Received 15 November 2018
Revised 23 November 2018
Accepted 14 December 2018

The evolution of *Industrial Management & Data Systems* over the past 25 years

A bibliometric overview

Chao Wang
Research Base of Beijing Modern Manufacturing Development, College of Economics and Management, Beijing University of Technology, Beijing, China and
Center for Polymer Studies and Department of Physics, Boston University, Boston, Massachusetts, USA
Longfeng Zhao
School of Management, Xi'an Polytechnic University, Xi'an, China and
Center for Polymer Studies and Department of Physics, Boston University, Boston, Massachusetts, USA
André L.M. Vilela
Universidade de Pernambuco, Escola Politécnica de Pernambuco, Pernambuco, Brazil, and
Ming K. Lim
Centre for Business in Society, Coventry University, Coventry, UK and
College of Mechanical Engineering, Chongqing University, Chongqing, China

Abstract

Purpose – The purpose of this paper is to examine publication characteristics and dynamic evolution of the *Industrial Management & Data Systems* (*IMDS*) over the past 25 years from volume 94, issue 1, in 1994 through volume 118, issue 9, in 2018, using a bibliometric analysis, and identify the leading trends that have affected the journal during this time frame.

Design/methodology/approach – A bibliometric approach was used to provide a basic overview of the *IMDS*, including distribution of publication and citations, articles citing the *IMDS*, top-cited papers and publication patterns. Then, a complex network analysis was employed to present the most productive, influential and active authors, institutes and countries/regions. In addition, cluster analysis and alluvial diagram were used to analyze author keywords.

Findings – This study presents the basic bibliometric results for the *IMDS* and focuses on exploring its performance over the last 25 years. And it reveals the most productive, influential and active authors, institutes and countries/regions in *IMDS*. Moreover, this study detects the existence of at least five different keywords clusters and discovers how themes have evolved through the intricate citation relationships in *IMDS*.

Originality/value – The main contribution of this paper is the use of multiple analysis techniques from a complex network paradigm to emphasize the time evolving nature of the co-occurrence networks and to explore the variation of the collaboration networks in the *IMDS*. For the first time, the evolution of research themes is revealed with a purely data-driven approach.

Keywords Literature review, Citation analysis, Bibliometric, *Industrial Management & Data Systems*

Paper type Literature review

Industrial Management & Data Systems
Vol. 119 No. 1, 2019
pp. 2-34

0263-5577
DOI 10.1108/IMDS-11-2018-0506

1. Introduction

The *Industrial Management & Data Systems* (*IMDS*) is an international journal that explores and applies the potential of new technologies to all aspects of management activities such as marketing, management information systems, operations management, business strategy, innovation, organization behavior, business process management and supply chain management. *IMDS* is published by Emerald and included in the Journal Citation Reports of Thomson & Reuters Web of Science (WoS). The major aims of *IMDS* are: to provide cross-disciplinary research in the areas of operations management and information systems, to study different range of information systems development and usage in businesses, to promote awareness of new technology and related concepts and their implications in business and to disseminate knowledge for improving operations management practice and to improve the theoretical base necessary for supporting sound management decisions.

In 2014, Professor Hing Kai Chan and Professor Alain Yee Loong Chong, both from the University of Nottingham Ningbo China, became the Editor-in-Chief and they are still leading the journal now. Today, the journal is a leading international peer-reviewed scientific journal focusing on topics treating the interface between operations management and information systems. In 2017, *IMDS* had an impact factor of 2.948 and was ranked in the 11th position out of 44 journals in the WoS category of Engineering, Industrial. The journal also appeared in the WoS category of computer science, interdisciplinary applications in the 26th position out of 105 journals.

In the literature, it is very common to conduct a bibliometric overview of the journal because it gives some general and historical results that permit a retrospective evaluation (Ghadimi *et al.*, 2019). Such bibliometric reviews are especially welcome when the journal reaches an important milestone. Van Fleet *et al.* (2006) performed a study on the first 30 years of the *Journal of Management*. Laengle *et al.* (2017) studied the evolution of the *European Journal of Operational Research* over 40 years of existence. Cancino *et al.* (2017) provided the retrospective evolution of *Computers & Industrial Engineering* between 1976 and 2015 to celebrate its 40th anniversary. Wang *et al.* (2018) presented a general overview of the *International Journal of Logistics Research and Applications* from 1998 to 2017 by using a bibliometric analysis in commemoration of the 20th anniversary of the journal. Ji *et al.* (2018) studied the evolution of the *Resources Conservation and Recycling* over the past 30 years. Such analysis and information present an added value for the journals. To the best of our knowledge, bibliometric analysis has not yet been applied to analyze the development and evolution of *IMDS*.

Therefore, as an expansion of the previous studies, the main purpose of this study is to provide a general overview of *IMDS* journal over the past 25 years through bibliometric analysis since it was indexed by WoS from 1994 to now (2018). The main objective of this paper is to reveal the contribution of *IMDS* to scientific research and its most influential thematic work in operations management and information systems. This bibliometric study addresses the following research questions:

RQ1. What are the distributions of publications and citations across the time period?

RQ2. Which journals are citing IMDS articles?

RQ3. Which are the top-cited papers of the IMDS?

RQ4. What are the publication patterns of the IMDS?

RQ5. Who are the most productive, influential and active authors, institutes and countries/regions?

RQ6. What is the evolution of themes in the IMDS?

This work justifies *IMDS*'s contribution to the cross-disciplinary research in the areas of operations management and information systems, and support strategic decisions for potential authors, readers and journal editors. The remainder of the paper is structured as follows. Section 2 describes the data sources used in the analysis, and briefly reviews the bibliometric methodology and topological parameters for a complex network. Section 3 presents the basic bibliometric results for the *IMDS* and focuses on exploring its performance over the last 25 years. Section 4 reveals the most productive, influential and active authors, institutes and countries/regions by using the citation analysis and co-occurrence networks. Section 5 detects the author keywords clusters and discovers the evolution of research themes in *IMDS*. Concluding remarks are summarized in Section 6.

2. Database and methodology

2.1 Database

Industrial Management & Data Systems appeared online in Emerald Publishing from volume 80 issue 9 in 1980 and was indexed by the WoS database from volume 94, issue 1, in 1994. Compared with Scopus and Google Scholar, WoS is recognized with the highest quality in the three major bibliometric databases (Jacso, 2005). To guarantee a similar high-quality level for the papers, this paper only studied the publications from 1994 (volume 94, issue 1) to now (2018, volume 118, issue 9). A total of 1,668 articles were retrieved with six different document types. There were 1,616 research articles comprising 96.88 percent of the total production, followed by book reviews (24; 1.44 percent), editorials (12; 0.72 percent), erratum (9; 0.54 percent), publisher's notes (4; 0.24 percent) and awards for excellence (3; 0.18 percent). It is likewise worth highlighting that only "research articles" were taken into consideration; that is, only research papers were subject to a peer review process.

From these 1,616 articles, we extracted the title of publication, authors, institutes, countries/regions of origin, author keywords associated with the publication, year of publication, volume and issue of the journal and built a database in Microsoft Excel 2013. It is noted that, for convenience's sake, People's Republic of China is shortened to Mainland China, Hong Kong Special Administrative Region of the People's Republic of China is shortened to Hong Kong, and Taiwan, China is shortened to Taiwan in this study. For the number of citations, WoS was used to collect citations in October 2018. The results give a picture of the current situation, but may change over time, particularly for the most recent publications for which impact may still be growing.

2.2 Bibliometric methods

Bibliometric methods use bibliographic data from publication databases to construct structural images of scientific fields (Zupic and Čater, 2015). They are also effective ways to describe, evaluate and monitor published research in a journal. Bibliometric methods have traditionally been divided into two categories according to whether they yield activity or relationship indicators. The former provide the data relating to the force of impact or strength of influence of research efforts, while the latter trace the links and interaction between different researchers and different fields of research (Ramos, 2004).

Co-occurrence network analysis based on graph theory can be adapted to map the relationships between various nodes and detect the network structure (Boccaletti *et al.*, 2006). In the bibliometric mapping, a node can be an author, an institute, a keyword or even a country/region, where links can take the form of authorship. The co-occurrence network can be also used to discover the scientific collaboration relationship and the status of individual researchers. Several software packages have been developed, such as UCINET®, Pajek®, VOSviewer® or Gephi®, which are able to construct a large co-occurrence network by means of, for example, zoom functionality, special labeling algorithms, and density metaphors (Van Eck and Waltman, 2009). In this study, Gephi® was used to visualize and represent these networks. It can deal with large networks (i.e. over 20,000 nodes) and, because it is built on a multi-task model, it takes advantage of multi-core processors (Bastian *et al.*, 2009). The program is freely available to the bibliometric research community (see https://gephi.org).

2.3 Basic topological parameters for complex networks

For a network $G(V, E)$ with vertex number N_v and edge number N_e, the following topological parameters can serve as tools to capture its basic topology structure. The network density ρ can be defined as the ratio between the actual edges and the total possible edges. The network information can be presented as a matrix representation of a graph. A network will be fully determined by its $N \times N$ adjacency matrix A, where each entry $a_{ij}(i, j = 1, 2, ..., n)$ is equal to 1 when there is a link between nodes i and j, and zero otherwise. Also, any element a_{ij} can assume other non-zero values representing the weight of the edge between i and j in a weighted network.

2.3.1 Node (weighed) degree, (weighed) degree distribution and heterogeneity. The degree of a node i is denoted as k_i, which is the number of edges connected with the node. In the context of co-occurrence network, the degree means the number of collaborators, i.e., the number of co-authors, institutes and countries/regions that collaborate with a specific researcher, institute or country/region. For a weighted network, the weighed degree or the strength of the node i is denoted as s_i, which refers to the collaboration strength (number of papers) between two researchers, institutes or countries/regions. The degree is defined in terms of the adjacency matrix A, $k_i = \sum_{j \in V} a_{ij}$. Then, the average degree is defined as the mean value of the degree sequence of a network: $K = \langle k \rangle = 1/N_e \times \sum_{j \in N} k_i$.

Usually one can use the degree distribution of a network to characterize the overall connectivity of the network. The degree distribution $P(k)$ is defined as the probability that a node – chosen uniformly at random from the set of all nodes – has a degree k. The distribution $P(k)$ is also related to the fraction of nodes that having degree k in the network. It is found that the degree distributions of many real-world networks are very heterogeneous. The heterogeneity of the degree distributions reminds us of the similarity between these networks and the scale-free network, which is the state-of-the-art model in network science for the interpretation of the power law distribution of many real-world networks. The scale-free network can be characterized by a single parameter – the power law exponent. But in many real situations, we cannot determine the power law exponent since many heterogeneous networks are not exactly in the scale-free class. Thus, here we adopt the heterogeneity index proposed in Estrada (2010), which is defined by the following equation:

$$H = N - 2\frac{\sum_{i,j \in e}\left(k_i k_j\right)^{-1/2}}{N - 2\sqrt{N-1}}. \quad (1)$$

2.3.2 Shortest path length and diameter. Shortest path length is a metric that has a decisive influence on the communication performance of a network. The shortest path length between two nodes i and j is denoted as d_{ij}, and it is the shortest path to reach j from i or vice versa. The maximum shortest path length between all couples of nodes is the so-called diameter of a network, represented by Diam(G). The average shortest path length of the whole network is also known as characteristic path length, which is defined as the mean geodesic distance between all couples of nodes:

$$L = \frac{\sum_{i,j \in N, i \neq j} d_{ij}}{N(N-1)}. \quad (2)$$

2.3.3 Clustering coefficient. The clustering coefficient is also known as transitivity that can quantify the connectivity among the neighbors of a node. If two nodes have a common connected node, they are more likely to be connected with each other.

It can be defined as the ratio between the number of triangles and the number of connected triples of nodes:

$$t = \frac{3 \times (\text{No. of triangles in } G)}{\text{No. of connected triples of vertices in } G}. \quad (3)$$

An alternative local definition for each node i was proposed by Watts and Strogatz (1998). It is defined as the ratio between the number of edges e_i, related to the subgraph G_i of the neighbors of node i, and the maximum possible number of edges in G_i:

$$c_i = \frac{2e_i}{k_i(k_i-1)} = \frac{\sum_{j,m} a_{ij} a_{jm} a_{mi}}{k_i(k_i-1)}. \quad (4)$$

Thus, the clustering coefficient of the whole network is then given by the average of c_i:

$$C = \langle c \rangle = \frac{\sum_{i \in N} c_i}{N}. \quad (5)$$

2.3.4 Assortativity. The assortativity of a network is a metric that depicts the correlation between nodes that have similar characteristics, such as degree, strength or any other values that are vertex specified. Here, we use the degree assortativity proposed by Newman (2002). The degree assortativity coefficient is defined as follows:

$$r_d = \frac{1}{\sigma_q^2} \sum_{jk} jk\left(e_{jk} - q_j q_k\right), \quad (6)$$

where $q_k = (k+1)p_{k+1} / \sum_j j p_j$ is the distribution of the remaining degree and $\sigma_q^2 = \sum_k k^2 q_k - \left[\sum_k k q_k\right]^2$ represents its variance.

The assortativity is normalized in the range [−1, +1]. A positive value means nodes with similar degree connect preferably. A negative value means the network is disassortative, i.e., nodes with low degree tend to connect with highly connected nodes.

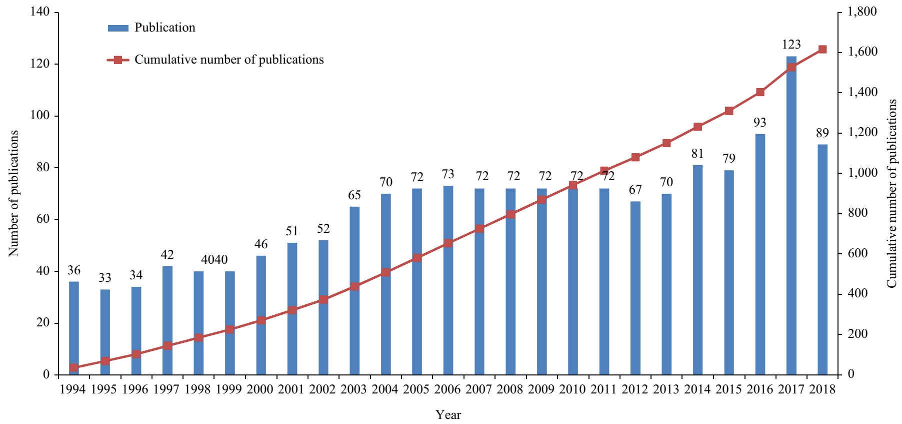
3. Basic bibliometric analysis

3.1 Publications and citations across the time period

Since the first publication in 1994, the number of total articles published in *IMDS* is 1,616. In the 1990s, the number of articles published was around 38 per year. In the 2000s, the number of articles published increased to around 65 per year. After 2010, the number of articles published increased to around 80 per year, as shown in Figure 1.

There are several approaches to measure the influence and impact of papers. One of the most straightforward methods is to determine the number of citations for an article. However, one of the drawbacks of this method is that, typically, older papers are expected to have higher citation rates. In addition, the articles' electronic accessibility also plays an influential role. Allowing for these initial limitations, it was decided to evaluate the papers on citation count. Figure 2 shows the number of citations of all the articles received per year. As illustrated, most citations occurred from 2000 to 2012, totaling 82.31 percent of all citations. In the 2000–2012 date range, 1,638 is the average number of citations per year.

Next, let us consider the annual citation structure of *IMDS*. To do so, we examine several specific citation thresholds to establish the number of articles published in each year that have exceeded each of the respective thresholds. In Table I, we present the results.



Note: There is a dip in 2018 as data were collected only up to October 11, 2018

Figure 1.
The number of publications per year across the period studied

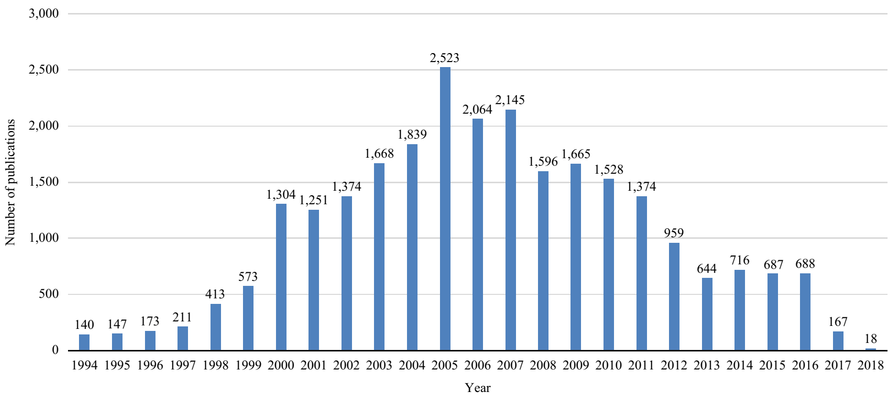


Figure 2.
The number of citations for the articles per year

Table I shows that the journal is able to maintain an impressive level of citations over the past 25 years, with each paper having 16 citations on average. Obviously, the contributions from recent years still need some time to catch up. It is worth noting that most of the highly-cited papers have been published from 2000 to 2007. Around 1.67 percent of the papers have received one hundred citations or more. Around 63.92 percent of the papers received at least five citations, and 88.43 percent have received at least one citation. In total, the journal has received 26,000 citations since the journal was indexed in the WoS database from 1994.

3.2 Analysis of articles that cite the IMDS

Another interesting topic is to track where *IMDS* is cited. This criterion can reveal the spreading of *IMDS*'s academic influence. As depicted in Section 2, we use the citation report provided by WoS to conduct the analysis in this section. Table II presents the 25 journals, years, institutes and countries/regions that have most articles citing *IMDS*.

IMDS is the journal with the highest number of articles citing *IMDS*. This finding is not surprising and quite logical as the material appearing in *IMDS* tends to influence future research in the same journal. The *International Journal of Production Economics*,

Year	⩾100	⩾50	⩾20	⩾10	⩾5	⩾1	TP	TC	TC/TP	IF
1994	0	0	1	2	10	30	36	140	3.89	–
1995	0	0	2	4	9	27	33	147	4.45	–
1996	0	0	1	4	13	31	34	173	5.09	–
1997	0	0	1	6	17	34	42	211	5.02	–
1998	0	2	7	13	21	35	40	413	10.33	–
1999	1	1	7	14	24	33	40	573	14.33	–
2000	4	8	18	27	34	45	46	1,304	28.35	–
2001	2	6	21	32	43	50	51	1,251	24.53	–
2002	1	8	26	37	44	51	52	1,374	26.42	–
2003	2	7	27	50	58	65	65	1,668	25.66	–
2004	3	9	29	54	60	70	70	1,839	26.27	–
2005	4	17	28	57	66	72	72	2,523	35.04	–
2006	2	11	38	54	66	69	73	2,064	28.27	–
2007	4	7	33	57	68	72	72	2,145	29.79	–
2008	0	7	29	50	66	72	72	1,596	22.17	0.945
2009	1	9	28	50	59	71	72	1,665	23.13	1.535
2010	1	9	25	44	64	71	72	1,528	21.22	1.569
2011	1	2	20	39	62	72	72	1,374	19.08	1.472
2012	0	1	15	36	58	67	67	959	14.31	1.674
2013	0	0	6	26	46	67	70	644	9.20	1.345
2014	0	0	8	28	58	77	81	716	8.84	1.226
2015	0	1	9	19	48	74	79	687	8.70	1.278
2016	1	2	4	12	33	84	93	688	7.40	2.205
2017	0	0	0	1	6	75	123	167	1.36	2.948
2018	0	0	0	0	0	15	89	18	0.20	–
Total	27	107	383	716	1,033	1,429	1,616	25,867	16.01	
%	1.67	6.62	23.70	44.31	63.92	88.43				

Notes: TP is total number of publications; TC is total number of citations; TC/TP is number of cites per publication; % is percentage of publications. IF is impact factor, which is obtained from annual Journal Citation Reports

Table I.
Annual citation structure of *IMDS*

International Journal of Production Research and *Journal of Cleaner Production* cite *IMDS* frequently, with 281, 279 and 190 articles, respectively. In general, operations management journals are prominent although some general management journals also have respectable figures for their *IMDS* cites.

With respect to different countries/regions, USA, Mainland China and UK are unsurprisingly the countries/regions that cite *IMDS* the most. However, some unexpected countries/regions appear in very good positions including Taiwan in the fourth position and Malaysia in fifth. With respect to contributing institutes, The Hong Kong Polytechnic University is the one with the highest number of publications citing *IMDS*, following by Universiti Teknologi Malaysia and Indian Institute of Technology Delhi.

3.3 Top-cited papers across the time

Since its first publication, *IMDS* has published many influential cross-disciplinary articles in the areas of operations management and information systems. Table III provides a list resulting from the citation analysis of the documents most often cited research papers published in *IMDS* during the period analyzed. It is noted that in inter-country/region collaboration column, the sub-column A denotes the internationally collaborative publication, which means the article was co-authored by researchers from more than one country/region and sub-column B denotes single country publication, indicating that the researchers' affiliations were from the same country/region. In the cross-institute

R	Journal	TP	Year	TP	Institutes	TP	Country/ region	TP
1	*Industrial Management & Data Systems*	978	2018	1,706	Hong Kong Polytech University	271	USA	2,377
2	*International Journal of Production Economics*	281	2017	2,227	University Teknologi Malaysia	189	Mainland China	1,877
3	*International Journal of Production Research*	279	2016	2,020	IIT Delhi	161	UK	1,369
4	*Journal of Cleaner Production*	190	2015	1,769	Islamic Azad University	143	Taiwan	1,136
5	*Expert Systems with Applications*	187	2014	1,145	University Malaya	140	Malaysia	1,073
6	*Computers in Human Behavior*	164	2013	989	City University of Hong Kong	133	Spain	1,006
7	*Sustainability-Basel*	149	2012	927	University Sains Malaysia	130	India	822
8	*International Journal of Operations & Production Management*	143	2011	896	State University of Florida	123	Australia	788
9	*Product Plan Control*	133	2010	771	University of North Carolina	122	South Korea	572
10	*Procedia – Social and Behavioral Sciences*	118	2009	753	University of Granada	111	Canada	488
11	*Supply Chain Management*	110	2008	597	National Cheng Kung University	108	Germany	477
12	*Total Quality Management and Business Excellence*	110	2007	422	Louisiana State University	102	Iran	420
13	*Journal of Computer Information Systems*	100	2006	298	University Utara Malaysia	101	Italy	399
14	*Journal of Knowledge Management*	96	2005	225	University Teknologi Mara	96	Brazil	389
15	*International Journal of Information Management*	92	2004	170	University of Texas	94	Turkey	388
16	*International Journal of Mobile Communications*	86	2003	115	Brunel University	90	Finland	360
17	*Benchmarking*	85	2002	49	Monash University	90	Sweden	313
18	*Lecture Notes in Computer Science*	85	2001	32	Multimedia University	89	Portugal	261
19	*Industrial Marketing Management*	80	2000	22	University of Tehran	88	France	245
20	*Information and Management*	78	1999	16	University of Georgia	88	Greece	234
21	*Journal of Business Research*	78	1998	11	University of Massachusetts	86	Netherlands	229
22	*Advanced Science Letters*	76	1997	4	University of Sevilla	80	Indonesia	196
23	*African Journal of Business Management*	76	1996	3	Cardiff University	75	South Africa	196
24	*Internet Research*	71	1995	2	Pennsylvania State System of Higher Education	77	Poland	192
25	*The International Journal of Logistics Management*	69	1994	0	University of São Paulo	76	Thailand	189

Note: *R* means rank

Table II. Number of studies citing *IMDS*

collaboration column, sub-column C denotes inter-institutionally collaborative publication, which means the authors were from different institutes, and sub-column D denotes the single institute publication, indicating that the researchers were from the same institute. The descriptive study of the aforementioned documents shows or supports the following research outcomes:

(1) The study by Wong (2005) would top the ranking of the most cited work with a total of 322 citations received. It is a research paper on analyzing critical success factors for implementing knowledge management in small and medium enterprises (SMEs).

(2) The second most cited paper was published by Low *et al.* (2011) about the investigation of the factors that affect the adoption of cloud computing by firms belonging to the high-tech industry, which has received 249 citations. The eight factors examined in this study were the relative advantage, complexity, compatibility, top management support, firm size, technology readiness, competitive pressure and trading partner pressure.

Table III.
The 30 most cited articles in *IMDS*

R	TC	Title	Author (year)	Inter-country/region collaboration *A*	Inter-country/region collaboration *B*	Inter-institutionally collaboration *C*	Inter-institutionally collaboration *D*	*C/Y*
1	322	Critical success factors for implementing knowledge management in small and medium enterprises	Wong (2005)		X		X	24.77
2	249	Understanding the determinants of cloud computing adoption	Low *et al.* (2011)		X		X	35.57
3	214	Using PLS path modeling in new technology research: updated guidelines	Henseler *et al.* (2016)	X		X		107.00
4	212	Initial trust and online buyer behavior	Chen and Barnes (2007)		X		X	19.27
5	197	Consumer trust, perceived security and privacy policy: Three basic elements of loyalty to a website	Flavián and Guinalíu (2006)		X		X	16.42
6	192	Defining supply chain management: a historical perspective and practical guidelines	Lummus and Vokurka (1999)		X	X		10.11
7	184	Benefits of information sharing with supply chain partnerships	Yu *et al.* (2001)		X		X	10.82
8	181	Adoption of internet shopping: the role of consumer innovativeness	Varma *et al.* (2000)		X		X	10.06
9	176	Perceived security and World Wide Web purchase intention	Salisbury *et al.* (2001)		X	X		10.35
10	169	A conceptual model of supply chain flexibility	Duclos *et al.* (2003)		X	X		11.27
11	160	Acceptance and adoption of the innovative use of smartphone	Park and Chen (2007)	X		X		14.55
12	148	RFID-enabled traceability in the food supply chain	Kelepouris *et al.* (2007)	X		X		13.45
13	147	Knowledge management: practices and challenges	Gupta *et al.* (2000)		X	X		8.17
14	142	B2C e-commerce website quality: an empirical examination	Cao *et al.* (2005)		X		X	10.92
15	142	What drives Malaysian m-commerce adoption? An empirical analysis	Wei *et al.* (2009)		X	X		15.78
16	131	The impact of supply chain management practices on performance of SMEs	Koh *et al.* (2007)	X		X		11.91
17	128	Motivating employees for environmental improvement	Govindarajulu and Daily (2004)		X		X	9.14
18	128	Synthesizing e-government stage models – a meta-synthesis based on meta-ethnography approach	Siau and Long (2005)		X		X	9.85
19	118	Understanding e-business adoption across industries in European countries	Oliveira and Martins (2010)		X	X		14.75
20	117	Assessing risk in ERP projects: identify and prioritize the factors	Huang *et al.* (2004)		X		X	8.36
21	114	Enterprise resource planning: the emerging organizational value systems	Gupta (2000)		X		X	6.33
22	111	Knowledge management metrics	Bose (2004)		X		X	7.93
23	108	Customer relationship management: key components for IT success	Bose (2002)		X		X	6.75
24	107	Toward understanding members' interactivity, trust, and flow in online travel community	Wu and Chang (2005)		X		X	8.23

(*continued*)

				Inter-country/region collaboration		Inter-institutionally collaboration		
R	TC	Title	Author (year)	*A*	*B*	*C*	*D*	*C/Y*
25	101	Supply chain management in theory and practice: a passing fad or a fundamental change?	Chandra and Kumar (2000)		X	X		5.61
26	101	Understanding trust in supply chain relationships	Sahay (2003)		X		X	6.73
27	101	Knowledge management enablers: a case study	Yeh *et al.* (2006)		X	X		8.42
28	98	Six Sigma: concepts, tools, and applications	Raisinghani *et al.* (2005)		X	X		7.54
29	98	Antecedents and consequences of organizational innovation and organizational learning in entrepreneurship	García-Morales *et al.* (2006)		X	X		8.17
30	94	CPFR: an emerging supply chain tool	Fliedner (2003)		X		X	6.27

Note: Abbreviations available in Tables I and II, except for *C/Y* means citations per year

Table III.

(3) Note that Lummus, R.R., from Central Missouri State University and Iowa State University, and Bose, R., from the University of New Mexico both have two papers in this list.

(4) In the top 30 most cited articles, 6 papers are solely authored articles. For the remaining 24 co-authored papers, the single institute publication ranked first in terms of the total publications (11), followed by the single country and inter-institutionally collaborative publication (9) and then internationally collaborative and inter-institutional publication (4).

3.4 Publication patterns

The 1,616 published papers represent the efforts of authors from 67 countries/regions across the world with 78.71 percent of the published articles emanating from ten countries/regions, as shown in Figure 3. We chose to use the country/region of residence of the corresponding author because we believe that the corresponding author was the author most likely to have been the driving force behind the article. When the corresponding author could not be determined in the publication, we choose the country/region of residence of the first author.

As shown in Figure 4(a), around twenty percent of all published papers involved authors from more than one country/region, with this being almost always a collaboration between authors from two countries/regions, except in 50 papers (3.09 percent) where it extended to three and four countries/regions. Figure 4(b) shows that over half of the papers are written by the authors in the same institute. The clear majority of papers are co-authored by authors from two or fewer institutes (84.52 percent). The size of the author teams for these papers is also worth examining, as shown in Figure 4(c). It was most common for an article to have two authors (30.88 percent) and three authors (30.38 percent). The clear majority of papers had four or fewer authors (95.98 percent). Considering the increasing number of cross-national collaborations in the field, it is likely that many future studies published in *IMDS* will involve multiple investigators and the number of co-authors will continue to increase.

4. Authors, institutes and countries/regions analysis in *IMDS*

4.1 Most productive and influential authors, institutes and countries/regions

Besides the authors listed in Table III, many others also have contributed significantly to *IMDS*. Table IV presents a list of the top 15 authors with more than ten publications in *IMDS*. The ranking is based on the author's total number of publications and not on authorship order.

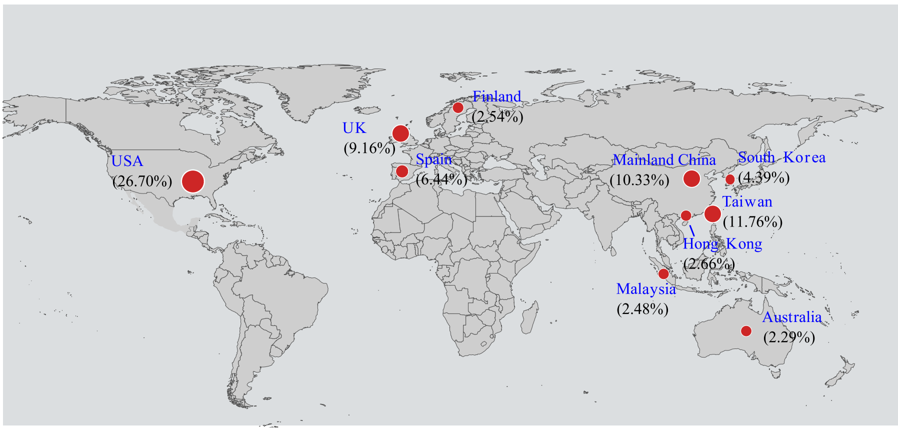


Figure 3.
Country/region of origin of papers published in *IMDS*, 1994–2018

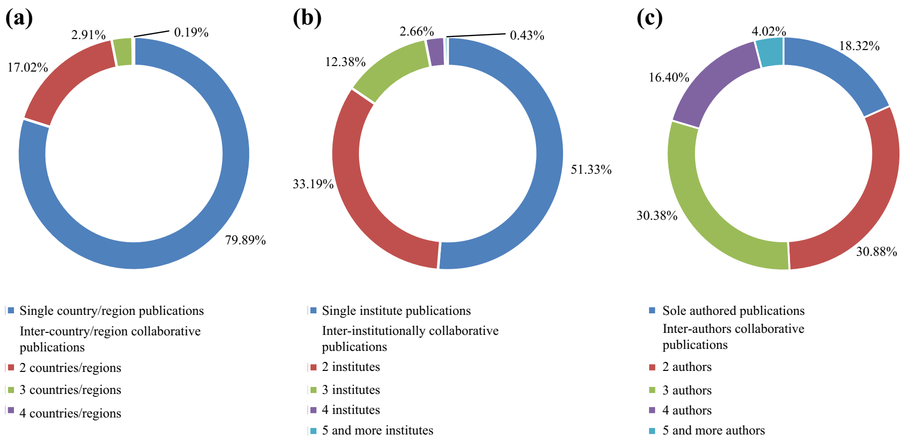


Figure 4.
Publication patterns in *IMDS*, 1994–2018

In order to get a general picture of the results of each author, the table considers several bibliometric indicators for *IMDS* publications: the number of papers, the number of citations, the citations per paper, and *h*-index. With regard to the total number of publications, Phusavat, K., is the most productive author in *IMDS* with 19 articles. With regard to the total number of citations, Vokurka, R.J., is the most influential author in *IMDS* with 599 citations.

A total of 1,088 institutes from all over the world have published in *IMDS*. Table AI presents the most productive institutes which are ranked according to the number of publications of each institute. Each institute has no less than ten publications. The Hong Kong Polytechnic University is the most productive institute with 31 publications, and the National Cheng Kung University is the most influential institute with 804 citations.

Next, we scale our analysis up to the country/region level. The USA is the country with the highest number of publications with 495 in *IMDS*, 8,495 citations, and 14 papers that have been cited at least 100 times with an average of 38.68 citations per publication. The UK also has an average of 2.07 publications and 28.14 citations per million inhabitants. The USA is in a league of its own, the number of publications was more than double its nearest rivals, Mainland China, Taiwan and the UK. Per capita, a number of European countries/regions

Rank	Author	Affiliation	Country/region	TP	TC	TC/TP	*h*
1	Phusavat, K.	Kasetsart University	Thailand	19	269	14.16	–
2	Lee, S.M.	University of Nebraska, Lincoln	USA	15	363	24.20	–
3	Lin, B.S.	Louisiana State University	USA	14	390	27.86	56
4	Ooi, K.B.	Multimedia University	Malaysia	14	488	34.86	50
5	Chan, T.S.	Hong Kong Polytechnic University	Hong Kong	13	98	7.54	–
6	Hilletofth, P.	University of Skövde	Sweden	13	166	12.77	17
7	Zhao, X.D.	South China University of Technology	Mainland China	13	79	6.08	–
8	Huo, B.F.	Zhejiang University	Mainland China	12	72	6.00	23
9	Caputo, A.C.	University of Roma Tre	Italy	12	188	15.67	–
10	Yen, D.C.	Miami University	USA	11	220	20.00	–
11	Pelagagge, P.M.	University of L'Aquila	Italy	11	175	15.91	–
12	Hilmola, O.P.	Turku School of Economics	Finland	11	83	7.55	–
13	Lin, C.H.	National Cheng Kung University	Taiwan	11	164	14.91	–
14	Green, K.W.	Henderson State University	USA	11	180	16.36	27
15	Vokurka, R.J.	Texas A&M University	USA	10	599	59.90	–

Notes: Abbreviations available in Tables I and II. The *h*-index was obtained from GS and "–" means not available

Table IV.
The most productive and influential authors in *IMDS*

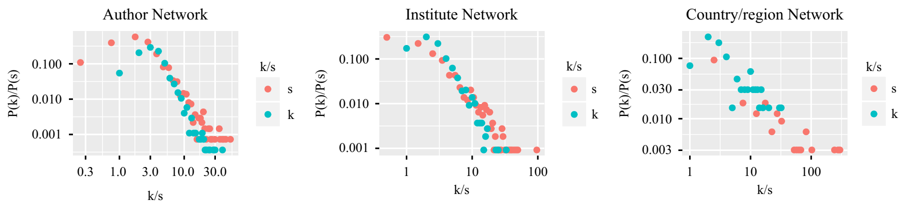
publish well. In particular, researchers in Liechtenstein, Slovenia and Finland contribute significantly to *IMDS*. Exact numbers are given in Table AII. Developing countries/regions are still far away from the leading positions but are starting to increase their profiles, and expectations are that these countries/regions will increase their presence in *IMDS*. Noteworthy are the results of Mainland China, which show strong potential, having grown quickly during the last few years.

4.2 Topological analysis of co-occurrence networks

The degree (strength) distribution will deliver all the information about the connectivity of a network. In Figure 5, we present the degree (strength) distributions for the author co-occurrence network, institute co-occurrence network and country/region co-occurrence network. A common finding is that the heterogeneity degree (strength) distributions which resemble the "rich get richer" phenomena in social science. Most of the authors, institutes and countries/regions are loosely connected with other nodes. Thus, the degree (strength) for most nodes is quite small with only two or three collaborators. However, as seen in the heterogeneity degree (strength) distributions, there exists some hub authors (authors with a lot of collaborators), institutions and countries/regions with very strong connections with other researchers, institutions and countries/regions. The description about these hub authors, institutes and countries/regions will be presented in a highly detailed manner.

The degree (strength) distributions for institute and country/region co-occurrence networks give us a comprehensive description of the tightness of the collaboration among institutes and countries/regions. The heterogeneity degree distribution of the country/region co-occurrence network in Figure 5 shows that over 75 percent of countries/regions collaborate with less than 9 countries/regions. Furthermore, over 50 percent of countries/regions only collaborate with no more than three countries/regions. The same situation applies quite well at the institute and author level, which is consistent with Figure 4 that over 80 percent of institutes (authors) collaborated with no more than 3 other institutes (authors).

In Table V, we present the basic topological parameters for the three co-occurrence networks. It indicates that the three networks have both small-world and scale-free characteristics.



Note: The blue points are the distribution of degree k_i and the red points are the distribution of strength s_i

Figure 5. The degree (strength) distribution of three co-occurrence networks

Table V. The basic topological parameters for three co-occurrence networks

	N_v	N_e	C	L	H	K	ρ	r_d	Diam(G)
Author	2,747	3,772	0.462	6.990	0.117	2.7467	0.001	0.100	25
Institute	1,088	1,275	0.236	5.734	0.287	2.344	0.002	0.058	27
Country/region	66	179	0.323	2.478	0.401	5.424	0.083	−0.232	12

Notes: N_v the number of vertices, N_e the number of edges, C the average clustering coefficient, L average the shortest path length, H the heterogeneity of the network, K the average degree of the network, ρ the network density, r_d is the degree assortativity, Diam(G) the diameter of the network

The high clustering coefficient C and relatively small shortest path length L are the main characteristics of a small-world network. It is well known that the heterogeneity index of the Barabási-Albert (BA) network is 0.11 (Estrada, 2010). However, the heterogeneity index H of these three networks are larger than the BA network, indicating that the network structures are extremely heterogeneous. The average degrees of these three networks are relatively low, which depict the sparse identity of the collaborative relationships among authors, institutes and countries/regions. The assortativity r_d is used to reveal the tendency of nodes to connect to other nodes with a similar degree in the co-occurrence network. We find that the author and institute networks have positive assortativity, which means the most influential authors and institutes are tightly connected with each other. On the contrary, the assortativity index of the country/region network is negative, which may result from the "preferential attachment" property during the formation of the country/region level collaboration. The countries/regions with relatively low research influence are more likely to pursue collaboration with influential countries/regions, such as the UK and USA, to reduce the science gap and improve academic competence.

Figure 6 displays the time series of basic topological parameters for these three co-occurrence networks. The basic trend we can obtain from the vertex and edge numbers is that the total authors, institutes, and countries/regions are gradually increasing.

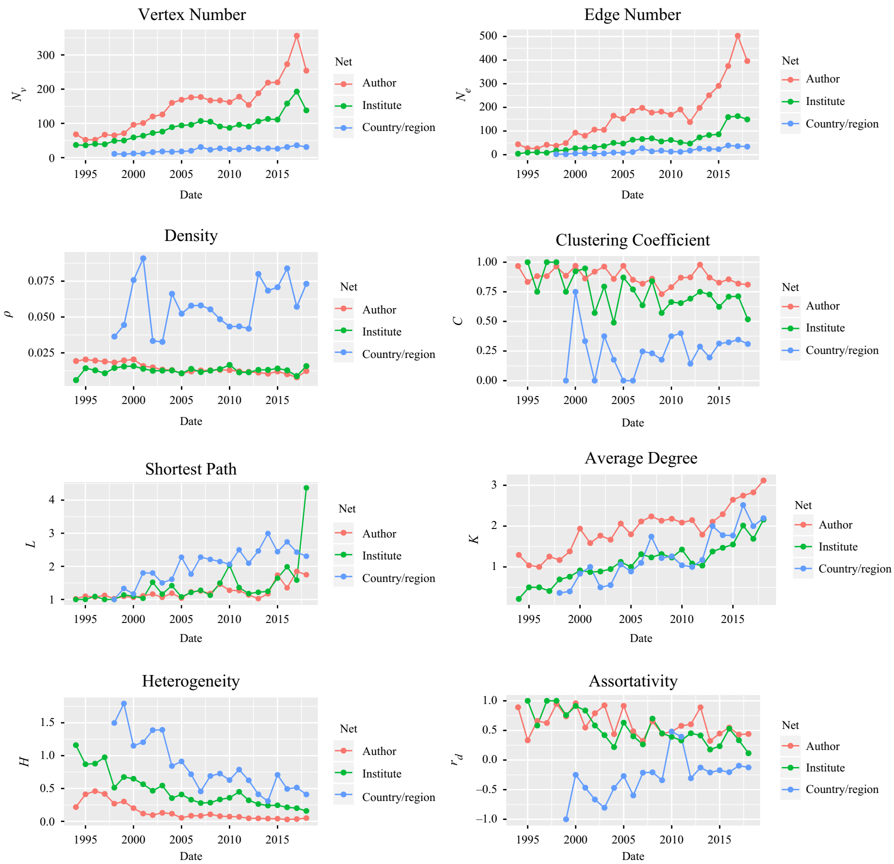


Figure 6.
The yearly topology evolution of the author co-occurrence network from 1994–2018

This witnesses the increasing activity of the research community and the degree of participation from author, institute and country/region levels. Meanwhile, with the increase of the publication quantity, the clustering coefficient always stays at a relatively high level, which depicts the extremely local tightness of the research community. The increase in the shortest path length can be regarded as a signal that the sparsity of the research community has been experiencing a slow increase until the present. This characteristic, together with the decrease of the heterogeneity, as well as the increase of the average degree and density, can be interpreted as the flourishing of collaboration of the research community in *IMDS*.

In general, these topological parameters are evolving in a very similar pattern except the assortativity. The assortativity of the author co-occurrence network is always positive, which means the collaboration among hub authors are very likely to co-author with other hub authors. The assortativity of institute co-occurrence network has the same fluctuation pattern as the author co-occurrence network. Both assortativity indexes decreased to a very large extent after the year 2000, which is a signal of collaboration diversity. In other words, non-influential authors and institutes began to collaborate with hub authors and institutes. When it comes to the country co-occurrence network, the basic topological parameters such as clustering coefficient, shortest path length, heterogeneity, average degree and density evolve quite similarly to the co-occurrence networks at the author and institute levels. Again, an exception is assortativity index. The assortativity index of the country/region co-occurrence network is always negative, which is a basic characteristic of the "preferential attachment" property.

4.3 Author co-occurrence network

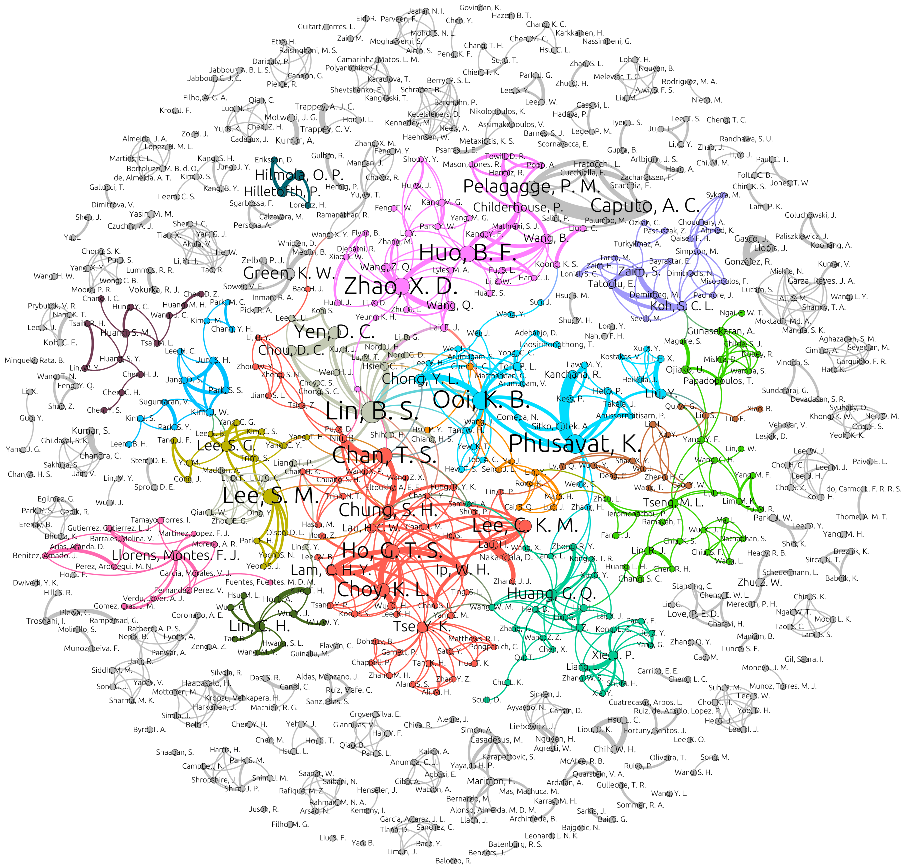
In Figure A1, we display the co-author network built from the bibliographic record. We applied the Louvain modularity method (Blondel *et al.*, 2008) to detect the authors' community in this network. The size of the nodes corresponds to the number of co-authors, which is the degree index in the network. Here, we define author activity as the strength of the author. In this context, Lin, B.S., is the most active author with the largest strength ($s = 52$ and $k = 38$), followed by Phusavat, K. ($s = 44$ and $k = 21$), Ooi, K.B. ($s = 41$ and $k = 23$), Zhao, X.D. ($s = 39$ and $k = 28$) and Huo, B.F. ($s = 36$ and $k = 24$). The communities in Figure A1 illustrate the results in Table IV. Figure 7 depicts a simplified bibliographic coupling of authors with a minimum threshold of four links and k-core value equal to 2.

4.4 Institute co-occurrence network

In Figure A2, we show the institute co-occurrence network built from the bibliographic record. Figure 8 presents the collaboration network between institutes, considering a minimum threshold of two degrees in each institute. By the analysis of the institute co-occurrence network, we verify that The Hong Kong Polytechnic University is the most active institute with the largest strength ($s = 97$ and $k = 32$), followed by Zhejiang University ($s = 50$ and $k = 15$), University of Nebraska ($s = 47$ and $k = 24$), Seoul National University ($s = 44$ and $k = 15$) and Kasetsart University ($s = 41$ and $k = 12$).

4.5 Country/region co-occurrence network

Next, we scale the analysis up to the country/region level. A total of 67 countries/regions from all over the world have published in *IMDS*. Figure 9 presents the cross-country/region collaboration in co-author papers and Figure 9(a) shows the collaboration among the 67 countries/regions. The red nodes are the countries/regions with strength above the first quartile (Q_1) of the strength sequence of the co-country network, and the blue nodes are the remaining countries/regions. Figure 9(b) only shows the collaboration among the Q1 countries/regions. An analysis of Figure 9(a), it shows that the UK is the most active country



Note: Node indicates author, and edge indicates co-occurrence relationship

Figure 7.
Simplified co-author network

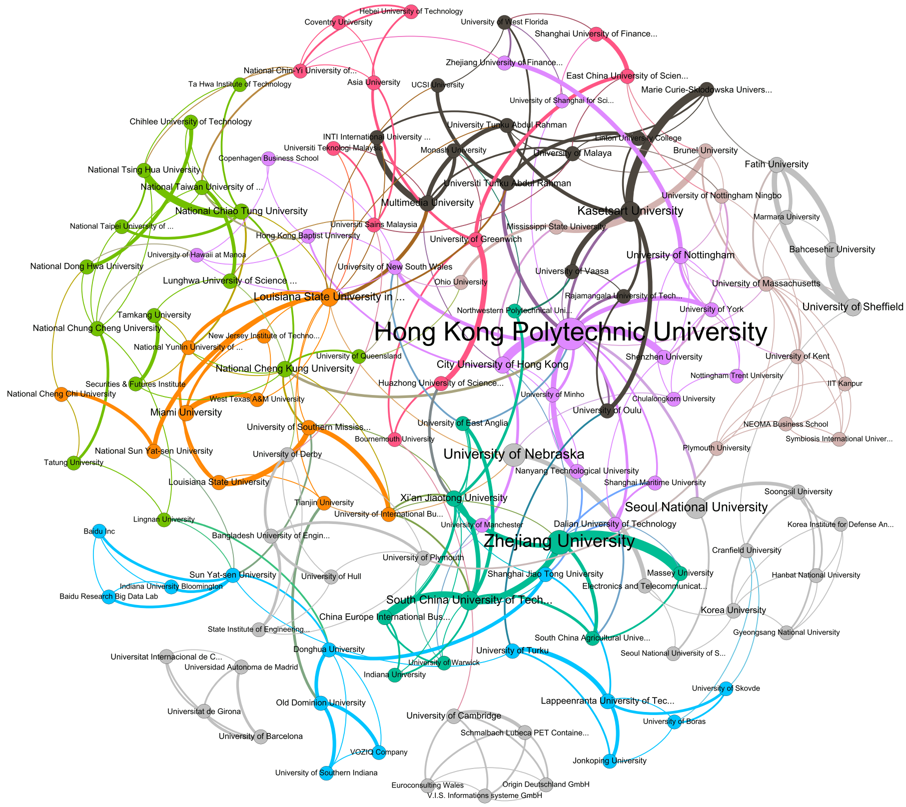
with the largest strength and 29 collaborative countries/regions ($s = 296$ and $k = 29$), followed by ($s = 280$ and $k = 19$), the USA ($s = 245$ and $k = 31$), Hong Kong ($s = 103$ and $k = 14$) and South Korea ($s = 83$ and $k = 8$). Notably, it shows a strong research collaboration among North America, Europe and Asia.

5. Themes evolution in *IMDS*

5.1 Descriptive statistics of author keywords

For the 1,616 articles, there are totally 3,076 author keywords used, 2,195 (71.36 percent) keywords appeared only once, 338 (10.99 percent) keywords were used twice and 151 (4.91 percent) keywords appeared three times. The large number of author keywords used only once probably indicates a lack of continuity in research and a wide disparity in research focuses.

In Table AIII, we present the related top-25 keyword list both over the last 25 years and the three intervals. It appears from Table AIII, that many of the key topics have persisted over the last 25 years in *IMDS*, such as "supply chain management," "information system" and "information technology," which indicates that these topics are invariable hotspots in *IMDS*.



Note: Node indicates institute, and edge indicates co-occurrence relationship

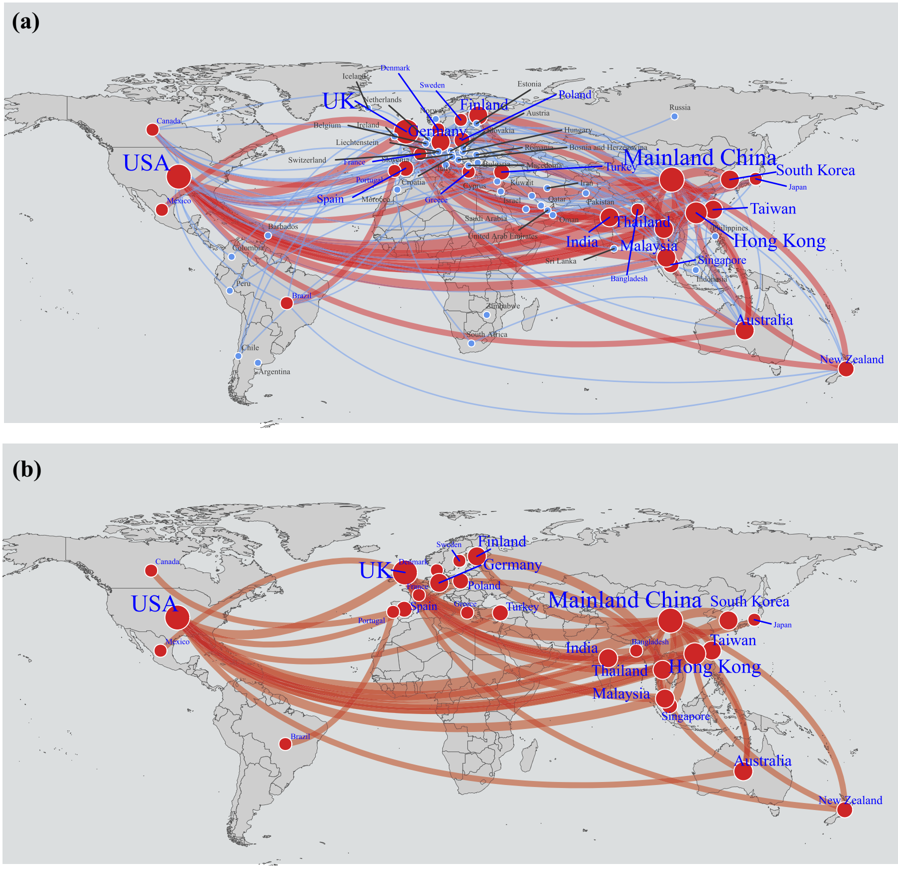
Figure 8.
Simplified collaboration network between institutes

5.2 Author keywords clusters

Figure 10 depicts a simplified keywords co-occurrence network, and only nodes with a frequency of 20 or more are shown. The colors represent the community partition of those keywords and we added the dashed boundaries to make the clusters more visible. We detect the existence of at least five different clusters, as shown in Figure 10 and Table VI.

Cluster I brings together by far the largest number of works, which covers the main scope of *IMDS*, which is applying the potential of new technologies to the management activities. In this cluster, we can find strategic management, human resource management, quality management, project management, process management, decision making and marketing. Cluster II mainly studies supply chain management and operation management in the manufacturing industry, which are related to performance management, production planning and scheduling, supplier relations, service quality and competitive strategy. In addition, research methodology (e.g. modeling, simulation and case study) seemed to receive a great deal of attention in these studies. The most popular clusters are the first two, characterized by older articles (by publication date).

The latter three clusters are smaller compared with the first two clusters. Cluster III places more emphasis on SMEs, knowledge management and innovation management, and organization (e.g. organization culture, organizational performance, organizations). Cluster IV focuses on the study of electronic commerce and IT, customer behavior and satisfaction

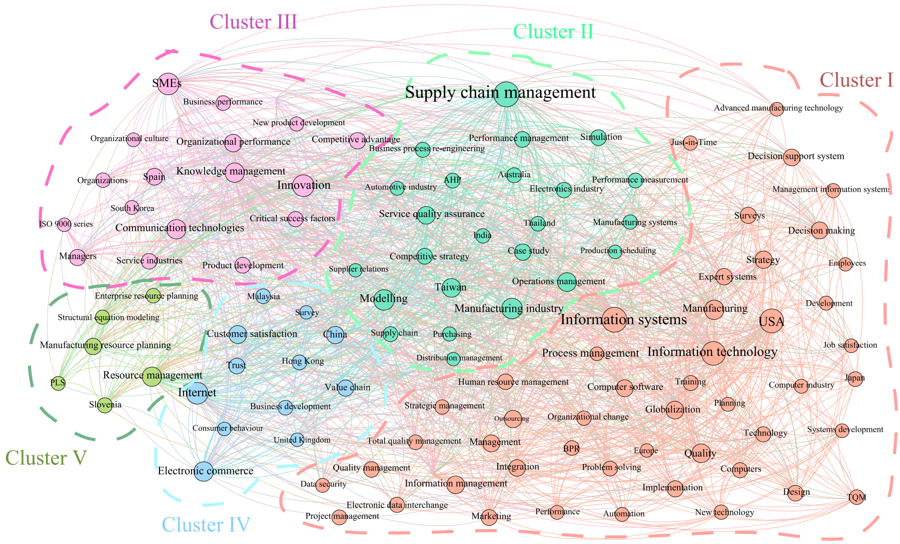


Note: Node indicates country/region, and edge indicates co-country/region relationship

Figure 9.
Bibliographic coupling between countries/regions with publications in the *IMDS*

and value chain. We also detect the close connections among China, Hong Kong, Malaysia and the UK. Cluster V represents papers focusing on enterprise resource management. Moreover, structural equation modeling and partial least squares were widely adopted methods for investigations on these issues as reflected in the keywords. With an emphasis on innovation management, circular economy, and sustainable consumption and production (Nambisan *et al.*, 2017; Wang *et al.*, 2019; Geissdoerfer *et al.*, 2017), it is expected that the latter three clusters will continue to grow for the next decade.

Compared with the scope of *IMDS* listed on the journal's webpage, our five-cluster classification shows that "green," "sustainability" and "big data" have received significantly less attention over the 25 years period. This is consistent with observations of some of the recent reviews (Fahimnia *et al.*, 2015; Wang *et al.*, 2016). Therefore, the insight that can be obtained from this classification is the opportunity for additional research in "big data analytics," "green information systems" and "sustainable supply chain management." In fact, more recently some of the scholars have focused on closing these topics gap (Cheng *et al.*, 2016; Bhat and Quadri, 2015; Comuzzi and Patel, 2016; Zhao *et al.*, 2015; Verma and Singh, 2017; Chongwatpol, 2016; Chen *et al.*, 2015; Amankwah-Amoah, 2015; Wang and Dai, 2018; Liu *et al.*, 2017; Wu *et al.*, 2016;



Note: Node indicates keyword, and edge indicates co-occurrence relationship

Figure 10.
Main clusters of keyword co-occurrence network

Table VI.
Main themes identified in the cluster analysis

	Keywords and themes
Cluster I	Keywords: advanced manufacturing technology, just-in-time, decision support system, management information systems, surveys, decision making, strategy, employees, expert systems, development, manufacturing, information systems, USA, job satisfaction, process management, information technology, Japan, computer industry, systems development, TQM, design, technology, design, planning, quality, computers, new technology, training, globalization, implementation, computers software, organizational change, Europe, automation, problem solving, BPR, problem solving, human resource management, outsourcing, integration, performance, marketing, information management, strategic management, total quality management, management, information management, quality management, electronic data interchange, data security, project management Themes: implementation of information systems and information technology in management activities
Cluster II	Keywords: supply chain management, performance management, simulation, business process re-engineering, performance measurement, manufacturing systems, production scheduling, Australia, electronics industry, Thailand, case study, operations management, manufacturing industry, AHP, automotive industry, service quality assurance, India, competitive strategy, supplier relations, Taiwan, modeling, supply chain, purchasing, distribution management Themes: supply chain management and operation management, manufacturing industry
Cluster III	Keywords: SMEs, business performance, new product development, organizational culture, organizational performance, competitive advantage, organizations, Spain, knowledge management, innovation, South Korea, critical success factor, ISO 9000 series, communication technologies, managers, service industries, product development Themes: SMEs (small and medium-sized enterprises), knowledge management and innovation, service industry
Cluster IV	Keywords: Malaysia, survey, China, customer satisfaction, trust, Hong Kong, value chain, internet, business development, consumer behavior, UK, electronic commerce Themes: electronic commerce and IT, customer behavior and satisfaction
Cluster V	Keywords: enterprise resource planning, structural equation modeling, manufacturing resource planning, PLS, resource management, Slovenia Themes: enterprise resource management

Tseng *et al.*, 2015; Kazancoglu *et al.*, 2018), but none of these efforts have been captured in our five-cluster topical classification due to their relatively recent publication and hence the inability of the keywords to reach a frequency of 20.

5.3 Keywords evolution

To assess the evolution of author keywords, it is necessary to divide the study period into a number of sub-periods. We divided the study period into three sub-periods: 1994–1999 (1990s), 2000–2009 (2000s) and 2010–2019 (2010s) and constructed an alluvial diagram (Rosvall and Bergstrom, 2010) to map the evolution in *IMDS*.

Figure 11 presents the major shifts of author keywords in the last 25 years of *IMDS*. Each significance clustering for the keywords networks in the periods of the 1990s, 2000s and 2010s occupies a column in the diagram and is horizontally connected to preceding and succeeding significance clustering by stream keywords. Each block in a column represents a keyword cluster and the height of the block reflects citation flow through the keyword cluster. The keyword clusters are ordered from bottom to top by their size. In order to increase the readability, the keywords are placed inside the central column for 2000s.

From post-industrial economies to emerging economies: the research related to post-industrial countries/regions, such as USA and Japan, has reduced. The finding is consistent with the statistical results in Table AIII. The keyword frequency of the USA ranked in the top 3rd in the 1990s, and reduced to 23th in the 2000s, ranked 65th in the 2010s. The research related to emerging industries in countries/regions, such as Mainland China and Taiwan, has grown in importance in recent years. Themes related to China experienced a dramatic growth in the last 25 years and took the 7th place between 2010 and 2018.

From manufacturing to service industry: the manufacturing industries constitute a large proportion of the previous research, such as "advanced manufacturing technology," "just-in-time," "TQM" and "manufacturing system." Recent decades have witnessed the rapid economic evolution from a manufacturing base to a service orientation. Servitization is even predicted as being a future significant research area within operations management (Taylor and Taylor, 2009; Wang *et al.*, 2019). We can detect this trend in this alluvial diagram.

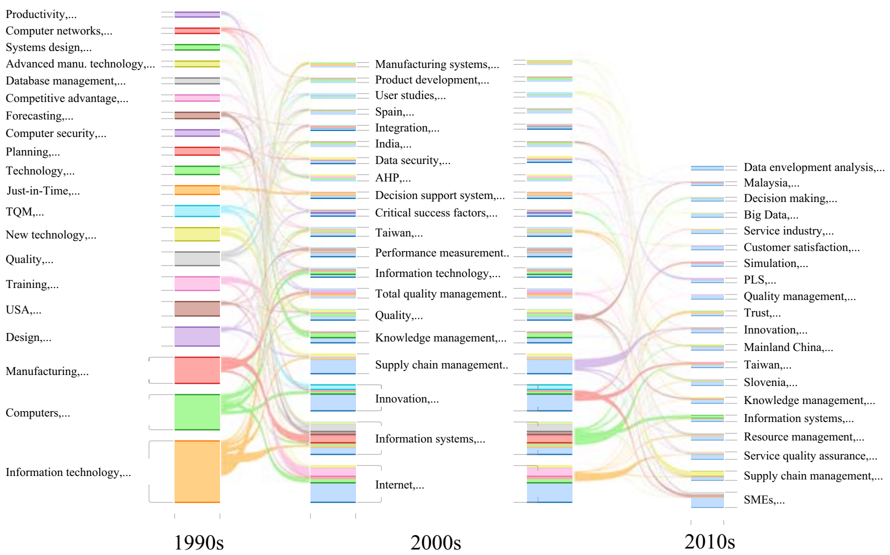


Figure 11.
Mapping changes in author keywords in *IMDS*, 1994–2018

From information technology and management to knowledge sharing and management: it is not surprising to find that there are several popular topics in the past such as "computer networks," "database management," "data security," etc., that are becoming gradually less significant as noted during our 25-year study period. On the contrary, little has been done before on "SMEs," "innovation," "knowledge sharing and management," "Internet of Things," "big data" and "data mining," but articles on these aspects have obviously increased in recent years. "SMEs" took 3rd place between 2010 and 2018, which is consistent with the research trends (Ghadimi *et al.*, 2019). Reinforcing our former findings in subsection 5.2, it can be expected that the emerging topics will continue to grow at an increased pace.

6. Concluding remarks and limitations

Since the founding, *IMDS* has given voice to a growing international and interdisciplinary community of researchers in the field of operations management and information systems. The study collects all the publications of the journal between 1994 and 2018, and reviews 1,616 full-length articles in a bibliometric way. A number of highlights can be summarized as follows:

- The annual number of publications exhibits a gradual increase in *IMDS* in recent years. The publications that have received the most attention from the research community are in the area of operations management. The most cited paper was published by Wong (2005) and has 322 citations. It is common for articles in *IMDS* to have a single author or two authors, and we speculate the number of co-authors is likely to increase due to cross-national studies. Over half of papers are written by the authors in the same institute.
- Phusavat, K., is the most productive author in *IMDS* with 19 articles, Vokurka, R.J., is the most influential author in *IMDS* with 599 citations, and Lin, B.S., is the most active author with 38 co-authors and strength equals 52. The Hong Kong Polytechnic University is the most productive and active institute with 31 publications, 32 collaborative institutes, and strength equals 97. The National Cheng Kung University is the most influential institute with 804 citations. The number of publications from the USA is more than double its nearest rivals, Mainland China, Taiwan, and the UK. However, the UK is the most active country with 31 collaborative countries/regions with strength as large as 245.
- For three co-occurrence networks (i.e. author co-occurrence network, institute co-occurrence network and country/region co-occurrence network), they have both small-world and scale-free characteristics. And the average degrees of these three networks are relatively low, which depict the sparse identity of the collaboration relationships among authors, institutes and countries/regions. In addition, we find that the author and institute networks have positive assortativity, which means the most influential authors and institutes are tightly connected with each other. On the contrary, the assortativity index of the country/region network is negative, which may result from the "preferential attachment" property during the formation of the country/region level collaboration.
- Many of the key topics have persisted over the last 25 years of the journal, such as "supply chain management," "information system" and "information technology," which indicates that these topics are invariable hotspots in *IMDS*. We find the existence of at least five different clusters. The biggest cluster is aligned with the main scope of *IMDS*, that applying the potential of new technologies to the management activities, such as strategic management, human resource management, quality management, project management, process management, decision making

and marketing. Moreover, we detect keywords evolution from post-industrial economies to emerging economics, from manufacturing to service industry and from information technology and management to knowledge sharing and management, by constructing an alluvial diagram.

This study presents a systematic review and bibliometric analysis of literature in *IMDS* over the last 25 years, which can be seen as a snapshot of the *IMDS* journal. With the information and insights provided in this paper, we manage to obtain a quick overview of *IMDS* that can support strategic decisions for potential authors, readers and journal editors. First, for potential authors, it serves as a guide orientating them in relation to the main scope (i.e. applying the potential of new technologies to the management activities) and emerging topics of interest (e.g. big data, knowledge and innovation management, green and sustainable, emerging economies, service industry, SMEs), and, in general, providing them with a historical roadmap that may help with their plans to publish their research in *IMDS*. Second, for readers, it is helpful to have an overview of the types of publications, journal style and topics in *IMDS*. Third, for journal editors, this study represents a useful tool to showcase the progress and evolution that *IMDS* has experienced during its last 25 year history, highlighting trends that can signal new opportunities and relevant challenges to support or re-direct strategic decisions.

Acknowledgements
Financial support was provided in part by Chinese and Brazilian institutions and funding agents: National Natural Science Foundation of China (61603011, 61773029 and 71772016), Beijing Social Science Foundation (16JDGLC005), International Postdoctoral Exchange Fellowship Program (20170016), UPE (PFA2016, PIAEXT2016), FACEPE (APQ-0565-1.05/14), CAPES, and CNPq. The Boston University Center for Polymer Studies is supported by NSF Grants PHY-1505000, CMMI-1125290 and CHE-1213217, and by DTRA Grant HDTRA1-14-1-0017.

References

Amankwah-Amoah, J. (2015), "Safety or no safety in numbers? Governments, big data and public policy formulation", *Industrial Management & Data Systems*, Vol. 115 No. 9, pp. 1596-1603.

Bastian, M., Heymann, S. and Jacomy, M. (2009), "Gephi: an open source software for exploring and manipulating networks", *3rd International AAAI Conference on Weblogs and Social Media, San Jose, CA*, pp. 361-362.

Bhat, W.A. and Quadri, S.M.K. (2015), "Big data promises value: is hardware technology taken onboard?", *Industrial Management & Data Systems*, Vol. 115 No. 9, pp. 1577-1595.

Blondel, V.D., Guillaume, J.-L., Lambiotte, R. and Lefebvre, E. (2008), "Fast unfolding of communities in large networks", *Journal of Statistical Mechanics: Theory and Experiment*, Vol. 2008 No. 10, pp. 1-12.

Boccaletti, S., Latora, V., Moreno, Y., Chavez, M. and Hwang, D.-U. (2006), "Complex networks: structure and dynamics", *Physics Reports*, Vol. 424 Nos 4-5, pp. 175-308.

Bose, R. (2002), "Customer relationship management: key components for IT success", *Industrial Management & Data Systems*, Vol. 102 No. 2, pp. 89-97.

Bose, R. (2004), "Knowledge management metrics", *Industrial Management & Data Systems*, Vol. 104 No. 6, pp. 457-468.

Cancino, C., Merigó, J.M., Coronado, F., Dessouky, Y. and Dessouky, M. (2017), "Forty years of computers & industrial engineering: a bibliometric analysis", *Computers & Industrial Engineering*, Vol. 113, pp. 614-629.

Cao, M., Zhang, Q. and Seydel, J. (2005), "B2C e-commerce web site quality: an empirical examination", *Industrial Management & Data Systems*, Vol. 105 No. 5, pp. 645-661.

Chandra, C. and Kumar, S. (2000), "Supply chain management in theory and practice: a passing fad or a fundamental change?", *Industrial Management & Data Systems*, Vol. 100 No. 3, pp. 100-114.

Chen, K., Li, X. and Wang, H. (2015), "On the model design of integrated intelligent big data analytics systems", *Industrial Management & Data Systems*, Vol. 115 No. 9, pp. 1666-1682.

Chen, Y.H. and Barnes, S. (2007), "Initial trust and online buyer behaviour", *Industrial Management & Data Systems*, Vol. 107 No. 1, pp. 21-36.

Cheng, S., Zhang, Q. and Qin, Q. (2016), "Big data analytics with swarm intelligence", *Industrial Management & Data Systems*, Vol. 116 No. 4, pp. 646-666.

Chongwatpol, J. (2016), "Managing big data in coal-fired power plants: a business intelligence framework", *Industrial Management & Data Systems*, Vol. 116 No. 8, pp. 1779-1799.

Comuzzi, M. and Patel, A. (2016), "How organisations leverage big data: a maturity model", *Industrial Management & Data Systems*, Vol. 116 No. 8, pp. 1468-1492.

Duclos, L.K., Vokurka, R.J. and Lummus, R.R. (2003), "A conceptual model of supply chain flexibility", *Industrial Management & Data Systems*, Vol. 103 No. 6, pp. 446-456.

Estrada, E. (2010), "Quantifying network heterogeneity", *Physical Review E*, Vol. 82 No. 6, Article No. 066102.

Fahimnia, B., Sarkis, J. and Davarzani, H. (2015), "Green supply chain management: a review and bibliometric analysis", *International Journal of Production Economics*, Vol. 162, pp. 101-114.

Flavián, C. and Guinalíu, M. (2006), "Consumer trust, perceived security and privacy policy: three basic elements of loyalty to a web site", *Industrial Management & Data Systems*, Vol. 106 No. 5, pp. 601-620.

Fliedner, G. (2003), "CPFR: an emerging supply chain tool", *Industrial Management & Data Systems*, Vol. 103 No. 1, pp. 14-21.

García-Morales, V.J., Llorens-Montes, F.J. and Verdú-Jover, A.J. (2006), "Antecedents and consequences of organizational innovation and organizational learning in entrepreneurship", *Industrial Management & Data Systems*, Vol. 106 No. 1, pp. 21-42.

Geissdoerfer, M., Savaget, P., Bocken, N.M. and Hultink, E.J. (2017), "The circular economy: a new sustainability paradigm?", *Journal of Cleaner Production*, Vol. 143, pp. 757-768.

Ghadimi, P., Wang, C. and Lim, M.K. (2019), "Sustainable supply chain modeling and analysis: past debate, present problems and future challenges", *Resources, Conservation and Recycling*, Vol. 140, pp. 72-84.

Govindarajulu, N. and Daily, B.F. (2004), "Motivating employees for environmental improvement", *Industrial Management & Data Systems*, Vol. 104 No. 4, pp. 364-372.

Gupta, A. (2000), "Enterprise resource planning: the emerging organizational value systems", *Industrial Management & Data Systems*, Vol. 100 No. 3, pp. 114-118.

Gupta, B., Iyer, L.S. and Aronson, J.E. (2000), "Knowledge management: practices and challenges", *Industrial Management & Data Systems*, Vol. 100 No. 1, pp. 17-21.

Henseler, J., Hubona, G. and Ray, P.A. (2016), "Using PLS path modeling in new technology research: updated guidelines", *Industrial Management & Data Systems*, Vol. 116 No. 1, pp. 2-20.

Huang, S.M., Chang, I.C., Li, S.H. and Lin, M.T. (2004), "Assessing risk in ERP projects: identify and prioritize the factors", *Industrial Management & Data Systems*, Vol. 104 No. 8, pp. 681-688.

Jacso, P. (2005), "As we may search: comparison of major features of the web of science, scopus, and Google scholar citation-based and citation-enhanced databases", *Current Science*, Vol. 89 No. 9, pp. 1537-1547.

Ji, L., Liu, C., Huang, L. and Huang, G. (2018), "The evolution of resources conservation and recycling over the past 30 years: a bibliometric overview", *Resources, Conservation and Recycling*, Vol. 134, pp. 34-43.

Kazancoglu, Y., Kazancoglu, I. and Sagnak, M. (2018), "Fuzzy DEMATEL-based green supply chain management performance: application in cement industry", *Industrial Management & Data Systems*, Vol. 118 No. 2, pp. 412-431.

Kelepouris, T., Pramatari, K. and Doukidis, G. (2007), "RFID-enabled traceability in the food supply chain", *Industrial Management & Data Systems*, Vol. 107 No. 2, pp. 183-200.

Koh, S.C.L., Demirbag, M., Bayraktar, E., Tatoglu, E. and Zaim, S. (2007), "The impact of supply chain management practices on performance of SMEs", *Industrial Management & Data Systems*, Vol. 107 No. 1, pp. 103-124.

Laengle, S., Merigó, J.M., Miranda, J., Słowiński, R., Bomze, I., Borgonovo, E., Dyson, R.G., Oliveira, J.F. and Teunter, R. (2017), "Forty years of the European journal of operational research: a bibliometric overview", *European Journal of Operational Research*, Vol. 262 No. 3, pp. 803-816.

Liu, S., Delibasic, B., Butel, L. and Han, X. (2017), "Sustainable knowledge-based decision support systems (DSS): perspectives, new challenges and recent advance", *Industrial Management & Data Systems*, Vol. 117 No. 7, pp. 1318-1322.

Low, C., Chen, Y. and Wu, M. (2011), "Understanding the determinants of cloud computing adoption", *Industrial Management & Data Systems*, Vol. 111 No. 7, pp. 1006-1023.

Lummus, R.R. and Vokurka, R.J. (1999), "Defining supply chain management: a historical perspective and practical guidelines", *Industrial Management & Data Systems*, Vol. 99 No. 1, pp. 11-17.

Nambisan, S., Lyytinen, K., Majchrzak, A. and Song, M. (2017), "Digital innovation management: reinventing innovation management research in a digital world", *MIS Quarterly*, Vol. 41 No. 1, pp. 223-238.

Newman, M.E. (2002), "Assortative mixing in networks", *Physical Review Letters*, Vol. 89 No. 20, Article No. 208701.

Oliveira, T. and Martins, M.F. (2010), "Understanding e-business adoption across industries in European countries", *Industrial Management & Data Systems*, Vol. 110 No. 9, pp. 1337-1354.

Park, Y. and Chen, J.V. (2007), "Acceptance and adoption of the innovative use of smartphone", *Industrial Management & Data Systems*, Vol. 107 No. 9, pp. 1349-1365.

Raisinghani, M.S., Ette, H., Pierce, R., Cannon, G. and Daripaly, P. (2005), "Six sigma: concepts, tools, and applications", *Industrial Management & Data Systems*, Vol. 105 No. 4, pp. 491-505.

Ramos, M.M. (2004), "Change in the logistics management style through performance indicators: a case study", *International Journal of Logistics Research and Applications*, Vol. 7 No. 4, pp. 313-324.

Rosvall, M. and Bergstrom, C.T. (2010), "Mapping change in large networks", *PloS One*, Vol. 5 No. 1, Article No. e8694.

Sahay, B.S. (2003), "Understanding trust in supply chain relationships", *Industrial Management & Data Systems*, Vol. 103 No. 8, pp. 553-563.

Salisbury, W.D., Pearson, R.A., Pearson, A.W. and Miller, D.W. (2001), "Perceived security and World Wide Web purchase intention", *Industrial Management & Data Systems*, Vol. 101 No. 4, pp. 165-177.

Siau, K. and Long, Y. (2005), "Synthesizing e-government stage models: a meta-synthesis based on meta-ethnography approach", *Industrial Management & Data Systems*, Vol. 105 No. 4, pp. 443-458.

Taylor, A. and Taylor, M. (2009), "Operations management research: contemporary themes, trends and potential future directions", *International Journal of Operations & Production Management*, Vol. 29 No. 12, pp. 1316-1340.

Tseng, M., Lim, M. and Wong, W.P. (2015), "Sustainable supply chain management: a closed-loop network hierarchical approach", *Industrial Management & Data Systems*, Vol. 115 No. 3, pp. 436-461.

Van Eck, N. and Waltman, L. (2009), "Software survey: VOSviewer, a computer program for bibliometric mapping", *Scientometrics*, Vol. 84 No. 2, pp. 523-538.

Van Fleet, D.D., Ray, D.F., Bedeian, A.G., Downey, H.K., Hunt, J., Griffin, R.W., Dalton, D., Vecchio, R.P., Kacmar, K.M. and Feldman, D.C. (2006), "The journal of management's first 30 years", *Journal of Management*, Vol. 32 No. 4, pp. 477-506.

Varma, C.A., Sprott, D.E., Silverman, S.N. and Stem, D.E. (2000), "Adoption of internet shopping: the role of consumer innovativeness", *Industrial Management & Data Systems*, Vol. 100 No. 7, pp. 294-300.

Verma, N. and Singh, J. (2017), "An intelligent approach to big data analytics for sustainable retail environment using Apriori-MapReduce framework", *Industrial Management & Data Systems*, Vol. 117 No. 7, pp. 1503-1520.

Wang, C., Ghadimi, P., Lim, M.K. and Tseng, M.-L. (2019), "A literature review of sustainable consumption and production: a comparative analysis in developed and developing economies", *Journal of Cleaner Production*, Vol. 206, pp. 741-754.

Wang, C., Lim, M.K. and Lyons, A. (2018), "Twenty years of the international journal of logistics research and applications: a bibliometric overview", *International Journal of Logistics Research and Applications* (in press), doi: 10.1080/13675567.2018.1526262.

Wang, G., Gunasekaran, A., Ngai, E.W. and Papadopoulos, T. (2016), "Big data analytics in logistics and supply chain management: certain investigations for research and applications", *International Journal of Production Economics*, Vol. 176, pp. 98-110.

Wang, J. and Dai, J. (2018), "Sustainable supply chain management practices and performance", *Industrial Management & Data Systems*, Vol. 118 No. 1, pp. 2-21.

Watts, D.J. and Strogatz, S.H. (1998), "Collective dynamics of 'small-world' networks", *Nature*, Vol. 393, pp. 440-442.

Wei, T.T., Marthandan, G., Chong, Y.L., Ooi, K.B. and Arumugam, S. (2009), "What drives Malaysian m-commerce adoption? An empirical analysis", *Industrial Management & Data Systems*, Vol. 109 No. 3, pp. 370-388.

Wong, K.Y. (2005), "Critical success factors for implementing knowledge management in small and medium enterprises", *Industrial Management & Data Systems*, Vol. 105 No. 3, pp. 261-279.

Wu, J.J. and Chang, Y.S. (2005), "Towards understanding members' interactivity, trust, and flow in online travel community", *Industrial Management & Data Systems*, Vol. 105 No. 7, pp. 937-954.

Wu, K.-J., Liao, C.-J., Tseng, M. and Chiu, K.K.-S. (2016), "Multi-attribute approach to sustainable supply chain management under uncertainty", *Industrial Management & Data Systems*, Vol. 116 No. 4, pp. 777-800.

Yeh, Y.J., Lai, S.Q. and Ho, C.T. (2006), "Knowledge management enablers: a case study", *Industrial Management & Data Systems*, Vol. 106 No. 6, pp. 793-810.

Yu, Z., Yan, H. and Edwin, C.T.C. (2001), "Benefits of information sharing with supply chain partnerships", *Industrial Management & Data Systems*, Vol. 101 No. 3, pp. 114-121.

Zhao, X., Yeung, K., Huang, Q. and Song, X. (2015), "Improving the predictability of business failure of supply chain finance clients by using external big dataset", *Industrial Management & Data Systems*, Vol. 115 No. 9, pp. 1683-1703.

Zupic, I. and Čater, T. (2015), "Bibliometric methods in management and organization", *Organizational Research Methods*, Vol. 18 No. 3, pp. 429-472.

Appendix

Table AI. The most productive institutes in *IMDS*

R	Institutes	TP	TC	TC/TP	⩾100	⩾50	⩾20	⩾10	⩾5
1	Hong Kong Polytechnic University	53	786	14.83	1	3	11	18	32
2	National Cheng Kung University	31	804	25.94	1	5	12	22	27
3	University of Nebraska	23	639	27.78	1	4	10	16	16
4	University of Granada	22	378	17.18	0	1	6	13	17
5	National Cheng Chi University	21	224	10.67	0	0	3	9	12
6	City University of Hong Kong	19	330	17.37	0	1	7	11	14
7	Kasetsart University	19	269	14.16	0	0	4	9	16
8	University of Primorska	19	228	12.00	0	0	3	8	14
9	Seoul National University	18	207	11.50	0	1	3	6	11
10	Zhejiang University	17	63	3.71	0	0	1	2	4
11	University of Massachusetts	16	283	17.69	0	0	5	12	12
12	University of Hong Kong	16	196	12.25	0	0	4	7	9
13	South China University of Technology	15	57	3.80	0	0	0	2	5
14	National Chung Cheng University	15	540	36.00	2	4	7	11	13
15	National Tsing Hua University	15	258	17.20	0	1	4	9	11
16	University of L'Aquila	15	193	12.87	0	0	3	8	11
17	National Chiao Tung University	15	219	14.60	0	0	3	10	12
18	East Tennessee State University	14	44	3.14	0	0	0	1	2
19	University of Malaya	14	236	16.86	0	1	5	9	10
20	Louisiana State University in Shreveport	14	417	29.79	0	3	6	11	13
21	George Mason University	14	223	15.93	0	1	5	7	9
22	University of Vaasa	14	330	23.57	0	2	5	10	13
23	Texas A&M University	13	621	47.77	2	4	6	8	11
24	Multimedia University	13	506	38.92	1	3	11	11	12
25	University of North Texas	13	140	10.77	0	0	1	7	10
26	University of North Carolina	13	207	15.92	0	0	4	9	10
27	Lappeenranta University of Tech.	13	100	7.69	0	0	1	3	8
28	Lunghwa University of Science and Technology	12	297	24.75	0	2	5	10	12
29	National Taiwan University of Sci. and Tech.	12	190	15.83	1	1	3	3	8
30	Miami University	12	223	18.58	0	2	3	5	6
31	University of Southern Mississippi	12	235	19.58	0	0	5	10	10
32	Xi'an Jiaotong University	12	87	7.25	0	0	1	4	6
33	University of Valencia	11	233	21.18	0	1	5	7	8

(*continued*)

R	Institutes	TP	TC	TC/TP	⩾100	⩾50	⩾20	⩾10	⩾5
34	Sogang University	11	46	4.18	0	0	0	2	3
35	Louisiana State University	11	199	18.09	0	1	4	6	7
36	Shanghai Jiao Tong University	11	29	2.64	0	0	0	1	2
37	Yonsei University	11	133	12.09	0	0	3	4	9
38	Nanyang Tech. University	10	154	15.40	0	1	2	4	7
39	Edith Cowan University	10	244	24.40	0	2	4	8	8
40	University of Sheffield	10	399	39.90	1	3	7	7	8
41	California State University	10	87	8.70	0	0	2	2	4
42	National Chung Hsing University	10	137	13.70	0	0	3	3	7
43	University of Turku	10	91	9.10	0	0	2	3	6
44	Marie Curie-Sklodowska University	10	121	12.10	0	0	2	3	9

Note: Abbreviations available in Table I and Table II

Table AI.

R	Country/region	TP	TC	TC/TP	Pop	TP/Pop	TC/Pop	⩾100	⩾50	⩾20	⩾10	⩾5
1	USA	495	9,196	18.58	326,767	1.51	28.14	14	39	134	245	337
2	Mainland China	205	1,681	8.20	1,415,046	0.14	1.19	0	4	26	56	90
3	Taiwan	201	3,970	19.75	23,694	8.48	167.55	5	22	53	104	143
4	UK	193	2,720	14.09	66,574	2.90	40.86	3	14	38	68	102
5	Spain	107	1,919	17.93	46,397	2.31	41.36	1	7	30	57	78
6	South Korea	91	1,043	11.46	51,164	1.78	20.39	0	3	17	34	53
7	Hong Kong	67	865	12.91	7,429	9.02	116.44	1	2	13	24	36
8	Finland	55	836	15.20	5,543	9.92	150.83	0	3	12	24	42
9	Malaysia	54	1,447	26.80	32,042	1.69	45.16	2	7	21	34	42
10	Australia	51	738	14.47	24,772	2.06	29.79	0	3	12	24	34
11	Thailand	37	583	15.76	69,183	0.53	8.43	0	0	9	21	29
12	Italy	33	352	10.67	59,291	0.56	5.94	0	0	7	15	20
13	India	32	620	19.38	1,354,052	0.02	0.46	1	5	10	15	18
14	Slovenia	28	345	12.32	2,081	13.45	165.76	0	0	6	11	19
15	Sweden	27	321	11.89	9,983	2.70	32.16	0	0	6	11	17
16	Canada	26	535	20.58	36,954	0.70	14.48	0	1	12	16	24
17	Poland	25	267	10.68	38,105	0.66	7.01	0	0	4	8	19
18	Brazil	24	293	12.21	210,868	0.11	1.39	0	1	5	9	14
19	Greece	20	427	21.35	11,142	1.79	38.32	1	1	7	12	16
20	Singapore	18	311	17.28	5,792	3.11	53.70	0	2	6	9	13
21	Turkey	18	475	26.39	81,917	0.22	5.80	1	3	7	10	15
22	Denmark	16	249	15.56	5,754	2.78	43.27	0	1	4	10	12
23	Germany	15	210	14.00	82,293	0.18	2.55	0	1	3	7	11
24	Norway	15	294	19.60	5,353	2.80	54.92	0	2	6	10	12
25	New Zealand	14	196	14.00	4,750	2.95	41.27	0	2	2	5	6
26	France	13	91	7.00	65,233	0.20	1.39	0	0	1	3	5
27	Netherlands	13	313	24.08	17,084	0.76	18.32	1	1	2	6	9
28	Portugal	13	190	14.62	10,291	1.26	18.46	1	1	2	4	6
29	Iran	7	148	21.14	82,012	0.09	1.80	0	1	1	4	5
30	Belgium	6	17	2.83	11,499	0.52	1.48	0	0	0	1	1
31	Mexico	6	20	3.33	130,759	0.05	0.15	0	0	0	0	2
32	Hungary	5	30	6.00	9,689	0.52	3.10	0	0	0	1	3
33	Saudi Arabia	5	160	32.00	33,554	0.15	4.77	0	1	3	4	4
34	Japan	4	9	2.25	127,185	0.03	0.07	0	0	0	0	1
35	South Africa	4	76	19.00	57,398	0.07	1.32	0	1	1	2	3
36	United Arab Emirates	4	65	16.25	9,542	0.42	6.81	0	1	1	1	2
37	Ireland	3	55	18.33	4,804	0.62	11.45	0	0	1	2	2
38	Kuwait	3	52	17.33	4,197	0.71	12.39	0	0	2	2	3
39	Austria	2	10	5.00	8,752	0.23	1.14	0	0	0	1	1
40	Bangladesh	2	1	0.50	166,368	0.01	0.01	0	0	0	0	0
41	Barbados	2	83	41.50	286	6.98	289.82	0	0	2	2	2
42	Bulgaria	2	20	10.00	7,037	0.28	2.84	0	0	0	1	2
43	Chile	2	1	0.50	18,197	0.11	0.05	0	0	0	0	0
44	Colombia	2	12	6.00	49,465	0.04	0.24	0	0	0	0	2
45	Estonia	2	5	2.50	1,307	1.53	3.83	0	0	0	0	0
46	Peru	2	3	1.50	32,552	0.06	0.09	0	0	0	0	0
47	Philippines	2	20	10.00	106,512	0.02	0.19	0	0	0	1	1
48	Sri Lanka	2	9	4.50	20,950	0.10	0.43	0	0	0	0	1
49	Switzerland	2	21	10.50	8,544	0.23	2.46	0	0	0	1	2
50	Argentina	1	3	3.00	44,689	0.02	0.07	0	0	0	0	0
51	Bosnia and Herzegovina	1	5	5.00	3,504	0.29	1.43	0	0	0	0	1
52	Croatia	1	4	4.00	4,165	0.24	0.96	0	0	0	0	0
53	Cyprus	1	20	20.00	1,189	0.84	16.82	0	0	1	1	1
54	Iceland	1	2	2.00	338	2.96	5.92	0	0	0	0	0

(*continued*)

Table AII. The countries/regions of published articles in *IMDS*

R	Country/region	TP	TC	TC/TP	Pop	TP/Pop	TC/Pop	⩾100	⩾50	⩾20	⩾10	⩾5
55	Indonesia	1	13	13.00	266,795	0.00	0.05	0	0	0	1	1
56	Israel	1	16	16.00	8,453	0.12	1.89	0	0	0	1	1
57	Liechtenstein	1	10	10.00	38	26.21	262.09	0	0	0	1	1
58	Macedonia	1	7	7.00	2,085	0.48	3.36	0	0	0	0	1
59	Morocco	1	0	0.00	36,192	0.03	0.00	0	0	0	0	0
60	Oman	1	7	7.00	4,830	0.21	1.45	0	0	0	0	1
61	Pakistan	1	1	1.00	200,814	0.00	0.00	0	0	0	0	0
62	Qatar	1	6	6.00	2,695	0.37	2.23	0	0	0	0	1
63	Romania	1	9	9.00	19,581	0.05	0.46	0	0	0	0	1
64	Russia	1	0	0.00	143,965	0.01	0.00	0	0	0	0	0
65	Slovakia	1	16	16.00	5,450	0.18	2.94	0	0	0	1	1
66	West Indies	1	31	31.00	39,170	0.03	0.79	0	0	1	1	1
67	Zimbabwe	1	0	0.00	16,913	0.06	0.00	0	0	0	0	0

Notes: Abbreviations available in Tables I and II except for: Pop for population in thousands, TP/Pop and TC/Pop denote total publications and citations per million inhabitants. The population data were obtained from United Nations, Department of Economic and Social Affairs, Population Division

Table AII.

Table AIII. Most common author keyword occurrences in *IMDS*

	Period 1994–2018				1994–1999 (1990s)				2000–2009 (2000s)				2010–2018 (2010s)			
R	Keyword	*k*	*f*	*s*	Keyword	*k*	*f*	*s*	Keyword	*k*	*f*	*s*	Keyword	*k*	*f*	*s*
1	Supply chain management	323	133	503	Information technology	93	26	127	Supply chain management	154	71	221	Supply chain management	213	58	268
2	Information systems	275	113	407	Information systems	79	26	104	Information systems	128	63	188	Service quality assurance↑	89	33	108
3	Internet	163	75	246	USA↓	103	20	125	Internet	123	57	184	SMEs↑	110	28	135
4	Information technology	226	72	325	Manufacturing↓	64	18	72	Electronic commerce	114	57	171	Information technology	113	25	134
5	Electronic commerce	146	67	224	Strategy	55	15	60	Knowledge management	98	41	124	Trust	102	25	113
6	Innovation	174	61	231	Decision making↓	46	14	59	Communication technologies	94	37	113	Information systems	104	24	115
7	Knowledge management	154	58	206	Computers	57	13	68	Innovation	91	34	115	China↑	98	23	107
8	SMEs	167	57	228	Decision support system↓	32	12	42	Modeling	79	31	96	Innovation	85	22	98
9	Communication technologies	129	51	172	Expert systems	46	12	58	Resource management	65	24	76	PLS	79	20	96
10	Modeling	132	45	167	Internet	25	11	26	SMEs↑	59	24	76	Spain	94	19	114
11	Manufacturing industry	147	41	180	Computer software	43	11	46	Quality	62	22	73	Knowledge management	72	17	82
12	USA	174	40	231	Quality	45	11	49	Manufacturing industry	56	21	64	Organizational performance	76	16	86
13	China	139	39	163	Training	38	10	46	Outsourcing	46	21	62	Structural equation modeling	66	15	72
14	Manufacturing	111	39	140	Management	31	10	40	Information technology	52	21	64	Data mining	57	15	63
15	Decision support system	106	37	130	Implementation	35	10	42	Manufacturing resource planning	47	21	56	Customer satisfaction	64	15	74
16	Decision making	122	36	151	Modeling	37	10	46	Manufacturing↓	47	17	52	Communication technologies	52	14	59
17	Trust	124	36	145	TQM	35	10	36	Decision support system↓	49	16	51	Case study	50	14	54
18	Resource management	112	35	144	Globalization	35	9	45	Information management	48	16	53	Knowledge sharing	57	14	63
19	Quality	104	34	125	Design	38	9	44	Customer satisfaction	41	16	47	Decision making↓	54	12	57
20	Service quality assurance	89	33	108	Manufacturing industry	41	8	44	Competitive strategy	37	16	48	Simulation	51	12	56
21	Outsourcing	86	33	119	New technology	38	8	49	China↑	47	15	53	Internet of Things	38	12	42
22	Customer satisfaction	100	32	123	Software development	22	7	27	Performance measurement	42	15	47	Manufacturing industry↓	65	12	72
23	Spain	119	29	150	Just-in-Time	27	7	29	USA↓	49	14	55	Taiwan	54	11	59
24	Strategy	95	29	117	Competitive advantage	27	7	29	Management	39	14	46	Human resource management	41	11	42
25	Case study	89	28	104	Employees	30	7	33	Computer software	29	13	35	Supply chain integration	35	11	43

Notes: Abbreviations available in Tables I and II except for: *k* means degree of keyword in keywords co-occurrence networks, *f* indicates the number of times the keyword appeared. *s* indicates strength of the keyword, which is the sum of weights attached to ties belonging to a node. ↓, percentage went down significantly over time; ↑, percentage went up significantly over time

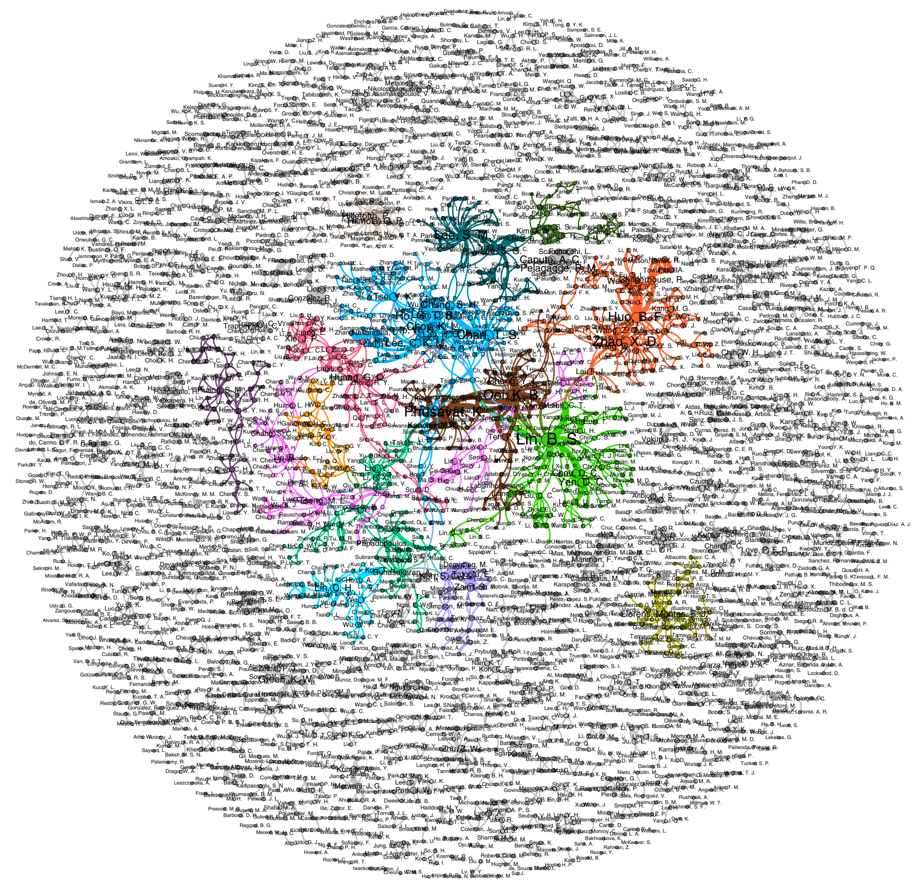


Figure A1.
Author co-occurrence network, 1994–2018

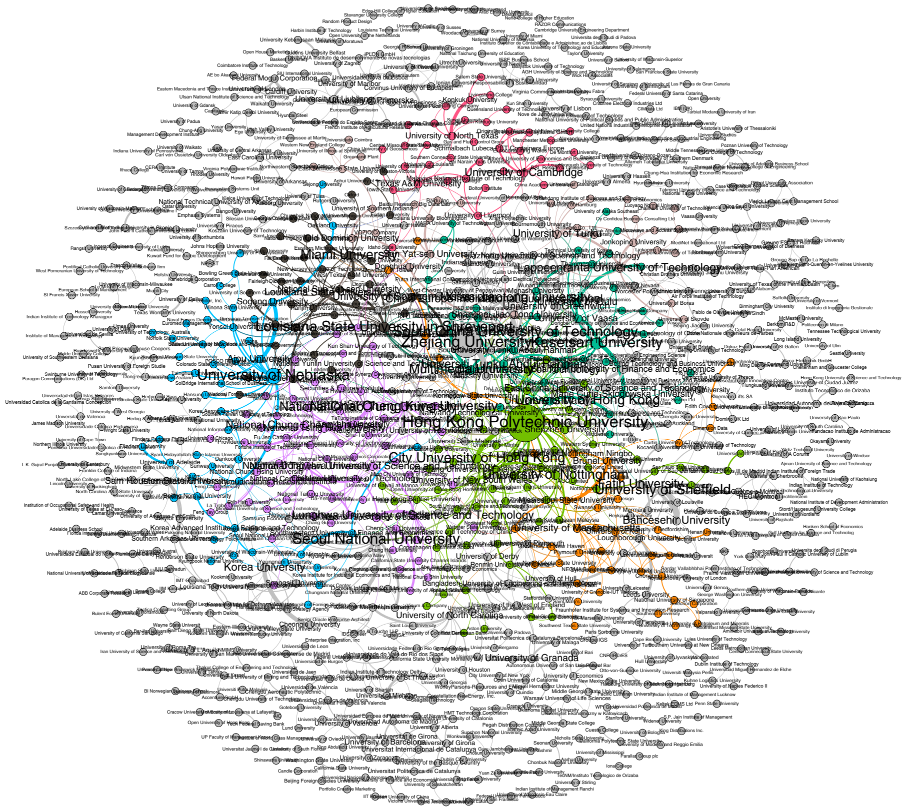


Figure A2.
Institute co-occurrence network, 1994–2018

About the authors

Dr Chao Wang received the PhD Degree from Beijing Jiaotong University (BJTU) in 2015 with joint training by Purdue University in 2013 and 2014. He is currently Associate Professor with the College of Economics and Management, Beijing University of Technology, China. He is also Postdoctoral Fellow at Center for Polymer Studies and Department of Physics of Boston University, USA. His research interests include GSCM, SCP, SSCM, Metaheuristics and Econophysics. His research has been published in the *Journal of Cleaner Production*, *Computers & Industrial Engineering*, *Resources, Conservation and Recycling*, *Engineering Computations*, *Physica A*, *Applied Energy*, *International Journal of Logistics Research and Applications* and other journals.

Dr Longfeng Zhao is Associate Professor at School of Management, Xi'an Polytechnic University, China. He received a PhD Degree from Complexity Science Research Center, Central China Normal University, in 2018. From 2016 to 2018, he was Visiting PhD Candidate at Center for Polymer Studies, Boston University. His research interests mainly include the applications of complex network theory to the logistics and supply chain, financial economics, time series, Econophysics and many other related research fields. His research has been published at *Physics letters A, Journal of statistical mechanics, Physica A, Applied Energy, Journal of International Financial Markets & Institutions and Money, Financial Research Letters, Physical Review E, Scientific Reports, PLOS One* and other journal. Dr Longfeng Zhao is the corresponding author and can be contacted at: zlfccnu@mails.ccnu.edu.cn

Dr André L.M. Vilela is Associate Professor at the University of Pernambuco, Brazil, and Distinguished Visiting Scientist at Center for Polymer Studies and Department of Physics, Boston University, USA. He received a PhD Degree in Physics and his research integrates the physics of economic and social systems, information spreading, complex networks, magnetic systems, phase transitions, renormalization group, universality, disordered systems, Monte Carlo method and technologies for education. He is also Coordinator of the Materials Physics undergraduate course and coordinator of distance education in his institution.

Professor Ming K. Lim is currently Executive Dean of College of Mechanical Engineering at Chongqing University (China) and Adjunct Professor of Supply Chain and Operations Management at Coventry University (UK). He received the PhD Degree in Manufacturing Systems from University of Exeter (UK) and BEng (Hons) Degree in Manufacturing Engineering from the University of Liverpool (UK). Professor Lim's research is multi-disciplinary, integrating engineering, computer science, information technology and operations management. Most of his recent research work revolved around sustainable supply chain management, green/low carbon logistics, circular economy, radio-frequency Identification (RFID) technology, incorporated with Industry 4.0, Internet of Things, cloud manufacturing and big data analysis. Prior to this role, he was Professor of Supply Chain and Logistics Operations and Head of Center of excellence for Supply Chain Improvement at University of Derby (UK). Professor Lim is Co-Editor-in-Chief of *International Journal of Logistics Research and Applications* and Editor-in-Chief of *International Journal of Supply Chain and Operations Resilience*. He is also Chairman of European Business Innovation and Technology Management Society, Advisory Council Member and Board of Trustees of the Asia Pacific Business Innovation and Technology Management Society and Member of IFIP (International Federation for Information Processing) WG 5.7.