Jiuping Xu · Fulya Altiparmak ·
Mohamed Hag Ali Hassan ·
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Asaf Hajiyev   *Editors*

Proceedings of the Sixteenth International Conference on Management Science and Engineering Management – Volume 2

Springer

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Volume 145

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Preface

ICMSEM is an international academic research cooperation and scientific research achievement exchange conference platform. Over 362 papers from 30 countries were received, and 115 papers from 25 countries, Australia, Belgium, Canada, China, Egypt, France, India, Iran, Italy, Japan, Kuwait, Melbourne, Moldova, Morocco, Multan, Pakistan, Russia, Spain, Thailand, Turkey, the UK, Ukraine, the USA, and Wales, were accepted for presentation or poster display. Many authors have been involved in international academic research collaborations, with 54 of the accepted papers being co-authored by academics from different countries. Each accepted paper was reviewed by three reviewers, who when necessary have provided revision advice to ensure the conference proceedings is of very high quality, as also evidenced by ICMSEM's active promotion of international academic exchanges and disciplinary development. The proceedings papers have been classified into six sections: dynamic analysis; machine learning; supply chain management; operations management; environmental management; and health and hygiene. The key issues at the sixteenth ICMSEM cover many popular topics, on which experts have been invited to give the keynote speeches. Based on the proceedings divisions, the conference has established six parallel sessions, in which experts from the University of Melbourne, Imperial College London, the University of Castilla-La Mancha (UCLM), the University of Southern California, the University of Michigan, Huazhong University of Science and Technology, the Karlsruhe Institute of Technology, and other related institutions have been invited to preside over. The parallel sessions provide a chance for scholars in the same fields to discuss their research, evaluate and promote each other's work, share frontier research developments, and innovate for future scientific research.

ICMSEM is committed to promoting innovative management science (MS) and engineering management (EM) academic research and development. Every year, renowned experts are invited to deliver the "Developments in Management Science and Engineering–Perspectives from Scientific Journal Report" forum, at which the innovations in Management Science in Engineering journals are discussed.

To further encourage Management Science and Engineering Management state-of-the-art research, ISMSEM awards papers that have made outstanding contributions, which are then included in the IJMSEM journal. ICMSEM is constantly innovating to improve its international conference platform. COVID-19 has brought many unknown challenges to the global community, for which researchers have proposed many innovative theories, methods, and policies for epidemic, social, and economic management; therefore, this year, ICMSEM has a special forum on "International frontiers in COVID-19 research and innovation."

We would like to take this opportunity to thank the participants, all of whom have worked hard to ensure this conference was a success. We want to express our sincere gratitude to the following prestigious academies and institutions for their high-quality papers and ongoing support for ICMSEM: the Azerbaijan Academy of Sciences, Azerbaijan; the Academy of Sciences from the Republic of Uzbekistan, Uzbekistan; the Fuzzy Logic Systems Institute, Tokyo University of Science, Japan; Brock University, Canada; the Moldova Academy of Sciences, Moldova; the University of Castilla-La Mancha (UCLM), Spain; the University of Belgrade, Serbia; the Russian Academy of Sciences, Russia; Gazi University, Turkey; and Sichuan University, China. We would also like to acknowledge the assistance received from the International Society of Management Science and Engineering Management (ISMSEM), Gazi University, and Sichuan University in organizing this conference. We also appreciate the "Lecture Notes on Data Engineering and Communications Technologies" from Springer for the publication of the proceedings. We are grateful to Professor Fulya Altiparmak as the general chair, and Prof. Mehmet Kabak, Prof. Selcuk Kursat Isleyen, and Assoc. Prof. Gul Didem Batur Sir as the organizing committee chairs. We appreciate the support received from all members of the organizing committee, the local arrangement committee, and the program committee, as well as all participants. Finally, we would like to thank all authors for their excellent conference papers, which have significant educational and research value. Conference papers and recommendations can also serve as guiding materials for the administration and management of institutes and enterprises to encourage innovative, scientific business projects and draft or amend relevant policies.

Many new MSEM development trends have emerged, and more innovative development activity needs to be encouraged. Next year, we plan to continue ICMSEM and hope to further improve the quality of the proceedings and recommend additional papers for the ISMSEM Advancement Prize. We sincerely hope

you can submit your new MSEM findings and share your great ideas in Ankara, Turkey, in 2022.

August 2022   Jiuping Xu
                                                                                                          Fulya Altiparmak
                                                                                               Mohamed Hag Ali Hassan
                                                                                          Fausto Pedro García Márquez
                                                                                                           Asaf Hajiyev

Organization

ICMSEM 2022 was organized by the International Society of Management Science and Engineering Management (ISMSEM), Sichuan University, Gazi University. It was held in cooperation with Lecture Notes on Data Engineering and Communications Technologies (LNDECT) of Springer.

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Contents

Health and Hygiene

Advancement of Enterprise Resource Planning, Environmental Management, and Health and Hygiene Based on the Sixteenth ICMSEM Proceedings

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Abstract. Management Science and Engineering Management (MSEM) is a consolidated management theory and management practice that is focused on the study of management theories, methods, and tools for the development of modern production, management, science and technology, the economy, and society. This paper begins with an introduction to the primary notions discussed in Volume II of the 16th ICMSEM Proceedings, followed by a brief review of engineering management (EM) research. Then, the hot research topics; "Enterprise Resource Planning", "Environmental Management" and "Health and Hygiene" are identified based on research reviews and bibliometrics and the popular studies in each research area are discussed. Lastly, CiteSpace, a scientific literature analysis tool, is used to summarize the EM and ICMSEM trends. ICMSEM is committed to providing an innovative international forum for management science and engineering management researchers and practitioners.

Keywords: Enterprise Resource Planning · Environmental management · Health and Hygiene

1 Introduction

Management Science and Engineering Management (MSEM) is the decision-making and organizational implementation of operations management, organizational management, and technical management with its disciplinary management science and engineering system being based on theoretical knowledge of the discipline and wisdom from other fields [14]. The critical information provided by MSEM researchers promotes new scientific research and improves the field's capacity, efficiency, and productivity.

With the rapid development of science and technology and the improvement in people's living standards, there has been a deepening of knowledge in the management science and engineering disciplines. Management science and engineering are also widely used in other industrial engineering fields, such as production

planning management, technical decision-making, financial management, systems design, management services, system optimization, control management and other related fields [23]. Engineering management (EM) is the application of management practice to the engineering practice that brings together technological problem-solving and organizational, administrative, legal, and planning management to enhance the operational performance of complex engineering-driven enterprises [6]. Therefore, the analysis of EM research developments and the identification of its priorities and trends is of significant interest.

In this paper, Sect. 2 provides a literature review on the key three areas, Sect. 3 presents the core themes discussed in Proceedings Volume II; enterprise resource planning, environmental management, and health and hygiene. Section 4 evaluates EM and ICMSEM foreground, and Sect. 5 concludes this paper. The technical route for this paper is shown in Fig. 1.
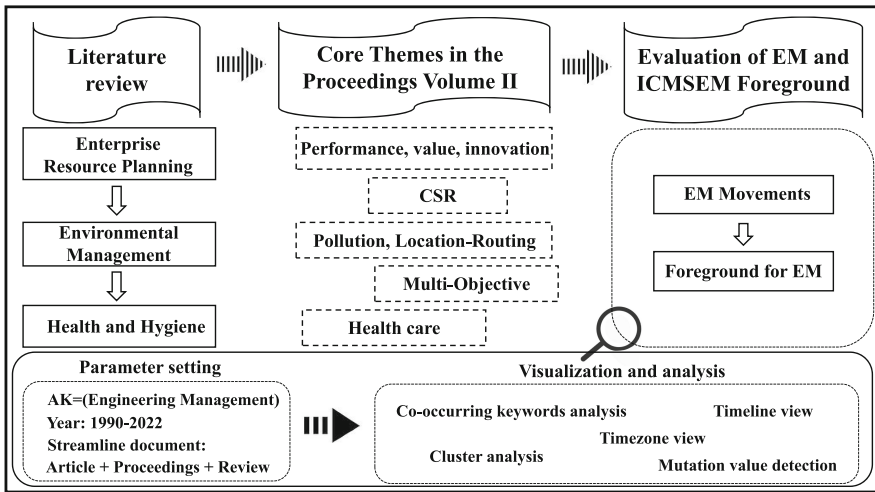
Fig. 1. Framework of the structure of proceeding Volume II

2   Literature Review

To better analyze the related research areas and research directions, the most popular research areas in recent EM researches were reviewed. The most widely discussed areas in recent years have been enterprise resource planning, environmental management, and health and hygiene.

2.1   Enterprise Resource Planning

An Enterprise Resource Planning (ERP) system is a business management system that comprises an integrated, comprehensive set of software that when successfully implemented can be used to manage and integrate all business functions

within an organization. ERP systems are the core of the organization as many organizations need to integrate their enterprise-wide functions, such as accounting, sales and order management, customer relationship management (CRM), and supply chain management (SCM) [12]. The emergence and development of cloud computing have promoted the rapid development of ERP. Consequently, many companies have been pursuing a postmodern ERP strategy that offers best-in-class cloud solutions [19]. The emergence of cloud-based ERP in the mid-2000s has changed the way systems are provided, acquired, implemented, used, maintained, developed, and even retired [3]. Picture 2-tuple linguistic aggregation operators have been applied to multi-attribute decision-making problems in enterprise resource planning systems [20]. For example, Islam et al. used neural networks and linear regression to develop prediction-based resource measurement and provisioning strategies, with the and experimental results showing that the proposed technique provided more adaptive resource management for cloud-hosted applications and can be an important mechanism for achieving on-demand resource allocation [10]. The 21st century had seen digital innovations such as Robotic Process Automation (RPA) and Artificial Intelligence (AI). In the future, ERP systems are expected to adopt more digital innovations such as RPA and AI [12].

2.2   Environmental Management

Environmental issues, such as climate change, resource abuse, air pollution, and water pollution have meant that companies now need to focus on environmental management and integrate environmental foci into their corporate and competitive strategies [9]. Therefore, the relationship between environmental practices, such as environmental management systems and core competencies, has received academic and practitioner attention, generating important debates on environmental management and corporate competitiveness [4,21]. Based on the integration of previous studies, Albertini conducted a meta-analysis of 52 studies over 35 years and confirmed that there was a positive relationship between environmental and financial performances [1]. Environmental management is based on an understanding of the environment. By integrating a spatial analysis of geographic information system (GIS) methods and multi-criteria decision analysis (MCDA), He et al. constructed a general ecological vulnerability index to describe the vulnerability status of ecological hotspots in China [8]. Environmental management needs to start from the pollution source. Muhammad et al. used nonlinear model robustness to demonstrate that positive transport shocks increase carbon emissions [17]. Developments in artificial intelligence have provided better environmental degradation monitoring and treatment. Hafiz et al. presented a holistic model that used a hybrid forest fire assessment and mitigation approach that integrated geographic information systems (GIS), remote sensing, and unmanned aerial vehicle (UAV) observations to assist local disaster management authorities to assess bushfire hazards and develop response plans [13]. The current algorithms could be complemented by additional research to ensure the scientificity and effectiveness of environmental management.

2.3   Health and Hygiene

The World Health Organization (WHO) offers this interpretation of health management that has goals beyond biomedical understanding, and the absence of disease, that is, person's health is a comprehensive state of social, mental, and physical well-being [18]. Issues associated with social health security have been elevated to national security because the health of a country has become one of the most important indicators of national capabilities [11]. Consequently, health management attracted significant research attention. Covid-19, a previously unknown respiratory disease caused by the Coronavirus SARS-COV-21,2, has had serious global health and socio-economic consequences [15]. As with previous outbreaks and epidemics, controlling the spread of Covid-19 depends on detection, the isolation of infected groups, and the implementation of community programs. Many COVID-19 diagnostics now rely on deep learning (DL) algorithms and associated adversarial examples (AEs). Diagnostics tests have shown that DL defense models that do not consider adversarial perturbations are still vulnerable to adversarial attacks [15]. Similarly, for other health problems, management science is needed. Mobile-medical-based systems use data decision-making and wireless network communications to assist the elderly in implementing telemedicine services and a deep learning model combined with sparse autoencoder (CSAE) in the decision module has also been proposed. CSAE has been found to outperform other algorithms in single-patient predictions with a more than 10% higher accuracy than other algorithms [22]. When there are limited medical resources, medical advances can assist both physicians and patients.

3   Core Themes in Proceedings Volume II

The summary review identified that the focus areas in volume II of the Proceedings; enterprise resource planning, environmental management, and health and hygiene; were closely related to sustainable human society development.

The enterprise economy is an important part of the national economy; therefore, good enterprise resources management can conserve societal resources and create national wealth, which means that strengthening enterprise resource management (ERM) is vital for enterprise and national growth. In this volume, several studies have noted the value that modern firms place on corporate social responsibility (CSR). For example, Li et al. examined the relationship between the quality of CSR disclosure and finance constraints, finding that the higher the CSR disclosure quality, the lower the level of financing constraints. Peng et al. found that the formulation and implementation of sustainable management plans and the maintenance of social and public interests were directly conducive to improvements in corporate value, and improvements in corporate reputation and the recognition of stakeholders indirectly promoted improvements in corporate value. Innovation is always the best way for an enterprise to maintain vitality and build core competitiveness. Duca et al. emphasized the need to increase the key performance indicators of the research and development (R&D)

sector and scientific development in the Republic of Moldova as synchronization of management and creativity are the key to the development of knowledge. The main enterprise management resources, such as customer relationships, enterprise brand resources, intellectual property and other knowledge resources, and corporate image can be transformed into intangible enterprise assets, with the main goal of enterprise management being to maximize the enterprise value.

Environmental management began in the early 1970s and has gradually developed into a discipline. Because of the need to focus on sustainability, national governments and scientific research have been paying greater attention to ecology, energy, and the industrial environment. Research on natural resources has always been at the forefront of environmental management. Hu et al. conducted a bibliometric analysis of international river water ecological governance and found that the challenges, models, and benefits coordination of river ecological governance were the key concerns. Using coal as the main energy source for industrial production has greatly increased CO_2 emissions; therefore, there is still significant research being conducted into carbon emissions. Shu et al. Established a multi-objective optimal quota allocation model based on equilibrium strategy, comprehensively considered the economic and environmental issues at the coal mine level, and proposed a coal production quota allocation mechanism. Zheng et al. took the Jiuzhaigou earthquake as an example and constructed a cooperative relationship network between the disaster emergency response partners in the process and then used social network analysis methods to analyze the cooperative relationship network efficiencies. Studies on the sectoral industrial environment can also be found in this volume.

Maslow's Hierarchy of Needs states that physiological needs need to be guaranteed first after which people seek to satisfy their psychological needs. Health and hygiene research has received more attention in the context of the Covid-19 pandemic, with many studies having investigated the factors that may make people more susceptible to the infection. Due to uncertainties in the data obtained from the centers for disease control and prevention (CDCP), Dengiz and Atalay utilized a hesitant fuzzy linear regression (HFLR) model with input and output variables as hesitant fuzzy elements (HFE) to estimate the number of COVID-19 deaths, which in turn was used to determine the effects of the selected variables on the COVID-19 deaths. Studies have also been conducted on the location of Covid-19 facilities and Covid-19 emergency management. Besides the concerns about physical health and hygiene, researchers have also been examining human mental health. Sha and Long used an interdisciplinary thinking model to propose a tourism therapy concept to quantify the effects of seasonal tourism activities on the health of depressed tourists. The dynamic requirements of traditional Chinese medicine (TCM) practice have also prompted researchers to examine TCM's differentiated knowledge system, which is detailed in the "Health and Hygiene" section of this volume.

4 Evaluation of EM and ICMSEM Foreground

To visualize and analyze the trends and patterns in the current research in MSEM journals, the EM and ICMSEM research was examined using CiteSpace, a tool for progressive knowledge domain visualization that focuses on finding critical points in the development of a field or a domain, and especially the intellectual pivotal points and pivotal points [5].

4.1 EM Movements

CiteSpace visual analysis draws various knowledge graphs using node size, network connectivity, and keyword co-occurrence to reveal the research trends within a field [7]. The Web of Science (WOS) core set was the data source as it is the largest scholarly journal network. The dataset search was ((TS = (engineering management)) AND PY = (1990–2022)) AND AK = (engineering management), with the category set to paper and review so that nonacademic papers such as reports and proceedings were ignored, from which 3,623 articles were identified. The following parameters were used in CiteSpace: (1) time slice from 1990 to 2022 and year per slice = 1; (2) term source = title, abstract, author keywords, keywords plus; (3) node type = keywords; (4) pruning = pathfinder; and (5) the scale factor was set at k = 25. After running CiteSpace, the co-occurrence keyword network was output as Fig. 2, after which "find cluster" - "find keyword cluster", and keyword clustering was adopted.

Proceedings Volume I is focused on management science (MS) and its future development trends, and Volume II is focused on engineering management (EM).

Fig. 2. Keywords co-occurrence network of EM

EM is a broad field that covers a wide range of technical and managerial topics. An important resource is the Engineering Management Body of Knowledge (EMBoK) [16]. As shown in Fig. 3 and Table 1, in recent years, the EM theme has been widely distributed across many fields, such as management, resource management, project management, big data, risk management, technological innovation, and environmental management, with enterprise resource planning, environmental management, and health management being the three main clusters. These three core emerging areas were discussed in the literature review; however, because of the multi-dimensional nature of the field, it was difficult to distinguish specific topics across broad domains.

Table 1. Summarization of top 10 clusters

Cluster ID	Size	Silhouette	Year	Label
0	183	0.637	2004	Knowledge management
1	149	0.690	2010	Technological innovation
2	78	0.854	2011	Environmental management
3	77	0.787	2009	Enterprise resource planning
4	66	0.787	2007	Health management
5	64	0.769	2007	Environmental science
6	63	0.838	2011	Risk management
7	62	0.819	2007	Big data
8	61	0.912	2002	Management
9	30	0.934	2009	Climate change
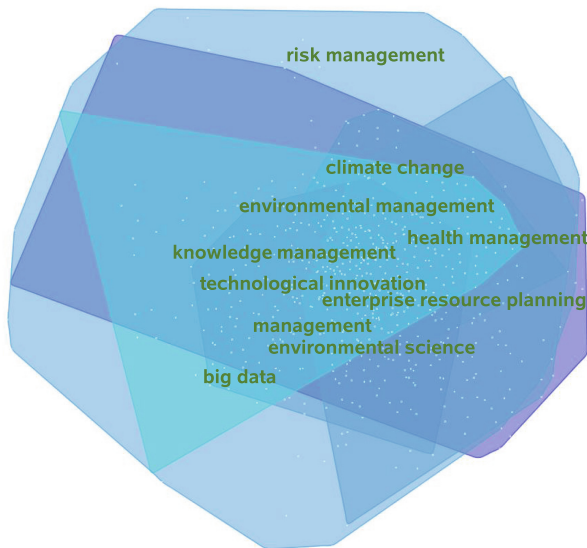
Fig. 3. Keywords clustering diagram in EM

4.2   Foreground for EM

The statistics from the 3,623 papers recorded output were saved and converted into CiteSpace, which transformed the data into a format that could be identified by the software to allow for parameter selection. In this operation, the time span was set from 1990 to 2022 with the time slice set at one year and the theme selection based on the titles, abstract subject words, identifiers, and keywords to allow for node selection. Then, each zone with the highest keyword records was clustered and analyzed, from which a map was drawn for the minimum spanning tree.

Figure 4 gives a timezone view of the EM research. Each circle in the figure represents a keyword, which is the year it first appeared in the dataset. When a keyword was identified, it was set in the year it occurred. As can be seen, the larger circles occurred in the early stages of the EM development, which indicated that the research in these areas had continued to expand. The keyword timezone diagram in Fig. 4 shows that the research was initially focused on the basic project management scope. From 1995 to 2000, system and knowledge management began to appear, and in the 21st century, the research field gradually broadened and many emerging research directions emerged to include research involving simulation, machine learning, health, cost, and climate. As climate change and environmental pollution became more critical global issues, researchers from various fields and environmental monitoring and environmental engineers have begun leading the way in the field of environmental management and health management. The development of an ideal environment has become a primary prerequisite, and later economic construction requires a renewed focus

Fig. 4. The timezone view of research on EM

Top 20 Keywords with the Strongest Citation Bursts

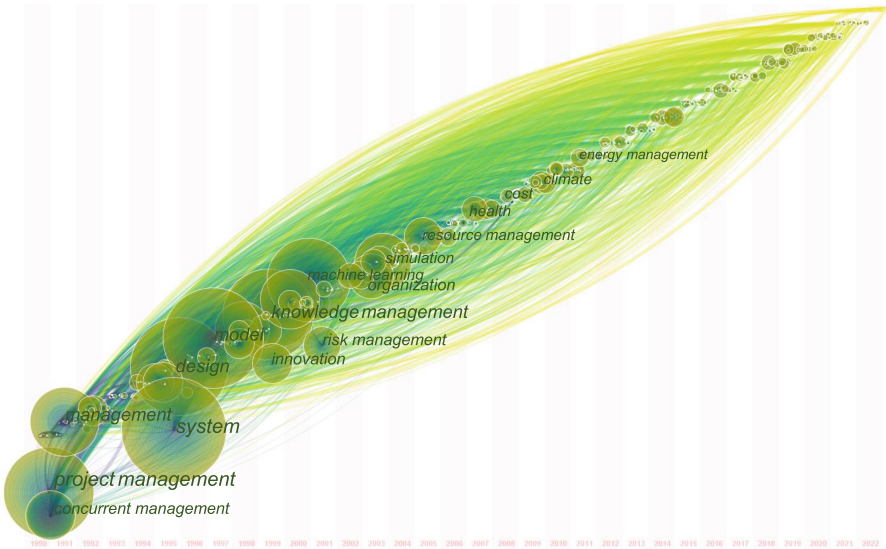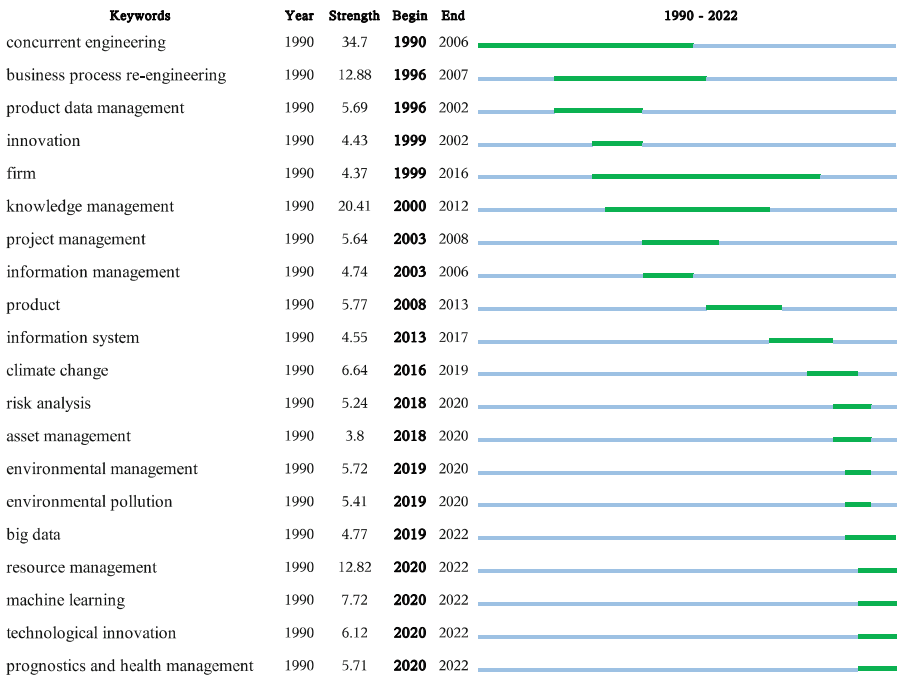| Keywords	Year	Strength	Begin	End	1990 - 2022
concurrent engineering	1990	34.7	**1990**	2006	
business process re-engineering	1990	12.88	**1996**	2007	
product data management	1990	5.69	**1996**	2002	
innovation	1990	4.43	**1999**	2002	
firm	1990	4.37	**1999**	2016	
knowledge management	1990	20.41	**2000**	2012	
project management	1990	5.64	**2003**	2008	
information management	1990	4.74	**2003**	2006	
product	1990	5.77	**2008**	2013	
information system	1990	4.55	**2013**	2017	
climate change	1990	6.64	**2016**	2019	
risk analysis	1990	5.24	**2018**	2020	
asset management	1990	3.8	**2018**	2020	
environmental management	1990	5.72	**2019**	2020	
environmental pollution	1990	5.41	**2019**	2020	
big data	1990	4.77	**2019**	2022	
resource management	1990	12.82	**2020**	2022	
machine learning	1990	7.72	**2020**	2022	
technological innovation	1990	6.12	**2020**	2022	
prognostics and health management	1990	5.71	**2020**	2022	

Fig. 5. Top 20 keywords with the strongest citation bursts for EM

on socio-economic construction and the optimum allocation of resources across all economic entities; therefore, the emergence of focused resource management research can ensure that enterprise resources are not over-allocated across multiple projects. EM is experiencing constant change, with improvements related to human existence being the main focus of recent research.

The analysis of the relevant keywords in Citespace identified the top 30 high-frequency keywords from the 986 keywords, as shown in Table 2, which indicated the primary research foci. Volume II of the 16th ICMSEM Proceedings reflect these critical recent research areas, as we summarize the three themes and their related research directions as follows: enterprise resource planning, which encompasses firm, innovation, product development, strategy, resource management, project and people management; environment management, which encompasses climate change, ecosystem engineer, and environmental pollution; and health and hygiene, which encompasses health care, regenerative medicine, artificial organs, prognostics, and health management. From Table 2, it can be seen that EM research has begun to move from a focus on benefits to a focus on survival and sustainability.

The identification and tracking of research fronts provide knowledge on the latest evolutions in disciplinary research, predict developments in research fields,

Table 2. The top thirty central keywords of EM

Frequency	Centrality	Year	Keywords
290	0.16	1997	Management
281	0.09	1996	System
281	0.11	2000	Resource management
257	0.13	2016	Health care
251	0.07	1993	Machine learning
196	0.05	2003	Sustainable development
185	0.07	2003	Environment management
165	0.11	1999	Innovation
157	0.09	1998	Product development
147	0.04	2016	Human resource management
124	0.04	1998	Climate change
98	0.04	2000	Information
83	0.07	2007	Strategy
87	0.02	1999	Firm
83	0.05	2000	Knowledge management
79	0.04	2019	Environmental pollution
74	0.04	2002	Ecological engineering
72	0.02	1991	Regenerative medicine
72	0.01	2010	Governance
68	0.05	2010	Challenge
67	0.11	2006	Project and people management
65	0.05	2012	Sustainability science
64	0.04	2007	Artificial organs
60	0.03	2008	Cost
60	0.07	2007	Ecosystem engineer
59	0.01	2015	Clinical engineer
58	0.03	2020	Prognostics and health management
56	0.03	2018	Big data
53	0.02	2012	Artificial neural network
53	0.03	2003	Support

and identify issues that need further exploration. The identification of frontiers involves an analysis of the number of occurrences of words or phrases in recent research [2]. Therefore, compared with traditional high-frequency keyword analysis, emergent topics are more suitable when seeking to detect emerging trends and sudden changes in disciplinary development. Emerging word detection technology and algorithms examine the time-frequency distribution of keywords to

detect the topic words that have a high-frequency change rate. The data were exported into Citespace and the top 20 keywords with the strongest citation bursts in the field of EM research were identified.

Figure 4, Fig. 5, and Table 2 show that research focused on the firm had been the main focus since 1999, but more recently, the research on enterprise resource management has become more innovative. In 2016, climate change began to attract significant research attention, and in 2019, environmental management and environmental pollution became research hotspots area. Due to the significant impact of the global pandemic, prognostics and health management have become more recent research foci.

5   Conclusion

EM is a broad field that covers a wide range of technical and managerial topics. In recent years, EM research had widened its diverse knowledge base and hot topics, and constructing, with many advanced research concepts and methods having been developed. The development of modern EM needs to be guided by new, relevant theories; therefore, ICMSEM is focused on advancing EM development hand in hand with MSEM scholars. As intelligence and informatization are closely related to the future of EM, it is necessary to encourage innovation and cross-disciplinary research to find solutions to areas of social concern. ICMSEM will continue to identify the frontier issues and lead development in EM, as EM topics such as the environment, health, information system, artificial intelligence, big data, etc. are expected to continue to be the mainstream research in EM foci in the coming decades.

References

1. Albertini, E.: Does environmental management improve financial performance? A meta-analytical review. Organ. Environ. **26**(4), 431–457 (2013)
2. Barnett, J.: Security and climate change. Glob. Environ. Chang. **13**(1), 7–17 (2003)
3. Bjelland, E., Haddara, M.: Evolution of ERP systems in the cloud: a study on system updates. Systems **6**(2), 22 (2018)
4. Martín-de Castro, G., Amores-Salvadó, J., Navas-López, J.E.: Environmental management systems and firm performance: improving firm environmental policy through stakeholder engagement. Corp. Soc. Responsib. Environ. Manag. **23**(4), 243–256 (2016)
5. Chen, C.: Searching for intellectual turning points: progressive knowledge domain visualization. Proc. Natl. Acad. Sci. **101**(suppl 1), 5303–5310 (2004)
6. Wikipedia contributors: Engineering management–wikipedia, the free encyclopedia (2022). https://en.wikipedia.iwiki.eu.org/w/index.php?title=Engineering_management&oldid=1067766767. Accessed 26 Feb 2022

7. Farr, J.V., Buede, D.M.: Systems engineering and engineering management: keys to the efficient development of products and services. Eng. Manag. J. **15**(3), 3–9 (2003)

8. He, L., Shen, J., Zhang, Y.: Ecological vulnerability assessment for ecological conservation and environmental management. J. Environ. Manage. **206**, 1115–1125 (2018)

9. Hoffman, A.J., Bansal, P.: Retrospective, perspective, and prospective: introduction to the Oxford handbook on business and the natural environment. In: The Oxford Handbook of Business and the Natural Environment. Oxford University Press (2012)

10. Islam, S., Keung, J., et al.: Empirical prediction models for adaptive resource provisioning in the cloud. Futur. Gener. Comput. Syst. **28**(1), 155–162 (2012)

11. Kasyanov, V.V., Minasyan, L.A., et al.: Health management and the strategies to meet a healthy society. Int. Trans. J. Eng. Manage. Appl. Sci. Technol. **9**(4), 357–369 (2018)

12. Katuu, S.: Enterprise resource planning: past, present, and future. New Rev. Inf. Netw. **25**(1), 37–46 (2020)

13. Munawar, H.S., Ullah, F., et al.: UAV assisted spatiotemporal analysis and management of bushfires: a case study of the 2020 Victorian bushfires. Fire **4**(3), 40 (2021)

14. Qi, E.: Research on Education and Teaching Reform and Development Strategy of Management Science and Engineering in China. Higher Education Press (2002). (in Chinese)

15. Rahman, A., Hossain, M.S., et al.: Adversarial examples·security threats to covid-19 deep learning systems in medical IoT devices. IEEE Internet Things J. **8**(12), 9603–9610 (2020)

16. Shah, H.: A Guide to the Engineering Management Body of Knowledge. American Society for Engineering Management (2012)

17. Sohail, M.T., Ullah, S., Majeed, M.T., Usman, A.: Pakistan management of green transportation and environmental pollution: a nonlinear ARDL analysis. Environ. Sci. Pollut. Res. **28**(23), 29046–29055 (2021)

18. Reform at the United Nations: Reference reports and materials (2007). Accessed 1 Mar 2022

19. Van Decker, J., Anderson, R., Leiter, G.: Magic quadrant for cloud core financial management suites for midsize, large and global enterprises. Gartner (2019). https://b2bsalescafe.files.wordpress.com/2019/09/gartner-magic-quadrantfor-cloud-core-financial-management-suites-for-midsize-large-and-globalenterprises-may-2019.pdf. Accessed 22 Aug 2020

20. Wei, G., Alsaadi, F.E., Hayat, T., Alsaedi, A.: Picture 2-tuple linguistic aggregation operators in multiple attribute decision making. Soft. Comput. **22**(3), 989–1002 (2016). https://doi.org/10.1007/s00500-016-2403-8

21. Wong, C.W., Lai, K., et al.: Green operations and the moderating role of environmental management capability of suppliers on manufacturing firm performance. Int. J. Prod. Econ. **26**(4), 431–457 (2012)

22. Wu, J., Chang, L., Yu, G.: Effective data decision-making and transmission system based on mobile health for chronic disease management in the elderly. IEEE Syst. J. **15**(4), 5537–5548 (2020)

23. Zhou, J.: Empirical analysis in the development of management science and engineering. In: E3S Web of Conferences, vol. 253, p. 02038 (2021)

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