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UNDERSTANDING THE EVOLUTION OF INFORMATION SYSTEMS RESEARCH FROM THE PERSPECTIVE OF CO-AUTHORSHIP NETWORK: A COMPREHENSIVE DATA ANALYSIS FROM 1993 TO 2012

Guijie Zhang
Harbin Institute of Technology, zgjzxmtx@163.com

Yuqiang Feng
Harbin Institute of Technology, fengyq@hit.edu.cn

Luning Liu
Harbin Institute of Technology, liuluning@hit.edu.cn

Zhen Shao
Harbin Institute of Technology, shaozhenlily@gmail.com

Yangyang Han
Harbin Institute of Technology, hyy_yy@sina.cn

See next page for additional authors

Authors
Guijie Zhang, Yuqiang Feng, Luning Liu, Zhen Shao, Yangyang Han, and Jianben Wu

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Guijie Zhang, School of Management, Harbin Institute of Technology, Harbin, Heilongjiang, China, zgjzxmtx@163.com

Yuqiang Feng, School of Management, Harbin Institute of Technology, Harbin, Heilongjiang, China, fengyq@hit.edu.cn

Luning Liu, School of Management, Harbin Institute of Technology, Harbin, Heilongjiang, China, liuluning@hit.edu.cn

Zhen Shao, School of Management, Harbin Institute of Technology, Harbin, Heilongjiang, China, shaozhenlily@gmail.com

Yangyang Han, School of Management, Harbin Institute of Technology, Harbin, Heilongjiang, China, hyy_yy@sina.cn

Jianben Wu, School of Management, Harbin Institute of Technology, Harbin, Heilongjiang, China, 15385726299@163.com

Abstract

Based on the articles published in three top journals in the field of information systems (MISQ, ISR and JMIS) from 1993 to 2012, we conduct a research of the structure, characteristics and development trend of co-authorship network through scientometrics and social network analysis approaches. We gain a number of insights after synthetical analysis. In the last two decades the whole co-authorship network density in information systems faces a tendency of decrease. The co-authorship network presents properties of "small world". The number of articles published by scholars and institutions in the three elite journals all display a 'long tail' phenomenon. The field of information systems has a stable development in the biggest component, and has not yet went into a mature and steady stage. Quite a lot of outstanding scholars and educational resources came from USA, Canada and Hong Kong, and USA has held eight institutions of the top ten. The ranking of an entire institution can be influenced by even one or two authors, indicating that outcome from one level might propagate to the next level.

Keywords: Social network, Information systems research, Co-authorship network, Evolution

1 INTRODUCTION

In order to evaluate cooperation status of scientific researches, scholars tend to build co-authorship network of the corresponding fields (Larivière et al. 2006; Abbasi et al. 2011; Zhai et al. 2013). In a co-authorship network, scientists are connected when they publish papers together, where nodes represent scientists while edges represent co-authorship relations (Newman 2001a). In recent years, there has been a sharp increase in the number of articles addressing the topic of collaborations among scholars (Larivière et al. 2006; Chen et al. 2013). Researches on co-authorship network have essential functions that combine distributed knowledge and methodology together to create novel knowledge (Heinze and Kuhlmann 2008). Through collaboration behaviors, researchers have the opportunities to share their knowledge which are crucial for knowledge creation (Abbasi et al. 2011).

In recent years, a large number of scholars have conducted empirical studies to research the evolution of co-authorship networks (Perc 2010; Pepe and Rodriguez 2010; Ronda and Guerras 2010; Guan and Chen 2012; Zhai et al. 2013). Using different sources of data and diverse perspectives to analyze, these papers provide us a comprehensive insight of multiple disciplines. The details of some of the representative papers are shown in Table 1.

Articles	Discipline	Source of data	Analytic angle	Focus
Chen et al. (2011)	Health insurance	NHIRD (2000~2009)	International & institutional perspectives	Exploring authors' productivity patterns
Tang & Shapira (2011)	Nanotechnology	SCI-E of Thomson Reuters (1990~2009)	International & institutional perspectives	Detecting patterns and dynamics of China and US scientific collaboration in nanotechnology
Uddin et al. (2012)	Steel structures	Scopus (1990~2009)	International perspectives	Measuring efficiency and trend of co-authorship networks
Liu et al. (2012)	Biotechnology, information and computer technology, future energy and nanotechnology	SCI-E and SSCI of Thomson Reuters (1996~2010)	Institutional & international perspectives	Analyzing domestic and international collaboration of Taiwan
Kumar & Jan (2013)	Business and management	Web of Science database (1980~2010)	Individual, institutional & international perspectives	Explicating research collaboration via a social network lens
Zhai et al. (2013)	Management research	Web of Science database (1985~2011)	International & individual perspectives	Exploring the characteristics, structure and development trend of collaboration network of Chinese scholars

Table 1. Studies on co-authorship network of diverse disciplines

Though previous researches have proceeded with plenty of empirical analysis of the characteristics of collaboration networks in a wide range of disciplines (Ronda and Guerras 2010; Guan and Chen 2012;

Zhai et al. 2013), by synthetical analysis, we find out that few attention has been paid to the evolution of the structure and dynamics of the field of information systems. Using scientometrics and social network approaches, we carried out a detailed analysis of research collaborations in this field in the last twenty years so as to know the status of international collaboration in information systems. This study has a significant practical contribution for international scholars in the field of information systems since the results will provide more profound understanding about the status and evolutionary trend of collaboration network in this field.

Accordingly, the rest of this paper is organized as follows. Section 2 introduces the analytical method used in the later section; Section 3 describes the details of the data selection, collection and unification procedures. Section 4 provides four network perspectives (overall, individual, institutional and international) of analysis to show the evolution and the current state of the collaboration network in the field of information systems. Section 5 presents the corresponding conclusions and discussions.

2 ANALYTICAL METHOD

In order to make our analysis clearer and more reasonable, we classified our study into four levels, which are overall, individual, institutional and international perspective. From the overall perspective, we can obtain the overall structural features of a network and capture the global characteristics of a social network as a whole (Liu et al. 2005). From the individual perspective, we can discover the differential opportunities and constraints that shape individuals' social behaviors (Yin et al. 2006). From the institutional perspective, we can capture the distribution of main collaborative institutions from the location of them (Liu et al. 2012). From the international perspective, we can explore the rules of collaboration between countries all over the world (Zhai et al. 2013).

Drawing upon the abundant previous literatures (Newman 2010; Abbasi et al. 2011; Uddin et al. 2012; Zhai et al. 2013), we abstracted and generalized the measures used in their papers into formulas and analyzed the significance of the measures which make our analysis more precise. The details of analysis are shown in Table 2 and Table 3.

Measures	Formula	Significance
Statistical analysis of collaboration of articles published in the three top journals	$P_{ij} = \frac{a_{ij}}{A_i};\ P_j = \frac{\sum_{i=1}^{3} a_{ij}}{\sum_{i=1}^{3} A_i}$ a_{ij}: the number of papers which have j authors published in journal i; A_i: the number of papers published in journal i; P_{ij}: the percentage of papers which have j authors published in journal i; P_j; the percentage of papers which have j authors published in three top journals	From this measure we can learn the distribution of the number of authors in single article (Zhai et al. 2013) and the tendency of collaboration among researchers in producing scientific publications (Uddin et al. 2012).
Evolution of collaboration degree of articles published in the	$D_{ik} = \frac{\sum_{j=1}^{n} j*a_{ijk}}{A_{ik}};\ D_k = \frac{\sum_{i=1}^{3}\sum_{j=1}^{n} j*a_{ijk}}{\sum_{i=1}^{3} A_{ik}}$ j: the number of author/authors in a paper; a_{ijk}: the number of papers which have j authors of	This measure refers to the average number of co-authors of these articles in a certain period (Zhai et al. 2013) and the tendency of scientific

three top journals	journal i in the year of k; D_{ik}: the collaboration degree of journal i in the year of k; D_k: the collaboration degree of the three top journals in the year of k;	collaboration with the passage of time (Uddin et al. 2012).
Evolution of the average distance in the whole co-authorship network	$$L = \frac{1}{N(N-1)} \sum_{i,j} d_{ij}$$ N: the number of nodes in the whole network; d_{ij}: the distance between the node v_i and v_j; L: the average distance in the whole co-authorship network of the three top journals	This measure implies that one scholar in the network needs how many steps to reach another one in average which means scientific information can be obtained easily or not by peoples who demand them (Newman 2001b).
Evolution of network density of whole co-authorship network	$$\text{Density} = \frac{2M}{N(N-1)}$$ M: the number of ties in the whole network; N: the number of nodes in the whole network;	This measure shows the ratio of the actual number of edges and the maximum possible number of edges (Newman 2010) which describes network's general level of cohesion (Abbasi et al. 2011).

Table 2. Details of analysis from the overall perspective

Analysis perspective	Measures	Formula	Significance
Individual perspective	Distribution of number of scholars publishing articles in the three top journals	$$T_i = \sum_{j=1}^{2298} t_j$$ T_i : the number of scholars publishing the number of i articles in the three top journals t_j : if author j published the number of i articles, $t_j = 1$; otherwise $t_j = 0$	The distribution of the number of scholars publishing articles in the top journals displays some phenomenon, such as long tail, exponent form, etc., and we can analyze and find out the reason behind this (Zhai et al. 2013).
	Ten top authors ranked by the number of articles published in the three top journals	$$U_i = \max u_j$$ U_i: the ten top authors ranked by the number of articles published in the three top journals u_j : the number of articles published in the three top journals by author j	This measure reveals which authors occupy key roles in the co-authorship network (Chen et al. 2013) and the change of the elite scholars in the field of the information systems with the passage of time.
Institutional perspective	Distribution of number of institutions publishing articles in the three top journals	$$M_i = \sum_{j=1}^{733} m_j$$ M_i: the number of institutions publishing the number of i articles in the three top journals	To some extent, this measure reflects the reputation of research institutions which can attract high qualified students from all over the world, introduce outstanding scholars, and obtain government

		m_j: if institution j published the number of i articles, $m_j = 1$; otherwise $m_j = 0$	funding and social donation (Abbasi et al. 2011)
	Top ten institutions ranked by the number of articles published in the three top journals	$V_i = \max v_j$ V_i: the ten top institutions ranked by the number of articles published in the three top journals v_j : the number of articles published in the three top journals by institution j	This measure can give us a help when analyzing which institutions occupy key roles in the institutions collaboration network (Chen et al. 2013), the evolution law and the reason behind this.
International perspective	Distribution of number of countries publishing articles in the three top journals	$N_i = \sum_{j=1}^{40} n_j$ M_i : the number of countries publishing the number of i articles in the three top journals n_j: if country j published the number of i articles, $t_j = 1$; otherwise $t_j = 0$	This measure is useful when analyzing the evolution law of countries publishing articles in the top journals and the results can give the visiting scholars a hand when making a decision which country to visit.
	Top ten countries or territories ranked by the number of articles published in the three top journals	$W_i = \max w_j$ W_i: the ten top countries ranked by the number of articles published in the three top journals w_j : the number of articles published in the three top journals by country j	From this measure we can learn which countries or territories occupy key roles in the countries collaboration network (Chen et al. 2013), the evolution law and the scope of collaboration in the world.

Table 3. Details of analysis from individual, institutional and international perspectives

3 DATA COLLECTION AND UNIFICATION

According to Peffers and Ya (2003), Rainer and Miller (2005) and Dennis et al. (2006), MISQ, ISR and JMIS are recognized as the three elite journals in the field of information systems. We chose the three top academic journals as the data sources to extract the information of articles and construct the co-authorship networks to analyze the status and evolutionary trend of collaboration network in the field of information systems.

Since different journals may have different styles of name writing and different scholars may have different habit of institution and country name writing, there might be cases where the identical author, institution or country has different writing addresses. Compared with the inconformity of countries and institutions, there are much more difficulties in authors names which confused scholars (Tang & Walsh 2010; Chen et al. 2013). Since the scale of our dataset is not big, we carry out hand cleaning for possible author name variations thoroughly using Google to consult scholars' resume to ascertain

whether the two papers were written by the same scholar. One PhD and two lecturers involved in this process.

The data was retrieved from the EBSCO's Business Source Premier during December, 2012 and articles were downloaded from the above top three journals from January 1, 1993 to December 31, 2012. Then we extracted information of article titles, authors, author institutions, countries, etc. for future analysis. After cleaning the publication data, there are totally 1745 articles contributed by 2298 unique authors, 733 unique institutions and 40 unique countries or regions. During the procedure of data collection, papers written by editors and papers with only one author were excluded from our dataset, for the reason that an article is considered as the result of a collaborative activity when it is written by more than one author (Larivière et al. 2006).

4 RESULTS AND ANALYSIS

4.1 Overall analysis of co-authorship network

The distribution of the number of authors in a single article published in the three top journals in the last two decades is shown in Table 4. From Table 4 we can see that most articles (72.6% ~ 75.3%) are completed by two or three authors while only a small number of articles (2.7% ~ 4.0%) are written by more than five authors. These results are similar with those of Zhai (2013). Maybe these results indicate that papers written by two or three authors are the most effective cooperation pattern. In addition, the smallest percentage of author number in a single article is 10.1% from ISR, which means about 90% papers of ISR are the outcome of co-authorship behaviors. In contrast, the biggest scale of author number in a single article is 15.4% from MISQ, which indicates about 85% papers of MISQ are completed by the means of co-authorship behaviors.

Number of authors		Distribution of number of authors a in single article				
		1	2	3	4	>=5
Number of articles (percent)	Total	254(12.7%)	791(39.6%)	684(34.2%)	205(10.3%)	65(3.3%)
	MISQ	98(15.4%)	282(44.2%)	181(28.4%)	59(9.2%)	18(2.8%)
	ISR	57(10.1%)	227(40.2%)	198(35.1%)	67(11.9%)	15(2.7%)
	JMIS	99(12.4%)	282(35.4%)	305(38.3%)	79(9.9%)	32(4.0%)

Table 4. Statistical analysis of collaborated articles published in the three top journals

The average collaboration degree of articles refers to the average number of co-authors of these articles in a certain period (Zhai et al. 2013). In order to understand the historical changing rules of collaboration degree, we drew the evolution chart of collaboration degree of articles published in the three top journals from 1993 to 2012 (see Figure 1). From Figure1 we can see that collaboration degree of articles published in the three elite journals fluctuated from 1.89 to 3.04. The whole curve rises as a whole which means collaboration behaviors are popular among scholars in the field of IS. Through collaboration behaviors, researchers have the opportunities to share their knowledge (Abbasi et al. 2011). Combining distributed knowledge and methodology together, collaboration among scholars has an irreplaceable role in the process of knowledge creation (Heinze and Kuhlmann 2008).

In order to learn the evolution of average distance in the whole co-authorship network of the three top journals, we draw the Figure 2. The average distance is affected by two kinds of newly added links:

the external links and internal links (Elmacioglu and Lee 2009). By establishing new paths between new vertices and the existing ones, the external links have a significant impact on increasing the average distance, while by cresting new paths between the existing vertices, the internal links play an important role in decreasing the average distance. Affected by the two fundamentally different types of newly added links, the average distance presents a series of changes. As is shown in Figure 2, by the year of 2012, the average distance achieves 5.85 with 2298 authors. This implies that one scholar in the network only needs five or six steps to reach another one, demonstrating character of "small world" which is first proposed by Milgram (1967).

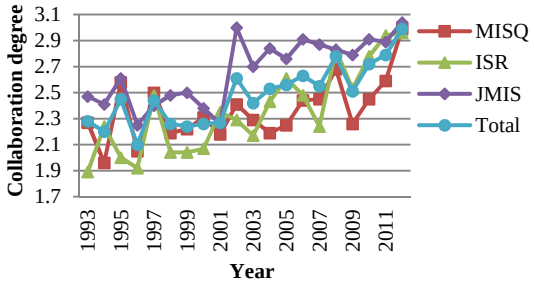

Figure 1. Evolution of collaboration degree of articles published in the three top journals

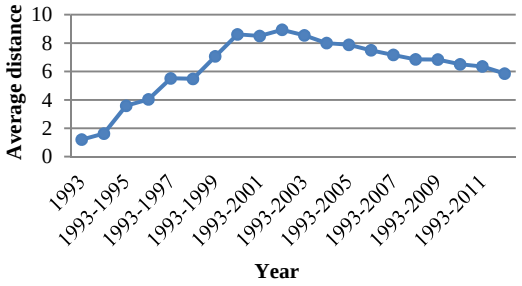

Figure 2. Evolution of the average distance in the whole co-authorship network

The density of a graph is defined as the ratio of the actual number of edges and the maximum possible number of edges (Newman 2010). Table 5 illustrates the evolution of the network density of the whole co-authorship network. As Table 5 shows, the whole co-authorship network density in information systems faces a tendency of decline, from 0.0043 to 0.0016. After analysis, we found that the primary cause is the number of scholars joining the collaboration network has been increased, from 576 to 2298, which leads the maximum possible number of edges goes up rapidly. Nevertheless, since growth rate of the number of collaboration among scholars in the network is relatively limited, the network density goes down. In addition, compared with some other scholarly networks (Ronda-Pupo and Guerras-Martin 2010; Zhai et al. 2013), this network density is relatively low and is sparsely connected. Since network density describes the general level of connection among vertices in the network (Liu et al. 2011), this result means that in the field of IS, the scholarly relationship among authors is not so close. This phenomenon may be related to the diversification of the research topics in the field of IS and scholars with the same research topic tend to produce more cooperation.

Years	1993-1997	1993-2002	1993-2007	1993-2012
Network density	0.0043	0.0028	0.0020	0.0016

Table 5. Evolution of network density of whole co-authorship network

In order to address the issues about the trend of authorship change over the years, we divided the time period into four pieces and we draw Figure 3~6 and illustrate related details in Table 6. There are 132 components during 1993 to 1997 and the number has increased to 205 up to the year 2012. The scale of the biggest component keeps increasing all the time and has not stepped into a mature and steady stage, which is much larger than the scale of the second one. These results indicate that more and more new scholars join in the co-authorship network and old scholars who have not collaborated before have built new relationship collaboration. There are several possible explanations for this

phenomenon，including broad international collaboration in the IS research community, increase in the number of cross between different research subjects, the relative maturity of the IS field and so on. With more and more scholars publishing excellent articles in the field of IS and the increase of collaboration behaviors among scholars, the proportion of the biggest connect component will become larger and larger.

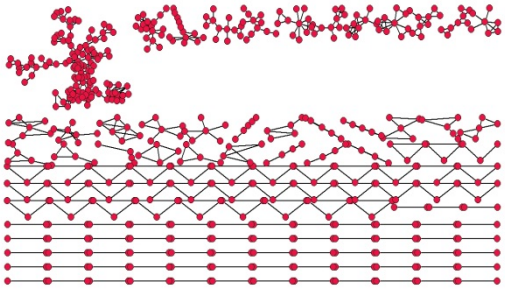

Figure 3. Collaboration authors network in information systems from 1993 to 1997

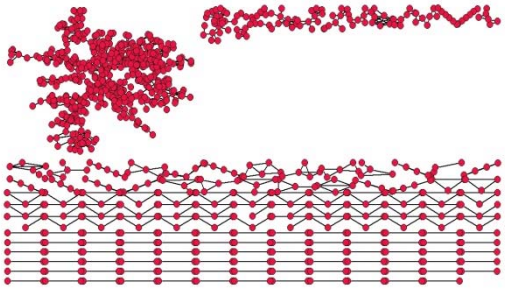

Figure 4. Collaboration authors network in information systems from 1993 to 2002

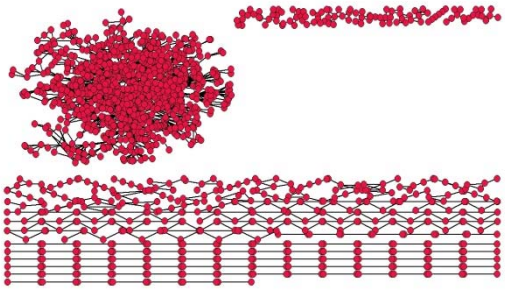

Figure 5. Collaboration authors network in information systems from 1993 to 2007

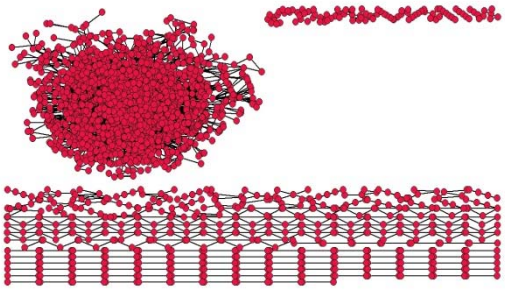

Figure 6. Collaboration authors network in information systems from 1993 to 2012

Year	Number of components	Scale and percentage of the biggest component	Scale and percentage of the second biggest component
1993-1997	132	121 (21%)	18 (3.1%)
1993-2002	155	514 (50.6%)	24 (2.4%)
1993-2007	175	993 (64.6%)	10 (0.7%)
1993-2012	205	1677 (73%)	12 (0.5%)

Table 6. Evolution of proportion of the first and second biggest connect components in the whole co-authorship network of the three top journals

4.2 Analysis of the individual level

As is well known, in the field of scientometrics, one of the key indexes to evaluate a scholar's contribution is his or her number of published articles (Zhai 2013). Figure 7 indicates that about 65% scholars published only one article while only 2% scholars published more than ten articles in the three elite journals. Most scholars (about 94%) published no more than five articles. The distribution of the number of articles published in the three elite journals displays "long tail" phenomenon. One of

the reasons is that the publication frequency of the premier journals are too long and top journals in the field of information systems need to publish bimonthly (Valacich et al. 2006). In this situation, the competition of publishing an article in elite journals is very fierce and a new-come scholar has more difficulties to overcome the excellent scholars.

From Table 7 we can find out that the maximum value of the published number of articles, betweenness centrality and degree centrality is that of Izak Benbasat. In order to learn the reason behind the phenomenon, we abstract the papers written by Izak Benbasat and other scholars and draw the co-authorship network as is shown in Figure 8. There are as much as 46 authors in the whole network. The average degree centrality is 3 which means that each scholar has three connections with others on average. The average distance is 1.932 which indicates that one scholar in the network only needs two steps to reach another one and it does not present the character of "small world". This is because that the network is not big enough, which shows the characteristics of the star network.

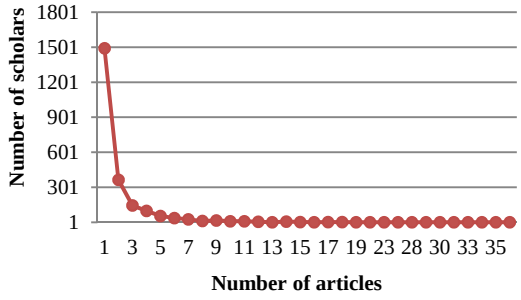

Figure 7. Distribution of number of scholars publishing articles in the three top journals

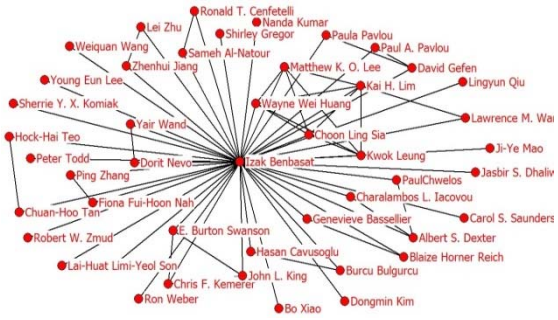

Figure 8. Collaboration network of Benbasat and his co-authors in the three top journals

Table 7 shows the top ten authors ranked by the published number of articles, degree centrality and betweenness centrality in the three elite journals in the last two decades, which takes five years as the unit. Analysis from the three perspectives, a minority of scholars maintain top ten in the three elite journals from 1993 to 2012, while some authors who never appeared in the earlier stage rank highly in the later years. These results might be due to the fact that elder scholars have retired and younger scholar will board on the stage of history and play a pivotal role with time goes on (Chen 2013). As is shown in Table 7, the lists of authors ranked by the published number of articles, betweenness centrality and degree centrality are quite different from each other. The reasons behind the differences among the three indicators are described as follows. Authors' published number of articles identifies the amount of the outcome of researchers. Degree centrality features the number of attachments of vertices in the network. Whereas betweenness centrality measures the importance of a vertex corresponding to the number of paths in which the vertex participates in the network. Vertices with high betweenness centrality are the connectors and brokers who bring others together (Yin et al., 2006). The selection of the indicators depends on the purpose of the researchers' study.

	Number of published articles		Degree centrality		Betweenness centrality	
1993-1997	Varun Grover	13	Joseph S. Valacich	18	Gordon B. Davis	4397
	William J. Kettinger	9	Gordon B. Davis	16	Joseph S. Valacich	3640
	Magid Igbaria	8	Dennis R. Goldenson	15	Alan R. Dennis	3414
	Eric K. Clemons	8	Varun Grover	14	Jay F. Nunamaker	2273

	Jack J. Baroudi	7	Alan R. Dennis	13	James C. Brancheau	1664
	James T. C. Teng	7	Jay F. Nunamaker	12	Ralph H. Sprague Jr.	1575
	Jay F. Nunamaker	6	J. Daniel Couger	11	Dale L. Goodhue	1575
	Tor Guimaraes	6	Joyce Currie Little	9	Varun Grover	1529
	Sirkka L. Jarvenpaa	6	K. S. Raman	9	Douglas R. Vogel	1502
	Joseph S. Valacich	6	David L. Feinstein	9	Ronald L. Thompson	1484
1993-2002	Varun Grover	21	Alan R. Dennis	24	Detmar W. Straub	51187
	Alan R. Dennis	16	Jay F. Nunamaker	22	Bruce W. Weber	36807
	Eric K. Clemons	15	Varun Grover	20	Eric K. Clemons	36412
	Izak Benbasat	15	Joseph S. Valacich	19	Alan R. Dennis	33499
	Jay F. Nunamaker	11	Douglas R. Vogel	17	Joseph S. Valacich	33165
	Robert J. Kauffman	10	Gordon B. Davis	17	Richard T. Watson	33085
	Sirkka L. Jarvenpaa	10	Tridas Mukhopadhyay	16	Gordon B. Davis	27471
	Magid Igbaria	10	Mark Keil	15	Robert J. Kauffman	24987
	Detmar W. Straub	9	Starr Roxanne Hiltz	15	Tridas Mukhopadhyay	21670
	William J. Kettinger	9	Andrew B. Whinston	13	James C. Brancheau	21416
1993-2007	Izak Benbasat	32	Jay F. Nunamaker	37	Jay F. Nunamaker	100765
	Varun Grover	26	Varun Grover	27	Alan R. Dennis	71426
	Jay F. Nunamaker	23	Alan R. Dennis	27	Robert W. Zmud	70561
	Eric K. Clemons	22	Izak Benbasat	25	Carol S. Saunders	53277
	Alan R. Dennis	21	Gordon B. Davis	22	Izak Benbasat	50859
	Robert J. Kauffman	21	Robert W. Zmud	22	Varun Grover	50680
	Andrew B. Whinston	17	Andrew B. Whinston	21	Vallabh Sambamurthy	49973
	Robert O. Briggs	16	Tridas Mukhopadhyay	21	M. S. Krishnan	49609
	Robert W. Zmud	15	Robert J. Kauffman	21	Traci A. Carte	49582
	Detmar W. Straub	14	Joseph S. Valacich	21	Tridas Mukhopadhyay	49387
1993-2012	Izak Benbasat	49	Izak Benbasat	55	Izak Benbasat	261152
	Robert J. Kauffman	35	Alan R. Dennis	50	Alan R. Dennis	243793
	Andrew B. Whinston	33	Jay F. Nunamaker	49	Alok Gupta	179185
	Varun Grover	33	Detmar W. Straub	40	Jay F. Nunamaker	163599
	Jay F. Nunamaker	32	Varun Grover	39	Detmar W. Straub	143044
	Alan R. Dennis	30	Andrew B. Whinston	39	Ritu Agarwal	114728
	Ritu Agarwal	29	Robert J. Kauffman	38	Robert J. Kauffman	108495
	Detmar W. Straub	28	Ritu Agarwal	38	Vallabh Sambamurthy	103915
	Eric K. Clemons	26	Alok Gupta	34	Rajiv D. Banker	94471
	Robert O. Briggs	23	Vallabh Sambamurthy	29	Andrew B. Whinston	90371

Table 7. Top ten authors ranked by the number of published articles in the three top journals

4.3 Analysis of the institutional level

Performance evaluation is an inevitable function of management at institutional level. All of the research institutions pursue good reputation since good reputation can attract high qualified students from all over the world, introduce outstanding scholars, and obtain government funding and social donation (Abbasi et al. 2011). The number of high-level papers published in the elite journals is one of

the key indicators that reflects the research capability of the research institutions. From Figure 9 we can find that 401 institutions (55%) publish only one paper. Specifically, Georgia State University is the most productive institution that published 103 papers. 92 institutions (12%) published more than ten papers in the three elite journals while most institutions (80%) published less than six articles. As is explained later, this phenomenon demonstrates that there are many excellent scholars in some institutions who contribute greatly to the reputation of the institutions.

Figure 10 illustrates the collaboration network of institutions in the field of information systems from 1993 to 2012, which provide us an overall image of the network. As is described before, there are 733 unique institutions in the network. After analysis we find that there are 44 components in the network. The largest one contains 664 points (about 90.6%) while the scales of others are all less than three. The results are similar with those of the network of Medline, whose size of giant component obtains 92.6% of the total volume (Newman 2001a).

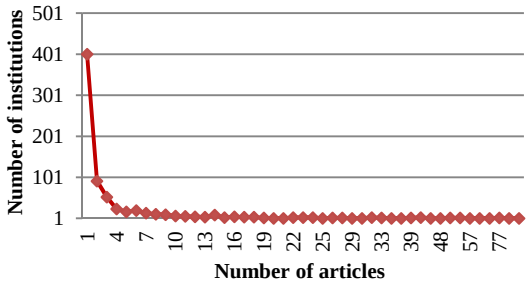

Figure 9. Distribution of number of institutions publishing articles in the three top journals

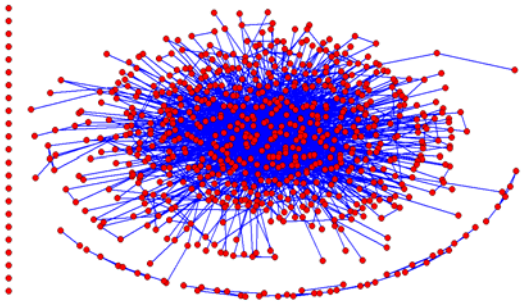

Figure 10. Collaboration institutions network in information systems from 1993 to 2012

When analyzing the evolution law of institution collaboration networks, we found that a few famous institutions maintain their leading position in the top ten lists. Since the outcomes of institutions come from scholars, famous institutions should have some outstanding scholars who constitute the hubs in the co-authorship network. Accordingly, these institutions may occupy more human resources. Take University of British Columbia and University of Texas for instance, Professor Izak Benbasat, Andrew B. Whinston, and Sirkka L. Jarvenpaa, etc. are all famous scholars in the field of IS. Besides, the ranking of an entire institution can be influenced by even one or two authors (Chen et al. 2013). For example, Professor Ritu Agarwal published 26 articles which occupy about 34% of University of Maryland. University of British Columbia has totally published 71 articles. Among all the 71 articles, there are 49 articles (69%) written by Professor Izak Benbasat.

1993-1997		1993-2002		1993-2007		1993-2012	
New York University	23	University of Arizona	37	Georgia State University	60	Georgia State University	103
University of Arizona	20	University of Georgia	35	University of Arizona	54	University of Arizona	85
University of Georgia	18	Georgia State University	33	University of Minnesota	50	University of Minnesota	77
University of South Carolina	16	New York University	29	University of British Columbia	45	University of Maryland	77

University of Colorado	14	University of Minnesota	26	New York University	42	University of British Columbia	71
Carnegie Mellon University	12	University of Pennsylvania	24	University of Georgia	42	Carnegie Mellon University	66
University of Minnesota	12	University of California	24	University of California	40	University of California	57
University of California	11	Indiana University	24	Indiana University	40	University of Georgia	56
University of Pennsylvania	11	University of British Columbia	23	University of Maryland	38	New York University	56
National University of Singapore	11	University of Colorado	23	University of Texas	36	National University of Singapore	55

Table 8. Institution ranking of number of articles published in the three top journals

4.4 Analysis of the national level

In order to know the distribution of number of countries publishing articles in the three top journals in the last two decades, we illustrate the details in Figure 11. The most fertile countries or regions are USA, Canada and Hong Kong, with 1495, 198 and 104 papers respectively. These three countries and regions obtain 82% of the total papers, while some other countries just have one paper. This result means that quite a lot of outstanding scholars and educational resources concentrate upon USA, Canada and Hong Kong, especially USA, which holds eight institutions of the top ten. As a result, these three countries and regions may be the first choice for visiting scholars of IS.

In order to learn the collaboration network of countries, we draw Figure 12. From Figure 12 we can find that there is only one isolated country named Luxembourg, indicating that the isolated country does not collaborate with other countries. This result means that collaboration behaviors are popular all over the world. As is illustrated in Figure 12, eight of the top ten countries and regions, which are USA, Canada, Hong Kong, Singapore, Korea, UK, Australia, and Netherlands, are the center of the network, and USA is the absolute core of the network.

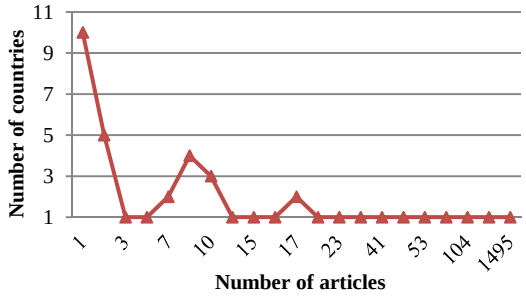

Figure 11. Distribution of number of countries publishing articles in the three top journals

Figure 12. Collaboration countries network in information systems from 1993 to 2012

As is illustrated in Table 9, eight of the top ten countries and regions, which are USA, Canada, Hong Kong, Singapore, Korea, UK, Australia, and Netherlands, maintain their leading position throughout the twenty years. In the four time periods, USA has 280, 571, 953 and 1495 articles, respectively, which are far beyond than that of any other countries or regions. Some countries, such as China

(mainland) and Germany, join the list of top ten countries, and this indicates that the level of scientific research of the two countries have gained considerable development in recent years.

1993-1997		1993-2002		1993-2007		1993-2012	
USA	280	USA	571	USA	953	USA	1495
Canada	41	Canada	75	Canada	124	Canada	198
UK	17	Singapore	26	Singapore	46	Hong Kong	104
Singapore	14	UK	24	Hong Kong	43	Singapore	86
Hong Kong	8	Hong Kong	24	UK	29	Korea	53
Netherlands	6	Netherlands	16	Korea	26	UK	43
New Zealand	5	Australia	15	Australia	24	Australia	41
Korea	5	Korea	14	Netherlands	22	Netherlands	34
Australia	5	France	8	Taiwan	11	China(mainland)	23
Israel	4	New Zealand	8	New Zealand	10	Germany	22

Table 9. Top 10 Frequencies of countries or territories ranked by the number of articles published in the three top journals

5 CONCLUSIONS AND LIMITATION

Based on all 1745 papers published in the international journals of MIS Quarterly, Information Systems Research and Journal of Management Information Systems from 1993 to 2012, this paper analyzed the evolution of collaboration networks in the field of IS. Through scientometrics and social network approaches, we carried out a detailed analysis and got the following conclusions.

Generally speaking, approach 90% papers were written by two or more authors, which means that cooperation is an universal phenomenon in the field of IS. The average collaboration degrees of the three elite journals are increasing slowly over the years with a few exceptions. This result indicates that the collaboration behavior of researchers in the field of IS is augmenting with time. Most scholars (94%) published no more than five articles while only 2% scholars published at least ten articles in the three elite journals. The number of articles published by scholars and institutions in the three elite journals all display a “long tail” phenomenon. The number of components is growing with more and more scholars joining the co-authorship network as time goes on.

By the year of 2012, the average distance achieves 5.85 in the collaboration authors’ network, showing character of “small world” which is first proposed by Milgram (1967). Through analyzing outcomes of excellent scholars in famous institutions, we demonstrate that the ranking of an entire institution can be influenced by even one or two authors and the similar conclusion can be found in Chen et al. (2013). We found that USA, Canada and Hong Kong are the three dominate countries in terms of outstanding scholars and educational resources concentrate, especially USA, which holds eight institutions of the top ten.

These three journals are different a lot in terms of levels and the number of issues, so when we discuss the geographic locations or productivity issues of authors, it may create bias. When considering the significance and the number of issues in each journal, further studies will collect data from more journals (e.g., MISQ, ISR, JMIS, JAIS, EJIS, ISJ) to make our analysis more accurate.

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