers, R & D expenditure and the scientific output in this country, but also influenced by other countries. Furthermore, with the development of globalization and the popularity of Internet, questions were posed: how spatial autocorrelation of the distribution of academic journals evolved? Is the distribution of academic journals becoming free from the spatial constraints or the spatial autocorrelation was enhanced?

In a nutshell, the geotemporal demographics of global academic journals deserved a deep investigation, especially the worlds' inequality in academic journal publishing and spatial autocorrelation of the distribution of academic journals. In this study, we address the following questions:

1. What's the distribution of academic journals?
2. How academic journals grew in different countries?
3. What is the evolutionary dynamics of world's inequality in scholarly journal publishing?
4. Is there a spatial autocorrelation of academic journal publishing between countries?

3. Material and methods

This section includes two subsections. First, we briefly introduce Ulrich's database and our reasons for its use. The specific data cleaning process is presented in the second subsection.

3.1 Data source

The dataset of this study spanning from 1950 to 2013 is exacted from Ulrich's Periodicals Directory (Ulrich's). This database covers more than 750,000 detailed pieces of information about all types of periodicals created from 1665 to 2017, including journals, magazines, newspapers, monographic series, proceedings and others. Different data sources of academic journals were compared, e.g. ISI-WoS databases(Braun, Glänzel, & Schubert, 2000; Garfield, Cronin, & Atkins, 2000), Scopus (de Moya-Anegón et al., 2007), and researchers have reached an agreement that Ulrich's is the most complete, consistent and reliable database of journal statistics (Gu & Blackmore, 2016; Jinha, 2010; Mabe & Amin, 2001; Tenopir & King, 2009). Ulrich's was regarded as a benchmark database of academic journals, which was used to assess the coverage of existing database (Archambault, Vignola-Gagne, Côté, Larivière, & Gingras, 2006; de Moya-Anegón et al., 2007).

Admittedly, Ulrich's suffers from various biases and time lag to update newly created journals so that its coverage can not represent a genuine universe of academic journals especially those created in the very early time. Morris has discussed the limitation of Ulrich's (Morris, 2007). First, newly launched journals are often not included immediately. Second, the data listed in Ulrich's depend on the information provided by the publishers of journals so that the accuracy and completeness of information are not supported by hard-and-fast guarantees. In addition, considering the dominance of the English language in scientific publishing, academic journals published in the English-speaking world especially in the US and the UK are well covered in Ulrich's while its coverage for the scientific periphery and academic journals published in non-English languages is not exhaustive. However, in comparison with the early studies based on estimations and other databases, Ulrich's remains the most comprehensive databases for detecting global totals (Jinha, 2010).

Because of biases in Ulrich's and the time lag to update newly created academic journals, we choose the sample of academic journals which are created between 1950 and 2013 to ensure the reliability and validity of the analysis. We observed a sharp drop in 2014 in terms of the number of newly created academic journals. To overcome the time lag in Ulrich's updating for newly created journals, Mabe and Amin (2001) selected the sample of academic journals which were launched from 1900 to 1996. Similarly, in Gu and Blackmore's (2016) study, academic journals in Ulrich's which were created after 2013 were excluded. Consistent with these strategies, we only analyze academic journals launched before 2014 to avoid time delay of data updating in Ulrich's.

Despite the limitation of coverage, Ulrich's is still the optimal data source of global scientific journals, which can help acquiring a glimpse of the whole picture of academic journals in the current period (de Moya-Anegón et al., 2007). Moreover, compared with other databases, e.g., Scopus, the bias for English academic journals is more moderate (de Moya-Anegón et al., 2007)[4].

[4] It is found that roughly 85% of Scopus journals are published in English while in this study, based on Ulrich's, we observed that English academic journals accounted for 56.35%.

3.2 Data cleaning process

We completed the data collection of Ulrich's in June 2016, including a total of 748,806 periodical titles. We excluded the non-journal serial types, e.g. magazines, newspapers, monographic series, proceedings and others, leaving 147,602 titles. Next, academic/scholarly journals were extracted, remaining 131,255 titles. After eliminating observations created after 2013, the number of samples dropped to 113,980. In Ulrich's, periodicals are displayed according to their ISSN so that the same journal can appear several times because of their multiple formats. Consistent with strategies in recent literature, based on the journal title, publisher and subject classification [5] (additional requirements we added), we acquired 78,918 unique journal titles by removing duplicates and generated their format dummy variables (Gu & Blackmore, 2016). Subsequently, observations with missing data were eliminated, leaving 72,650 unique titles. This number is reliable since it approximates the result in Mongeon and Paul-Hus's study which reaches 70,644 (Mongeon & Paul-Hus, 2016). Moreover, there are 40,042 refereed academic journals in the sample data, which is close to the result (36,442) Gu and Blackmore (2016) [6] attained. Finally, we constructed the local dataset in this study after excluding academic journals created before 1949, remaining 67,082. The data processing is presented in Figure 1.

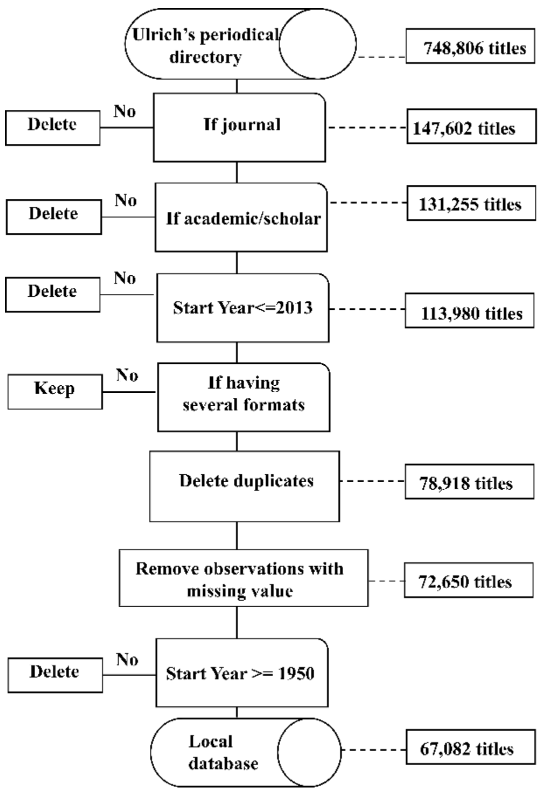

Figure 1. Workflow of the data processing

[5] Ulrich's provides the Dewey number of academic journals, which we assigned a unique category to each academic journal using the Dewey Decimal Classification based on.

[6] They downloaded the data in 2015.

In Ulrich's, academic journals may be published in multiple languages, formats and we assigned these attributes to academic journals using full counting method. Publishing countries of academic journals indicate the location of academic journals' publishers.

3.3 Methods

In this paper, we intend to study the geotemporal evolution of academic journals. This evolution can be divided into the growth of journals over time and the spatial distribution of journals.

As for the growth rate of academic journals, consistent with Mabe (2003), we used a log transformation on the number of academic journals created in each year to construct the fitted equation. We regarded the coefficient in the fitted equation as academic journals' growth rate. In addition, the death rate of academic journals in *i* year is calculated as below:

$$D_i = \frac{JD_i}{JT_i} \tag{1}$$

where JD_i denotes the number of inactive journals created in *i* year which are ceased, merged and suspended based on the current status in Ulrich's, and JT_i indicates the total number of academic journals created in *i* year. The death rate of academic journals in each decade is considered as the mean value of yearly death rate of academic journals in this decade.

To detect the spatial concentration trend, a locational Gini index and a central index (CR_3) (Audretsch & Feldman, 1996) were first computed. The locational Gini index is calculated as follow:

$$G = \frac{1}{2n^2\bar{z}}\sum_{i=1}^{n}\sum_{j=1}^{n}\left|z_i - z_j\right| \tag{2}$$

where *n* presents the total number of countries where academic journals are published, $\bar{z}$ denotes the average number of journals created in one country, z_i is the number of journals published in country *i*, as is the similar definition of z_j.

The central index is calculated by the following equation:

$$CR_3 = \sum_{i=1}^{3} w_i \tag{3}$$

Where w_i presents the number of newly created journals published in country *i* belonging to the top three countries in a period divided by the total number of academic journals created in this period.

In addition, exploratory spatial data analysis is implemented to further detect academic journals' spatial autocorrelation. The spatial relationship has been generally considered in many socioeconomic studies (Goodchild, Anselin, Appelbaum, &

Harthorn, 2000). This method contains two main measurements, global and local spatial autocorrelations. The former is used to identify whether there is a spatial autocorrelation as a whole. The latter is employed to find specific spatial relationships.

Moran's I statistic is the most common index of global spatial autocorrelation (Xing-zhu & Qun, 2014). The formula is presented as follow:

$$I_t = \frac{N}{S} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} \omega(i,j)(x_i-\bar{x})(x_j-\bar{x})}{\sum_{i=1}^{n}(x_i-\bar{x})^2} \tag{4}$$

where N means the total number of countries where academic journals are published at time t; using K=13 nearest neighbor spatial weighting matrices, $\omega(i,j)$ is computed; $S=\sum_i\sum_j \omega(i,j)$, which refers to the accumulation of total elements in the weight matrix $\omega(i,j)$; x_i and x_j denote the log number of journals published in i and j country, respectively; $\bar{x}$ equals the total average log number of academic journals. The Moran's I varies from -1 to 1. 1 refers to a positive spatial autocorrelation, and −1 means a negative spatial autocorrelation, and 0 denotes no spatial autocorrelation.

In addition, the Moran's scatterplot and the Local Indicator of Spatial Association (LISA) are conducted to detect the specific spatial relationship over space (Anselin, 1995). The Moran's scatterplot is composed of four quadrants: HH, LL, LH, HL. Specifically, in HH part, the number of journals in a region is as high as those in the surrounding regions; HL means that a region launched a higher number of journals while its neighbors published a smaller number of journals. In brief, quadrants HH and LL represent positive spatial autocorrelation, and quadrants LH and HL indicate negative spatial autocorrelation. Additionally, LISA is used to examine the significance of these four quadrants.

4. Results

In this section, we depict the general picture of global academic journals and present a specific analysis of academic journals to unveil the geotemporal demographics. Firstly, we present an overall picture and distribution of global academic journals across countries. Secondly, the growth rate of academic journals by publishing countries and languages are shown. Subsequently, we look into the process about how academic journals become globalized. At last, the world's inequality in scientific journal publishing across countries and the spatial clustering of academic journals are analyzed.

4.1 The overview and distribution of global academic journals across countries

There are 67,082 unique titles of academic journals that were launched between 1950 and 2013, 54.91% of which are refereed academic journals. Until 2016, 92.3% of the total number have been active. As can be seen from Figure 2(A), an increasing number of academic journals were created from 1950 to 2013. Academic journals in the categories of Technology, Social Sciences, Multidiscipline and Natural Sciences represented 79.52% of the total number as shown in Figure 2(B). Print, online academic journals accounted for 78.23%, 20.97% of all distribution formats (71,805)[7] respectively. Besides, there are 84,122 language counts of all unique academic journals, including 47,406 English academic journals.

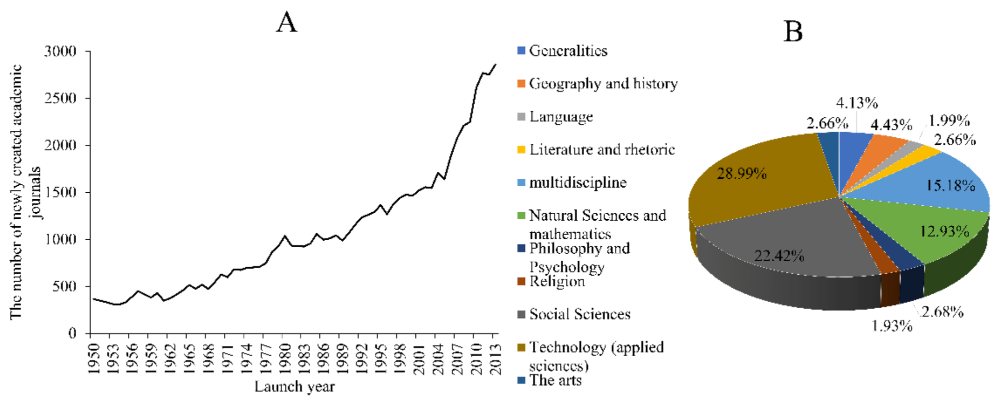

Figure 2. The overview of global academic journals from 1950 to 2013. (A) is the distribution of newly created academic journals by launch years. (B) is the percentage of academic journals by categories.

There is a skewed distribution of journals across countries with a dominant role that was played by the US and the UK. Not surprisingly, most of the academic journals are published by the US (22.48%) and the UK (11.7%) publishers, followed by publishers in China (7.36%), Germany (5.48%), India (4.38) and Russia (3.57%). In addition to these countries, the Netherlands (3.23%), Italy (3.06), Spain (2.85%) and Japan (2.84%) are also top ten publishing countries. As presented in Figure 3(A), America, Eastern Asia, Western Europe are the centers of academic journal publishing. By comparison, Africa and Central Asia publish a small number of academic journals. Furthermore, the top 20 countries in terms of the number of academic journals made up 82.39% of the total. Therefore, the distribution of academic journals is in disequilibrium.

[7] A unique title can be distributed in multiple formats or be published in several languages so that the number of distribution formats and the total language count are larger than the number of unique titles.

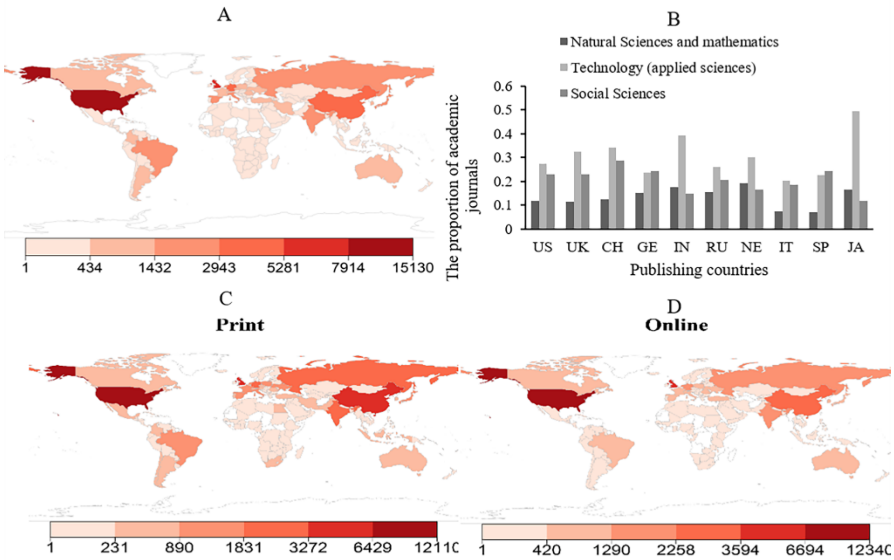

Figure 3. The map of academic journals' distribution from 1950 to 2013. (A) is the distribution of global academic journal. (B) is the percentage of academic journals in three categories in the top ten countries; CH, GE, IN, RU, NE, IT, SP, JA indicate China, Germany, India, Russia, Netherland, Italy, Spain and Japan. (C) and (D) are the distributions of Print and Online academic journals separately.

The English language holds the absolute advantage over the other languages with respect to academic journal publishing. English journals accounted for 56.35% of the total, far larger than the other language journals, which is in line with the monopoly that was obtained by the US and the UK in terms of academic journal publishing. Among the rest of the groups, Spanish (6.13%) and Chinese (6.33%) journals could not be ignored, taking second and third places. Except for the above languages, German (5.0%), Russian (4.67%), French (4.47%), Portuguese (2.68%), Italian (2.10%), Japanese (1.84%), and Ukrainian (1.30%) journals are listed in the top ten languages

Most countries were technology-dominant in terms of academic journal publishing. As shown in Figure 3(B), comparing the percentage of academic journals in the field of Technology, Natural Sciences and Social Sciences in the entire period, it is found that technology-based academic journals take up the highest proportion in the majority of top ten countries, except for Germany and Spain. In Japan, the percentage of technology-based journals reached 49.40%, which is far higher than that of other countries, followed by that in India (39.36%) and China (34.03%).

The digitalization of academic journals functioned well in the US and the UK. Figure 3(C) and (D) show where the print and online academic journals were distributed. Moreover, Brazil and India, two developing countries, had a comparatively larger number of online academic journals. However, most of the African countries and Asian countries not including India and Russia published a small number of online academic journals. On the other side, the US and the UK still headed the list of the number of print academic journals, followed by Germany, Japan and China.

4.2 The temporal evolution of academic journals

Differences in academic journal publishing between the top two countries (the US and the UK) and the other countries are becoming widening. The number of newly launched academic journals in different countries is shown in Figure 4(A). The US is the most productive countries in publishing academic journals, followed by the UK. Before 2000, most of other nations launched less than 100 academic journals annually with consistent growth. It is amazing that the number of newly created academic journals published in the US skyrocketed to 1000 approximately in 2013. However, for other countries, although their academic journal publishing increased more considerably than before, they still fell behind with the US and the UK a lot, and the gap has been widening in the 2000s.

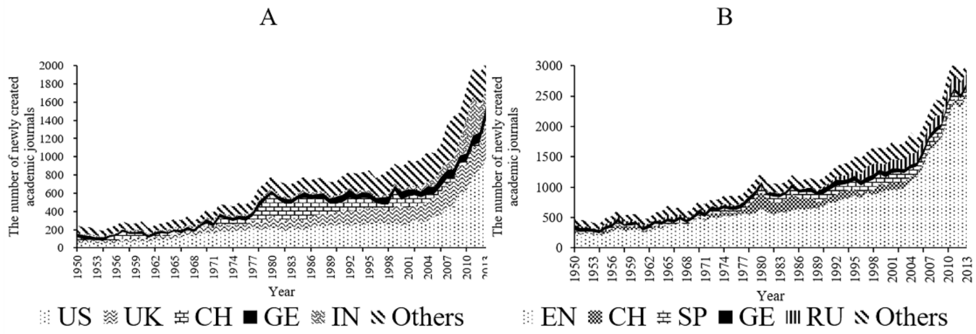

Figure 4. The number of newly launched academic journals from 1950 to 2013. (A) and (B) represent the number and of newly launched academic journals which were published in the top ten countries and top ten languages respectively. (Country code: US: United States ,UK: United Kingdom, CH: China, GE: Germany, IN: India, Others indicate the total number of academic journals published by India, Russia, Netherland, Italy, Spain and Japan; Language code: EN: English, CH: Chinese, SP: Spanish, GE: German, RU: Russian, Others denote the total number of academic journals published in French, Portuguese, Italian, Japanese and Ukrainian)

From the global perspective, the academic journal publishing has been noticeably prosperous in the 1970s and 2000s. The growth rate of academic journals in the top ten publishing countries is reported in Table 2. The rate of increase of global academic journals rose from 2.61% to 4.33% from the 1950s to 1970s, then significantly declined to 0.65% in the next decade. After experiencing a sudden drop in the 1980s, it increased to 3.22% and 5.66% in the 1990s and the 2000s separately. These Figures indicate that 1970s and 2000s are the most crucial period when the growth rate of newly created academic journals has been fast-growing.

Table 2. The growth rate of newly created academic journals in the top ten publishing countries

Decades / Countries	1950s	1960s	1970s	1980s	1990s	The 21st century	The whole periods
United States	3.90(0.35)	8.46(0.94)	3.19(0.70)	1.76(0.32)	1.01(0.40)	10.79(0.94)	3.70(0.90)
United Kingdom	1.67(0.05)	6.36(0.37)	1.56(0.18)	1.97(0.30)	2.30(0.42)	4.88(0.77)	4.20(0.95)

China	17.30(0.42)	-33.28(0.69)	19.02(0.55)	-5.15(0.38)	-3.73(0.05)	-9.08(0.58)	2.19(0.15)
Germany	-9.32(0.85)	0.94(0.05)	3.20(0.26)	3.66(0.42)	-1.89(0.09)	3.64(0.49)	2.28(0.79)
India	8.32(0.29)	2.70(0.04)	1.08(0.03)	0.21(0.01)	2.92(0.13)	20.72(0.86)	4.11(0.66)
Russia	28.02(0.47)	-9.22(0.10)	-24.32(0.47)	1.70(0.01)	16.14(0.66)	3.11(0.43)	5.35(0.41)
Netherlands	7.16(0.35)	11.48(0.80)	3.98(0.39)	-0.31(0.01)	-2.44(0.21)	7.04(0.30)	3.92(0.80)
Italy	0.90(0.02)	3.26(0.10)	7.40(0.81)	-0.68(0.01)	4.99(0.47)	-3.09(0.15)	2.92(0.81)
Spain	-11.86(0.59)	2.01(0.04)	13.07(0.63)	4.44(0.53)	4.24(0.45)	-0.73(0.02)	4.57(0.80)
Japan	-6.79(0.64)	-3.36(0.15)	1.62(0.09)	0.96(0.06)	-2.12(0.15)	-6.73(0.22)	-0.80(0.16)
Total	2.61(0.37)	3.81(0.63)	4.33(0.84)	0.65(0.14)	3.22(0.91)	5.66(0.95)	3.37(0.98)

Note: China means mainland China; R^2 is in parentheses.

The growth rate of academic journals across countries demonstrated a whirlwind of ups and downs in the 20th century. Other than China and Russia, most of the top ten countries have experienced a rising-decreasing-stabilizing pattern of academic journals' growth rate between 1950 to 2000, while stepping into the 21st century, there were two opposite trends for academic journal publishing in these countries. As Table 2 presented, at first glance, the trends of academic journal publishing in Russia and China were dramatically fluctuated and extremely distinct from that in other nations. Except these two countries, most of the top ten countries showed a growing trend in the 1950s, and a falling trend in the next decade then remained stable from 1970 to 2000. After 2000, the US, the UK, Germany, India, Italy and Netherlands consistently witnessed upward trends. It is surprising that the growth rate of newly launched academic journals published in the US and India reaches to 10.79% and 20.72%, far higher than other countries. In contrast, the growth rate of academic journals in other countries decreased, including China, Russia, Italy, Spain and Japan.

In each decade, countries which showed the most significant growth rate always changed. In the whole sample period, the total average growth rate of newly created academic journals is 3.37%. This figure is larger in more than half of the top ten countries: Russia (5.35%), Spain (4.57%), the UK (4.20%), India (4.11%), Netherland (3.92%) and the US (3.70%). In the 1950s, Russia and China experienced a sharp increase in academic journal publishing since the growth rates reached to 28.02% and 17.30% respectively. In contrast, Germany, Spain and Japan were subject to a fall in growth. However, after a rapid increase, in the 1960s, the growth rate of Russia and China even turned negative, indicating that the number of newly created academic journals dropped. In the same period, the performance of the US and Netherland is impressive. China has recovered from the loss of academic journal publishing in the 1970s because the growth rate went up to 19.02%, the highest among other countries. Fortunately, it showed negative growth rate in the next three decades. In the 1970s and 1980s, the growth rate of most of top ten countries remained steady while Spain achieved a high growth rate in this period, reaching to 13.07% and 4.44%. In the 2000s, India, the US and Netherland saw strong growth, while China, Italy, Spain and Japan experienced negative growth rate and the loss of newly created academic journals.

The gap between English academic journals and non-English academic journals has increasingly widened. Figure 4(B) shows the number of newly created academic journals published in the top ten languages. Apparently, the number of English academic journals have far exceeded those published in other languages, implies the absolute advantages of English in academic journal publishing. The gulf between the number of English academic journals and that of non-English academic journals have become increasingly huge, especially after 2000. In the group of non-English language, Russian and Spanish are the major languages of academic journals. From 1977 to 1990, a significant number of Chinese academic journals were launched, far outperformed other non-English language academic journals. However, after the 1980s, Chinese academic journals slumped significantly.

Most non-English language academic journals declined in the 21st century, while English academic journals continue to increase. Table 3 represents the growth rate of newly created academic journals published in different languages. Over the whole period, most of the top ten languages increased in the number of newly created academic journals other than Japanese, which was reflected by their total average growth rate in Table 3. The growth rates of Portuguese and Ukrainian academic journals are the most exceptional, reaching 5.08% and 6.04%, respectively. It is noted that moving into the 21st century, the growth rates of non-English-language academic journals except Russian academic journals decreased, while the number of newly launched English-language journals continued to demonstrate a high growth rate.

Table 3. The growth rate of academic journals in the top ten languages

Decades / Languages	1950s	1960s	1970s	1980s	1990s	The 21st century	The whole periods
English	3.31(0.52)	4.98(0.71)	2.33(0.80)	1.12(0.31)	2.99(0.87)	8.58(0.96)	3.42(0.95)
Chinese	19.52(0.44)	-33.47(0.70)	18.67(0.54)	-5.06(0.39)	-3.23(0.04)	-4.71(0.21)	2.63(0.18)
Spanish	0.08(0.01)	2.20(0.16)	6.59(0.84)	2.26(0.25)	5.21(0.77)	-3.48(0.37)	3.69(0.88)
German	-4.34(0.51)	1.63(0.43)	1.05(0.08)	1.70(0.11)	-2.54(0.28)	-1.36(0.11)	0.64(0.31)
French	1.45(0.13)	2.30(0.24)	-0.80(0.06)	-2.03(0.16)	0.94(0.03)	-4.03(0.22)	0.54(0.18)
Russian	12.96(0.43)	0.98(0.01)	-6.39(0.16)	3.92(0.05)	20.18(0.82)	2.06(0.32)	3.92(0.36)
Portuguese	-0.76(0.01)	5.07(0.13)	8.37(0.51)	-0.84(0.01)	11.30(0.77)	-3.45(0.41)	5.08(0.86)
Italian	1.66(0.07)	1.16(0.01)	5.80(0.62)	-2.29(0.12)	4.59(0.45)	-7.39(0.77)	1.63(0.53)
Japanese	-7.02(0.65)	-0.11(0.01)	1.33(0.08)	1.35(0.07)	-5.68(0.45)	-8.40(0.29)	-1.27(0.26)
Ukrainian	12.10(0.34)	18.95(0.21)	3.50(0.02)	5.02(0.18)	29.42(0.84)	-1.29(0.05)	6.04(0.52)
Total	2.73(0.39)	3.10(0.49)	3.51(0.82)	0.24(0.02)	3.98(0.95)	5.00(0.94)	2.91(0.97)

Note: R^2 is in parentheses

On the whole, a majority of top ten publishing countries except China, Italy and Japan experienced a rising-decreasing pattern in death rates of academic journals, although the tipping points of death rates in countries are not the same. The death rate of top ten publishing countries is reported in Table 4. Specifically, these seven countries firstly increased in death rates, then decreased. However, academic journals published in Italy and Japan had an increasingly high survival rate over the six decades. Besides, all top ten publishing countries declined in death rates of academic journals in the 2000s.

Table 4. Death rate of academic journals published in the top ten publishing countries

Decades / Countries	1950s	1960s	1970s	1980s	1990s	The 21st century	The whole periods
United States	12.66	12.24	14.50	19.98	22.00	12.04	15.35
United Kingdom	6.56	6.00	8.47	9.58	15.47	11.14	9.64
China	1.74	1.80	2.68	3.14	3.77	3.27	2.77
Germany	18.00	21.39	16.09	25.92	26.41	9.23	18.86
India	10.13	19.75	16.53	15.28	7.22	6.49	12.19
Russia	0.70	6.54	7.00	5.00	4.43	1.13	3.95
Netherlands	9.81	5.48	5.81	9.59	19.26	9.66	9.91
Italy	29.02	26.02	23.77	25.64	21.30	9.37	21.70
Spain	12.06	21.43	24.94	23.66	24.85	11.23	19.17
Japan	7.86	6.50	7.72	7.83	5.93	0.87	5.79
Total	10.41	12.16	12.23	13.70	14.79	8.36	11.72

The percentage of Social Sciences and Technology academic journals grew gradually, while those of the Natural Sciences declined. The total average proportion of Technology-based academic journals rose from 28.62% in the 1950s to 30.20% in the 2000s. The total average rate of academic journals in the field of Social Sciences increased by 6.92% in the whole sample period. Oppositely, the rate of academic journals in Natural Sciences decreased because it made up 18.24% in the 1950s and decreased to only 11.20% in the last sample decade. As presented in Figure 5, a majority of top ten countries followed this global trend in terms of the proportion of newly created academic journals in the three categories.

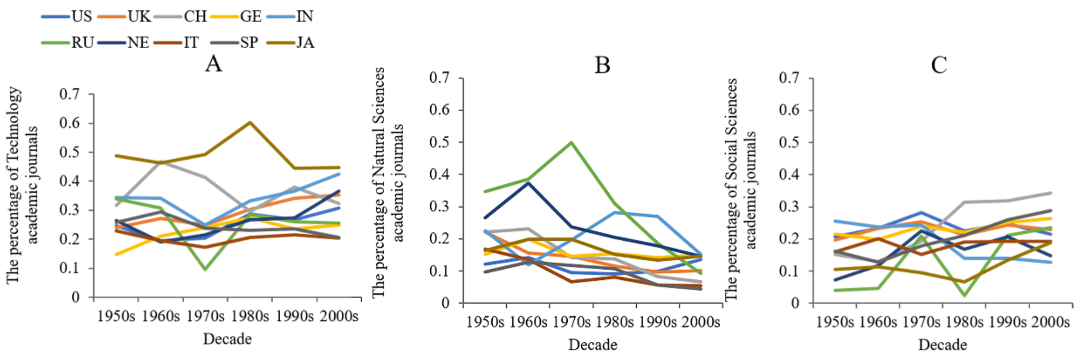

Figure 5. The proportion of newly created academic journals in the fields of Technology, Natural Science and Social Science from 1950 to 2013. (A) to (C) show the percentage of newly created academic journals in the field of Technology, Natural Sciences, Social Sciences in the top ten publishing countries. CH, GE, IN, RU, NE, IT, SP, JA indicate China, Germany, India, Russia, Netherland, Italy, Spain and Japan.

4.3 How did academic journals move toward globalization after 1950

The US and the UK have been the central countries in terms of academic journal publishing over the past six decades, while the strength of some developed countries, i.e. some Western European countries, Australia and Japan gradually decreased. The overall strength of developed countries in academic journal publishing first increased and then declined. Figure 6 provides a detailed evolutionary distribution of academic journals from 1950 to 2013 with a time interval of 10 years. It is pronounced that from the 1950s to 2000s, highlighted in dark red, the US and the UK had absolute advantages over the other countries. In the first sample decade, the UK, Germany and Italy were plotted in deep red and other Western Europe countries were represented in orange red, indicating their strong abilities to publish academic journals. However, half of a century passing, in the 2000s, as shown in Figure 6, the color of Western Europe countries except that of the UK turned lighter, which implies a fall of countries in Western Europe in scholarly publishing. For Japan and Australia, this declining trend of academic journal publishing was also founded. Calculating the share of developed countries in each decade, we found that in the 1950s, academic journals published in developed nations constituted 62% of the total number. This percentage went up to 70% and gradually fell back to 63% in the 2000s.

Even though an increasing number of countries has been involved in academic journal publishing, some countries in Western Asia and Africa are still immune to this global trend. In the 1950s, most of the African nations published no academic journals, as well as some countries in South America, Western Asia and Southeast Asia. In the next several stages, the globalization of scholarly publishing was enhanced because of more countries' involvement. In the 1950s, there were only 90 countries which published academic journals and this figure rose to 139 in the 2000s.

The ability of countries to publish academic journals fell and rose due most likely to political and economic factors. The variation of scholarly publishing in China and Russia was dramatic and unstable, probably resulting from the unstable political and economic circumstances in these countries. As for Russia, the number of newly launched academic journals experienced a sharp fall in the 1970s and 1980s. After Cold War had ended, Russia recovered in scholarly publishing in the 1990s and made considerable progress in the 2000s. For China's scholarly publishing, in 1988, the Press and Publication Administration of the People's Republic of China released Interim Regulations for Administration of Periodical Publication, which emphasized on the quality of academic journals, suppressing journals explosion (Liu, 2015).

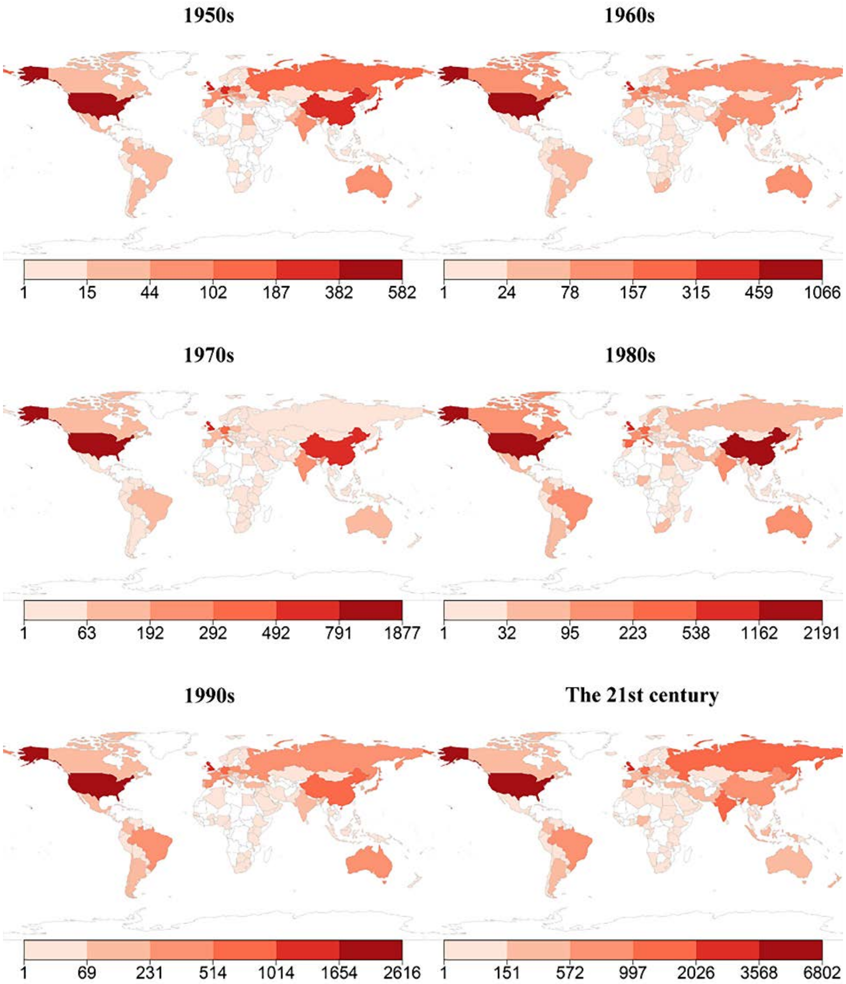

Figure 6. The distribution of newly created academic journals across countries from the 1950s to the 21st century

Countries that have a large size of the population and those that have a high GDP tend to show strong scholarly publishing strength. If we take the size of the population into account, Netherlands and the UK are the most powerful publishing countries while the US, China, Russia and India are not as extraordinary as they are in terms of the total number of academic journals. Comparing the total number and the per capita number, it seems that the overall scholarly publishing ability of countries is strongly related to the size of the population in countries. To test the association between population and academic journal publishing at the country level, we ran a correlation analysis. We also consider GDP of countries because it reflects the economic size of countries. From Table 5, we can see that there is a significant correlation between the number of academic journal and GDP, and countries' population size.

Table 5. Pearson Correlation Coefficients

	Journal counts	GDP	Population
Journal counts	1.00		
GDP	0.76*	1.00	

Population	0.36*	0.27*	1.00

Note: * denotes significant at 1% level.

4.4 The spatial autocorrelation of academic journals

To unveil the existence of spatial autocorrelation of academic journals' distribution, we take advantage of the exploratory spatial data analysis.

The inequality of academic journal publishing across countries shows a wavy change, as well as differences between the strength of the most dominant countries. As shown in Figure 7, the spatial Gini coefficient ascended from 0.64 to 0.80 from 1950 to 1980, reaching its peak, and then dropped back to 0.73 in 2000. Subsequently, it experienced an upward trend steadily, peaking at 0.81 in 2013. It signifies that academic journal publishing was distributed across countries more and more unevenly, while this inequality was mitigated in the 1980s and 1990s. However, after 2000, the disparities of academic publishing across countries was enhanced again. Over the period of 64 years, the geographic concentration of academic journals increased. The trend of CR3 is similar with the change of Gini index. The power of the most dominant countries (i.e., the US, the UK and China) in terms of scholarly publishing rose consistently before the 1980s and peaked at 0.58, and then slumped to 0.34 in 1998 and went up to 0.54 in the last sample year.

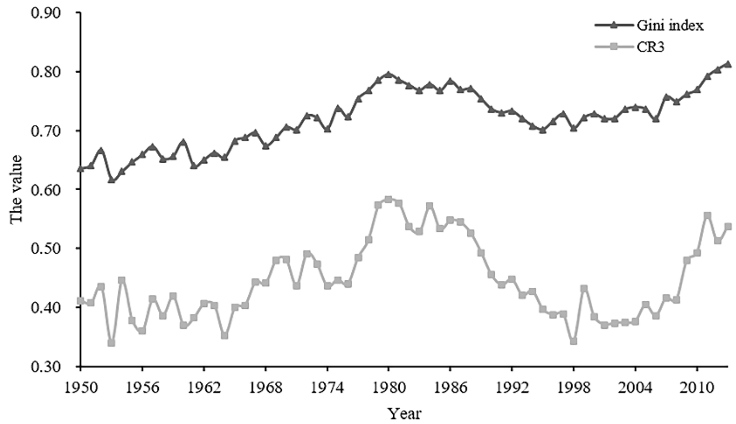

Figure 7. Gini index and CR3 index of newly created academic journals published in countries

There was a significant tendency towards geographical clustering in academic journals while in the recent decade the spatial autocorrelation decreased. As reported in Figure 8, Moran's I statistics for academic journals are significant with positive value at significance levels that are lower than 0.01 in every period, which signifies the existence of significant and positive spatial autocorrelation among countries. Specifically, the Moran's I statistics went up from 0.11 to 0.22, reaching the highest point in the 1990s, then decreased to 0.17 in the period 2000-2013. On the whole, the Moran's I statistics experienced growth, even though there were some fluctuations, which indicates that strong positive and significant spatial autocorrelation was strengthened. Clearly, there was a significant tendency towards geographical clustering in academic journals among countries over the entire sample period, which means that countries that published large numbers of academic journals approached each other, or those with few academic journals became close to their peers geographically. It is noted that in the recent decade, the spatial autocorrelation has become weaker.

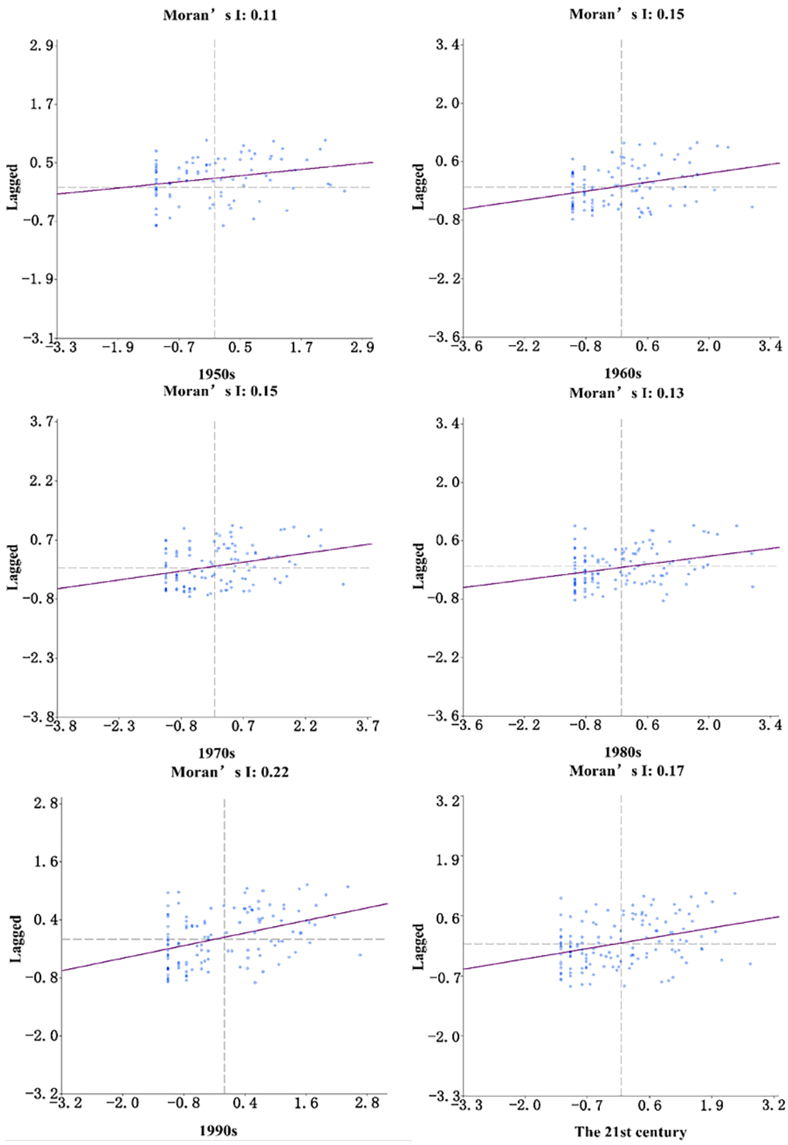

Figure 8. Moran’s scatterplot

To show more insight into the local spatial correlation between countries, a Moran’s scatterplot is presented Figure 8. In the first period, the countries that were located in the HH or LL quadrants accounted for 27.16%, and this proportion grew to 35.19% in the 1970s. Although experiencing a sharp drop (24.11%) in the 1970s, the percentage of countries in HH and LL clusters went up to 39.83% and slightly fell to 36.43% in the 2000s.

As discussed above, not only the Moran's I statistics but also Moran's scatterplot pinpoint significantly positive spatial autocorrelation and geographical clustering among countries in regard to academic journals publishing. In the whole period, the spatial autocorrelation of academic journal publishing was enhanced with some fluctuations while it weakened in the recent decade.

The European cluster has always been the hot-spot area in academic journals' distribution, while the Eastern Asian hot-spot area appeared and perished quickly. Furthermore, the African cluster was comprised of countries that published a few academic journals. The LISA statistics for each of the countries' academic journal publishing in the sample years are calculated and mapped using Moran significance maps in Figure 9. There are five types of countries, as follows: the first type is defined as a country whose LISA statistics are not significant; the rest of the categories are defined as countries that are located in the corresponding quadrants in the Moran's scatterplot. It is evident that the European cluster was a hot-spot area (HH clusters) in every period, where member countries published a considerable number of academic journals. This cluster involved more and more European countries over time except the period of the 1970s and the cluster range expanded to more Eastern European countries. In the 2000s, the number of countries in the European cluster was the largest compared with other periods. It is notable that the Asian cluster emerged in the 1970s, containing China, Indonesia, Malaysia and Singapore and disappeared in the subsequent stages. We also found that there was no significant shift in HH type clusters and LL type clusters during the period.

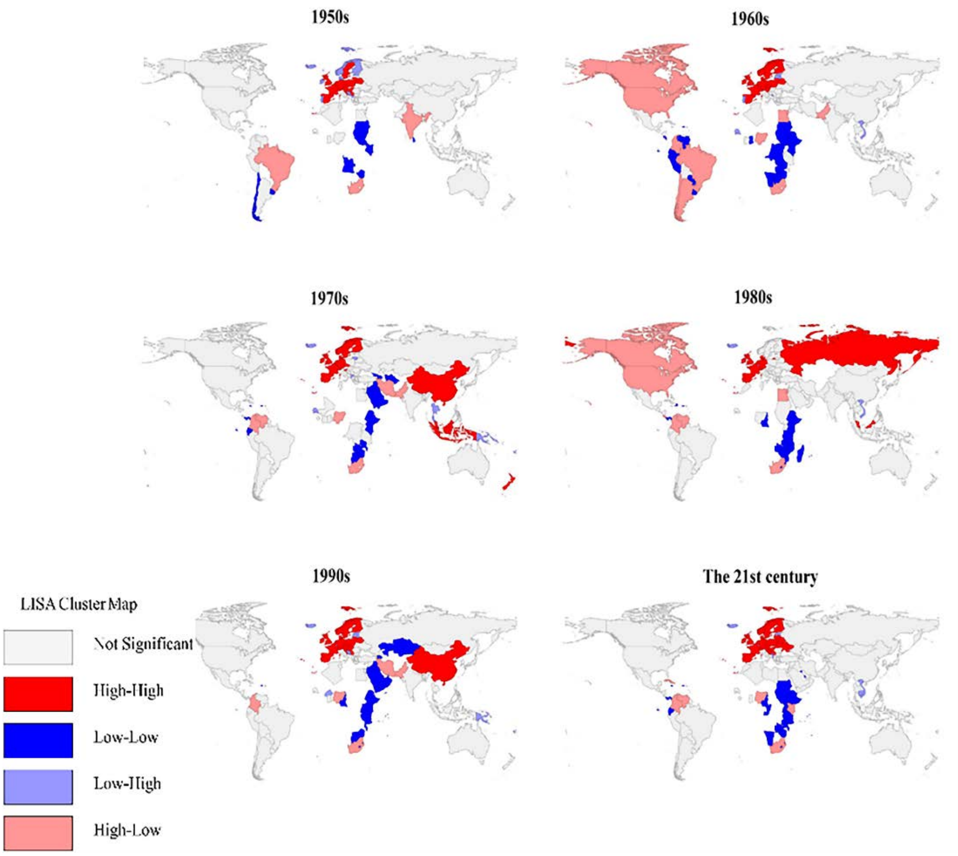

Figure 9. Moran significance map for the distribution of academic journals

5. Discussion and conclusion

As a critical intelligence carrier and recorder, academic journals are vital to the scientific development. Economic, political and scientific disparities between countries have been proved. Although numerous researchers have paid attention to academic journals, there is space to conduct an in-depth study on the geographic dynamics of academic journals to explore the world's imbalance in academic journal publishing. Using descriptive analysis and exploratory spatial data analysis, we provide results that cover the geotemporal demographics and spatial autocorrelation of academic journals. Our findings are as follows:

First, there are tremendous disparities in the distribution of academic journals at the country level from 1950 to 2013. Both the cross-country inequality of academic journal publishing and the differences in academic publishing between the top three publishing countries (the US, the UK and China) witnessed a wavy trend over the period of 64 years. Specifically, they widen in the first three decades with a tipping point at 1980, and then narrowed in the next two decades, and grew again in the 2000s. It seems contrary to some previous claims that the gap of academic publishing between the rich and the periphery countries is widening (Salager-Meyer, 2008). On the other side, researchers provided evidence that between-country difference in the number of articles narrowed from 1990 to 2011 (Xie, 2014). Considering the correlation between the number of articles published by authors in a given country and the number of all academic journals published in this country (Derek, 1963; Mabe, 2003), if the world's disparities in the number of articles are decreasing, it can be assumed that the cross-country inequality of academic journal publishing may be declining as well. However, our analysis shows a non-monotonic change of world's inequality of academic journal publishing. As some researchers suggested, the globalization and Internet technology may contribute to narrowing cross-country inequalities in scientific articles (Xie, 2014). With the introduction of Internet in the 1990s, technology facilitated people's access to information, improving visibility and readership of the academic journals published in peripheral countries or non-English speaking countries at the technical level. The visibility is an essential condition for the survival of academic journal (Salager-Meyer, 2008). For publishers in developing countries, they also easily gain the information about the experiences of developed countries in terms of academic journal publishing thanks to technology. On the contrary, as a double-edged sword, technology may aggravate the gap between countries in academic journal publishing since the digital divide can exacerbate the gap between developing and developed countries (Salager-Meyer, 2008). This may be a reason why with the popularization of Internet after 2000, between-countries disparities of academic journal publishing increased.

Second, the US, Eastern Asia and Europe are the central regions while Africa and Central Asia are lagging behind. The US and the UK maintained the absolute advantage in academic journal publishing over time and made a good performance in launching online academic journals. Given a correlation between research output and academic journal publishing, it is not surprising that the US and the UK dominate in both the online and print academic journal publishing market.

Third, most of the academic journals in the top ten countries were technology-based. The proportion of academic journals in the fields of Social Sciences and Technology went up while those that belong to Natural Sciences dropped. As Price identified, the new scientific discoveries are related to the twigging or creating of journals titles (Derek, 1963). In recent decades, applied technology studies have been booming for the economic development. At the same time, complex socio-economic issues occurred. Therefore, new research areas and new groups of scientists in these two fields have emerged, prompting the creation of new academic journal.

Besides, the 1970s and the 2000s are the most significant period when global academic journals witnessed the highest growth rate. Most of the top ten publishing countries in terms of the number academic journals have experienced a rising-decreasing-stabilizing pattern of academic journals' growth before 2000. In the 2000s, newly launched academic journals published in the US and India increased with a high growth rate. Furthermore, the growth rate of non-English academic journals fell after 2000 while English academic journals still maintained a high growth rate.

Furthermore, the temporal and spatial variation of the distribution of academic journals may be attributed to political and economic factors, which was demonstrated by the dramatic fluctuation of academic journal publishing in China and Russia, two nations that experienced economic and political restructuring. Besides, it is found that there is a significantly positive association between the number of academic journals and the size of the population in countries, and countries' GDP.

At last, there was a significant tendency towards geographical clustering in academic journals during the whole period. Specifically, the spatial autocorrelation of the distribution of academic journal was firstly strengthened and mitigated in the 2000s. The European cluster has been the hot-spot area in academic journal publishing since 1950, in which member countries are close to each other in the geographical, cultural, economic and political aspects. Another Asian clustering consisting of China, Indonesia, Malaysia and Singapore was merely a flash in the pan. This may imply that geographical clustering in scholarly publishing not simply results from physical proximity but also other complex factors driven by culture, economy, and politics of countries. In addition, before the popularization of the Internet, we observed the existence of an increasingly enhancing geographical clustering in countries' academic journal publishing. However, after 2000, the spatial clustering effect decreased. This result can be explained as follows. Firstly, organizational, social, ethnic and relational links between countries may exert stronger impact once countries have benefited from geographical proximity (Crescenzi, Nathan, & Rodríguez-Pose, 2016; Di Cagno et al., 2016). Secondly, information technology improves communication and weaken the restriction caused by geographical distance and thus geographical proximity does not matter as it did before.

This study has some limitations. Firstly, there is an inevitable data bias in Ulrich's as we expounded in detail in 3.1 section. Secondly, the change of cross-country differences in academic journals publishing was presented, but we did not inquire further for the reasons and we just interpret it from the technology perspective. Thirdly, although we veiled the existence of geographical clustering of academic journal publishing, we did not explore the causation of it and the underlying mechanism, e.g., collaboration, knowledge spillover across countries, which may be the further study.

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