

Scientific Progress in Management Science in Engineering

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By

Jiuping Xu

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Chapter 1

Introduction

Last year, we published the scientific journal report, titled “Recent Developments in Management Science in Engineering”, and presented it at the opening ceremony of the online 14th International Conference on Management Science and Engineering Management in Moldova. Participants gave a positive evaluation of the report at the conference. They believed that the report could provide an important reference and assistance for editors to improve the influence of their journals by evaluating them based on the impact factor and comprehensive index. These two aspects highlight the main differences between the journal report and other journal rankings, and affirmed the contribution of the report to: (1) determine the relationship dynamics between the seven management science engineering (MSE) journal categories and the frontier journals and emerging journal categories; (2) introduce five-year journal performance indicators as evaluation indicators; (3) define and classify the MSE journal categories for the first time; and (4) analyze and compare the performance of journals in different regions over the past three years for the first time. Encouraged by this positive response, we continued to work on MSE journal reports to develop and publish this 2020 edition.

As in previous editions, the purpose of this report is to identify the main MSE research categories and identify the most representative journals in each category. In this report, a comprehensive approach is proposed, including literature mining, cluster analysis, and expert systems. “The data of the proposed method mainly comes from Web of Science (WoS) and Journal Citation Reports (JCR), and the results identify seven categories most

relevant to MSE: civil engineering, engineering management, industrial engineering, energy engineering, environmental engineering, information engineering and agricultural engineering.” Using Note-Express and CiteSpace software to identify the most relevant journals in each category from the literature mining, it was found that there are 123, 60, 44, 96, 51, 74 and 13 journals in each category, respectively. Then, all of the identified journals in each category were divided into four zones, labeled A to D, where Zone A comprises the journals that have the greatest impact on the development of the topic; Zone B comprises the journals with high-quality papers, high submission rates, and low acceptance rates; Zone C comprises recognized journals but with limited impact; and Zone D comprises the journals with a low citation rate and low importance. The total data of journals in Zones A, B, C and D in the last three years were analyzed, and the main components of journal evaluation indicators are discussed. The main advantage of the report is that it can adjust a journal’s influence and citation differences in various disciplines over a long time, and provide a reference for the future development direction of the journal.

This report was developed with the joint efforts of members of the scientific committee, many of whom are editors of the most relevant journals, academics, researchers from different countries, and members of professional associations. We would like to sincerely thank them for their contributions in writing the report. Compared with the previous version released in 2019, some journal categories in this version have been replaced according to the degree of topic concentration, and other journal categories have been added. In addition, it is worth noting that the newly added three-year zoning data comparison further provides a reference for the future development and endeavors of journals in different regions. Since this collection of journals usually conforms to JCRs SCI journals, those that are excluded from WoS due to paper quality are not included in this report.

Chapter 2

Support Committee

Support for this proposed MSE journal report was received from both the expert committee and the organizational committee. In the expert support group, the expert-in-chief, professional expert board, and the working group all worked together. The expert-in-chief was Prof. Jiuping Xu, a distinguished MSE researcher, the professional expert board was made up of fellows from different national academies of sciences and editors from international journals, and the main members of the working group were PhD candidates with MSE majors. An introduction to the expert support is given in the following sections.

2.1 Expert Committee

The expert support for this journal report came from the expert-in-chief and the professional expert board.

2.1.1 Expert-in-chief

Jiuping Xu

Assistant Vice-President of Sichuan University and Dean of the Business

School;

Most cited Chinese researcher in the field of Decision Science (2018-2019) and Management Science (2020), Elsevier;

Honorary Academician, Academy of Sciences of Moldova, 2016; Academician, Mongolian National Academy of Sciences, 2016;

Lifetime Academician, International Academy for Systems and Cybernetic Sciences (IASCYS), 2010;

President, International Society for Management Science and Engineering Management (ISMSEM), 2007-present

2.1.2 Professional Expert Board

Benjamin Lev

Editor-in-Chief of Omega, the International Journal of Management Science;

Professor, LeBow College of Business, Drexel University, Philadelphia PA, USA.

Asaf Hajiyev

Secretary General of Parliamentary Assembly of the Black Sea Cooperation (PABSEC);

Academician at Azerbaijan National Academy of Sciences.

Gheorghe DUCA

President, academician, the Academy of Sciences of Moldova;

Chemist, founder of the Research School on Ecological Chemistry.

Editor-in-chief, Chemistry Journal of Moldova.

Mitsuo Gen

Tokyo University of Science, Research Institution for Science and Technology Fuzzy Logic Systems Institute, Japan.

Fausto Pedro García Márquez

Full Professor at University of Castilla-La Mancha (UCLM), Spain;

Honorary Senior Research Fellow, Birmingham University, United Kingdom.

Fulya Altiparmak

Professor of Industrial Engineering, Faculty of Engineering, Gazi University, Turkey.

Fang Lee Cooke

Professor of Human Resource Management, Monash Business School, Melbourne, Australia.

2.1.3 Working Group

Ziqiang Zeng

Researcher at Sichuan University, Business School, China.

Member of the American Institute of Electrical and Electronics Engineers (IEEE).

Associate Member of the American Society of Civil Engineers (ASCE).

Zongmin Li

Professor, Sichuan University, China.

Managing editor of the International Journal of Management Science and Engineering Management (IJMSEM).

Yi Lu

Professor, Sichuan University, China.

Guest editor of Environmental Hazards.

Liming Yao

Professor, Sichuan University, Business School, China.

Member of the Institute for Operations Research and Management Sciences (INFORMS).

Zhibin Wu

Professor and doctoral tutor at Sichuan University, China.

Visiting Scholar at the Department of Industrial and Systems Engineering, University of Washington.

Chengwei Lv

Assistant Professor, Sichuan University, China.

Visiting scholar at Joseph M. Katz Graduate School of Business, University of Pittsburgh.

Other members of the working group were: Yawen Deng, Fengjuan Wang, Qian Huang, Liying Liu, Chuandang Zhao, Guocan Yang, Kejing Shu, Keru Fan, Hongyan Tao and others.

2.2 Organizing Committee

The International Academy for Systems and Cybernetic Sciences (IAS-CYS);

International Society of Management Science and Engineering Management (ISMSEM); Sichuan University.

Chapter 3

General Methodology

Academic journals are one of the most important vehicles for academic exchange, and studying the co-citation relationships between academic journals can reveal the relationships in disciplinary subject development. Systematic theoretical analyses, that typically encompass concepts such as paradigms, theoretical models, phases, and quantitative or qualitative techniques, are necessary to elucidate the methods and principles associated with a certain branch of knowledge and determine the co-citation relationships. Therefore, to deeply evaluate journals, a systematic but general methodological classification method is needed to identify the journal categories and their rankings. Therefore, in this report, a specific literature analysis approach was taken in which: (a) the Web of Science database was employed for the literature analysis; and (b) CiteSpace was used to visualize the scientific literature patterns and trends. Compared to purely qualitative methods, this classification method was deemed to be fairer and more objective and could more accurately reflect the actual situation.

3.1 Data Acquisition

The data used for the category identification and journal recognition came mainly from the Web of Science (WoS) database, which is an online subscription based scientific citation indexing service that was originally estab-

lished by the Institute for Scientific Information (ISI) and has been maintained by Clarivate Analytics since December, 2017 [1]. This database has access to multiple databases that reference cross-disciplinary research, and therefore allows for an in-depth exploration of the specialized subfields within an academic or scientific discipline [4]. The WoS platform connects the WoS Core Collection to regional citation indexes, patent data, specialized subject indexes, and an index of research data sets, and contains more than 21,100 global peer-reviewed, high-quality academic journals (including open access journals) across 250 disciplines dating back to 1900 [2, 3]. To increase the accuracy of the analyses, the WoS Core Collection Indexes were chosen for the data acquisition. The Web of Science Core Collection-Citation index has six main online databases: the Science Citation Index Expanded (SCI-Expanded); the Social Sciences Citation Index (SSCI); the Arts & Humanities Citation Index (A&HCI) [8]; the Emerging Sources Citation Index (ESCI); Conference Proceedings Citation Index Science (CPCI-S); and Conference Proceedings Citation Index-Social Science & Humanities (CPCI-SSH) [2, 3], as shown in Fig. 3.1.

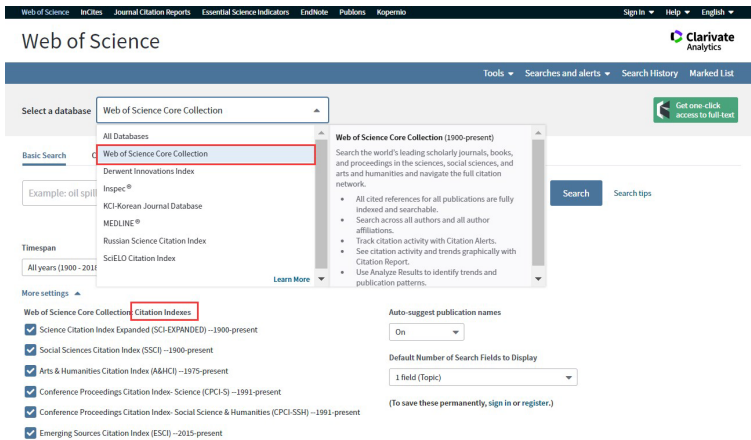


Fig. 3.1: Web of Science Core Collection Database

Advanced search

As it has been found to be a significant improvement on more conventional finite state algorithms, the WoS advanced search was chosen because it involves a finite state pattern-matching algorithm in a library bibliographic search program that can identify all the titles that satisfy the Boolean keywords and phrases in a citation index. An advanced search query consists of one or more field tags and a search string, with both Booleans and wildcards allowed. Records are searched using field tags, set combinations or a combination of both. Some commonly used file tags are: TS=Topic, TI=Title, AU=Author, AI=Author Identifiers, GP=Group Author, ED=Editor, SO=Publication Name, DO=DOI, PY=Year Published, CF=Conference, AD=Address, OG=Organization-Enhanced, OO=Organization, SG=Suborganization, SA=Street Address, CI=City, PS=Province/State, CU=Country/Region, ZP=Zip/Postal Code, FO=Funding Agency, FG=Grant Number, FT=Funding Text, SU=Research Area, WC=Web of Science Category, IS=ISSN/ISBN, UT=Accession Number, PMID=PubMed ID, ALL=All Fields.

The Boolean Operators in the Web of Science Advanced Search are: **AND**, to find records containing all terms; **OR**, to find records containing any of the terms; **NOT**, to exclude records containing certain words in the search; **Near**, to find records containing all terms within a certain number (n) of each other; and **SAME**, to search terms that must occur within the same sentence. Truncation and wildcard characters are used for more control when retrieving plurals and when there are different spellings; Item *, to retrieve words with a variant zero to many characters, Item ?, to retrieve words with the replacement of 1 character; Item \$, to retrieve zero or one character, and Item “”, to search for exact phrases.

To obtain the search results, the following steps for the “advanced search” were followed: (1) Go to the Web of Science website, select Web of Science Core Collection database and enter the Advanced Search item; (2) Set the search command as “TS=(management science)”, restrict the results by setting the language as “English” and document types as “Article OR Proceeding Paper OR Review”. Other items are set by default, including “Timespan=All years (1900-2020)”, “Web of Science Core Collection: Citation Indexes=SCI-Expanded, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI”; (3) Click the “Search” item and find the search results at the bottom

of the page in “Search History”, shown in Fig. 3.2.

Set		Results	Save History / Create Alert	Open Saved History	Edit Sets	Combine Sets	Delete Sets
						<input type="radio"/> AND <input type="radio"/> OR Combine	<input type="checkbox"/> Select All <input type="checkbox"/> Delete
#1	87,437	(IS=(management science) AND LANGUAGE: English) AND DOCUMENT TYPES: (Article OR Proceedings Paper OR Review) <small>influenza-SCI EXPANDED, SSCI, AB/CI, CPCI-S, CPCI-SSH, ESCI Timespan=1900-2100</small>		Edit		<input type="radio"/> AND <input type="radio"/> OR Combine	<input type="checkbox"/> Select All <input type="checkbox"/> Delete

Fig. 3.2: Search history in the Web of Science Core Collection Database

A search history is a search query or multiple search queries saved to a server or hard drive. There is no limit to the number of search histories that can be saved, and combined search sets can be created from the Search and Advanced Search functions. These are listed in the Search History table in reverse numerical order, with the most recently created set at the top. The operational steps for this are as follows: (1) Click the AND or the OR option; (2) Select the check box for each set that is to be combined; (3) Click the Combine button; (4) Click the link in the Results column to view the results of your search.

Data Export

In the Web of Science, the search results are displayed with the full title, author names, and source as a list of 10, 25, or 50 items per page. When the full text is available, the option to “view free full text” appears. Related records can be found and sorted by the latest date, times cited, relevance, first author, publication year, and source title. The results can also be analyzed (i.e., by author, country/territory or document type), and a citation report presented with a labeled bar chart. The results can also be further refined, and the records viewed or excluded.

Output options are available at the bottom of the Results pages (as shown in Fig. 3.4), including Save to Endnote Online, Save to EndNote Desktop, Save to ResearcherID, Save to Incites, and Save to Other File Formats. As CiteSpace software was used for the follow-up analysis, the Save to Other File Formats was chosen.

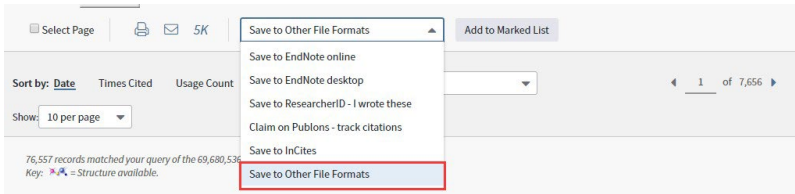


Fig. 3.3: Data Export in the Web of Science Core Collection Database

This option allowed for the output selection of all search results (no more than 500 at a time) or the specific record(s) such as: (1) Selected records on a page by checking the box for each desired record; (2) All records on a page by selecting a value in the Show 10, 25, or 50 per page list; and (3) Records, to select a range of records. In this case, 500 items at a time were selected until all the records had been exported.

Four record items are provided: (1) Author, Title, Source; (2) Author, Title, Source, Abstract; (3) Full record; and (4) Full Records and Cited References. The CiteSpace analysis was based on the “Full Records and Cited References”, as shown in Fig. 3.4. The following file formats are available for Saving to Other File Formats: Other Reference Software, HTML, Plain Text, Tab-delimited (Win), Tab-delimited (Mac), Tab-delimited (Win, UTF-8), and Tab-delimited (Mac, UTF-8). For this study, Plain Text was chosen. Click “send” and the system saves the document as a text file (for example, savedrecs.txt). The selected data include the following information: (1) Bibliographic Fields include author, title, and source information; (2) Bibliographic plus Abstract includes bibliographic fields and author abstract; (3) Full Record includes all data on the Full Record page; and (4) Full Record plus Cited Reference includes all data on the Full Record page as well as the cited references.

3.2 Category Identification

A systematic literature review allows for current findings to be discussed in relation to a particular research question, as scientific knowledge based on text usually has its own evolving lifecycle. Therefore, analyzing the evolu-

Send to File ✕

Number of Records: All records on page
 Records to

Record Content:

File Format:

Fig. 3.4: Send to File in the Web of Science Core Collection Database

tionary patterns has become an increasingly important text mining research direction in recent years [9, 10]. As the literature analysis expands the literature mining scope, it can be used to categorize the journals and rank the related journals. In this work, all MSE management related journals were identified, and categorized using CiteSpace software.

CiteSpace is Java language information visualization software based on the citation analysis theory developed by Dr. Chen [15]. The CiteSpace design was inspired by Thomas Kuhn's scientific revolution structure, with the central idea being that research foci change over time, sometimes incrementally and sometimes drastically. Therefore, scientific developments can be traced by studying the footprints revealed in scholarly publications. As contemporary scientific community members make contributions, these form a dynamic, self-organizing knowledge system that embodies consensus, disputes, uncertainties, hypotheses, mysteries, unsolved problems, and unanswered questions, thereby providing a better understanding of the ways that a specific topic is related to other topics.

The CiteSpace foundation is network analysis and visualization. Network modeling and visualization explore the intellectual landscape of a knowledge domain, discern the questions researchers have been trying to answer, and identify the methods and tools that have been developed to find solutions. The software integrates an information visualization method, a bibliometric method, a data mining algorithm, and a network algorithm, all of which allow the research data to be transformed into a scientific knowledge map, from which knowledge generation and interpretation, the critical evolutionary research field path, and the knowledge inflection points can be determined, thereby allowing for a

detailed exploration of the citations in the management science journals [5, 6].

Parameter Setting

The user interface is divided into left and right. The left-hand side has the project controls (i.e., input datasets) and the progress report windows, while the right-hand side contains several panels that allow the process to be configured using various parameters. Specifically, the CiteSpace process takes a current project input dataset, constructs network models of the bibliographic entities, and visualizes the trends and patterns extracted from the dataset in networks.

First, a new project is built so that the relevant research is entered into CiteSpace. The establishment of the literature database for entry into CiteSpace is shown in Fig. 3.5.

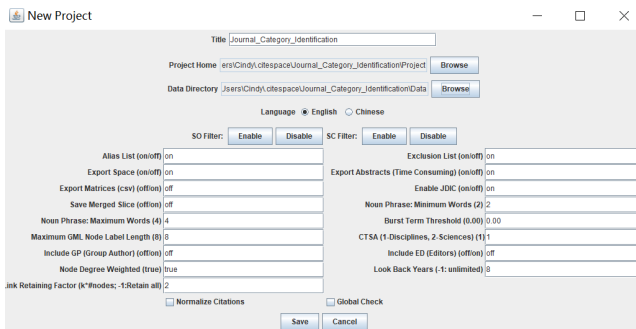


Fig. 3.5: Establishment of the literature database for entry into CiteSpace

Second, the basic parameters are set using the right-hand side panels and based on the research object, the Node Types chosen for the cited journals, as shown in Fig. 3.6.

CiteSpace has a variety of functions: as a collaboration atlas (author, institution and country), a co-occurrence atlas (feature word, keyword and subject category), and a co-citation atlas (literature, author and journal). A cited journal refers to the journals cited in the same document and reflects the

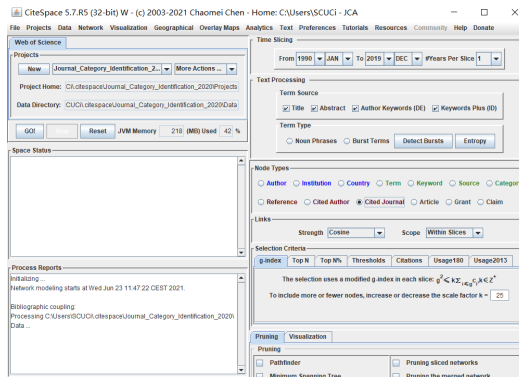


Fig. 3.6: CiteSpace interface for configuring analysis

relevance of the various journals and disciplines. The knowledge base distribution in a research field can be obtained from a cited journal analysis to further reveal the classifications for the cited periodicals.

Third, pressing the green GO button starts the process. CiteSpace reads the data files in the current project (Demo) and reports the progress in the two windows on the left-hand side of the user interface. When the modeling process is complete, there are three options given: Visualize; Save As GraphML; or Cancel. Visualize is selected, which moves the analysis to the visualization window for further interactive exploration.

Visualization results

After clicking the Visualize button, the Visualization Window appears, which initially has movements on a black background. Once the movements have settled, the background color turns white. Here, the initial visualization is examined and the additional functions explained. First, CiteSpace gives a merged network visualization of the developments in the field based on several networks that correspond to consecutive years from 1990 through 2018 and shows the most important footprints for the related research activities. Each dot represents a node or the cited journals in the network. CiteSpace can also generate networks for other types of entities. The lines that connect the nodes are the co-citation links; again, CiteSpace can generate network-

s for other types of links. The line colors indicate when a connection was made for the first time.

Fig. 3.7 is the original graph, in which each node represents a different journal and the lines indicate the connections between the journals. The node size is related to the number of journals, that is, the greater the frequency, the larger is the node. A control panel is shown on the right-hand side of the Visualization Window, in which the node labels are displayed and can be changed using the sliders and a combination of threshold values; the node size can also be changed using the node size slider.

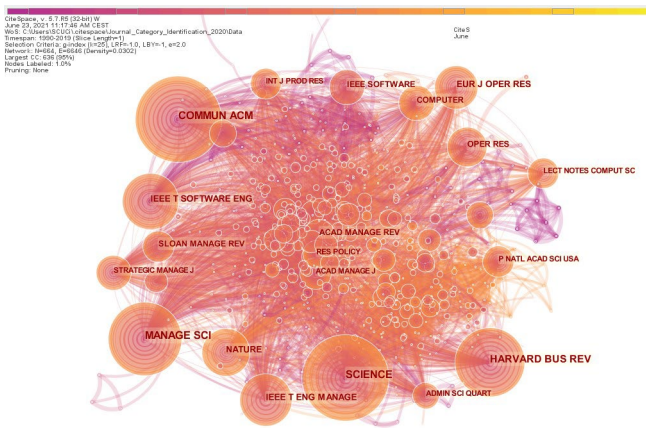


Fig. 3.7: Visualization window: Journal cooperation and affiliations

Clustering

Although it is possible to identify some prominent groupings by studying the visualized network, the clustering function in CiteSpace provides greater precision when seeking to identify the groupings or clusters. To start the clustering function, the Find cluster icon is simply clicked. To characterize the nature of an identified cluster, CiteSpace extracts noun phrases from the titles (T in the following icon), keyword lists (K) or abstracts (A) of articles that cite a particular cluster; here, T was chosen. Once the pro-

cess is finished, the chosen labels are displayed. By default, labels based on one of the three selection algorithms are shown; that is, TF*IDF. Cluster labels are displayed once the process is completed, and the “# Clusters” are shown in the upper right corner of the canvas. The clusters are numbered in descending order of cluster size, starting from the largest cluster # 0, the second-largest # 1, and so on.

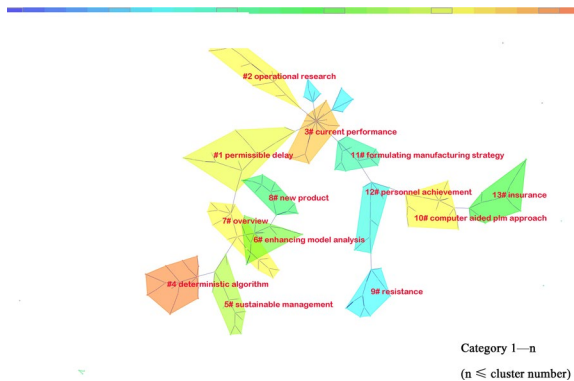


Fig. 3.8: Members of different clusters are shown in different colors

Fig. 3.8 shows the clustering from an analysis of relevant literature from a cited management science journal, with each cluster corresponding to an underlying theme, a topic, or a line of research. Kuhn’s paradigm involves time period clustering, with the cluster colors indicating the average years for that cluster [12]. From this visualization, a deeper understanding of the connections from one cluster to another cluster can be gained.

There are two important metrics for describing the overall structural properties of the network and modularity and the mean silhouette scores. As seen in Fig 3.8, the modularity values (0.918) were relatively high, indicating that the networks’ loosely coupled clusters were reasonably divided. The silhouette measure is used to determine whether the data are appropriately clustered: when the silhouette measure is close to one, the data are appropriately clustered and when the silhouette measure is close to minus one, the data are not appropriately clustered; however, when the silhouette measure is close to zero, the data are on the border of two

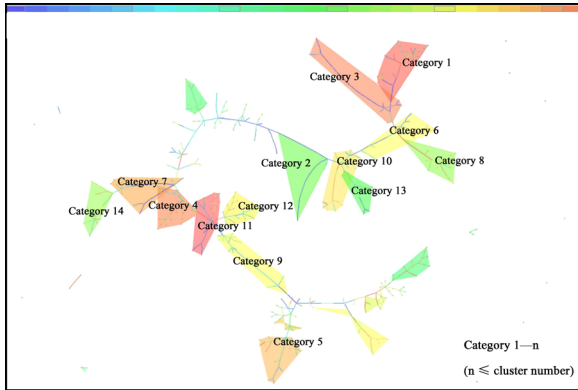


Fig. 3.9: Cluster view for category identification (C-A)

natural clusters [13]. The mean sil-houette scores from the analysis indicated that on average, the management science cluster homogeneity (0.2948) was relatively high.

Auto-labeling was used to identify the clusters; however, to determine which of these were the most appropriate, silhouette and size measures were used. n clusters with a high silhouette (ID: ID1, ID2, ..., ID n ; silhouette: S1, S2, ..., S n) and a large size (SZ1, SZ2, ..., SZ n) were extracted and the cluster labels (TF*IDF) summarized as “category 1”, “category 2”, ..., “category n ”. The category identification cluster view is shown in Fig. 3.9. Once the categories in the above n clusters were distinguished, the representative journals for the management science categories were identified. By summarizing the clusters, all n clusters and the respective details for each group were identified, as shown in Fig. 3.10.

3.3 Journal Recognition

To identify the related journals in each of the journal categories identified in the last section, a new data analysis system was designed. To determine the number of citations and the relationships between the cited journals,

Selected	Clust.	Size	Stho.	mean.	Top Terms (tfidf weighting)	Top Terms (log-likelihood ratio, p-lev...	Terms (mutual information)
<input type="checkbox"/>	0	30	0.586	1988	(10.85) overview, (10.85) soviet multi.	overview (25.02, 1.0E-4); soviet multi.	social science
<input type="checkbox"/>	1	29	0.855	1988	(8.25) permissible delay; (8.25) pay.	permissible delay (10.51, 0.005); pay.	myth
<input type="checkbox"/>	2	29	0.008	1978	(4.82) operational-research; (14.32)	operational-research (65.39, 1.0E-4);	placement
<input type="checkbox"/>	3	27	0.519	1992	(8.25) citation analysis; (7.83) organi.	complexity (7.93, 0.005); organisatio-	distribution problem
<input type="checkbox"/>	4	27	0.577	1991	(10.41) range; (8.93) coherent plurali.	community (17.75, 1.0E-4); uncertain-	omega
<input type="checkbox"/>	5	26	0.6	1988	(4.35) dss modeling technique; (9.3)	dss modeling technique (48.84, 1.0E-	pc-algorithm
<input type="checkbox"/>	6	26	0.626	1992	(7.04) insurance; (6.5) audit lang syn.	audit lang syne (10.51, 0.005); strate-	practitioner
<input type="checkbox"/>	7	25	0.56	1988	(10.08) coherent pluralism; (9.81) co.	concern (37.14, 1.0E-4); community	reflection
<input type="checkbox"/>	8	25	0.602	1987	(8.72) current performance; (8.72) cli.	assessment (17.05, 1.0E-4); current	placement
<input type="checkbox"/>	9	24	0.573	1991	(7.83) change; (7.04) economic forc.	effect (13.4, 0.001); economic forc.	dea-tobit analysis
<input type="checkbox"/>	10	24	0.625	1995	(8.25) past; (7.83) miang; (7.04) miu.	past (11.09, 0.001); method (7.61, 0.	dea-tobit analysis
<input type="checkbox"/>	11	24	0.509	1997	(9.92) sustainable management; (9.	sustainable management (19.44, 1.	group decision-making
<input type="checkbox"/>	12	24	0.706	1988	(11.52) enhancing model analysis; (.	decision support system (38.28, 1.0.	inventory allocation
<input type="checkbox"/>	13	23	0.497	1987	(7.04) formulating manufacturing str.	formulating manufacturing strateg	technique
<input type="checkbox"/>	14	23	0.487	1988	(9.14) new product; (9.14) analytic hi.	new product (34.74, 1.0E-4); analytic	profiling using artificial neur...
<input type="checkbox"/>	15	22	0.636	2003	(8.25) computer-aided pbi approach...	computer-aided pbi approach (13.25;	inventory allocation
<input type="checkbox"/>	16	21	0.571	1992	(8.25) engineering-operations persp.	engineering-operations perspective	construction
<input type="checkbox"/>	17	20	0.355	1988	(17.7) insurance; (6.85) audit lang sy.	insurance (216.52, 1.0E-4); audit lan-	insurance
<input type="checkbox"/>	18	19	0.352	1988	(8.25) blending boundary object; (8.2.	blending boundary object (13.47, 0.0.	mold
<input type="checkbox"/>	19	16	0.688	1988	(8.25) deterministic algorithm; (8.25)	deterministic algorithm (16.55, 1.0E-	facility
<input type="checkbox"/>	20	16	0.688	1992	(7.04) personnel achievement; (7.04)	communicating employability enhan-	practitioner
<input type="checkbox"/>	21	16	0.562	2002	(12.8) resistance; (12.71) weed contr.	future (31.64, 1.0E-4); weed control	selection
<input type="checkbox"/>	22	3	0.333	1994	(8.25) west bengal; (8.25) forest co-	west bengal (21.8, 1.0E-4); forest co-	india
<input type="checkbox"/>	23	3	0.333	2002	(8.25) energy-sponsored geophysica.	department (22.95, 1.0E-4); energy-s-	survey
<input type="checkbox"/>	24	2	0.5	1989		living laboratory (11.83, 0.001); com.	canadian regional develop...

Fig. 3.10: Cluster list for target categories

first the data analysis system was used to identify and review thousands of management science research papers, after which literature mining, the process of extracting unknown, comprehensible and available knowledge, was applied to organize the information [7, 14].

The scientific knowledge map analyses were made up of word frequency analysis, co-word analysis, co-citation analysis, and cluster analysis, which together showed the breadth of information in the scientific knowledge field and the scientific research directions. A knowledge map is based on a knowledge domain and illustrates the development and structure of the scientific knowledge by identifying the complex relationships between the knowledge units or knowledge groups, the network structure, the interactions, the evolution, and the new knowledge. The CiteSpace visualization process has four stages: document retrieval and preservation; data guide and tuning; map customization; and map analysis.

Data collection and tuning

The analyzed data, which included SCI-EXPANDED, SSCI, A&HCI, and other citation libraries [11] were also extracted from the WoS core collection. An advanced search was then used after which articles, proceedings

papers, and reviews were selected. After unnecessary research was filtered out, the related articles were downloaded in Plain Text format, with each data record made up of author, title, abstract, and research citation, and with the retrieval period being from 1990-2018. When searching, the search command was set at X_i AND Y_i , for which “ X_i ” represented “management” and “ Y_i ” represented “category n ”. When the search was complete, all related articles were downloaded and saved in CiteSpace, after which it was necessary to coordinate the data.

(a) Time slicing

The time span specifies the range of citations published over a certain time, the value of which is determined by the citation year distribution and the period the analyst is interested in. The time division length refers to the complete time span, which is divided into equal yearly time intervals.

(b) Term source and term type

The cluster tags are derived from the Title, Abstract, Author Keywords, and Keywords Plus (ID). The keywords are divided into noun phrases and emergent words; however, CiteSpace automatically extracts specific noun phrases as the cluster labels to reflect the specific research focus.

(c) Node types

Depending on the subject analysis, the cited journal is selected as the node type, which then determines the type of object that is represented in the graph. Cited journals are used as important indexes for the terms extracted from the published articles in the journals or databases.

(d) Set threshold

CiteSpace controls the number of network nodes based on a threshold value in a single time zone. The citation that satisfies the threshold condition is then visualized under four settings: Top N; Top N%; Threshold Interpolation; and Select Citers. Top N selects the highest cited N citations, Top N% selects first by the number of citations and then by the percentage of citations (N%) in the same time threshold, and Threshold Interpolation sets the threshold from the citation counts, co-citation counts, and co-citation coefficients (c , cc , ccv), the formula for which is:

$$CC_{\cosine}[i, j] = \frac{cc(i, j)}{\sqrt{c(i) \cdot c(j)}}. \quad (3.1)$$

A threshold anchor is set in the time span for the first, middle and last partitioned times, and a linear interpolation algorithm is used on the rest of

the time partition threshold to calculate the time needed to achieve a different personalized partition threshold. The citation literature was selected (Select Citers) based on the TC value in the citation records, and then one of the three methods (Top N, Top N%, Threshold Interpolation) was used to screen the references in the citation literature. A reasonable threshold can be calculated and compared depending on the number of selected citations, nodes, and connections in the lower left corner of the CiteSpace interface (Space Status and Process Reports).

(e) Pruning and visualization

The Minimum Spanning Tree is used to control the number of network connections, reduce connection density, and reduce cross connections. Using the Pruning sliced network and the Pruning merged network tools, the earliest connections are found and retained and the entire time span for the merged network structure is displayed. After setting the parameters, GO is clicked to start the document screening, from which a statistical analysis and a results graph that shows the nodes and lines are produced.

Atlas interpretation

The main purpose of the analysis is to clarify the graph's meaning and analyze the themes. The node object depends on the type of node set and node ring thickness, with the corresponding time partition being proportional to the number of cited journals for which the ring color represents the cited year; the greater the nodes across the time span, the higher is the number of citations. Therefore, the size of the node is proportional to the number of citations, with the number of citations being standardized by publication date. The connections between the nodes indicate common citation relationships, and the connections between the line length and thickness indicate the connection strength between two nodes. The length and width of the edges are proportional to the same coefficient. A visual view of the category identification is shown in Fig. 3.11.

As can be seen from Fig. 3.11, Journal 1 had the highest number of nodes, indicating that it was the most cited. Further, the connection degree between Journal 1 and Journals 2, 3 and 4 was also the highest. Fig. 3.11 only shows a selection of the higher frequency journals. It should also be noted that "m" is less than or equal to the total number of retrieved journals.

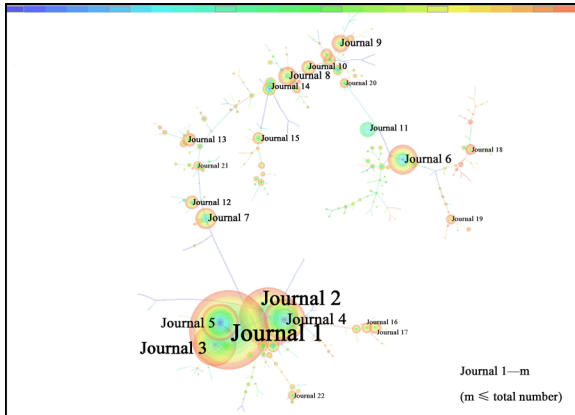


Fig. 3.11: Visual view for category identification (V-B)

Frequency selection

CiteSpace visualization is clear and easy to read. The different colors, node sizes, and node positions make it easy to identify the high citation frequency nodes, the distribution of the cited journals, and the citation years; that is, the cited journal analysis identifies the relevance and academic influence of the journals. Based on the cited frequency of the core journals, a list is generated, which can be sorted by citation frequency, centrality or year, that gives the name of the journal, the publication time and other information. A node in the list can also be shown or hidden. Fig. 3.12 shows the journal frequency list for management science.

Frequency refers to how often an event is repeated per unit time and a frequency distribution is a table that displays a sample of the frequencies from various outcomes by summarizing the data groupings and occurrences in a class. Generally, low frequency journals are not selected as sorting objects as journals that publish fewer articles each year are cited less frequently. Therefore, it is necessary to compare the number of selected journals with the total number of articles published each year, as shown in Eq. 3.2. If F is still small, the journal is not selected.

Visible	Count	Centrality	Year	Cited Journals
<input checked="" type="checkbox"/>	568	0.18	1988	MANAGE SCI
<input checked="" type="checkbox"/>	406	0.08	1983	EUR J OPER RES
<input checked="" type="checkbox"/>	312	0.14	1970	OPER RES
<input checked="" type="checkbox"/>	292	0.13	1980	J OPER RES SOC
<input checked="" type="checkbox"/>	279	0.19	1974	INTERFACES
<input checked="" type="checkbox"/>	218	0.12	1979	OMEGA-INT J MANAGE S
<input checked="" type="checkbox"/>	174	0.14	1973	HARVARD BUS REV
<input checked="" type="checkbox"/>	169	0.12	1973	SCIENCE
<input checked="" type="checkbox"/>	149	0.04	1991	ACAD MANAGE REV
<input checked="" type="checkbox"/>	109	0.05	1983	ACAD MANAGE J
<input checked="" type="checkbox"/>	107	0.07	1992	COMPUT OPER RES
<input checked="" type="checkbox"/>	107	0.14	1973	ADMIN SCI QUART
<input checked="" type="checkbox"/>	106	0.03	2000	INT J PROD ECON
<input checked="" type="checkbox"/>	104	0.01	1997	STRATEGIC MANAGE J
<input checked="" type="checkbox"/>	103	0.01	1982	DECISION SCI
<input checked="" type="checkbox"/>	98	0.04	1995	INT J PROD RES
<input checked="" type="checkbox"/>	98	0.01	1987	ORGAN SCI
<input checked="" type="checkbox"/>	93	0.05	2007	PIVOTAL ACAD SCI USA
<input checked="" type="checkbox"/>	92	0.06	1982	ECONOMETRICA
<input checked="" type="checkbox"/>	91	0.07	1973	MANAGE SCI EMPL
<input checked="" type="checkbox"/>	84	0.05	1976	AM ECON REV
<input checked="" type="checkbox"/>	80	0.01	1988	HANK OPER RES
<input checked="" type="checkbox"/>	80	0.06	1982	DECS SUPPORT SYST
<input checked="" type="checkbox"/>	78	0.04	1982	J MANAGE STUD
<input checked="" type="checkbox"/>	76	0.03	2006	EXPERT SYST APPL
<input checked="" type="checkbox"/>	73	0.01	2000	J MANAGE
<input checked="" type="checkbox"/>	70	0.05	1988	MIS QUART
<input checked="" type="checkbox"/>	67	0.00	2007	NATURE
<input checked="" type="checkbox"/>	66	0.01	2014	PLoS ONE
<input checked="" type="checkbox"/>	62	0.04	2014	PEST MANAG SCI
<input checked="" type="checkbox"/>	62	0.07	1988	SYSTEMS THINKING SYS
<input checked="" type="checkbox"/>	61	0.04	1976	J MARKETING
<input checked="" type="checkbox"/>	60	0.08	1970	COMBIN ACM
<input checked="" type="checkbox"/>	60	0.01	1997	COMPUT IND ENG
<input checked="" type="checkbox"/>	58	0.08	1974	HUM RELAT
<input checked="" type="checkbox"/>	55	0.06	2006	J OPER MANAG
<input checked="" type="checkbox"/>	55	0.00	2012	THEBIS
<input checked="" type="checkbox"/>	53	0.04	1982	NATIONAL ANNUAL PROBLE
<input checked="" type="checkbox"/>	51	0.00	1991	NAV RES LOG
<input checked="" type="checkbox"/>	51	0.08	2008	RES POLICY
<input checked="" type="checkbox"/>	43	0.03	1973	OPER RES QUART
<input checked="" type="checkbox"/>	42	0.08	1992	CREATIVE PROBLEM SOL
<input checked="" type="checkbox"/>	41	0.07	1991	J POLIT ECON
<input checked="" type="checkbox"/>	38	0.00	1994	HE TRANS
<input checked="" type="checkbox"/>	37	0.01	2015	J ECON SURVEIL
<input checked="" type="checkbox"/>	35	0.02	2006	CALIF MANAGE REV
<input checked="" type="checkbox"/>	34	0.03	2012	SCISYSTOMETRICS
<input checked="" type="checkbox"/>	33	0.03	1994	SOFT SYSTEMS METHODO
<input checked="" type="checkbox"/>	31	0.02	1975	J APPL PSYCHOL
<input checked="" type="checkbox"/>	31	0.04	1979	J MARKETING RES
<input checked="" type="checkbox"/>	31	0.00	2012	LECT NOTES COMPUT SC
<input checked="" type="checkbox"/>	31	0.05	1974	ISLAN MANAGE REV
<input checked="" type="checkbox"/>	31	0.04	1995	INFORM SYST RES
<input checked="" type="checkbox"/>	29	0.00	2012	J BUS RES
<input checked="" type="checkbox"/>	28	0.00	2009	IEEE T ENR MANAGE

Journal Rank

Journal 1

Journal 2

Journal 3

Journal 4

Journal 5

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Fig. 3.12: Journal ranking I for category identification

$$F = \frac{\text{Frequency}}{\text{Annual Total of Articles}} \tag{3.2}$$

3.4 Journal Classification

At present, the main evaluation system used for mainstream journals in China is the Chinese Academy of Sciences Journal partition table and Clarivate Analytics JCR Journal Ranking, and while both are based on SCI journal impact factors, there are many differences. Understanding the quality of a journal is important when seeking to study a subject or field from published articles.

(1) Clarivate Analytics Journal Ranking

JCR divides journals into 176 different categories, with the subjects first classified according to the impact factor (IF) in that year and then divided