Review

Global urbanization research from 1991 to 2009: A systematic research review

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ARTICLE INFO

ABSTRACT

We performed a bibliometric analysis of published urbanization research from 1991 to 2009, based on SCI and SSCI database. Our analysis reveals scientific outputs, subject categories and major journals, international collaboration and geographic distribution, and temporal trends in keywords usage in urbanization studies and discusses the relationships between urbanization papers and urbanization rate and offer a substitute demonstration of research advancements, which may be considered as a potential guide for future research. The growth of article outputs has exploded since 1991, along with an increasing collaboration index, references and citations. Environmental sciences, ecology, environmental studies, geography and urban studies were most frequently used subject categories and Landscape and Urban Planning was the most productive journal in urbanization studies. The United States was the largest contributor in global urbanization research, as the USA produced the most independent and collaborative papers. The geographic distribution of urbanization articles overlapped quite well with regions with high economic growth in North America, Europe, and Pacific-Asia. A keywords analysis found the USA and China were "hotspots", confirmed land-use's significant position and revealed keen interest in ecological and environmental issues in urbanization studies. In general, urbanization research was strongly correlated with the urbanization rate although there were different patterns and underlying processes across different countries. This is the first study to quantify global research trends in urbanization. Our study reveals patterns in scientific outputs and academic collaborations and serves as an alternative way of revealing global research trends in urbanization.

Contents

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1. Introduction

Our world is urbanizing at an unprecedented speed, as the global proportion of urban population has increased from 28.3% in 1950 to 50% in 2010 (World Bank, 2011). An understanding of the process of urbanization could help us cope with emerging problems associated with increased urban living, employ the agglomeration advantages of city clusters, and ultimately build a sustainable future. Urbanization has been studied from different social, economic, and environmental perspectives, ranging from economic agglomeration (Cohen, 2006), to rural–urban disparities (Ravallion, Chen, & Sangraula, 2007), to the loss of natural habitats and to biodiversity (Yeoman & Mac Nally, 2005), and an increasing emission of greenhouse gas (Banerjee & Srivastava, 2011; Fung, Lau, Lam, & Yuan, 2005). Qualitative attempts have also been made to summarize the development of urbanization studies (Morse, 1965). In addition to these qualitative methods, we argue that a bibliometric analysis of urbanization studies could provide an alternative and quantitative perspective of the field and could suggest potential research directions for the future.

Bibliometrics refer to visual and quantitative analytics that are used to summarize trends in selected research fields (Pritchard, 1969; Garfield, 1970). Bibliometric analyses could reveal different research patterns in a given field, such as temporal development of scholarly outputs, scientific collaborations, geographical and institutional distributions of publications, and major research directions (Chiu, Huang, & Ho, 2004; Li, Zhang, Wang, & Ho, 2009; Zhang, Qian, & Ho, 2009). Bibliometric analysis has been applied to a variety of fields, including natural science, engineering, and social studies (Falagas, Karavasiou, & Bliziotis, 2006; Li, Ho, & Li, 2008; Tarkowski, 2007; Tian, Wen, & Hong, 2008; Xie, Zhang, & Ho, 2008).

In this article, we offer an alternate perspective on the development of urbanization studies and present a bibliometric analysis of published urbanization studies from 1991 to 2009. More specifically, our analysis aims to (1) reveal categorical, temporal, and geographical patterns in scientific publications on urbanization; (2) associate the development of urbanization studies with revealed patterns in publications; and (3) identify future research directions, which could be used as a possible research guide for this field.

2. Materials and methods

We built our bibliometric database using publications on urbanization from the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI) bibliographic databases. The SCI and SSCI databases are regarded as the most frequently used and most robust databases for bibliomeric studies (Liu, Zhang, & Hong, 2011). We employed the search term "urbani*," which included any word that begins with "urbani," such as "urbanisation," "urbanization," "urbanizing," and "urbanized." This searching strategy allowed us to locate publications that contain these search terms in their titles, abstracts and/or keywords. We did not use the more simple search term of "urban," as it would gather papers from other subfields of urban studies distinct from urbanization studies, nor did we adopt keywords from related fields, such as "land use" and "land cover," since urbanization and land cover/change are two overlapping but different fields. Our bibliographic search resulted in 14,338 urbanization-related publications from the SCI and SSCI databases; we then extracted information about individual publications, including author name and affiliation, subject category, journal name, publication type, and publication year.

We then processed our bibliographic database to facilitate analyses at later stages. Following the norm of treating the geographic origin of publications (Liu et al., 2011), we grouped publications originating from England, North Ireland, Scotland and Wales as

publications from the United Kingdom (UK). However, we treated publications from Mainland China, Hong Kong, Macau and Taiwan separately, as these territories would have different underlying urbanization processes and thus different research patterns in urbanization studies. Additionally, we gathered the 5-year impact factors of journals and subject categories in our bibliographic database from the 2009 ISI Journal Citation Report (JCR). The citation counts and h-indexes were also retrieved for journals appearing in our database. The h-index is an alternative measure of both the productivity and scholarly impact of a journal: a higher h-index value is associated with a more productive and influential journal, and vice versa. Research collaborations were decided with the complete count strategy. In other words, each signatory on individual publications was treated equally. Therefore, collaborated publications referred to those co-signed by more than two authors, institutions, and countries, at authorial, institutional, and national levels, respectively. Supplementary data on the Gross Domestic Products (GDP in current US$), urbanization rates, and populations of individual countries appearing in our study were also gathered (World Bank, 2011). The urbanization rate is defined as the ratio of urban population to the total population for individual countries. Commonly used acronyms, TP and TC, represent total papers and total citations, respectively.

We then performed a bibliometric analysis to reveal patterns in global urbanization research from the following aspects: publication types and publishing languages, major research output indicators, subject categories and journals, geographic distribution of publications, temporal evolution of keyword appearances, and relationships between urbanization studies and urbanization rates.

3. Results and discussion

3.1. Document types and publishing languages

Seventeen publication types were found among the 14,338 papers generated in our search, and research article (9907) was the most common document type, comprising 69.1% of the total output. Book reviews (2130; 14.9%), proceeding papers (1074; 7.5%), reviews (597; 4.2%), meeting abstracts (240; 1.7%), and editorial material (240; 1.6%) also accounted for a substantial proportion of the publications accessed. Other less significant document types included notes (89), letters (32), discussions (19), corrections (13), news items (10), biographical items (5), abstracts of published items (3), reprints (2), bibliographies (1), additions (1), and items about individuals (1). As common with other bibliometric research, original and peer-reviewed articles were the focus of this study, and publications of all other types were discarded from further analysis. Articles and papers were used interchangeably to denote peer-reviewed articles, whereas publications included documents of other types.

Regarding publishing languages, 13,458, or 93.9%, of the 14,338 publications were written in English, which reflected the fact that English is the leading scientific language (Hsieh et al., 2004; Wang, Yu, & Ho, 2010) and that most ISI-indexed journals were published in English (Chiu & Ho, 2007). Other significant publishing languages included French (329; 2.3%), German (190; 1.3%), and Spanish (132; 0.9%). Several other languages appeared, although publishing fewer papers, such as Portuguese (65), Russian (42), Czech (21), Italian (15), Slovak (13), Hungarian (12), Dutch (10), Turkish (10), and Croatian (10).

3.2. Research output indicators

Although the first urbanization-related publication was included in 1907 by SSCI (Fig. 1a), a substantial interest in
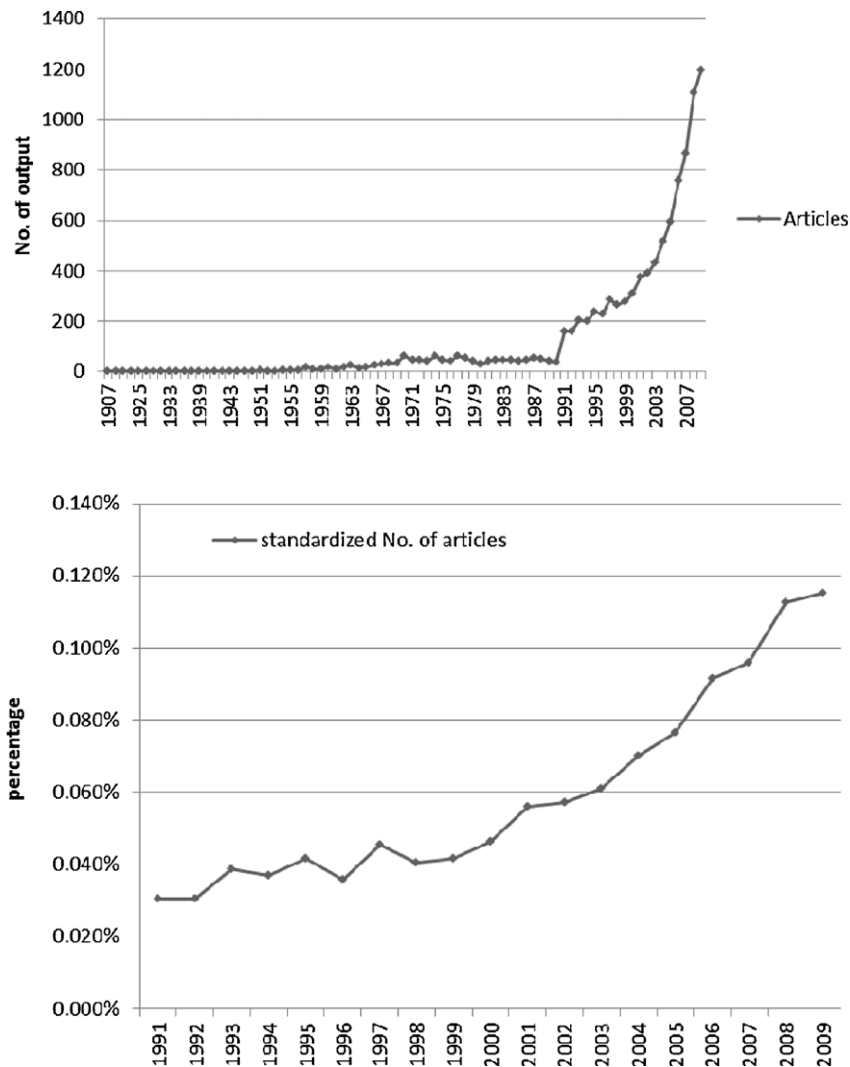
Fig. 1. (a) The number and (b) standardized number of articles on urbanization by year.

urbanization study did not emerge until the 1960s. Along with the expansion of SCI and SSCI databases, urbanization continued to grow, and the number of urbanization publications soared in the last two decades (Fig. 1a). This growing number of urbanization studies is consistent with the world's urbanization processes and increasing social awareness of related urban issues. For instance, the United Nations Conference on Human Settlements (Vancouver, Canada 1976) raised worldwide concern for the impact of human communities and released *The Vancouver Action Plan* while the United Nations Commission on Human Settlements was established in 1978 to promote the development of human settlements and entered into force in 1989 with the set up of the United Nations Habitat Scroll of Honor Award. The 46th Session of the United Nations Economic and Social Commission for Asia and the Pacific was held in Bangkok in 1990 and adopted resolutions to control population growth and urban expansion. Urbanization research became more important in the new century with increasing social concerns about urban issues, which is reflected in the establishment of the World Urban Forum. Therefore, we further restricted our analysis to research articles published during the period of 1991–2009. Although this growing research output has been observed in many fields and was associated with expanding population values and an increasing number of online publications, we noted that the standardized number of publications on urbanization, which is defined as the ratio of the number of

urbanization publications to the total number of articles in the SCI and SSCI databases, showed an "absolute" increase of interest in urbanization studies (Fig. 1b).

Table 1 presents the temporal development of research articles on urbanization for the period of 1991–2009, which increased from 160 in 1991 to 1196 in 2009. As the table shows, the average length of the individual articles increased slightly with small fluctuations. In contrast, the average number of references grew substantially from 27.6 in 1991 to 41.7 in 2009, suggesting an expanding knowledge base on urbanization. Another indicator of substantial development in this field was the collaboration index, which was defined as average number of signatories on a single paper and grew from 2.7 in 1991 to 3.3 in 2009, indicating an increasingly cooperative research field. Although we note that the scientific community has generally becoming more collaborative (Liu et al., 2011), these research output indicators revealed the stable growth and increased cooperation among urbanization studies in terms of the number of articles, the average number of references, and the collaboration index.

3.3. Subject categories and major journals

There were 8534 urbanization articles in our database for the period of 1991–2009, which covered 211 ISI-defined subject categories. We present the top 20 subject categories in Table 2.

Table 1
Scientific outputs on urbanization from 1991 to 2009.

PY	TP	AU	AU/TP	NR	NR/TP	PG	PG/TP	TC	TC/TP
1991	160	425	2.7	4418	27.6	1962	12.3	2215	13.8
1992	161	348	2.2	4718	29.3	2124	13.2	2226	13.8
1993	205	492	2.4	6023	29.4	2726	13.3	2745	13.4
1994	202	520	2.6	6317	31.3	2538	12.6	2951	14.6
1995	236	545	2.3	7517	31.9	3173	13.4	3653	15.5
1996	229	539	2.4	7305	31.9	2968	13.0	4303	18.8
1997	287	823	2.9	10,281	35.8	3945	13.7	6429	22.4
1998	264	668	2.5	9626	36.5	3638	13.8	5322	20.2
1999	277	763	2.8	10,248	37.0	3865	14.0	5384	19.4
2000	310	861	2.8	11,277	36.4	4119	13.3	6161	19.9
2001	376	1038	2.8	13,783	36.7	5116	13.6	8826	23.5
2002	391	1092	2.8	14,102	36.1	5232	13.4	10,003	25.6
2003	431	1301	3.0	16,490	38.3	5743	13.3	9994	23.2
2004	518	1587	3.1	20,128	38.9	6924	13.4	8287	16.0
2005	596	1986	3.3	23,524	39.5	7836	13.1	8287	13.9
2006	758	2465	3.3	30,165	39.8	9920	13.1	8754	11.5
2007	865	3063	3.5	35,339	40.9	11,313	13.1	6969	8.1
2008	1107	3754	3.4	45,179	40.8	14,306	12.9	5904	5.3
2009	1196	3986	3.3	49,908	41.7	15,009	12.5	3260	2.7
Average	451	1382	2.8	17,176	35.8	5919	13.2	5878	15.9
Total	8569	26,256	–	326,348	–	112,457	–	111,673	-

TP, number of publications; AU, number of authors; PG, page count; NR, cited references; TC, total citation count; AU/TP, PG/TP, NR/TP, and TC/TP, average of authors, pages, references, and citations in a paper.

The five most common categories were environmental sciences (1653 papers; accounting for 19.4% of the total), ecology (1084; 12.7%), environmental studies (821; 9.6%), geography (805; 9.4%) and urban studies (803; 9.4%). We first noticed the interdisciplinary nature of urbanization studies, as the first two of these five dominant categories were from SCI databases and the latter three were SSCI subject categories. These top categories also suggested the high priority of ecological and environmental issues in urbanization research. Similar rankings could be observed in the number of times that papers have been cited within individual subject categories.

Table 2
Distribution of the subject categories: the top 20.

SCI/SSCI subject category in 2009	TP (R; %)	TC (R; %)	TC/TP (R)
Environmental Sciences	1653 (1; 19.4)	27,337 (1; 24.5)	16.5 (9)
Ecology	1084 (2; 12.7)	17,608 (2; 15.8)	16.2 (13)
Environmental Studies	821 (3; 9.6)	9362 (4; 8.4)	11.4 (12)
Geography	805 (4; 9.4)	8597 (5; 7.7)	10.7 (14)
Urban Studies	803 (5; 9.4)	8590 (6; 7.7)	10.7 (6)
Water Resources	660 (6; 7.7)	6184 (10; 5.5)	9.4 (11)
Geosciences, Multidisciplinary	615 (7; 7.2)	6949 (8; 6.2)	11.3 (3)
Public, Environmental & Occupational Health	604 (8; 7.1)	10,649 (3; 9.5)	17.6 (10)
Geography, Physical	423 (9; 5.0)	5757 (12; 5.2)	13.6 (15)
Meteorology & Atmospheric Sciences	386 (10; 4.5)	6200 (9; 5.6)	16.1 (8)
Planning & Development	385 (11; 4.5)	3630 (15; 3.3)	9.4 (16)
Economics	382 (12; 4.5)	3487 (16; 3.1)	9.1 (5)
Engineering, Environmental	329 (13; 3.9)	7850 (7; 7.0)	23.9 (4)
Marine & Freshwater Biology	323 (14; 3.8)	5007 (13; 4.5)	15.5 (18)
Biodiversity Conservation	281 (15; 3.3)	4877 (14; 4.4)	17.4 (19)
Engineering, Civil	260 (16; 3.0)	1950 (19; 1.7)	7.5 (17)
Sociology	240 (17; 2.8)	2057 (18; 1.8)	8.6 (20)
Medicine, General & Internal	161 (18; 1.9)	5875 (11; 5.3)	36.5 (1)
Psychiatry	155 (19; 1.8)	3299 (17; 3.0)	21.3 (7)
Zoology	143 (20; 1.7)	1223 (20; 1.1)	8.6 (2)

TP (R; %), number of publications (the rank and percentage of the subject in the study field); TC, total citation counts.

We summarize the annual growth of publications in the top five categories from 1991 to 2009 in Fig. 2, which included 5166 papers that accounted for 60.5% of the total articles. Fig. 2 also reflects an increasing trend in terms of subject categories associated with urbanization, increasing from only 81 in 1991 to 161 in 2009. The number of subjects reached its peak of 161 in 2009, accounting for 76.3% of the total urbanization-related subjects defined in the SCI and SSCI. This result indicated the steady development of urbanization studies, as urbanization research was covered in a wide range of categories.

These 8534 urbanization articles also appeared in 2144 ISI-indexed journals, and the average number of journals per year grew from 123 to 678 during our study period. We observed a concentration of urbanization articles within major journals: the top 20 (0.9%) out of the 2144 total journals published 1369 (16.0%) of the 8569 total publications. Alternately, 1062 journals (49.5%) published one urbanization paper, 363 (16.9%) published two, and 173 (8.1%) published three. In total, 1789 journals (83.4%) published less than five urbanization articles.

We summarize the top 20 most productive journals in Table 3, along with the total article numbers, 5-year impact factors (IF) and h-indexes of individual journals. The IF was the most direct indicator for evaluating the influence of academic journals, particularly in comparison with journals in the same field (Benavent, Zurian, Gomez, Melendez, & Molina, 2004). The h-index, developed by Hirsch in 2005, served as an alternative in evaluating journal influence, focusing on most cited works (Hirsch, 2005). Landscape and Urban Planning ranked consistently high in total articles (1st), h-index (1st), and average citations (6th), suggesting the journal's considerable influence in this field. Moreover, these top journals' titles and subject categories confirmed the central position of ecology and environmental studies in urbanization research. Additionally, the h-indexes of these 20 journals, calculated based on urbanization articles, were generally higher than those calculated using all of the articles in these journals, indicating that articles on urbanization contributed positively to the top journals' scholarly influence. This positive impact was also confirmed by the fact that the average citations received by urbanization-related articles in these journals were greater than the average citations received by all of the papers in these journals.
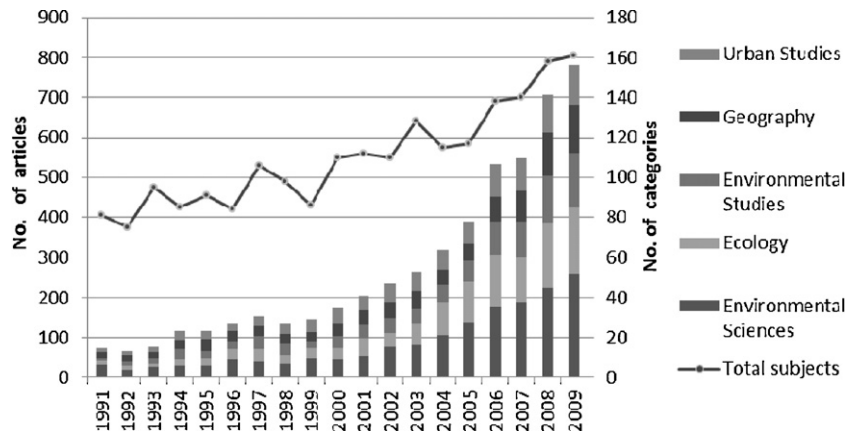
Fig. 2. Growth trends of the top five subject categories and total subjects related to urbanization during 1991–2009.

Table 3
Most active journals during 1991–2009: the top 20.

Journal title	TP	IF	Total		Urbanization	
			h-Index (R)	TC/TP	h-Index (R)	TC/TP
Landscape and Urban Planning[a]	181	2.9	29 (14)	8.5	20 (1↑)	11.0↑
Journal of the American Water Resources Association	92	1.7	19 (26)	5.0	9 (15↑)	6.2↑
Environmental Monitoring and Assessment	91	1.4	20 (23)	4.1	9 (15↑)	4.5↑
Urban Studies[b]	89	2.1	21 (21)	6.0	10 (9↑)	6.9↑
Science of The Total Environment	76	3.4	46 (8)	10.1	13 (6↑)	11.3↑
Atmospheric Environment	73	3.6	49 (3)	11.1	15 (4↓)	12.0↑
Biological Conservation	70	3.9	43 (10)	12.9	19 (2↑)	17.8↑
Environmental Management	69	1.8	20 (23)	5.3	10 (9↑)	6.4↑
Environmental Geology	68	1.3	21 (21)	3.6	6 (27↓)	3.8↑
Landscape Ecology	65	3.6	29 (14)	10.4	17 (3↑)	14.0↑
Environmental Science & Technology	55	5.4	95 (1)	17.4	14 (5↓)	16.9↓
International Journal of Urban and Regional Research[b]	55	2.1	16 (30)	5.8	8 (20↑)	6.6↑
Urban Geography[b]	52	1.2	10 (36)	3.1	6 (27↑)	4.0↑
Journal of Hydrology	52	3.2	41 (11)	9.7	10 (9↑)	7.9↓
Cities[b]	52	1.5	11 (34)	3.9	5 (32↑)	3.7↓
Habitat International[b]	51	1.2	11 (34)	3.6	8 (20↑)	5.7↑
Social Science & Medicine[b]	48	3.6	47 (5)	11.3	8 (20↓)	10.3↓
Environment and Planning A[b]	44	2.3	23 (20)	6.3	5 (32↓)	4.9↓
Journal of Environmental Management	43	2.7	28 (17)	6.8	11 (7↑)	9.1↑
International Journal of Remote Sensing	43	1.6	26 (18)	5.0	8 (20↓)	5.2↑

TP, total number of publications; IF, 5-year impact factor; h-index (R), 5-year h-index (rank of h-index in the top 40 most productive journals); TC, total citation counts; TC/TP, average citations; ↑, the rank or average citations of journal's h-index on urbanization is greater than that in all areas; ↓, the rank or average citations of h-index on urbanization is less than that in all areas.
  [a] Journal collected by SCI and SSCI.
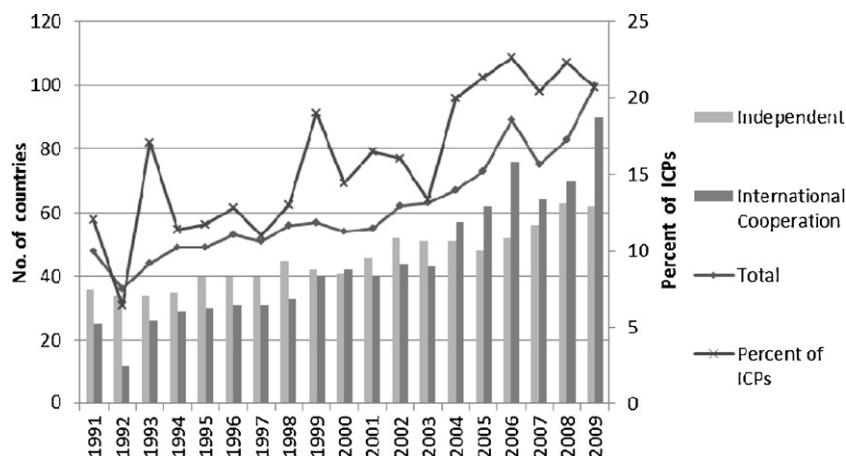 [b] Journal collected by SSCI only.

Fig. 3. Trend of the number of countries and percentage of internationally collaborated articles.

Table 4
Most productive countries of urbanization-related papers during 1991–2009.

Country/territory	TP	Av.TC	Independent papers				International collaboration				CP/TP (%)	Papers/10^6 people (R)
			IP	TC	Av.TC	NJ	CP	TC	Av.TC	NJ		
USA	3364	17.3	2673	45,600	17.1	953	691	12,480	18.1	509	20.5	11.0 (11)
UK	769	16.5	448	6165	13.8	239	321	6526	20.3	223	41.7	12.4 (10)
Mainland China	550	12.5	302	2057	6.8	150	248	4832	19.5	161	45.1	0.4 (29)
Canada	433	15.5	279	2716	9.7	170	154	4002	26.0	115	35.6	12.8 (8)
Australia	418	13.5	292	3432	11.8	166	126	2228	17.7	104	30.1	19.1 (2)
Netherlands	301	19.4	196	3574	18.2	131	105	2266	21.6	85	34.9	18.2 (3)
France	291	12.9	155	1404	9.1	124	136	2338	17.2	105	46.7	4.6 (16)
Japan	251	8.2	158	1028	6.5	103	93	1036	11.1	79	37.1	2.0 (23)
Germany	236	12.8	132	1248	9.5	111	104	1768	17.0	93	44.1	2.9 (20)
Italy	234	13.7	153	1733	11.3	114	81	1465	18.1	72	34.6	3.9 (18)
India	231	10.5	189	1186	6.3	105	42	1231	29.3	40	18.2	0.2 (30)
Brazil	229	7.2	165	861	5.2	93	64	787	12.3	59	27.9	1.2 (26)
South Africa	218	12.9	159	1830	11.5	101	59	978	16.6	53	27.1	4.4 (17)
Turkey	171	6.1	151	909	6.0	93	20	132	6.6	19	11.7	2.3 (21)
Spain	165	7.7	100	514	5.1	71	65	753	11.6	61	39.4	3.6 (19)
Sweden	142	13.6	64	753	11.8	58	78	1180	15.1	62	54.9	15.3 (7)
Finland	111	20.8	77	1360	17.7	62	34	950	27.9	29	30.6	20.8 (1)
Taiwan	110	24.5	79	994	12.6	60	31	1696	54.7	27	28.2	4.8 (15)
Switzerland	98	21.2	36	873	24.3	33	62	1200	19.4	43	63.3	12.7 (9)
South Korea	97	8.3	56	413	7.4	45	41	392	9.6	37	42.3	2.0 (23)
Belgium	95	15.6	42	602	14.3	33	53	879	16.6	49	55.8	8.8 (14)
Denmark	92	18.7	47	1123	23.9	39	45	597	13.3	42	48.9	16.6 (4)
Singapore	81	30.4	54	728	13.5	42	27	1732	64.1	24	33.3	16.2 (5)
Poland	80	5.2	58	272	4.7	46	22	147	6.7	20	27.5	2.1 (22)
Mexico	77	6.7	54	316	5.9	40	23	197	8.6	23	29.9	0.7 (27)
Russia	74	1.6	67	77	1.1	26	7	43	6.1	7	9.5	0.5 (28)
Israel	72	8.7	45	245	5.4	41	27	378	14.0	27	37.5	9.7 (13)
New Zealand	69	16.4	38	390	10.3	30	31	740	23.9	27	44.9	16.0 (6)
Kenya	58	12.8	18	67	3.7	17	40	675	16.9	30	69.0	1.5 (25)
Norway	53	18.8	26	337	13.0	26	27	660	24.4	26	50.9	11.0 (11)

TP, total publications; Av.TC, the average number of citations; IP, the number of independent publications by single-country; TC, total citations; CP, the number of internationally collaborative publications; NJ: the number of journals; CP/TP (%), percentage of internationally collaborative publications to total publications.

3.4. International collaborations and geographic distribution

We estimated the geographic distribution of the articles based on the information regarding author affiliation. After excluding 131 articles without full affiliation information, we found that 8438 papers were published by 152 countries/territories, and 6896 (81.7% of the total 8438) were independent papers produced by 109 countries/territories. Additionally, 1542 papers (18.3%) were internationally collaborated articles, completed by 141 countries/territories. There was a concentration of 25 countries/territories that contributed only one independent paper while 27 countries/territories contributed only one internationally collaborated paper. In addition, 94 countries/territories (86.2%) published less than 1% of independent papers, which was much less than the proportion of countries/territories (93.6%) that contributed less than 1% of internationally collaborated articles to the total number of countries/territories that participated in such collaborations. International cooperation, which plays an increasingly important role in modern scientific research, generally manifested itself in internationally collaborative publications (Schubert & Braun, 1990). Fig. 3 shows that the growth trend in the percentage of internationally collaborated articles to the total number of papers on urbanization somewhat accorded with the temporal evolution of the number of countries that contributed to urbanization research. The correlation coefficient between the two was 0.8. It was in 2004 that the number of countries participating in internationally collaborated articles exceeded those publishing independent papers. After dividing the study period into two intervals using the year 2004 as a separation point, the incremental percentages of independent papers and internationally collaborated articles on urbanization reached −11.3% and 12.7%, respectively. After dividing the study period into two new periods, 1991–2000 and 2001–2009, to make the year-to-year fluctuations

minimum, the incremental percentages were −2.2% and 32.0%, respectively. This suggested that urbanization research had made a more global connection as time progressed. The increasing collaboration may have resulted from the growth of intercommunion in an economically and technologically conjoined world. This could be seen in the growing number of international academic exchanges, such as the "World Urban Forum," which has been held every two years since 2002 and draws more attention to urbanization issues.

Table 4 summarizes the 30 most productive countries/territories, providing the number of total articles, independent articles, and internationally collaborated articles produced by each. Among these 30 countries, 14 were from Europe, 8 from Asia, 3 from North America, 2 from Oceania and Africa, and 1 from South America. The USA, with the most independent (2673) and internationally collaborative (691) articles, led this productivity ranking, which was consistent with country's leading position in many scientific fields (Matthiessen, Schwarz, & Find, 2002, 2010; Willett, 2008). The UK ranked second in production of urbanization-related articles (769), followed by Mainland China (550). As revealed by other bibliometric analyses (López-Muñoz, Alamo, Quintero-Gutiérrez, & García-García, 2008; Tarkowski, 2007), our study suggested that academic outputs are positively correlated with economic development and academic investment. The seven industrialized nations (G7: Canada, France, Germany, Italy, Japan, the UK, and the USA) were all among our list of top 30 countries, accounting for 66.1% of the total 8438 papers. In addition, four major developing countries (BRIC: Brazil, Russia, India, and China) produced 12.9% of the total articles. We also conjectured that international collaborations were positively associated with the citation rate, as the average citations of internationally collaborated articles and independent articles produced by these 30 countries were 19 and 13, respectively. Table 4 also lists the number of urbanization papers per 1,000,000 people for
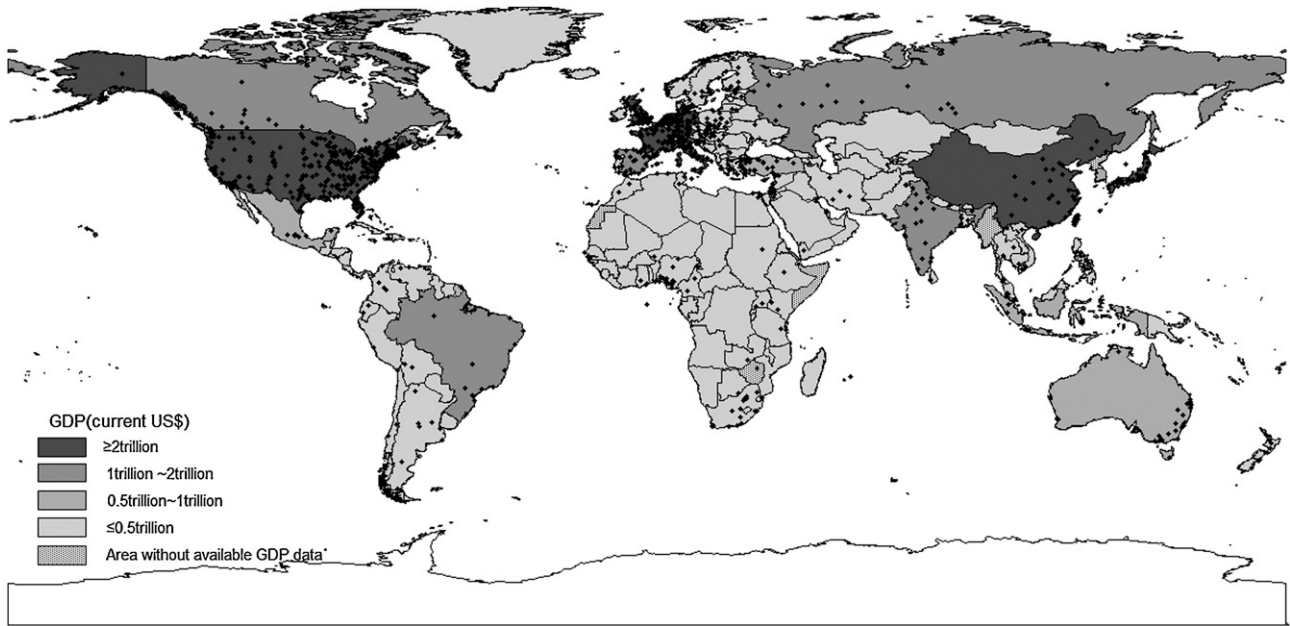
Fig. 4. Comparison spatial distribution of urbanization-related authors with GDP (current US$) of different countries in 2009 (data from the World Bank database).

each country, which shows that Finland ranked first and India ranked last among the top 30. Although the USA published the largest number of papers on urbanization, it ranked 11th among the 30 after taking population base into consideration.

We employed CiteSpace (Chen, 2004) to geocode the affiliations of authors and plot the global geographic distribution of urbanization studies (see Fig. 4). We identified major clusters of authors in North America, Europe, and East Asia and several minor clusters elsewhere. We also produced a choropleth map to depict the Gross Domestic Products of individual countries for the year 2009, as the background (GDP values for Afghanistan, Congo Democratic Republic, Cuba, Greenland, Guyana, Kuwait, and Suriname were from 2008). The spatial clustering of urbanization research overlapped

quite well with regions with a GDP exceeding two trillion US dollars. Again, this observation suggested that economic development was associated with academic outputs.

3.5. Temporal evolution of title words and keywords

First, we analyzed words contained in article titles, as they reflected the content of the papers and contained information that the authors would like to deliver most (Wang et al., 2010; Zhang, Wang, Hu, & Ho, 2010). We dropped prepositions and conjunctions such as "of," "in," and "and" from our analysis. The most frequently used word in titles of urbanization articles was "urban," which appeared in 1562 papers (accounting for 18.2% of the total 8534

Table 5

Frequency of author keywords and keywords plus used in articles: to p25.

Period	Total	1991–1995		1996–2000		2001–2005		2006–2009	
	P	P	R (%)	P	R (%)	P	R (%)	P	R (%)
Urbanization	1802	90	1(14.4)	176	1(16.0)	509	1(23.8)	1027	1(27.2)
USA	540	33	2(5.3)	68	2(6.2)	140	2(6.6)	299	3(7.9)
Land-use↑	490	6	17(1.0)	33	11(3.0)	134	3(6.3)	317	2(8.4)
Urban	327	25	4(4.0)	44	5(4.0)	88	4(4.1)	170	7(4.5)
Patterns	281	14	11(2.2)	36	8(3.3)	76	5(3.6)	155	8(4.1)
Conservation↑	280	1	23(0.2)	18	19(1.6)	58	16(2.7)	203	4(5.4)
China↑	263	7	15(1.1)	21	16(1.9)	60	12(2.8)	175	5(4.6)
Population↓	253	23	5(3.7)	45	4(4.1)	72	6(3.4)	113	17(3.0)
Growth	252	18	10(2.9)	40	7(3.6)	67	8(3.1)	127	14(3.4)
Biodiversity↑	245	1	23(0.2)	12	24(1.1)	59	14(2.8)	173	6(4.6)
Cities	234	5	19(0.8)	34	10(3.1)	58	16(2.7)	137	10(3.6)
Model↑	233	6	17(1.0)	25	14(2.3)	60	12(2.8)	142	9(3.8)
Prevalence↓	231	21	6(3.4)	54	3(4.9)	68	7(3.2)	88	23(2.3)
City	229	10	12(1.6)	22	15(2.0)	65	9(3.0)	132	12(3.5)
Health	222	21	6(3.4)	33	11(3.0)	57	19(2.7)	111	18(2.9)
Management↑	211	3	20(0.5)	15	20(1.4)	57	19(2.7)	136	11(3.6)
Landscape	205	0	25(0.0)	10	25(0.9)	64	10(3.0)	131	13(3.5)
Mortality↓	205	19	9(3.0)	36	8(3.3)	58	16(2.7)	92	22(2.4)
Pollution	195	8	14(1.3)	21	16(1.9)	64	10(3.0)	102	20(2.7)
Epidemiology	191	20	8(3.2)	43	6(3.9)	57	19(2.7)	71	24(1.9)
Ecology	189	9	13(1.4)	20	18(1.8)	59	14(2.8)	101	21(2.7)
Diversity	186	2	21(0.3)	13	23(1.2)	53	23(2.5)	118	16(3.1)
GIS	183	2	21(0.3)	15	20(1.4)	47	24(2.2)	119	15(3.2)
Migration↓	181	28	3(4.5)	26	13(2.4)	56	22(2.6)	71	24(1.9)
Impact	173	7	15(1.1)	14	22(1.3)	46	25(2.2)	106	19(2.8)

P, articles in the study period; R (%), the rank and percentage of author keywords and plus keywords; ↑, the upward trend in rank; ↓, the downward trend in rank.
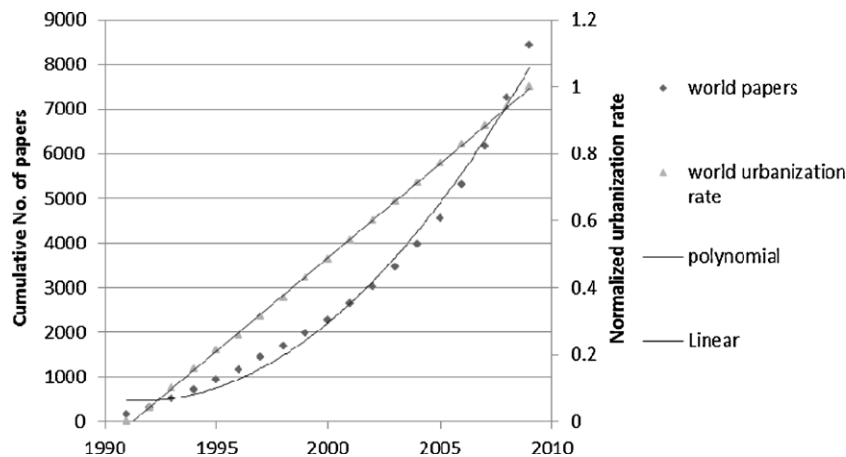
Fig. 5. Relationship between evolution of worldwide papers on urbanization and world urbanization rate during 1991–2009.

publications), followed by "urbanization" (789; 9.2%), "study" (466; 5.4%), "China" (407; 4.8%), "land" (406; 4.7%), "use" (386; 4.5%), "development" (356; 4.2%) and "analysis"(344; 4.0%).

Author keywords and keywords plus were both used to offer alternative perspectives of research trends (see Table 5). Author keywords were keywords supplied by the articles' authors that offered a summary of each article's contents (Li et al., 2008). Keywords plus, which were produced by ISI using individual papers' citations and references, provided an alternative perspective on article contents (Zhang et al., 2010). We grouped author keywords and keywords plus in our analysis, and both are termed as "keywords" hereafter. The 8569 articles in our database contained 71,690 occurrences of 24,377 unique keywords. However, 17,525 or 71.9% of these 24,377 keywords appeared in only one paper, and 22,625 (92.8%) keywords appeared in less than five papers. We concluded that this large number of less frequently used author keywords was associated with a lack of close contact with urbanization and a lack of continuity in research (Tian et al., 2008). As revealed in other bibliometric studies (Li et al., 2008; Liu et al., 2011; Xie et al., 2008), the frequencies and rankings of keywords followed a power-law distribution, where a small number of keywords appeared most frequently and most keywords were rarely used.

One of our search terms, "urbanization," was among the 25 most frequently used keywords, where other search terms, such as "urbanize," "urbanizing," "urbanism," and "urbanized" were not listed. Table 5 reveals a close relationship between "land use" and urbanization, as the rank of "land use" grew from 17th in 1991–1995 to 2nd in 1996–1999. This is consistent with the fact that spatiotemporal characteristics of land use change are important for understanding urbanization (Wang, Deng, Hong, & Qi, 2009), and urbanization, in turn, has a positive influence on land use diversity and landscape (Wang, 2007). As we would expect, urbanization studies are numerous in the USA, one of world's most urbanized countries, and China, one of world's fastest urbanizing regions. "USA" appeared in 540 articles, and "China" appeared in 263, with ranks of 2nd and 7th, respectively. However, the rank of "China" increased from 15th to 5th from 1991 to 2009, whereas the rank of "USA" decreased from 2nd to 3rd during the same period. In addition, the ranks of "conservation," "biodiversity," "model," and "management" increased continuously, suggesting that these would become important subfields in urbanization studies. On the contrary, we noted that urban-related keywords, such as "population," "mortality," and "migration" were becoming less significant during our study periods. As mentioned previously, the subject areas of environment and ecology held pivotal positions in urbanization studies. For example, in this study, "conservation,"

"biodiversity," "ecology," and "diversity" ranked 6th, 10th, 21st, and 22nd, respectively.

3.6. Relationship between urbanization research and urbanization

In addition to evaluating keywords and search terms, we analyzed associations between urbanization studies and the urbanization rate (UR) at both the global and the national levels. Fig. 5 suggests that the cumulative number of urbanization papers worldwide increased along with the global urbanization rate during our study period. The cumulative number of urbanization papers was accurately approximated by a quadratic polynomial model $y = 24.4210x^2 - 97,269.8616x + 96,858,021.4368$ ($r^2 = 0.9909$), where x and y denote the year and article number, respectively. Meanwhile, we also noticed a linear growth of the normalized urbanization rate, which can be approximated by $y = 0.056x - 111.510$ ($r^2 = 0.9997$), with x and y denoting time and the normalized urbanization rate, respectively. Additionally, the cumulative number of urbanization articles was positively correlated with worldwide urbanization rate (correlation coefficient = 0.960). Therefore, we concluded that the urbanization rate had a positive impact on urbanization studies (Fig. 5).

We then performed the same correlation analysis with the article and urbanization datasets for G7 and BRIC (see Fig. 6), where we found patterns similar to those associated with the worldwide data. In the G7 and BRIC datasets, there was a statistically significant linear growth in urbanization articles as well as significant polynomial growth in the urbanization rate. Still, the cumulated number of urbanization articles was highly correlated with urbanization rate for both G7 and BRIC (with correlation coefficients of 0.958 and 0.889, respectively).

Despite these general patterns at the global and multinational levels, relationships between the cumulative number of urbanization articles and the urbanization rate varied across countries. Some countries, such as the UK, followed global patterns and showed linear growth in the urbanization rate and polynomial growth in the number of urbanization articles. However, other countries deviated from these general patterns: the USA and Italy had quadratic polynomial growth for both their urbanization rates and their urbanization articles during our study period. The growth of urbanization rate in Germany (see Fig. 7) was three-stepped and could not be modeled linearly, whereas the increase of urbanization articles in this country followed the global pattern of polynomial growth. The urbanization rate in Germany grew linearly from 1991 to 1995 and declined for the next five years, before it increased again after 2001. This three-stepped growth was consistent the
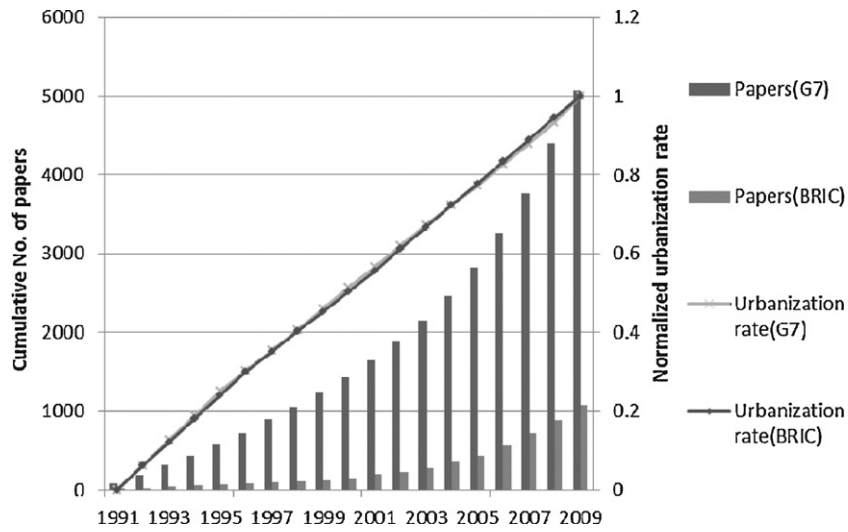
Fig. 6. Relationship between growth trend of urbanization-related papers and urbanization rate of G7 and BRIC during 1991–2009.
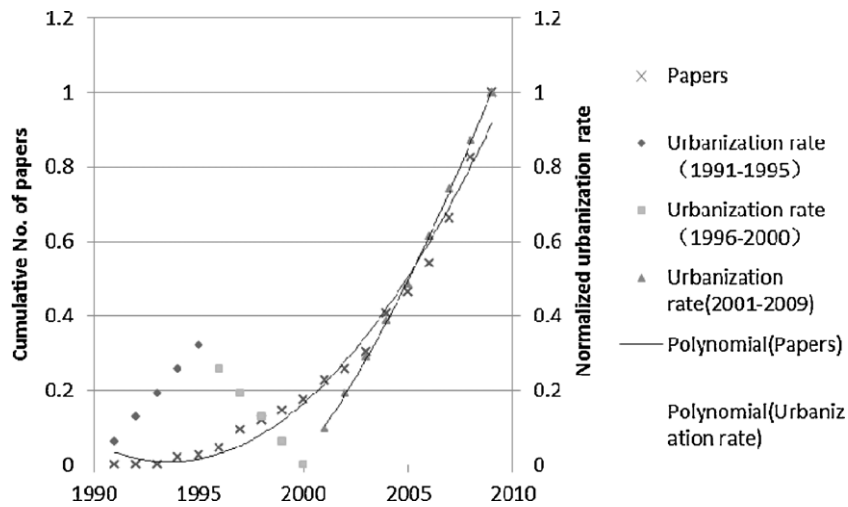

Fig. 7. Relationship between Germany's trend of papers on urbanization and urbanization rate during 1991–2009.
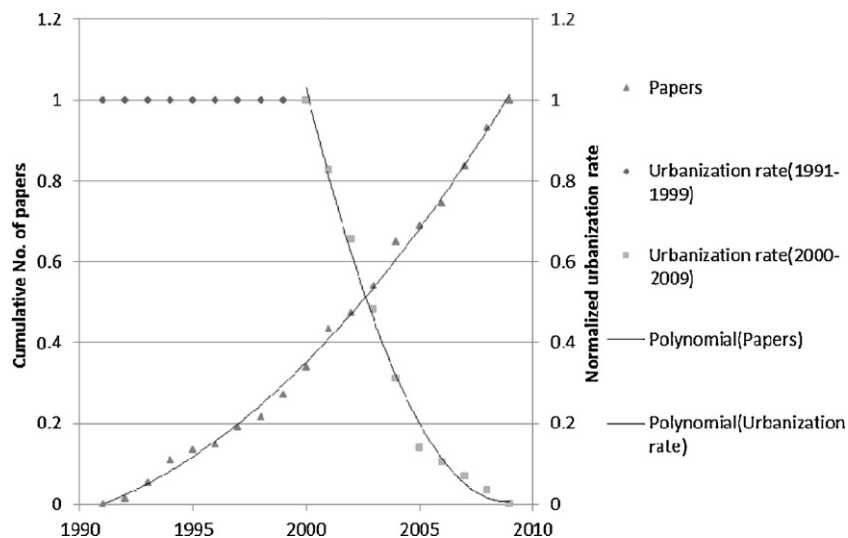

Fig. 8. Relationship between Russia's trend of the papers on urbanization and urbanization rate during 1991–2009.

Table 6
Correlation analysis of urbanization and bibliometrics in G7 and BRIC during 1991–2009.

Correlation coefficient r	TP and urbanization rate (relevance)	TP and urban population (relevance)
USA	0.948 (H)	0.953 (S)
UK	0.962 (S)	0.993 (S)
France	0.947 (H)	0.968 (S)
Germany	0.910 (H)	0.663 (M)
Italy	0.995 (S)	0.985 (S)
Canada	0.910 (H)	0.974 (S)
Japan	0.927 (H)	0.886 (H)
G7	0.958 (S)	0.961 (S)
Brazil	0.854 (H)	0.869 (H)
Russia	−0.955 (S)	−0.991 (S)
India	0.968 (S)	0.965 (S)
China	0.838 (H)	0.835 (H)
BRIC	0.889 (H)	0.893 (H)

TP, the number of yearly publications on urbanization; S, H, M, the significant, highly and moderate correlation between the two variables studied.

country's suburbanization (Koppen, Mai, & Schlomer, 2007), unification, and policies for environmental protection, and limitation on urban expansion (Kunzmann, Liu, & Wang, 2007) during the 1990s. Moreover, the urbanization rate in Russia (see Fig. 8) remained almost still from 1990 to 2000 and decreased rapidly in the new century. This decline of the urbanization rate occurred at an even faster pace than the decrease of the population in Russia, which could be associated with ascending mortality, an increasing emigration rate among urban populations, and continued economic recession and social unrest from the 1990s (Medvedkov & Medvedkov, 1999).

Table 6 summarizes correlations between the cumulative number of urbanization articles and the urbanization rate for individual countries in the G7 and BRIC. Within the G7 group, correlation between the urbanization rate and urbanization articles was highest in Italy (correlation coefficient = 0.995), followed by the UK (0.962), the USA (0.948), Japan (0.927), and Canada (0.910). In the BRIC group, the correlation coefficient for India (0.968) was the largest while China had a less correlated relationship between urbanization rate and article quantity (0.838). We also noted that the correlation coefficient for Russia was negative. We regarded correlations with coefficients greater than 0.95 as significantly correlated and those with coefficients larger than 0.8 as highly correlated. There are four countries with significant correlations and seven countries with high correlations between the urbanization rate and urbanization articles. These results once again reflected the close relationship that exists between the urbanization rate and scholarly output of urbanization studies.

Urbanization-related articles grew globally and nationally with different growth rates among the countries assessed. The growth of the urbanization rate and urbanization articles in most countries followed the global pattern; however, countries like Germany and Russia were exceptions. Scholarly output in urbanization studies was closely related to the urbanization rates of individual countries, and this relationship was more evident in developed countries. On the one hand, these developed countries invested more in scientific research in general and urbanization studies specifically. On the other hand, developed countries usually had larger urbanization rates and experienced more severe urban issues, which, in turn, led to academic interest in and social concerns about urbanization.

4. Conclusions

In this article, we have provided an alternative perspective on global research trends in urbanization studies. A bibliometric analysis was performed to reveal scientific outputs, subject categories, major journals, international collaboration, geographic distribution, and temporal trends in keyword usage in urbanization studies. Our observations suggest that urbanization studies were marked by stable growth and dynamic collaboration during the time period of 1991–2009, with an increasing number of articles, citation counts, and collaboration indexes being seen among these studies.

Environmental sciences, ecology, environmental studies, geography and urban studies were all subject categories that published the most urbanization-related papers. In addition, *Landscape and Urban Planning* was the most productive and influential journal in this area, with a large number of urbanization publications, a large impact factor, and a high h-index.

The USA had a leading position in global urbanization research, with the largest number of independent and internationally collaborated urbanization articles. International collaborations were more prevalent in recent years, and the number of countries participating in international collaboration surpassed the number of those publishing independently in 2004. Moreover, internationally collaborated articles drew more citations than those produced by authors from the same country. Additionally, scientific outputs were positively associated with economic development and research investment, as the geographic distribution of urbanization articles overlapped quite well with regions featuring high economic growth in North America, Europe, and Pacific-Asia.

Furthermore, a keywords analysis suggested that the USA and China were "hotspots" in urbanization research, confirmed the significant position of land use in urbanization studies, revealed an increasing adoption of advanced technologies, such as modeling techniques and geographic information systems, and presented the importance of ecological and environmental issues. In general, urbanization research was strongly correlated with the urbanization rate although there were different patterns and underlying processes across different countries.

Acknowledgements

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