International Journal of Robotics and Control Systems
Vol. 5, No. 2, 2025, pp. 1458-1480
ISSN 2775-2658
http://pubs2.ascee.org/index.php/ijrcs

Trend Analysis of Ergonomics in Improving Supply Chain Management Systematic Literature Review in Last Twenty Years: Knowledge Taxonomy

Soulaiman Louah [a,1,*], Hicham Sarir [a,2]

[a] Information System and Logistics Engineering, ENSA Tetouan, Abdelmalek Esaadi Unversity, Morocco
[1] soulaiman.louah@etu.uae.ac.ma; [2] hsarrir@uae.ac.ma
* Corresponding Author

ARTICLE INFO

Article history
Received April 16, 2025
Revised May 13, 2025
Accepted June 11, 2025

Keywords
Co-Citation Analysis;
Trend Analysis in SCM;
Knowledge Taxonomy;
Macro-Ergonomics;
Analysis Literature Review

ABSTRACT

The last ten years have seen a rise in scholarly interest in ergonomics in the supply chain management (SCM) discipline because of technological advancements, as it's possible effects on productivity, worker satisfaction, and overall business success become more apparent. Nevertheless, there aren't many review studies on the subject at hand. To overcome the restriction, the study thoroughly examined the body of research on ergonomics in SCM that is currently available to enhance comprehension of the state of knowledge. This research article examines peer-reviewed works that have been published between 2000 and 2024 and are accessible through the Scopus database. After thoroughly searching the literature using the Scopus database, 84 papers published in 27 peer-reviewed international journals were found. The current study examines the trend of publications in the area of the analysis of ergonomics in sustaining SCM as well as the most well-known and prolific authors and articles. Then, to find topic clusters, a bibliometric analysis was done with VOSviewer as the primary metric tool in this study for visualizing and analyzing the major hotspots and the evolution of ergonomics in SCM research. The using of co-citation analysis and bibliographic coupling to construct the network map uncovers intriguing themes and patterns in the field of ergonomics in SCM and that points to the need for greater international cooperation in tackling this problem. That's why our work has improved our understanding of ergonomics in SCM, and the results have led to recommendations for further research.

1. Introduction

The creation of ever-more intricate global SCM is one of the major tendencies of globalization. However, only a small portion of a final product's production is under control, and operations are regularly transferred to other units. The problems that global supply networks pose to the long-term viability of ergonomics are covered. All industrial systems use SCM, which is a form of competitive excellence. When value addition yields maximum production, the supply chain becomes highly competitive [73]. SCM involves overseeing the production and supply processes while taking into account the entire supply chain network from the start of the product lifecycle to the finish [1]. The ability of firms to carry out continuous improvement programs rests on their awareness of their strengths and shortcomings in this cutthroat business environment. A key factor in the effectiveness of SCM is supplier selection, which is a multi-criteria decision-making challenge [50]. The driving force behind preserving the connection between business and environmental factors is ergonomics [73]. The science of ergonomics connects human limitations and capabilities to occupational needs [3]-[5]. Jobs might include more conventional, concrete tasks like running machinery or using hand tools, as well as more symbolic tasks like using a cell phone or driving a car [83].

The application of ergonomics in SCM for many domains for example, pharmaceutical supply chain [32], digitalization [20], [21], [23], industrial ergonomics [9], [68], [64], macro-ergonomics [6], [58], ergonomics and sustainability [34], [48], innovations [2], [23], and healthcare [41], [56], [78]. Thus, how can ergonomics performance be improved in SCM? What is her effect? [8].

The macro-ergonomics approach, as proposed by Herrera S.M. and Huatuco L.H. [6], applies collaborative supply chains and is a crucial interdisciplinary link to put into practice. It comprises various satisfactory results in terms of the quality of the working life, the productive results, and the appropriate relationships that are established within the supply chain. The creation of a graduate-level health systems program at Binghamton University's Department of Systems Science and Industrial Engineering (SSIE) is presented by Wang S. and colleagues [10]. Details on how to use internal and external resources to make the curriculum comprehensive and adaptable, as well as course creation, modification, and selection are covered. Gu H and associates [21] provided a precise and useful ergonomics assessment method for newly created smart cockpits in the automotive sector. Furthermore, Modern cars are increasingly featuring smart cockpits. García-Alcaraz J.L and al [40] used tools like the NASA Task Load Index (NASA-TLX), the National Institute for Occupational Safety and Health (NIOSH) model, the Rapid Upper Limb Assessment (RULA), and the Rapid Entire Body Assessment (REBA), ergonomics assesses the risks faced by the workforce. Then, revamping workstations or work procedures, to minimize or eliminate hazards, enhancing employee performance initially and the company's performance later on [11]-[16].

Consequently, the booming of ergonomics in SCM research over the last five years, the studies that are currently available are out of date due to the timing of their release, the volume of papers they contain, and other factors. Thus, a quantitative and objective study of the total development of ergonomics in SCM is highly significant both theoretically and practically. Moreover, it's can be used to chart the development of research trends, pinpoint important contributors, and evaluate the effects of different ergonomic interventions on productivity, security, and employee well-being. Therefore, the goal of this study is to construct the knowledge categorization system for ergonomics in SCM by conducting a thorough analysis of the worldwide ergonomics in SCM literature, exploring hotspots and research trends in the field. In particular, monitoring and assessing the development of ergonomics in the field of SCM research, beginning with publishing year and journals, document type and publication domains, nations, regions, and organizations, significant documents, and keyword clustering and research themes. Secondly, using the scientometric data to build the knowledge taxonomy. Finally, finding the gaps in the literature and potential areas for future research comes in third. It is anticipated that the results will give scholars and practitioners a comprehensive overview and deep comprehension of ergonomics in SCM research. Furthermore, the suggested knowledge structure can be utilized to evaluate, increase, and offer references for other cutting-edge logistics projects in the field of ergonomics in SCM [18], [19].

This paper's structure has been thoughtfully created to offer a thorough examination in order to accomplish these goals. The second segment will examine the technique is described in depth, the simulation and findings are presented in Section 3, the discussion, consequences, and recommendations for additional research are provided in Section 4, and the main conclusions and restrictions are outlined in Section 5.

2. Materials and Methods

Bibliometric analysis has been used to investigate the analysis of ergonomics in SCM literature reviews, evaluate the merits of studies, and identify research trends for literature that is becoming more and more abundant due to technological advancements and ongoing investments in scientific research. A thorough and precise technique for looking through and evaluating a lot of scientific material is bibliometric analysis. The method attempts to identify the relationships between journal citations and provide an overview of recent developments in hot, trending research subjects [87]. This quantitative analysis of the literature, free from subjectivity and other non-scientific influences, is frequently employed in many areas as bibliometric software and scientific databases have become more accessible and functional [24], [26].

The analysis of ergonomics in SCM-related publications published between 2000 and 2024 was retrieved using the advanced retrieval feature in the Scopus core collection database (see Table 1). We sifted the research based on the field of study and the study language, such as its disregard for grey literature and materials written in languages other than English. Furthermore, to ensure the quality of the literature, the document types were research articles, conference papers, conference reviews, books, reviews, and book chapters. The abstracts of each document were thoroughly examined at the following step in the selection process [28], [29], [31].

Numerous tools are available for bibliometric analysis, including the R package Bibliometrix, which is based on code commands; CiteSpace, VOSviewer, and HistCite, which offer visual views based on user interfaces; and Pajek and Gephi, which concentrate on building complex network analysis. However, Bibliometrix offers a thorough R-based framework for bibliometric analysis, whereas CiteSpace offers sophisticated temporal analysis and citation network research. on the other hand, VOSviewer's selection might be provided by a discussion of its particular advantages in connection to the goals of this investigation, such as its special capabilities for network analysis and clustering. The Visualization of Similarities viewer (VOS) is one of them [85] and is gaining popularity in bibliometric research due to its exceptional visualization powers and ease of use in loading and exporting data from several sources for the creation of maps based on network data, as well as the ability to see and interact with these maps [86]. Researchers can acquire the themes or clusters used in the titles and abstracts of nations, organizations, and published papers by using citation connections, bibliographic coupling, and co-occurrence analysis [88]. The program is frequently used in bibliometric research for analysis in a variety of disciplines, including knowledge management [89] and geography [90]. As a result, VOSviewer software serves as the primary metric tool in this study for visualizing and analyzing the major hotspots and the evolution of ergonomics in SCM research, and is a potent tool for visualizing and studying huge bibliometric networks. Knowledge graphs featuring network visualization, overlay visualization, and density visualization are used to present the co-occurrence of keywords and co-citations in the literature [33], [36], [39].

Based on the above criteria for searching, filtering, and data processing, Fig. 1 presents the bibliometric flow implemented in this study. In addition, Scopus's sophisticated retrieval feature was used to obtain the ergonomics in SCM-related publications published between 2000 and 2024. Additionally, despite the process's difficulties, those research that were entirely or partially irrelevant were eliminated. Examining the abstracts of each document in detail was the next stage in the selection process. The inclusion and exclusion criteria for this round focused on whether the research met the study's emphasis on ergonomics in SCM advancements specifically [42], [45]-[47].

In **step 1**, to get visual results for the bibliographic study, we opened VOSviewer and imported the downloaded database. Since data cleansing is typically required when making maps based on a web of Scopus, it lets us choose and configure criteria according to various analysis aims and data sources [49].

To determine the most cited journals and the research fields they are associated with four scientometric tests were conducted for **step 2**. These tests included (a) Journal co-citation analysis, which shows how often journals are mentioned together to highlight important linkages, prominent publications, and emerging trends within the literature, is essential for determining the intellectual structure for the ergonomics-related reviewed publications in SCM is made clear by this study. (b) Analysis of collaboration between countries and organizations: to illustrate the global network of collaborative research in ergonomics in SCM between nations and organizations, enabling readers to rapidly comprehend the alliances and restrictions between significant international research communities and academic institutions. On the other hand, analysis of documents co-citations (c) is crucial for determining the connections between important ergonomics in SCM papers because it identifies foundational works, tracks the evolution of important concepts, and reveals research clusters that advance our understanding of ergonomics in SCM. (d) Co-occurrence analysis of keywords is crucial for determining the thematic structure of ergonomics in SCM because it highlights the most talked-about ideas and shows how closely related subjects develop and relate to one another, providing information about new trends and areas of interest in the ergonomics literature in SCM [51], [53], [55].

Step 3 involved proposing the ergonomics in SCM hierarchical knowledge structure for a theme discussion. In addition, the text mining program to display the time perspective of the clustered keywords derived from the same data, VOSviewer was used in conjunction with scientific mapping. Van Eck and Waltman's software analyzes the input file, generates a network map, and then provides choices for exploring and visualizing the map [95]. Furthermore, it is a complete tool for visualizing similarities (VOS)-based bibliometric analysis. It has the unique feature of being able to group different pieces of information from different fields according to how similar and relatable they are. A country, organization, word, reference, etc. are examples of bibliographic items that are represented by nodes in the networks that are shown. Besides, the node size shows the number of citations or occurrences taken into account during the examination [60], [61]. A co-citation, co-occurrence, or collaboration relationship is indicated by a link. The software generates a measure of the degree of correlation between any two nodes in the networks it creates, called total link strength (TLS). A greater TLS value increases an item's centrality and significance. Low similarity nodes should be kept as far away as possible, but high similarity nodes were grouped together and distinguished from other clusters by their colors [94].

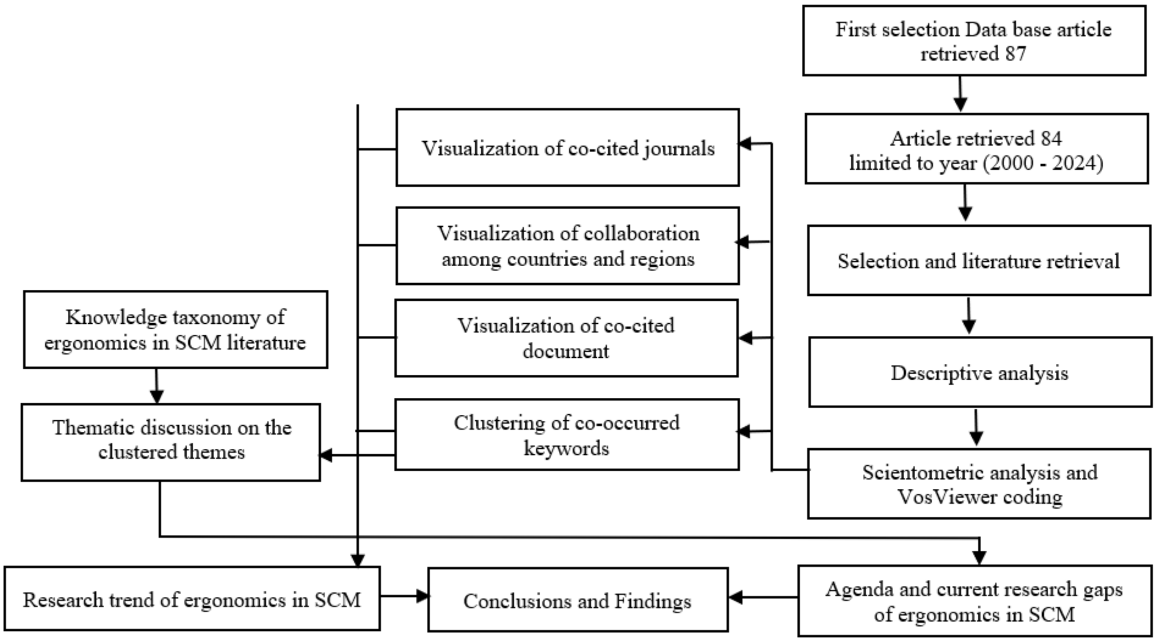

Fig. 1. This research's bibliometric flowchart comprises three steps

3. Results and Findings

3.1. Yearly Publication of Ergonomics in SCM

Fig. 2, which shows the growth from 2000 to 2024, presents the number of publications on the analysis of ergonomics in SCM research. There is a growing body of published articles that support the general growth trend. The research trend that has been observed can be categorized into three phases based on the average annual number of publications. (i) Before 2007, the field of the analysis of ergonomics in SCM research saw a period of gradual expansion, with fewer than 3 publications per year. An average of 2 publications were made annually. (ii) There was a minor increase in the quantity of publications between 2008 and 2017. (iii) Research in the analysis of ergonomics in SCM has grown rapidly since 2018, with slightly negative growth in publications in 2023 and 2024, with the number of publications peaking in 2019 (n = 13, 14.28%), the observed decline in publications post-2019 is attributed to the COVID-19 pandemic and other potential factors, such as shifts in research priorities or funding constraints. In addition, a further increase in research trends likely to be seen in 2025 and 2026, because of the importance of ergonomics in SCM in future.

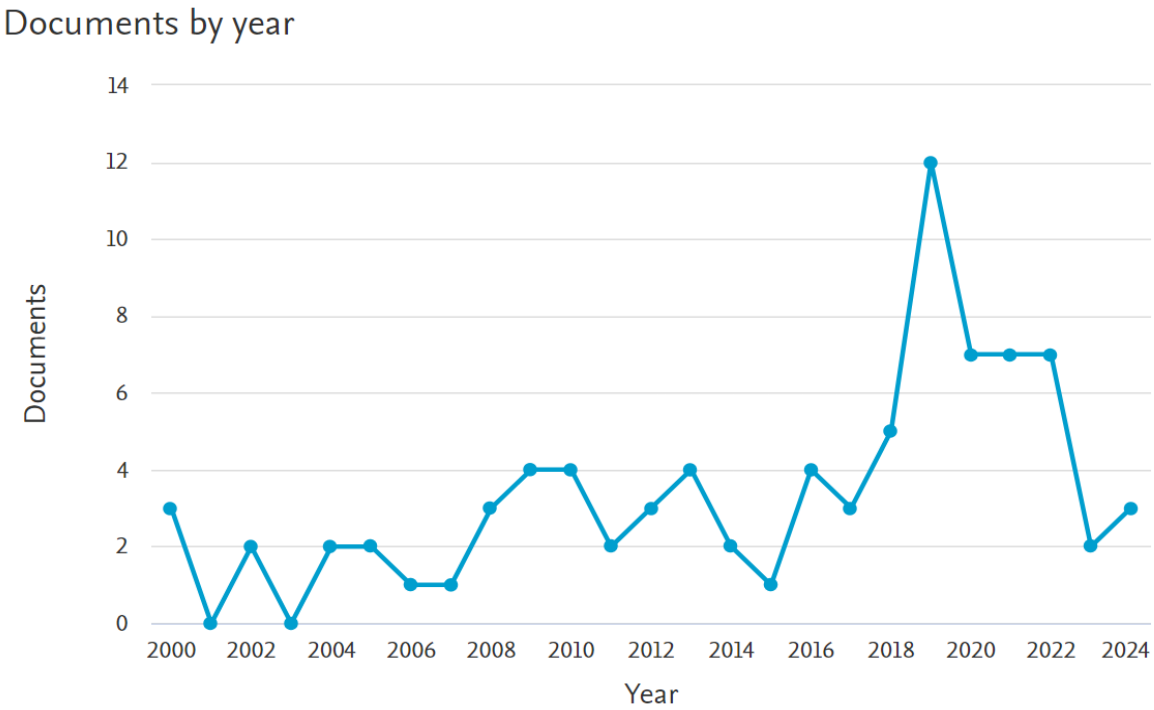

Fig. 2. Annual output of ergonomics in SCM published

3.2. Document Type of Ergonomics in SCM

As seen in Fig. 3, we looked at the different kinds of documents that contained ergonomics in SCM studies. The publications with topic names are categorized by type of document. Furthermore, according to the presented statistics, the majority of the documents 33.3% and 32.1%, respectively published as conference papers and articles, and they fell into two categories. Moreover, 14.3% of the document types are conference reviews, perhaps because ergonomics in SCM has been debated and discussed informally in addition to being a widely recognized emergent research issue. As well as the books made up 8.3%. Only 7.1% of publications have been reviewed since, between 2000 and the present, only 84 papers have been proposed, and the results are not clear. The Book chapters make up 4.8% of the other document types [63], [66].

3.3. Domains of Publications

The Scopus database's results were used to create the data for the research categories. The top ten research categories of publications are displayed in Fig. 4. The data indicates that research encompasses a broad range of fields, with "engineering" (i.e., 30.1%) continuing to be the most researched field in the study. Furthermore, significant research areas included "business management" (14.7%), "social sciences" (10.9%), and "decision science" (10.3%). The initial fields of applied study, computer science, medicine, economics, finance, and econometrics, as well as materials science, are still garnering attention less. Furthermore, related research focuses on assisting people in their daily lives and helping them make decisions that are healthier and more sustainable. It encompasses areas such as "Environmental science" and other areas. We advise actively participating in expanding ergonomics SCM knowledge and practice in different subjects mostly environmental and healthcare [69]-[71], [74].

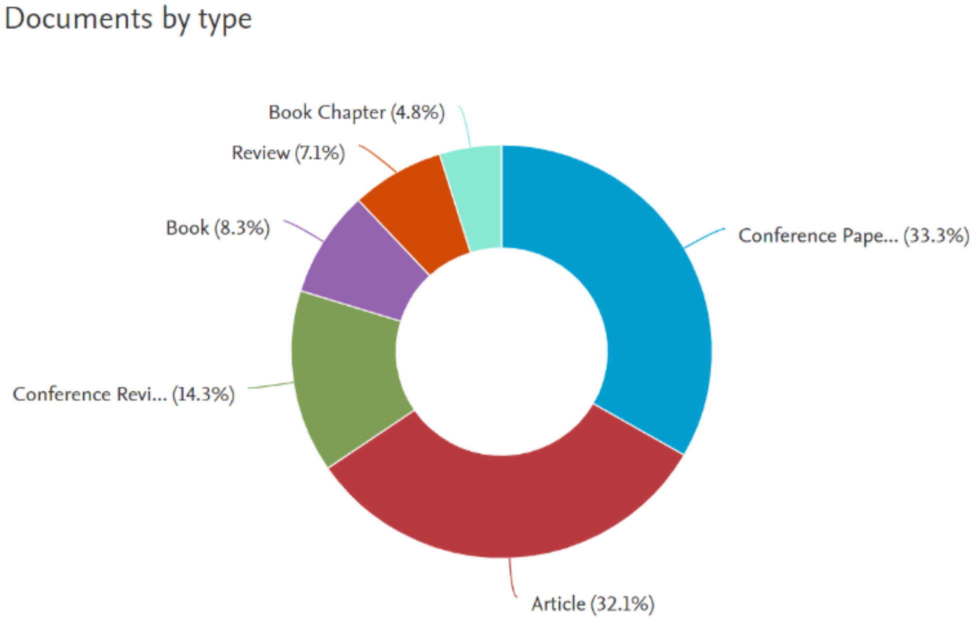

Fig. 3. Publications by document type

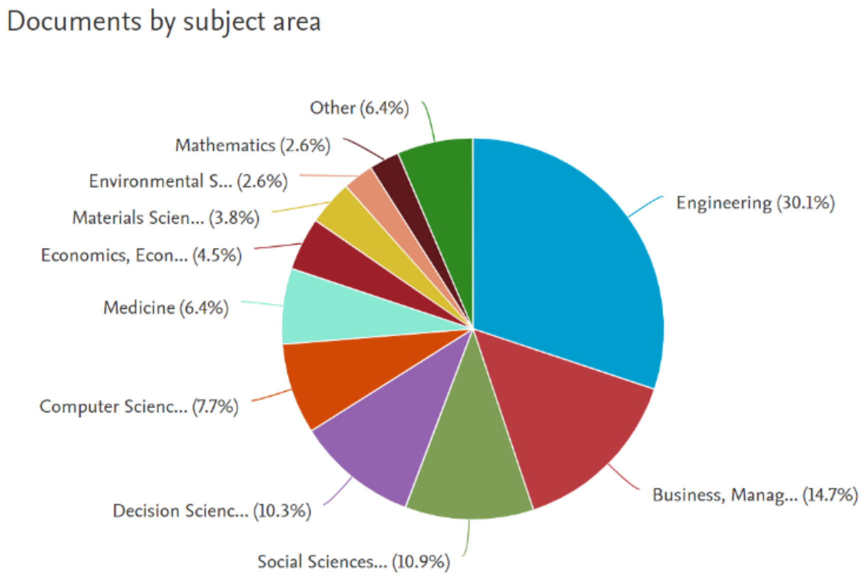

Fig. 4. The top research categories of publications

3.4. Journal Allocation and Co-Citation Analysis

We discovered that related research articles are published in a variety of journals and suggesting a noteworthy advancement in the field. The researchers reviewed and chose 84 papers, which were then published in 27 different publications. Table 1 summarizes the top 18 most prolific journals their number of citations and the normalized citation of the journals. The final top 18 journals were ranked based on the number of publications, and two conferences (Iop conference series: materials science and engineering and Asee annual conference and exposition, conference proceedings) and book (Lean engineering for global development) proceedings were also disqualified. The journal's number of citations was considered in the event of a tie. The journals' citation counts do not match their ranks when the number of published articles determines the ranking of the journal. Some journals publish very few publications but have a large number of citations. We investigated the causes of this by building a treemap (Fig. 5) of the average citations and normalized citations of the top 18 journals, which is an effective and space-saving method of visualizing the data [85]. Six of the most productive journals, according to Table 1 data, have an ergonomics focus, and three of the top five journals with the highest average citation in Fig. 5 also have an association with health care, ergonomics, and technology [81], [82], [84].

Table 1. Top 18 most productive journals

Journals	Publications	Cita-tion	Average Citation	Normalized Citation
Advances in Intelligent Systems and Computing	4	24	6	3.67
Applied Ergonomics	2	74	37	4.75
International Journal of Industrial Ergonomics	2	89	44.5	5.52
Work	2	31	15.5	2.51
Anaesthesia	1	226	226	6.70
Cirp Journal of Manufacturing Science and Technology	1	72	72	1.92
Ergonomics in Design	1	54	54	5.52
International Journal of Production Research	1	48	48	2.34
International Journal of Physical Distribution & Logistics Management	1	38	38	1.07
Engineering Economics	1	16	16	3.00
Ergonomics	1	16	16	4.09
Journal of Medical Internet Research	1	17	17	4.25
Human Factors and Ergonomics in Manufacturing	1	15	15	0.42
Buildings	1	12	12	4.00
Revista de Gestao	1	10	10	2.94
Uncertain Supply Chain Management	1	7	7	0.91
Journal of Applied Engineering Science	1	6	6	0.49
Sustainability (Switzerland)	1	5	5	1.25

3.5. Institution Distribution and Country

As significant analytical variables in bibliometric analysis, nation and institution can represent the amount of research conducted in a given area and the relative contributions made by various institutions or areas. We can assess the academic standing and collaboration networks of various nations or institutions by examining the citation and co-citation of their papers [93]. The 84 publications were spread among 38 nations, according to statistics from the Scopus database, and Table 2 lists the top 12 countries with the most publications. This represented 64.2% of the publications (n = 54) in total. With 13 publications or 15.4% of all publications, the United States ranked top, far ahead of other nations. The United Kingdom is in second place with 14.2%, while Germany is third with 5.9% [91].

The most significant nations for ergonomics in SCM research were then examined using bibliographic coupling linkages. Moreover, Bibliographic coupling follows from the logical assumption that two texts with a large number of shared literature references will have comparable content [92]. Accordingly, the number of similar references given by the papers is displayed in the coupling analysis as a gauge of the nation's level of cooperation with the publication in question. In VOSviewer, we chose the "bibliographic coupling" analysis type with "countries" as the unit of analysis. To acquire the greatest number of linkages generated between nations, we also set the minimum number of documents and number of citations for each country in VOSviewer to be 2 and 2 respectively. Finally, a map was created with 12 elements,14 linkages, and 17 countries. Fig. 6 presents a network depiction of the four main groups based on the country analysis by bibliographic coupling. The blue and green clusters, which stand for the United States and the United Kingdom, respectively, are by far the most noticeable of the clusters. There are four dispersed countries in the red cluster: European nations like Germany and Italy, as well as Asian nations like India and Iran. These nations are mentioned in related articles in addition to their geographic separation. Regarding the relatively sparse cluster, Portugal and Poland are most visible in the yellow cluster. Consequently, there hasn't been much collaboration across countries until now.

Table 2. Publication countries of ergonomics in SCM

Region / Country	Continent	NP	TLS	Average year	Total Citations	Average Citation	Normalized Citation	Average Normalized Citation
United States	North America	13	55	2013	172	13.23	24.53	1.89
United Kingdom	Europa	12	24	2012	121	10.08	6.70	0.56
Germany	Europa	5	2	2013	12	2.40	1.66	0.33
Italy	Europa	4	50	2016	288	72.00	11.71	2.93
Canada	North America	3	11	2013	58	19.33	4.60	1.53
Iran	Asia	3	53	2017	35	11.67	4.91	1.64
Portugal	Europa	3	72	2018	23	7.67	5.52	1.84
France	Europa	3	82	2020	16	5.33	5.33	1.78
Denmark	Europa	2	1	2017	31	15,50	3.36	1.68
India	Asia	2	1	2022	4	2.00	1.83	0.91
Romania	Europa	2	14	2021	3	1.50	2.00	1.00
Poland	Europa	2	73	2023	2	1.00	1.20	0.60

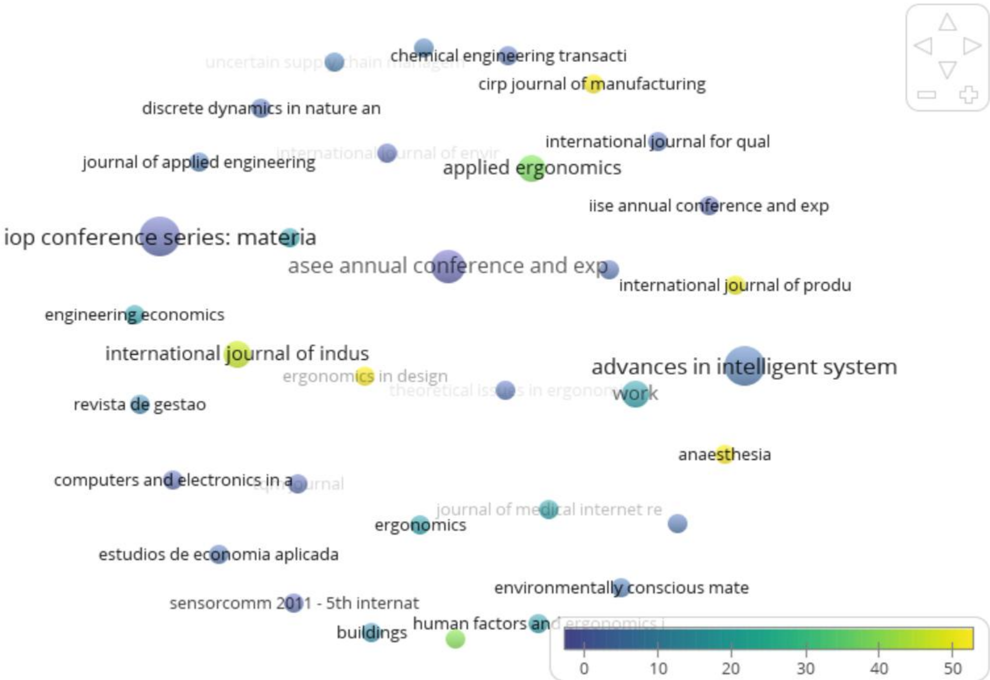

Fig. 5. A treemap displaying the most cited journals on average

Fig. 6. The network representation of countries using bibliographic coupling

Fig. 7 depicts the network of eight items and nineteen links that were created from the 34 organizations that contributed to ergonomics in SCM research and had more than five papers and ten citations. Because they have received more citations, academic institutions in North America and Europe are more well-known in the field of ergonomics in SCM. Including the Humanitas University (Milan, Italy, 226 citations), Vienna University of Technology and Fraunhofer Austria Research Gmbh (Austria, 72 citations), Ryerson University, Toronto, (Canada, 55 citations), Chalmers University of Technology, (Gothenburg, Sweden, 55 citations), Loughborough University (United Kingdom, 50 citations) and University of Pittsburgh, (united states, 48 citations). Moreover, inadequate cross-organizational collaboration in research is depicted in Fig. 7. As a result, there is currently little evidence of collaboration between academic institutions with disparate histories.

Fig. 7. Mapping the worldwide network of collaboration between organizations

3.6. Highlight of Important Research

By using the portfolio's document co-citation test, the co-citation network was created and the most significant ergonomics in SCM publications during the last 20 years were examined. To create a co-cited visual network map of seven items, as seen in Fig. 8 and 19 of TLS, the minimum number of citations in VOSviewer was set to five. The nodes on the map represent the documents that were located based on the year of publication and the name of the first author. The dates of publication and co-citation for the two documents are shown, respectively, by the colors of the nodes and the links. An evident kind of "local concentration and overall dispersion" can be seen in the co-occurrence of the literature, suggesting that some ergonomics in SCM studies were well-known and yielded some shared concepts and outcomes. The years 2002 and 2010, which were significant for ergonomics in SCM research, are when the majority of highly cited papers first emerged. The knowledge of ergonomics in SCM is disseminated ever more quickly, according to the co-citation time series.

The publication year, title, *total link strength* (*TLS*), citation counts, and themes of the top 7 most referenced publications are displayed in Table 3. The most cited study was by Neumann W.P and Medbo L. [17], Technical and ergonomic considerations for redesigning material supply systems: large vs small boxes. The second is Siemieniuch C.E and Sinclair M.A [77], whose main contribution is regarding organizational learning, process ownership, and complexity in industrial organizations from an ergonomics standpoint. Other highlighted documents' primary subjects include (i) implementation of the SCM and ergonomics (e.g., concurrent engineering [25], [50], [35], healthcare [58]). (ii) Causes of workplace stress in the textile industry of developing countries [80].

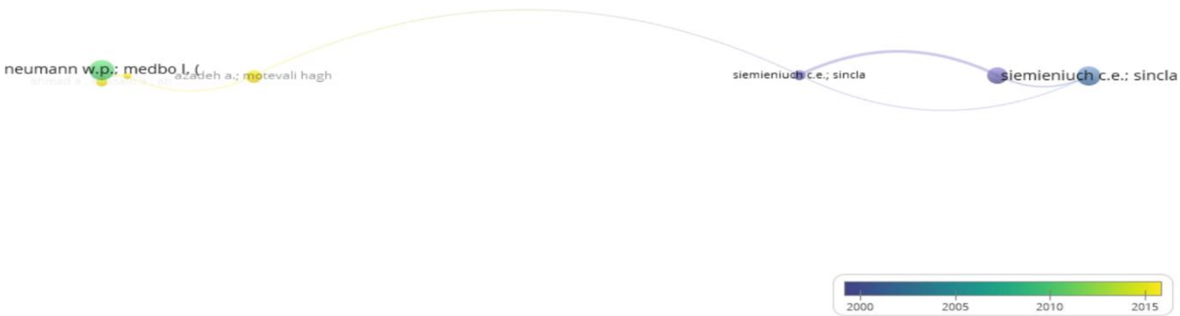

Fig. 8. An analysis of the co-citation relationships between key documents

Table 3. List of papers that have had the biggest influence on SCM ergonomics

Author	Year	Title	TLS	Citation	Topics Concerning Ergonomics in SCM
Neumann W.P and Medbo [17]	2010	Ergonomic and technical aspects in the redesign of material supply systems: Big boxes vs. narrow bins	1	55	Industrial ergonomics
Siemieniuch C.E and Sinclair M.A [77]	2002	On complexity, process ownership and organisational learning in manufacturing organisations, from an ergonomics perspective	4	50	Applied ergonomics
Anumba C.J and al [35]	2000	Supply chain implications of concurrent engineering	14	38	Physical distribution and logistics management
Azadeh A and al [58]	2016	Optimization of healthcare supply chain in context of macro-ergonomics factors by a unique mathematical programming approach	2	24	Applied ergonomics
Siemieniuch C.E and Sinclair M.A. [25]	2000	Implications of the supply chain for role definitions in concurrent engineering	13	15	Human factors and ergonomics in manufacturing
Ahmad A and al [80]	2017	Causes of workplace stress in textile industry of developing countries: A case study from Pakistan	1	12	Advances in intelligent systems and computing
Amalnick M.S and Saffar [50]	2017	An integrated approach for supply chain assessment from resilience engineering and ergonomics perspectives	3	7	Supply chain management

3.7. Analysis of Co-Occurring Keywords

The last research questions for this study focused on the publication's content and examined current or potential correlations between themes of ergonomics in SCM. The keyword of co-occurrence analysis, is a method for analyzing the publication's content by extracting terms from the complete text of the articles, was used for this purpose. To improve the study's interpretation of co-citation analysis (in the past) or bibliographic coupling (in the present), as well as forecast the field's future development, keyword co-occurrence analysis can be applied longitudinally to predict future research in the field [87]. Furthermore, to achieve more precise outcomes, a threshold level of three keyword occurrences was established, and less relevant terms were manually eliminated. According to Fig. 9, the network visualization was built using 373 linkages and the co-occurrence frequency of 44 keywords out of a total of 814 obtained keywords. Each keyword in a network visualization is represented by a node, and the size of each node indicates how many articles the keyword appears in. The nodes' clusters are shown by corresponding colors, and the distance between different clusters shows how related they are to one another. In particular, if there is less distance between two clusters, then there may be a close relatedness between them, and vice versa. The network visualization displayed in Fig. 8 is composed of five primary clusters: red, green, blue, yellow, and purple.

First, Cluster #1 (11 items) includes topics related to efficient information management systems that take ergonomics and human factors into consideration maximize productivity and user experience by creating tools, workflows, and interfaces that complement human capabilities, lowering stress levels, and improving overall performance. Second, Cluster #2 (11 items) includes topics related to the incorporation of human factors into supply chain performance challenges conventional models by emphasizing the crucial role of employee behavior, decision making, and leadership all of which are frequently overlooked in conventional industry practices while existing theories primarily focus on operational efficiency and technical optimization. The third cluster #3, which is colored blue, has 8 items concentered on SCM in industrial engineering, by incorporating ergonomic concepts that reduce physical strain, equipment design and materials handling play a crucial role in increasing productivity in SCM, while industrial engineers make sure systems are optimized for both operational efficiency and worker well-being. The yellow cluster #4 focuses (contains 7 items) on reducing expenses, maximizing resources, and enhancing overall operational efficiency all depend on effective management and control in SCM. The purple cluster #5 emphasizes (7 items) designing methods and procedures that maximize human performance is the goal of human engineering management and organization, guaranteeing worker safety, effectiveness, and well-being. These terms, however, are inadequate for researching how well ergonomics work in SCM. The size of cluster #2 (green) is larger than the rest, as shown in Fig. 9. This clarifies the function and significance of ergonomic techniques in enhancing manufacturing SCM performance.

Table 4 displays the important keywords full information, to clarify, metrics such as TLS, which gauges the overall impact based on the quantity and caliber of citations, are used to analyze the frequency of citations for a publication. The average citation indicates the average number of times the publication is cited, and the average norm citation modifies this number to take into consideration citation variations across disciplines. The ten most often examined terms with the highest degree of correlation are ergonomics (Feq. = 49, TSL = 207), supply chain management (Feq. = 28, TSL = 113), supply chains (Feq. = 21, TSL = 69), human (Feq. = 13, TSL = 95), humans (Feq. = 11, TSL = 80), human factors (Feq. = 10, TSL = 56), human engineering (Feq. = 10, TSL = 64), article (Feq. = 8, TSL = 59), supply chain (Feq. = 8, TSL = 31) and decision making (Feq. = 7, TSL = 48). These terms are essential for defining ergonomics in SCM research areas and tying together important areas of expertise. According to the metric of average citations, the following keywords, including ergonomics, SCM, sustainable development, human factors, industrial management, and quality control, aroused a lot of attention.

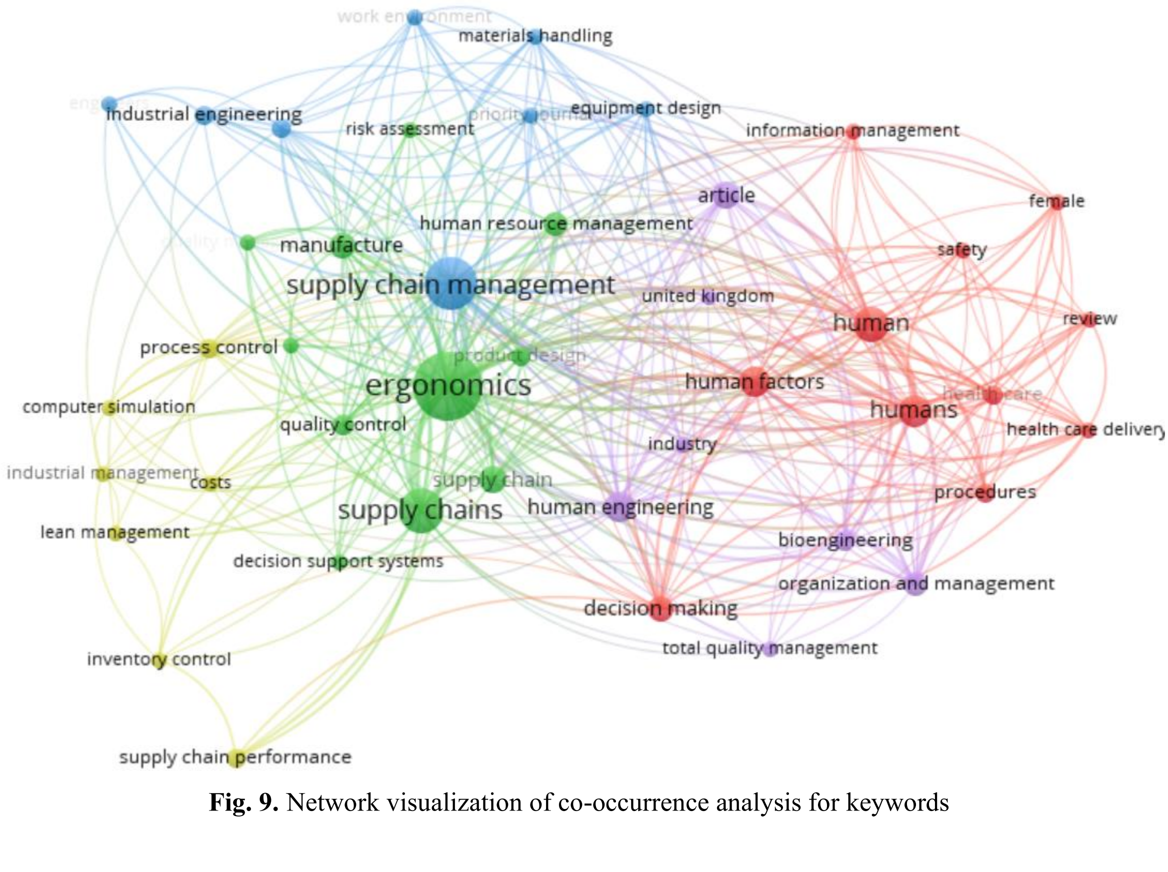

Fig. 9. Network visualization of co-occurrence analysis for keywords

4. Discussion

The importance of ergonomics in SCM knowledge from 2000 to 2024 was further classified using a taxonomy based on the clustering analysis of high-frequency keywords. Each distinct branch was then further examined thematically in the next section. To streamline and simplify the taxonomy, topics sharing similar characteristics were combined into various theme groups and given new names by hand. The ergonomics function in SCM research themes is mind-mapped, as shown in Fig. 10, which has constructed 18 sub-branches and 4 alignments overall.

Table 4. Ergonomics in SCM study theme clusters and important keywords summarized

Cluster ID	Keywords	Occurrence	TLS	Average Citation	Average Norm Citation	Period
Cluster #1 (Red) Size = 64	Human	13	95	35,54	2,15	2015-2024
	Humans	11	80	38,73	2.39	2014-2024
	Human factors	10	56	8.50	1.16	2018-2024
	Decision making	7	48	18.00	1.56	2016-2024
	Health care	4	34	11.00	1.96	2016-2024
	Procedures	4	34	11.75	2.25	2018-2024
	Health care delivery	3	30	15.00	2.80	2019-2024
	Female	3	22	7.00	1.78	2020-2024
	Safety	3	22	25.00	2.26	2013-2024
	Review	3	22	82.33	4.10	2021-2024
	Information management	3	16	5.67	1.42	2022-2024
Cluster #2 (Green) Size = 112	Ergonomics	49	207	14,41	1.12	2014-2024
	Supply chains	21	69	1.95	0.64	2016-2024
	Manufacture	7	32	18.43	1.87	2016-2024
	Supply chain	8	31	8.88	0.75	2014-2024
	Quality control	5	26	2.60	0.61	2013-2024
	Human resource management	6	24	3.33	1.13	2016-2024
	Product design	4	23	5.00	1.20	2017-2024
	Sustainable development	3	15	18.00	1.39	2017-2024
	Decision support systems	3	15	2.33	0.48	2019-2024
	Quality management	3	13	3.67	0.67	2014-2024
	Risk assessment	3	11	7.67	1.39	2016-2024
Cluster #3 (Blue) Size = 51	Supply chain management	28	113	8.82	1.22	2015-2024
	Equipment design	3	25	41.67	3.15	2009-2024
	Priority journal	3	24	30.33	1.86	2014-2024
	Materials handling	3	22	29.67	1.84	2015-2024
	Productivity	4	20	31.75	1.69	2011-2024
	Industrial engineering	4	20	18.25	1.54	2008-2024
	Work environment	3	15	24.33	2.51	2013-2024
	Engineers	3	8	1.00	0.96	2009-2024
Cluster #4 (Yellow) Size = 23	Process control	4	20	13.75	0.97	2006-2024
	Costs	3	14	1.67	0.26	2014-2024
	Supply chain performance	4	12	2.00	0.51	2019-2024
	Inventory control	3	11	1.67	0.76	2014-2024
	Computer simulation	3	10	1.00	0.38	2005-2024
	Industrial management	3	10	5.00	0.81	2003-2024
	Lean management	3	9	24.33	0.98	2012-2024
Cluster #5 (Purple) Size = 38	Human engineering	10	64	20.30	1.26	2009-2024
	Article	8	59	28.12	1.53	2012-2024
	Organization and management	6	48	27.17	1.68	2010-2024
	Bioengineering	5	39	31.80	1.75	2008-2024
	Industry	3	24	28.00	1.19	2008-2024
	United Kingdom	3	20	17.67	0.77	2014-2024
	Total quality management	3	12	1.67	0.4	2014-2024

4.1. Technologies and Methods of Ergonomics in Supply Chain Management

To improve worker comfort and safety, supply chains can benefit from ergonomic technologies such as artificial intelligence (AI) [23], [38], augmented data intelligence (ADIA), and interface, process, integration, and intelligence (IPII) [38].

Sayem A.S.M and al [23] AI used data to train computer programs for higher-order applications. A variety of AI techniques, including machine learning, decision support systems, expert systems, optimization, and vision, have already been used in the design and production of textiles, clothing, and fabrics. In order to shift the wood supply chain to Forestry 4.0 principles, Alexandru Borz S. and

Daniel Niţă M [27] have explored a number of methods and techniques to overcome the current challenges. The contemporary wood supply chain sector requires log measurement systems to perform better in terms of precision, portability, safety, ergonomics, data transfer, and traceability. Nevertheless, a lot of companies continue to face the same problem, which is the high expense of gathering data. Xu W and colleagues [38] proposed interaction, process, integration, and intelligence (IPII) design method are based on the analysis and aims to create a comprehensive experience. The point of cloud data on 612 logs of different sizes were collected using a freeware program. Two external shape reconstruction algorithms poisson interpolation and Random Sampling and Consensus (RANSAC) were then utilized to generate volume estimates under a mobile scanning approach. The impacts of incorporating new technology into ergonomics design are evaluated, together with prior research in UX design of digital solutions. The examination is then broadened in light of digital technologies for enterprise resource planning (ERP).

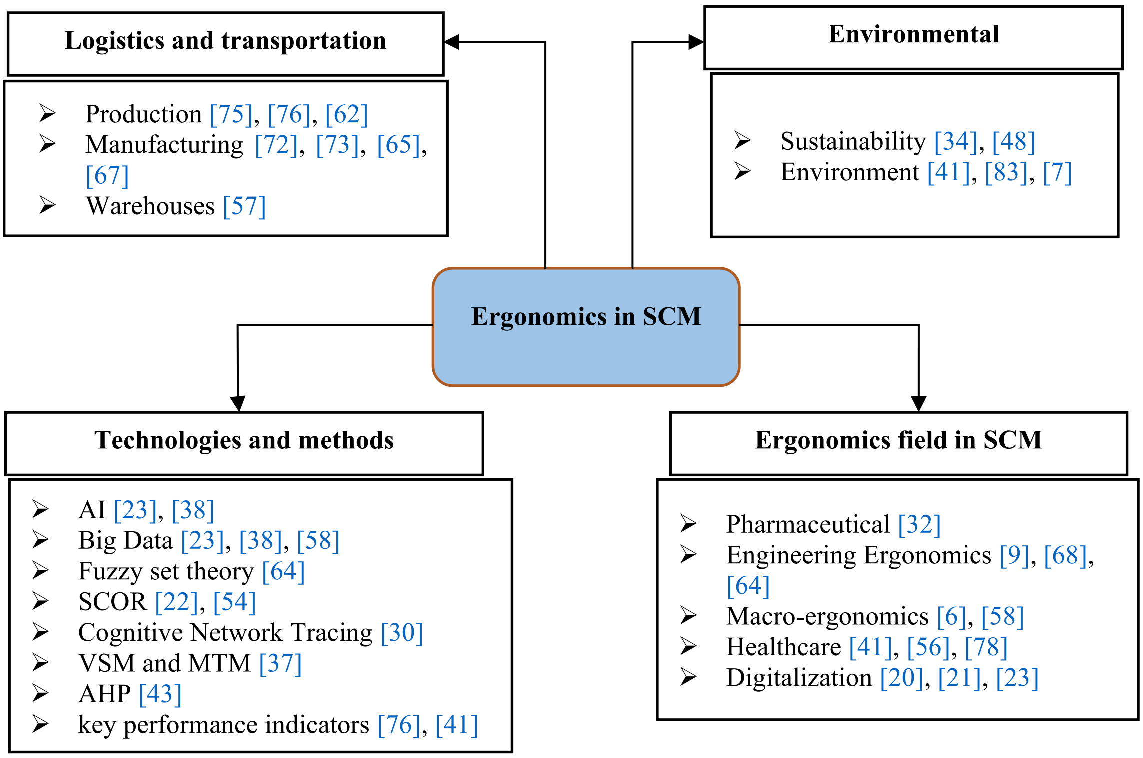

Fig. 10. The themes of ergonomics in SC knowledge taxonomy

To assist industrial engineering managers in two distinct areas of risk management supply chain disruptions management and ergonomics. Nunes I.L [64] provided two application examples of Fuzzy Decision Support Systems (FST). On the one hand, complex, imprecise, nebulous, incomplete, and subjective information and data can be dealt with and represented using the proper logical and mathematical framework that FST offers. On the other hand, it makes it possible to extract and encode imprecise information, offering a way to mathematically characterize complicated processes in situations where using conventional mathematical models is not feasible.

In supply chain production units, key performance indicators (KPIs) serve as the primary management tool. In independent businesses' supply chains, KPIs are incorporated into official contracts. Only a few KPIs are typically in jeopardy, the most common ones being pricing, timeliness of delivery, and quality. For instance, Zeinalnezhad M and al [41] determined indicators to evaluate the performance of Environment and Ergonomics Management Systems (HSEEMS) implementation. It initially begins with a review of various studies in HSEE and quality performance evaluation. As a result, eight strategies, risk analysis, personnel, resources, HSEE implementation, stakeholder effects, and key performance effects were recognized. A process-based approach called SCOR (Supply Chain Operation Reference) was used by Kusrini E. [54] et al. to measure supply chain performance. As well as the plan, the source, the make, the delivery, and the return are the five business operations that are the center of attention. In addition, five primary KPI traits, responsiveness, agility, cost, and asset management comprised 45 KPIs.

An approach based on the AHP was presented by Rossi D and al [43] to assist in the solution of a practical problem: choosing the most feasible material handling options while assessing ergonomic standards and production performance metrics and an investigation comparing manual versus IAD-assisted material handling was done to validate this method. A methodology based on lean concepts and standardized processes was presented by Kuhlang P and al [37] to combine Value Stream Mapping (VSM) with Methods-Time Measurement (MTM). Already, this technique offers new and distinct advantages to minimize lead time and boost productivity. The workplaces, their surrounds, the supplier areas, and the entire value chain are all taken into consideration in the mutually aligned design and improvement of assembly and (production) logistic operations. A technique known as "Cognitive Network Tracing" was presented by Banbury S and al [30] to study how supply chain participants communicate and make decisions in these kinds of situations.

4.2. Ergonomics and Environmental from Supply Chain Management

One of the main obstacles to sustainability is the growth of globalized supply networks. Within the field, there has been debate for several years over the potential role that ergonomics and human factors may play.

As well as engineering facilitates comprehension and use of strategies to lessen the environmental impact of managing wastes and hazardous materials in addition, handling materials in manufacturing, warehousing, and distribution networks [83], encouraging safety and lower risk in the supply chain process [79], and enhancement of the healthcare supply chain considering macro-ergonomics aspects [58] and creation of environmentally friendly packaging using data from marketing studies [52]. While, research now concentrates on ergonomics, intelligence, global manufacturing, environmental issues, design for sustainability, product life cycle management, and green supply chain management, Chun Y and Bidanda B. [48] concentrated on safety, workplace, design, and process improvements. Also, the work by Boutayeb A and al. [7] is to draw attention to the impact that ergonomics and safety have on the planning, development, and execution of Lean management projects in the Moroccan industry. Hence, to track the development of all performance, reduce waste, and produce better, faster, and cheaper new indicators must be created.

4.3. Ergonomics Field in Supply Chain Management

The information technology is transforming many aspects of healthcare delivery and transforming the nature of many occupations. For example, the determination of performance assessment metrics for ergonomics, environment, safety, and health management systems [41], applications of digital twin systems, products, and processes as well as analysis of the potential of these applications for improving health care management [56]. While, the dental healthscape Kansei model offers guidelines for designing a healthscape that upholds the patient's happy mood during the procedure and encourages a high intention to return. By using an emotion-centered design for dental healthscapes, this method can support early detection, efficient use of medical resources, preventive dental care, and green dentistry supply chains. Consequently, the five positive emotions that were most closely linked to a higher intention to return were gentle, hopeful, snug, comfortable, and considerate [78].

The macro-ergonomics is a branch of ergonomics that specializes in the analysis of work system architecture. The application of collaborative supply chains in the macro-ergonomic approach is a crucial means of establishing proper relationships within the supply chain and achieving various satisfactory outcomes in terms of work-life quality, productivity, and other related areas [6]. According to the method given by Azadeh A. and colleagues [58], the "teamwork" issue is the most effective macro-ergonomics aspect of the healthcare supply chain (HCSC). Furthermore, managers would be able to define improvement goals and targets for the associated SCM system in the healthcare industry.

The pharmaceutical SCM is the strategic coordination of the logistics and the whole value-added process of a product (pharma value chain). To maximize the performance of systems involving human activity, the field of human factors and ergonomics (HFE) promotes sociotechnical systems thinking, one example of this kind of system is the global supply chain, but from this angle, it hasn't been thoroughly investigated either. The effective coordination and integration among the many supply chain components are essential to the smooth operation of this intricate system. In addition, effective development of these intricate social-technical systems can benefit greatly from the insights and solutions provided by HFE [32].

The ergonomics is an area of engineering that focuses on the interaction between employees and their workplaces. That's why, the potential of fuzzy set theory to handle complicated, ambiguous, and incomplete information a feature common to many industrial engineering problems was introduced by Nunes I.L. [64]. In order to help industrial engineering managers in their efforts to increase awareness among industrial engineers. This means that, it is convinced that all people should acquire interdisciplinary Industrial Engineering (IE) skills or IDDEAS. All RealTimePC initiatives cover the following IE role project management, quality measurement and improvement, SCM, production, distribution and logistics, human factors and ergonomics, financial engineering, manufacturing processes engineering, and strategic planning to give students an understanding of the various roles an industrial engineer can play inside a business. Also, a lot of students can practice and reflect on each role by using case studies that the RealTimePC team has prepared to promote experiential learning [68]. Das A and al [9], identified the bottleneck in the operations of a Third-Party Logistics (3PL) company situated in Chicago, Illinois. It is scope has been restricted to the facility's truckload division. And a task study looked at how employees' productivity levels appeared to be impacted by their existing surroundings and determined whether ergonomic adjustments were appropriate.

The modern digital technologies, such as industry 4.0, have completely changed the manufacturing sector. The digitalization has numerous benefits, both technologically and economically. Since, the manufacturing businesses, particularly small and medium-sized ones (SMEs), should leverage digitization to improve their social performance in addition to the economic advantages [20]. In addition, an accurate and practical ergonomics evaluation method was presented by Gu H and colleagues [21] for the recently developed smart cockpits in the automobile sector, smart cockpits are becoming more and more common in modern cars. While, Sayem A.S.M, [23] covered 2D/3D CAD, digital pattern cutting, virtual drape simulation, fit analysis, and digital fashion design and e-prototyping. Besides, covers VR/AR technologies and digital human modeling.

4.4. Logistics and Transportation in Supply Chain Management

A streamlined logistics chain where accuracy and speed go hand in hand benefits from ergonomics. Nevertheless, the logistics industry's investment in ergonomic worktables for packing stations is a calculated step toward improving overall efficiency and service quality, as well as a consideration for the welfare of the workforce.

Winkelhaus S. and Grosse E.H. [57] concentrated on order-picking, one of the key processes in the smart warehouse that is presently undergoing significant advancements and changes. Besides, four different order-picking systems are developed using a technological grid, and these systems codify how technology might assist human operators in warehouses to lessen physical labor and/or enhance cognitive ergonomics. Turi A. and al [76] examined the function that logistics efficiency and manufacturing organization have in building a trustworthy supply chain in the automotive sector. Even though the automobile industry has been the subject of much research, little of it identifies the precise key performance indicators (KPIs) that the sector uses to aid in strategic decision-making.

The enterprises can adopt a lean manufacturing posture by exploring the topic of Advanced Manufacturing Technology (AMT). For instance, an explanation of the creation of an expert system for the ergonomic compatibility assessment of AMT for lean environments was given by

Realyvásquez-Vargas A [67]. With the using of this method, a range of AMT alternatives tangible and intangible ergonomic compatibility qualities may be assessed using a fuzzy multiattribute axiomatic design approach. This expert system encourages the creation of new expert system methodologies that will help assess AMT more broadly. That's why, these methodologies include the following: productivity, adaptability, and ergonomics.

4.5. Research Gaps in the Field Now Being Studied and Potential Research Directions

Following a thorough analysis of the literature, we found that while there has been steady advancement in the field, there are still significant research gaps that are impeding the field's current state of inquiry. We suggest a few directions for additional ergonomics study in SCM.

In terms of research model ergonomics in SCM, applied studies are still lacking in the domain of medicine. Since, we find in this study, just 8 papers in domain healthcare site Scopus. The ergonomics of today place a major emphasis on the working and behaving man. It frequently takes into account economic linkages and goals to a restricted degree [44]. In addition, preventing physiological and psychological stress at work requires close coordination between management and staff. In which, the managers and staff alike should also be aware that stress at work can result in a host of health problems in addition to absenteeism [2]. To resolve this issue, more empirical studies are needed to be carried out in this domain for lower maintenance workers' occupational health and safety hazards and potential negative health effects.

The restrictions on international cooperation between businesses of ergonomics in SCM. For instance, the challenges faced by manufacturing and construction firms functioning in a simultaneous engineering setting, the consequences of cooperative behavior expected of supply chain enterprises [35]. In addition, limited cooperation on UI prototyping during the design phase exists between developers and usability professionals [38]. as a result, given the tendency of SCM globalization, development strategies for macro-ergonomics and technological innovation should be increased. Such as, the horizontal comparison of digitalization, industrial ergonomics, ergonomics and sustainability, and innovations might use greater focus.

The problems of increased expenses for logistics, transportation, and foreign exchange risk hedging, as well as the challenge of breaking into new markets and securing the required funding [7]. consequently, every section has an impact on every other section due to the possible implication of a limited total cost [59]. Finally, we need to monitor the supply base more closely throughout the supply chain of ergonomics to drastically cut costs and raise quality.

5. Conclusions

To the best of our knowledge, this study is the first to use bibliometric analysis to conduct a review in the field of ergonomics in the SCM. That's why, we used a three-step assessment process, and this study examined 84 significant contributions made to the field of ergonomics in SCM over the last 20 years. Then, to aid in understanding the general state of research and academic advancement globally, the bibliographic networks of nations, organizations, journals, document co-citations, and keyword co-occurrence. Also, an integrated knowledge taxonomy of ergonomics in the SCM discipline, comprising four major alignments and eighteen sub-branches, was provided. It was based on the scientometric analysis.

A closer look at the co-authorship or scientific collaboration network shows that certain authors and nations are decreasingly collaborating on similar research projects. For instance, communication constraints caused by cultural and linguistic variations make international collaboration in the ergonomics sector more difficult and less common. Besides, the national political and economic conflicts may deter people from exchanging research and information. Consequently, it's slower innovation in ergonomic solutions results, workplace injuries may rise. Also, it's reduced productivity and well-being of the workforce as a result of unresolved ergonomic concerns, which raise injury rates and decrease employee satisfaction.

The most frequently discussed ergonomics in SCM themes in each cluster, (cluster #1) include topics related to information management and the analysis of ergonomics in supporting healthcare, (cluster #2) concentrating on the analysis of ergonomics in improving supply chain performance in manufacturing, quality, human resource management, and sustainable development, (cluster #3) focused on SCM in industrial engineering, (cluster #4) focuses on the management and control of supply chain performance and costs, and (cluster #5) emphasize the organization and management of human engineering. The using this information as a basis, the SCM's manual knowledge taxonomy of ergonomics was created from four factors: (i) technologies and methods of ergonomics in SCM; (ii) ergonomics and environmental from SCM; (iii) ergonomics field in SC and (iv) logistics and transportation in SCM.

Lastly, a possible three-stream plan for addressing present research shortages was suggested: Firstly, the topic of medical ergonomics in SCM still has a large research deficit that hinders the creation of practical, evidence-based solutions that enhance worker health and safety. Secondly, to create and improve the ergonomics inside the SCM performance evaluation framework, greater international research collaboration should be promoted. This will result in more efficient and uniform solutions across industries. Thirdly, in an effort to achieve substantial cost reductions and improve quality, it is crucial to maintain continuous oversight of the supply base across the entire supply chain, ensuring consistency and performance at every stage.

It is anticipated that a comprehensive review of the body of existing literature, including books, articles, and conferences, will yield insightful information that will support the advancement of ergonomic practices in SCM going forward. To improve worker safety and operational efficiency, the article emphasizes the necessity for stakeholders to actively participate in research projects and cooperative collaborations. In order to enhance the current body of knowledge and encourage the incorporation of efficient ergonomic solutions into SCM practices, specific tactics like setting up international conferences, publishing collaborative research, building online knowledge portals, and formulating industry-specific guidelines are discussed. Moreover, this study intends to promote significant advancements in the field that will benefit both academics and industry by promoting interdisciplinary research and the adoption of training initiatives.

Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this review.

Funding: This is not applicable

Author Contribution: Conception or design of the work: Soulaiman Louah. Data collection: Soulaiman Louah. Data analysis and interpretation: Soulaiman Louah. Drafting the review: Soulaiman Louah. Critical revision of the review: Soulaiman Louah and Hicham Sarir. Final approval of the version to be published: Soulaiman Louah and Hicham Sarir.

Acknowledgment: The authors express their gratitude to the esteemed reviewers for their insightful feedback and recommendations. Their insightful recommendations have strengthened and elevated our paper. And we would like to thank Doc Hicham Sarir for his continued contributions.

References

[1] S. M. Lord, M. W. Ohland, R. A. Long and R. A. Layton, "Quantitative Exploration of International Female and Male Students in Undergraduate Engineering Programs in the USA," *2021 IEEE Global Engineering Education Conference (EDUCON)*, pp. 184-188, 2021, https://doi.org/10.1109/EDUCON46332.2021.9453872.

[2] K. Reinhold, P. Tint, V. Tuulik, S. Saarik, "Innovations at workplace: Improvement of ergonomics," *Engineering Economics*, vol. 5, no. 60, pp. 85-94, 2008, https://www.scopus.com/record/display.uri?eid=2-s2.0-70349815970&origin=inward&txGid=f82f65be7a96c08c6675616f9fd5ae0e.

[3] B. Y. Kaya, “Minimizing OHS Risks with Spherical Fuzzy Sets as a Verdict to Inventory Management: A Case Regarding Energy Companies,” *Discrete Dynamics in Nature and Society*, vol. 2022, no. 1, pp. 1-26, 2022, https://doi.org/10.1155/2022/9511339.

[4] L. L. Zhang, A. Ali, “2nd IEOM European International Conference on Industrial Engineering and Operations Management,” *IESEG Paris Campus*, 2018, https://ieomsociety.org/paris2018/.

[5] Z. Tahboub, A. Ali, M. Shamsuzzaman, “10th Annual International IEOM Conference,” *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 2020, https://ieomsociety.org/flyer-dubai2020.pdf.

[6] S. M. Herrera, L. H. Huatuco, “Macroergomonics’ contribution to the effectiveness of collaborative supply chains,” *WORK: A Journal of Prevention, Assessment & Rehabilitation*, vol. 41, no. S1, pp. 2695-2700, 2012, https://doi.org/10.3233/WOR-2012-0513-2695.

[7] A. Boutayeb, Y. Sabbani, A. Ennadi and A. Chamat, "Contribution of LEAN Management in the Moroccan Ecosystem: Industrial Sector," *2020 IEEE 13th International Colloquium of Logistics and Supply Chain Management (LOGISTIQUA)*, pp. 1-6, 2020, https://doi.org/10.1109/LOGISTIQUA49782.2020.9353886.

[8] J. Feinmann, “How covid-19 has highlighted the importance of design as well as price in the NHS supply chain,” *The BMJ*, vol. 370, pp. 1-3, 2020, https://doi.org/10.1136/bmj.m3192.

[9] A. Das. Msie, K. D. Bsie, A. E. Msie, Q. Williams, “Utilizing Business Process Re-Engineering for Optimization of a Third-Party Logistics Company,” *ProQuest*, pp. 217-222, 2021, https://www.proquest.com/openview/defde9ceabafbcc90f96ea4643cd6954/1?pq-origsite=gscholar&cbl=51908.

[10] S. Wang, M. Khasawneh, K. Srihari, “AC 2009-1166: Development of Health Systems Curriculum in Industrial and Systems Engineering,” *American Society for Engineering Education*, 2009, https://peer.asee.org/development-of-a-health-systems-curriculum-in-industrial-and-systems-engineering.pdf.

[11] A. Rudolf, Z. Stjepanovič, A. Cupar, “Study Regarding the Kinematic 3D Human-Body Model Intended for Simulation of Personalized Clothes for a Sitting Posture,” *Materials*, vol. 14, no. 18, p. 5124, 2021, https://doi.org/10.3390/ma14185124.

[12] A. Majumdar, D. Gupta, S. Gupta, “Functional Textiles and Clothing 2020,” *Functional Textiles and Clothing 2020*, pp. 1-212, 2021, https://doi.org/10.1007/978-981-15-9376-5.

[13] I. K. Nti, A. F. Adekoya, B. A. Weyori, O. Nyarko-Boateng, “Applications of artificial intelligence in engineering and manufacturing: a systematic review,” *Journal of Intelligent Manufacturing*, vol. 33, no. 6, pp. 1581-1601, 2022, https://doi.org/10.1007/s10845-021-01771-6.

[14] I. Hoque, P. Hasle, M. M. Maalouf, “Buyer–Supplier Role in Improving Ergonomics in Garment Supplier Factories: Empirical Evidence from the Garment Industry of Bangladesh,” *Sustainability*, vol. 14, no. 1, p. 492, 2022, https://doi.org/10.3390/su14010492.

[15] J. Peinado, A. R. Graeml, F. Vianna, “Operations management body of knowledge and its relevance to manufacturing and service organizations,” *Revista de Gestao*, vol. 25, no. 4, pp. 373-389, 2018, https://doi.org/10.1108/REGE-03-2018-0049.

[16] G. Ambrogio, L. Filice, F. Longo, A. Padovano, “Workforce and supply chain disruption as a digital and technological innovation opportunity for resilient manufacturing systems in the COVID-19 pandemic,” *Computers & Industrial Engineering*, vol. 169, p. 108158, 2022, https://doi.org/10.1016/j.cie.2022.108158.

[17] W. P. Neumann, L. Medbo, “Ergonomic and technical aspects in the redesign of material supply systems: Big boxes vs. narrow bins,” *International Journal of Industrial Ergonomics*, vol. 40, no. 5, pp. 541-548, 2010, https://doi.org/10.1016/j.ergon.2010.06.004.

[18] M. A. Abdullah, H. Hishamuddin, N. Bazin, “A System Dynamics Approach to Investigate the Effects of Disruption on the Supply Chain with A Mitigation Strategy,” *IOP Conference Series: Materials Science and Engineering*, *Anaesthesia*, vol. 697, no. 1, p. 12024, 2019, https://doi.org/10.1088/1757-899X/697/1/012024.

[19] L. Carenzo *et al*., "Hospital surge capacity in a tertiary emergency referral centre during the COVID-19 outbreak in Italy," *Anaesthesia*, vol. 75, no. 7, pp. 841-977, 2020, https://doi.org/10.1111/anae.15072.

[20] R. Kumar, U. U. Rehman, R. K. Phanden, "Strengthening the social performance of Indian SMEs in the digital era: a fuzzy DEMATEL analysis of enablers," *TQM Journal*, vol. 36, no. 1, pp. 139-160, 2022, https://doi.org/10.1108/TQM-06-2022-0193.

[21] H. Gu, B. Liang, H. Cao, "User-centered framework for assessing the performance of smart car cockpits," *The International Journal of Advanced Manufacturing Technology*, 2024, https://doi.org/10.1007/s00170-024-12994-1.

[22] E. Kusrini, M. A. B. Rifai, S. Miranda, "Performance measurement using supply chain operation reference (SCOR) model: A case study in a small-medium enterprise (SME) in Indonesia," *IOP Conference Series: Materials Science and Engineering*, vol. 697, no. 1, p. 12014, 2019, https://doi.org/10.1088/1757-899X/697/1/012014.

[23] A. S. M. Sayem, "Digital Fashion Innovations: Advances in Design, Simulation, and Industry," *CRC Press*, p. 218, 2023, https://doi.org/10.1201/9781003264958.

[24] B. Salah, S. Khan, M. Ramadan, N. Gjeldum, "Integrating the Concept of Industry 4.0 by Teaching Methodology in Industrial Engineering Curriculum," *Processes*, vol. 8, no. 9, p. 1007, 2020, https://doi.org/10.3390/pr8091007.

[25] C. E. Siemieniuch, M. A. Sinclair, "Implications of the supply chain for role definitions in concurrent engineering," *Human Factors and Ergonomics in Manufacturing & Service Industries*, vol. 10, no. 3, pp. 251-272, 2000, https://doi.org/10.1002/1520-6564(200022)10:3%3C251::AID-HFM3%3E3.0.CO;2-Q.

[26] S. E. Moussaoui, Z. Lafhaj, F. Leite, J. Flechard, B. Linéatte, "Construction Logistics Centres Proposing Kitting Service: Organization Analysis and Cost Mapping," *Buildings*, vol. 11, no. 3, p. 105, 2021, https://doi.org/10.3390/buildings11030105.

[27] M. D. Niţă, S. A. Alexandru Borz, "Accuracy of a Smartphone-based freeware solution and two shape reconstruction algorithms in log volume measurements," *Computers and Electronics in Agriculture*, vol. 205, p. 107653, 2023, https://doi.org/10.1016/j.compag.2023.107653.

[28] S. R. Ellis, "Collision in space," *Ergonomics in Design: The Quarterly of Human Factors Applications*, vol. 8, no. 1, pp. 4-9, 2000, https://doi.org/10.1177/106480460000800102.

[29] M. Woodward, A. Ansari, T. Draycott, C. Winter, S. Marjanovic, M. Dixon-Woods, "Characterising and describing postpartum haemorrhage emergency kits in context: a protocol for a mixed-methods study," *BMJ Open*, vol. 11, no. 4, p. e044310, 2021, https://doi.org/10.1136/bmjopen-2020-044310.

[30] S. Banbury, S. Helman, S. James, S. Tremblay, "Cracking the bullwhip: Team collaboration and performance within a simulated supply chain," *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, vol. 59, no. 19, pp. 1620-1624, 2010, https://doi.org/10.1177/154193121005401955.

[31] A. Benis, S. A. Nelke, M. Winokur, "Training the Next Industrial Engineers and Managers about Industry 4.0: A Case Study about Challenges and Opportunities in the COVID-19 Era," *Sensors*, vol. 21, no. 9, p. 2905, 2021, https://doi.org/10.3390/s21092905.

[32] B. Edwards, C. A. Gloor, F. Toussaint, C. Guan, D. Furniss, "Human factors: the pharmaceutical supply chain as a complex sociotechnical system," *International Journal for Quality in Health Care*, vol. 33, pp. 56-59, 2021, https://doi.org/10.1093/intqhc/mzaa102.

[33] I. Zaitceva, B. Andrievsky, "Methods of Intelligent Control in Mechatronics and Robotic Engineering: A Survey," *Electronics*, vol. 11, no. 15, p. 2443, 2022, https://doi.org/10.3390/electronics11152443.

[34] P. Hasle, P. L. Jensen, "Ergonomics and sustainability - Challenges from global supply chains," *WORK: A Journal of Prevention, Assessment & Rehabilitation*, vol. 41, S1, pp. 3906-3913, 2012, https://doi.org/10.3233/WOR-2012-0060-3906.

[35] C. J. Anumba, C. E. Siemieniuch, M. A. Sinclair, "Supply chain implications of concurrent engineering," *International Journal of Physical Distribution & Logistics Management*, vol. 30 no. 7/8, pp. 566-597, 2000, https://doi.org/10.1108/09600030010346233.

[36] A. B. Badiru, M. U. Thomas, "Handbook of Military Industrial Engineering," *CRC Press*, p. 828, 2009, https://doi.org/10.1201/9781420066296.

[37] P. Kuhlang, T. Edtmayr, W. Sihn, "Methodical approach to increase productivity and reduce lead time in assembly and production-logistic processes," *CIRP Journal of Manufacturing Science and Technology*, vol. 4, no. 1, pp. 24-32, 2011, https://doi.org/10.1016/j.cirpj.2011.02.001.

[38] W. Xu, D. Furie, M. Mahabhaleshwar, B. Suresh, H. Chouhan, "Applications of an interaction, process, integration and intelligence (IPII) design approach for ergonomics solutions," *Ergonomics*, vol. 62, no. 7, pp. 954-980, 2019, https://doi.org/10.1080/00140139.2019.1588996.

[39] L.A. Orobia, J. Nakibuuka, J. Bananuka, R. Akisimire, "Inventory management, managerial competence and financial performance of small businesses," *Journal of Accounting in Emerging Economies*, vol. 10 no. 3, pp. 379-398, 2020, https://doi.org/10.1108/JAEE-07-2019-0147.

[40] J. L. García-Alcaraz, A. Realyvásquez-Vargas, E. Z-Flores, "Trends in industrial engineering applications to manufacturing process," *Trends in Industrial Engineering Applications to Manufacturing Process*, 2021, https://doi.org/10.1007/978-3-030-71579-3.

[41] M. Zeinalnezhad *et al*., "Identification of performance evaluation indicators for health, safety, environment, and ergonomics management systems," *Chemical Engineering Transactions*, vol. 67, pp. 451-456, 2018, https://doi.org/10.3303/CET1867076.

[42] J. A. Torrecilla-García, M. D. C. Pardo-Ferreira, J. C. Rubio-Romero, "Prospective Analysis of Blockchain Applications Within the Occupational Health and Safety Management and Wearable-Related Ergonomics in Manufacturing Industry," *Occupational and Environmental Safety and Health II*, pp. 733-741, 2020, https://doi.org/10.1007/978-3-030-41486-3_78.

[43] D. Rossi, E. Bertoloni, M. Fenaroli, F. Marciano, M. Alberti, "A multi-criteria ergonomic and performance methodology for evaluating alternatives in "manuable" material handling," *International Journal of Industrial Ergonomics*, vol. 43, no. 4, pp. 314-327, 2013, https://doi.org/10.1016/j.ergon.2013.04.009.

[44] R. Ijioui, H. Emmerich, M. Ceyp, "Strategies and tactics in supply chain event management," *Springer Berlin*, 2008, https://doi.org/10.1007/978-3-540-73766-7.

[45] A. Schwartz *et al*., "The association between janitor physical workload, mental workload, and stress: The SWEEP study," *WORK*, vol. 65, no. 4, pp. 837-846, 2020, https://doi.org/10.3233/WOR-203135.

[46] P. Brauner, R. Philipsen, A. C. Valdez, M. Ziefle, "Human interaction under risk in cyber-physical production systems," *Advances in Intelligent Systems and Computing*, vol. 822, pp. 421-430, 2018, https://doi.org/10.1007/978-3-319-96077-7_45.

[47] M. L. Tseng, T. P. T. Tran, H. M. Ha, T. D. Bui, M. K. Lim, "Sustainable industrial and operation engineering trends and challenges Toward Industry 4.0: A data driven analysis," *Journal of Industrial and Production Engineering*, vol. 38, no. 8, pp. 581-598, 2021, https://doi.org/10.1080/21681015.2021.1950227.

[48] Y. Chun, B. Bidanda, "Sustainable manufacturing and the role of the International Journal of Production Research," *International Journal of Production Research*, vol. 51, no. 23-24, pp. 7448-7455, 2013, https://doi.org/10.1080/00207543.2012.762135.

[49] M. A. Greig, C. Searcy, W. P. Neumann, "Work environment in the context of corporate social responsibility reporting: Developing common terms for consistent reporting in organizations," *Journal of Cleaner Production*, vol. 328, p. 129513, 2021, https://doi.org/10.1016/j.jclepro.2021.129513.

[50] M. S. Amalnick, M. M. Saffar, "An integrated approach for supply chain assessment from resilience engineering and ergonomics perspectives," *Uncertain Supply Chain Management*, vol. 5, no. 3, pp. 159-168, 2017, https://doi.org/10.5267/j.uscm.2017.2.001.

[51] N. Vraňaková, Z. G. Babeľová, A. Chlpeková, "Sustainable Human Resource Management and Generational Diversity: The Importance of the Age Management Pillars," *Sustainability*, vol. 13, no. 15, p. 8496, 2021, https://doi.org/10.3390/su13158496.

[52] O. Bilovodska, A. Starostina, V. Vovk, O. Moroz, M. Mykola, "Environmental packaging in trade logistics and innovative entrepreneurship based on internet marketing online research and

communications," *Estudios de Economia Aplicada*, vol. 38, no. 4, p. 25115, 2020, https://doi.org/10.25115/eea.v38i4.3993.

[53] A. C. Alves, S. Flumerfelt, A. B. Siriban-Manalang, "Lean engineering for global development," *Springer Cham*, 2019, https://doi.org/10.1007/9783030135157.

[54] E. Kusrini, V. N. Helia, M. P. Maharani, "Supply Chain Performance Measurement Using Supply Chain Operation Reference (SCOR) in Sugar Company in Indonesia," *IOP Conference Series: Materials Science and Engineering*, vol. 697, no. 1, p. 12010, 2019, https://doi.org/10.1088/1757-899X/697/1/012010.

[55] F. Veiga, A. Gil-Del-Val, E. Iriondo, U. Eslava, "Validation of the use of concept maps as an evaluation tool for the teaching and learning of mechanical and industrial engineering," *International Journal of Technology and Design Education*, vol. 35, no. 1, pp. 383-401, 2025, https://doi.org/10.1007/s10798-024-09903-8.

[56] S. Elkefi, O. Asan, "Digital Twins for Managing Health Care Systems: Rapid Literature Review," *Journal of Medical Internet Research*, vol. 24, no. 8, p. 37641, 2022, https://doi.org/10.2196/37641.

[57] S. Winkelhaus, E. H. Grosse, "Smart warehouses—a sociotechnical perspective," *The Digital Supply Chain*, pp. 47-60, 2022, https://doi.org/10.1016/B978-0-323-91614-1.00003-4.

[58] A. Azadeh, S. Motevali Haghighi, Z. Gaeini, N. Shabanpour, "Optimization of healthcare supply chain in context of macro-ergonomics factors by a unique mathematical programming approach," *Applied Ergonomics*, vol. 55, pp. 46-55, 2016, https://doi.org/10.1016/j.apergo.2016.01.002.

[59] A. M. Bennett, S. M. Galster, A. W. Dukes, W. T. Nelson, R. D. Brown, "Managing a supply chain: What communication patterns might divulge about information availability and team performance," *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, vol. 52, no. 19, pp. 1445-1449, 2007, https://doi.org/10.1177/154193120805201930.

[60] J. Wang, C. Xu, J. Zhang, R. Zhong, "Big data analytics for intelligent manufacturing systems: A review," *Journal of Manufacturing Systems*, vol. 62, pp. 738-752, 2022, https://doi.org/10.1016/j.jmsy.2021.03.005.

[61] N. Elafri, J. Tappert, M. Yassine, "Lean 4.0: synergies between Lean management tools and Industry 4.0 technologies," *iFAc-PapersOnLine*, vol. 55, no. 10, pp. 2060-2066, 2022, https://doi.org/10.1016/j.ifacol.2022.10.011.

[62] P. Brauner, R. Philipsen, M. Ziefle, "Projecting efficacy and use of business simulation games in the production domain using technology acceptance models," *Advances in Ergonomics of Manufacturing: Managing the Enterprise of the Future*, vol. 490, pp. 607-620, 2016, https://doi.org/10.1007/978-3-319-41697-7_52.

[63] J. Hyon, "Emerging technologies," *Encyclopedia of Earth Sciences Series*, pp. 162-163, 2015, https://doi.org/10.1007/978-0-387-36699-9_43.

[64] I. L. Nunes, "Uzzy systems to support industrial engineering management," *Journal of Applied Engineering Science*, vol. 10, no. 3, pp. 143-146, 2012, https://doi.org/10.5937/jaes10-2510.

[65] S. Sahoo, "Lean manufacturing practices and performance: the role of social and technical factors," *International Journal of Quality & Reliability Management*, vol. 37 no. 5, pp. 732-754, 2020, https://doi.org/10.1108/IJQRM-03-2019-0099.

[66] V. Gaddam, I. Fidan, B. Barger, "Hands-on entrepreneurial engineering management course and its experiential learning," *ASEE Annual Conference and Exposition, Conference Proceedings*, 2016, https://doi.org/10.18260/p.25433.

[67] A. Realyvásquez, A. Maldonado, J. L. García-Alcaraz, A. Alvarado-Iniesta, "Expert System Development Using Fuzzy If–Then Rules for Ergonomic Compatibility of AMT for Lean Environments," *Lean Manufacturing in the Developing World*, pp. 347-369, 2016, https://doi.org/10.1007/978-3-319-04951-9.

[68] L. A. Medina, S. Sierra, M. González, M. Rios, N. Oquendo, C. Quijano, "RealTimePC: Case studies of the roles of an industrial engineer," *IISE Annual Conference and Expo*, pp. 1683-1688, 2018,

https://www.proquest.com/openview/32e1effd6cf0664f7f6d63758a75538b/1.pdf?pq-origsite=gscholar&cbl=51908.

[69] M. E. Erdem, D. Gunes, “Liquid level sensor in automotive design,” *International Conference on Sensor Technologies and Applications and WSNSCM 2011*, pp. 166-171, 2011, https://www.researchgate.net/publication/291145598_Liquid_level_sensor_in_automotive_design.

[70] S. Stiles, B. Ryan, D. Golightly, “Readiness to Change: Perceptions of Safety Culture up and down the Supply Chain: Volume II: Safety and Health, Slips, Trips and Falls,” *Advances in Intelligent Systems and Computing*, 2019, https://doi.org/10.1007/978-3-319-96089-0.

[71] E. Urwin, S. A. Pilfold, M. Henshaw, “Through Life Capability Management: Benefits and behaviours,” *Contemporary Ergonomics and Human Factors*, pp. 153-162, 2010, https://repository.lboro.ac.uk/articles/conference_contribution/Through_life_capability_management_benefits_and_behaviours/9554546?file=17186330.

[72] A. Sheth, A. Kusiak, “Resiliency of smart manufacturing enterprises via information integration,” *Journal of Industrial Information Integration*, vol. 28, p. 100370, 2022, https://doi.org/10.1016/j.jii.2022.100370.

[73] N. Sampouw, M. Hartono, “The Role of Ergonomics in Suporting Supply Chain Performance in Manufacturing Companies: A Literature review,” *IOP Conference Series: Materials Science and Engineering*, vol. 703, no. 1, p. 12034, 2019, https://doi.org/10.1088/1757-899X/703/1/012034.

[74] A. Kucińska-Landwójtowicz, I. D. Czabak-Górska, P. Domingues, P. Sampaio, C. F. de Carvalho, “Organizational maturity models: the leading research fields and opportunities for further studies,” *International Journal of Quality and Reliability Management*, vol. 41, no. 1, pp. 60-83, 2024, https://doi.org/10.1108/IJQRM-12-2022-0360.

[75] Y. Giat, D. Bouhnik, “A decision support system and warehouse operations design for pricing products and minimizing product returns in a food plant,” *Interdisciplinary Journal of Information, Knowledge, and Management*, vol. 16, pp. 39-54, 2021, https://doi.org/10.28945/4692.

[76] W. Liu, S. Wei, Y. Liang, D. Wang, and J. Wang, "Influencing factors on organizational efficiency of smart logistics ecological chain: a multi-case study in China,” *Industrial Management & Data Systems*, vol. 121 no. 3, pp. 545-566, 2021, https://doi.org/10.1108/IMDS-06-2020-0371.

[77] C. E. Siemieniuch, M. A. Sinclair, “On complexity, process ownership and organisational learning in manufacturing organisations, from an ergonomics perspective,” *Applied Ergonomics*, vol. 33, no. 5, pp. 449-462, 2002, https://doi.org/10.1016/S0003-6870(02)00025-X.

[78] L. H. Hsu, Y. H. Hsiao, “Facilitating green supply chain in dental care through kansei healthscape of positive emotions,” *International Journal of Environmental Research and Public Health*, vol. 16, no. 19, p. 16193507, 2019, https://doi.org/10.3390/ijerph16193507.

[79] A. Szymonik, R. Stanisławski, “Supply Chain Security: How to Support Safety and Reduce Risk in Your Supply Chain Process,” *Productivity Press*, 2022, https://doi.org/10.4324/9781003286110.

[80] A. Ahmad, A. Hussain, Q. W. Ahmad, B. U. Islam, “Causes of workplace stress in textile industry of developing countries: A case study from Pakistan,” *Advances in Intelligent Systems and Computing*, vol. 487, pp. 283-294, 2017, https://doi.org/10.1007/978-3-319-41688-5_25.

[81] D. Loske, M. Klumpp, M. Keil, T. Neukirchen, “Logistics Work, Ergonomics and Social Sustainability: Empirical Musculoskeletal System Strain Assessment in Retail Intralogistics,” *Logistics*, vol. 5, no. 4, p. 89, 2021, https://doi.org/10.3390/logistics5040089.

[82] J. Vasara, J. Kivistö-Rahnasto, “A qualitative examination of safety-related compliance challenges for global manufacturing,” *Theoretical Issues in Ergonomics Science*, vol. 16, no. 4, pp. 429-446, 2015, https://doi.org/10.1080/1463922X.2015.1033034.

[83] M. Kutz, “Environmentally Conscious Materials Handling,” *Environmentally Conscious Materials Handling*, pp. 1–272, 2009, https://doi.org/10.1002/9780470432730.

[84] A. M. Bennett, W. T. Nelson, S. M. Galster, A. W. Dukes, R. D. Brown, D. H. Schwartz, “Information availability and team performance: A network-centric supply chain simulation,” *Proceedings of the*

Human Factors and Ergonomics Society Annual Meeting, vol. 51, no. 18, pp. 1065-1069, 2007, https://doi.org/10.1177/154193120705101802.

[85] A. Shoshan, J. Oser, "Visualizing Scientific Landscapes: A Powerful Method for Mapping Research Fields," *PS: Political Science & Politics*, vol. 58, no. 1, pp. 147-154, 2025, https://doi.org/10.1017/S1049096524001057.

[86] J. A. Moral-Muñoz, E. Herrera-Viedma, A. Santisteban-Espejo, M. J. Cobo, "Software Tools for Conducting Bibliometric Analysis in Science: An up-to-Date Review," *Profesional De La información*, vol. 29, no. 1, p. e290103, 2020, https://doi.org/10.3145/epi.2020.ene.03.

[87] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, W. M. Lim, "How to Conduct a Bibliometric Analysis: An Overview and Guidelines," *Journal of Business Research*, vol. 133, pp. 285-296, 2021, https://doi.org/10.1016/j.jbusres.2021.04.070.

[88] S. Noor, Y. Guo, S. H. H. Shah, M. S. Nawaz, A. S. Butt, "Bibliometric Analysis of Social Media as a Platform for Knowledge Management," *International Journal of Knowledge Management*, vol. 16, pp. 33-51, 2020, https://doi.org/10.4018/IJKM.2020070103.

[89] Q. Xia, S. Yan, H. Li, K. Duan, Y. A. Zhang, "Bibliometric Analysis of Knowledge-Hiding Research," *Behavioral Sciences*, vol. 12, no. 5, p. 122, 2022, https://doi.org/10.3390/bs12050122.

[90] F. T. Gizzi, M. R. Potenza, "The Scientific Landscape of November 23rd, 1980 Irpinia-Basilicata Earthquake: Taking Stock of (Almost) 40 Years of Studies," *Geoscience*, vol. 10, no. 12, p. 482, 2020, https://doi.org/10.3390/geosciences10120482.

[91] L. Waltman, N. J. van Eck, E. C. M. Noyons, "A Unified Approach to Mapping and Clustering of Bibliometric Networks," *Journal of Informetrics*, vol. 4, no. 4, pp. 629-635, 2010, https://doi.org/10.1016/j.joi.2010.07.002.

[92] N. J. van Eck, L. Waltman, "Software survey: VOSviewer, a computer program for bibliometric mapping," *Scientometrics*, vol. 84, pp. 523-538, 2010, https://doi.org/10.1007/s11192-009-0146-3.

[93] Y.-M. Guo, Z.-L. Huang, J. Guo, H. Li, X.-R. Guo, M. J. Nkeli, "Bibliometric Analysis on Smart Cities Research," *Sustainability*, vol. 11, p. 3606, 2019, https://doi.org/10.3390/su11133606.

[94] S. Louah, H. Sarir, M. Kriouich, "A Systematic Literature Review of Performance Hospital Supply Chain Management," *Journal of Robotics and Control (JRC)*, vol. 5, no. 2, pp. 597-612, 2024, https://doi.org/10.18196/jrc.v5i2.21541.

[95] S. Louah, H. Sarir, Y. Saida, "A Systematic Mapping Study of Lean Supply Chain in Hospital," *Big Data and Internet of Things*, pp. 1021-1046, 2025, https://doi.org/10.1007/978-3-031-74491-4_78.