Predictive Maintenance for Chiller Equipment Sustainability: A Bibliometric Approach

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Abstract
This study investigates the intersection of chiller sustainability and predictive maintenance within the framework of operations management using a bibliometric analysis approach. The purpose of this research is to identify dominant themes, research gaps, and scholarly patterns to support future theoretical development and practical applications. Data were extracted from the Scopus database using a comprehensive query encompassing keywords such as "sustainability," "operational cost," "maintenance cost," and "IoT." After applying relevant filters, a curated set of 1,095 peer-reviewed journal articles was analysed using established bibliometric techniques, including Bradford's Law, word cloud generation, country-wise scientific productivity, co-occurrence, bibliographic coupling, and thematic mapping. The results highlight key themes such as sustainability, circular economy, stakeholder engagement, innovation, and digital transformation. Leading journals and countries, including Italy, the UK, and India, emerged as major contributors to this field. Thematic mapping identified "sustainability" and "environmental economics" as motor themes, while "innovation" and "decision-making" remained underdeveloped areas with high future potential. The findings support evidence-based decision-making in the adoption of smart technologies such as IoT sensors and AI diagnostics, aiding regulatory compliance and enhancing energy efficiency. From a theoretical standpoint, the study identifies opportunities to expand frameworks in operations management by incorporating environmental and digital considerations. This bibliometric review informs industry professionals, policymakers, and researchers of evolving trends and strategic gaps. It also promotes collaborative opportunities between academia and industry to enhance innovation in sustainable operations, particularly within energy-intensive facilities.
Keywords: Chiller Sustainability, Predictive Maintenance, Operations management, Cost and bibliometric analysis

INTRODUCTION

The sustainability of chillers has emerged as a pivotal concern in operations management, owing to the substantial energy consumption and environmental repercussions linked to HVAC systems, especially in large buildings and industrial environments. Chillers are one of the most energy-demanding elements in these systems, constituting a substantial fraction of overall building energy consumption. In response to escalating worldwide demands for reduced carbon emissions and enhanced energy efficiency, organisations are emphasising sustainable chiller operations by using environmentally benign refrigerants, energy-efficient technology, and sophisticated control systems. Sustainable methods diminish environmental impact while fostering long-term cost savings and ensuring regulatory compliance, so matching with business sustainability objectives (Cohen et al., 2008).

Simultaneously, predictive maintenance solutions have arisen as effective instruments in operations management to improve the reliability, efficiency, and lifespan of chiller systems. In contrast to conventional reactive or preventative maintenance, predictive maintenance utilises real-time data from sensors, machine learning algorithms, and condition-based monitoring to foresee equipment faults prior to their occurrence. This proactive strategy reduces unexpected downtime, prolongs the lifespan of essential components, and enhances maintenance scheduling. Integrating predictive analytics with chiller operation enables facilities to substantially minimise energy waste and operational interruptions while enhancing overall system efficiency and lifetime cost management (Canellas et al., 2024).

The integration of chiller sustainability and predictive maintenance signifies a pivotal change in operational management, wherein data-informed decision-making and environmental responsibility are interconnected. Organisations that effectively use these techniques can attain both economic and environmental advantages, enhancing their operational resilience and competitiveness. This integration fosters a culture of ongoing enhancement and innovation in facilities management, where sustainability and smart technology are imperative rather than optional. As companies advance towards digital transformation and sustainable practices, the significance of predictive maintenance in facilitating efficient chiller performance will grow substantially (Sroufe, 2003).

Method: This research utilised bibliographic data sourced from the Scopus database. Scopus is a globally recognised database that comprises high-quality, peer-reviewed scholarly articles. A precise search query was utilised to compile an extensive corpus of literature for the study. The used search query was "Sustainability" or "Operational cost" or "Maintenance cost" or "IOT". The search query included many aspects of operations management.

Various filters were utilised to improve and evaluate the results. The emphasis was restricted to social sciences, humanities, business, management, and accounting, all of which are intricately connected to marketing and agricultural products. To improve the overall quality of the bibliometric analysis, only articles and reviews were allowed as document types, whereas conference proceedings and book chapters were excluded. The source selection was restricted to journals to guarantee the inclusion of only peer-reviewed articles in the study. The training exclusively comprises readings written in English to improve comprehension. After filtration and refinement, 2100 papers have been obtained. Ten papers classified as superfluous or insufficiently informative were eliminated from the collection. A total of 1095 papers were analysed. See Figure 2.1.

Research equation in bibliometric analysis

RQ1: What are the topic trends in Chiller Sustainability and Predictive maintenance strategies?

RQ2: What is the gap in Chiller Sustainability and Predictive maintenance strategies?

RQ3: What is the relationship between all the themes related to Chiller Sustainability and Predictive maintenance strategies?

Data Extraction

Database: Scopus
Field: Article title, abstract and Keywords
Period: Up to 2025
Result: 2100 documents

Filters

Subject: Business, Management and Accounting, Economics, Econometrics and Finance

Cleaning

Duplicate data and documents with a lack of information like no author are removed from the dataset (65 documents)

Total documents for analysis: 1095 documents
Software used: Bibliophagy from R Studio and VOS Viewer.
Result: 1095 documents

Data analysis Techniques and software utilised

RQ1: What are the topic trends in Chiller Sustainability and Predictive maintenance strategies?

RQ2: What is the gap in Chiller Sustainability and Predictive maintenance strategies?

RQ3: What is the relationship between all the themes related to Chiller Sustainability and Predictive maintenance strategies?
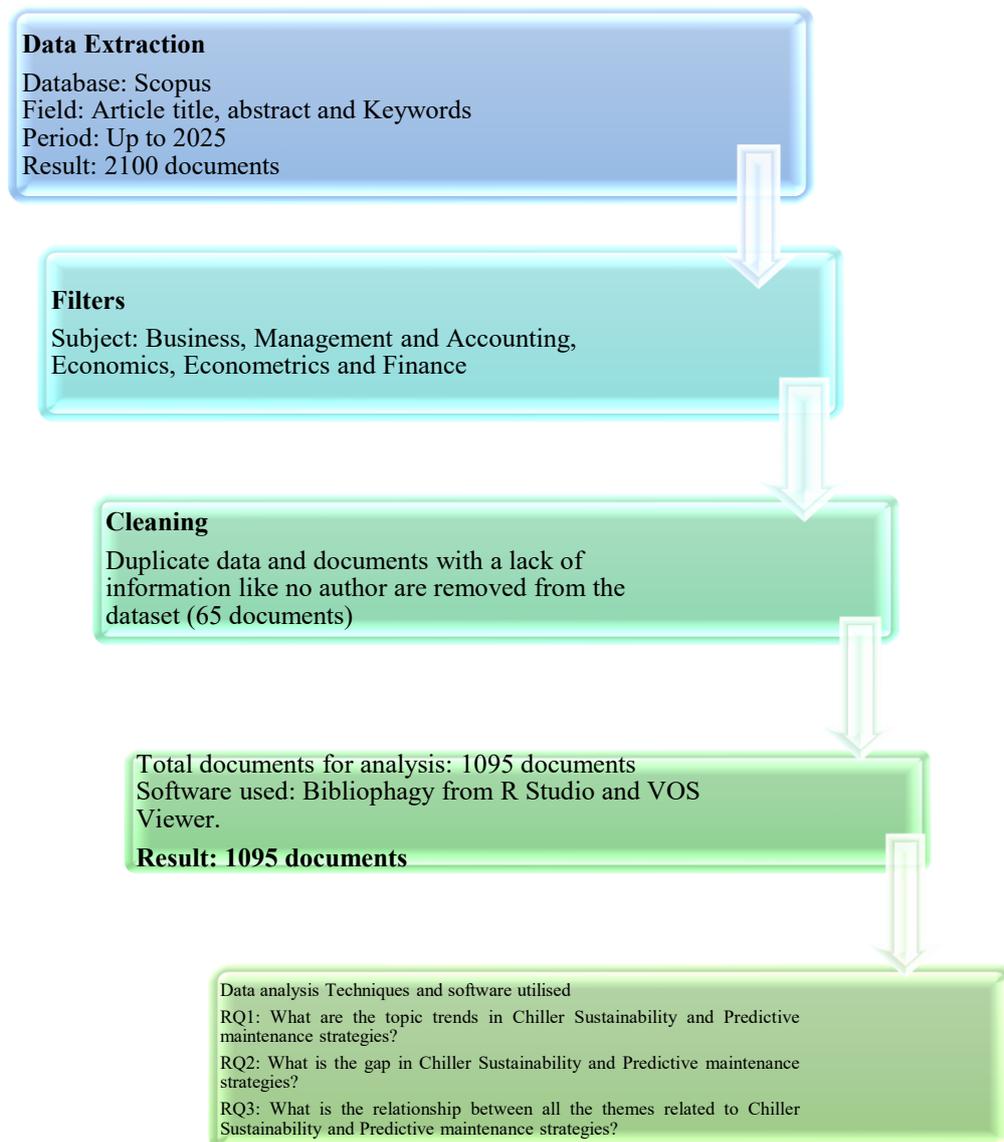
Figure 2.1: Bibliometric process

2.1.1 Bibliometric Analysis Results

Bradford's laws: Bradford's Law is a fundamental principle in bibliometrics, emphasising the quantitative evaluation of academic publications. This regulation, first proposed by Samuel C. Bradford in 1934, gives a framework for understanding the distribution of articles in scientific journals. Bradford's Law evaluates the productivity and importance of journals within certain research fields, aiding in the efficient allocation of resources for literature searches and the advancement of agricultural goods. In accordance with Bradford's Law, we categorised the articles into three zones, each comprising several journals, with the number of journals in each category following the ratio $1:n:n^2$. See Figure 2.2 and Table 2.1.
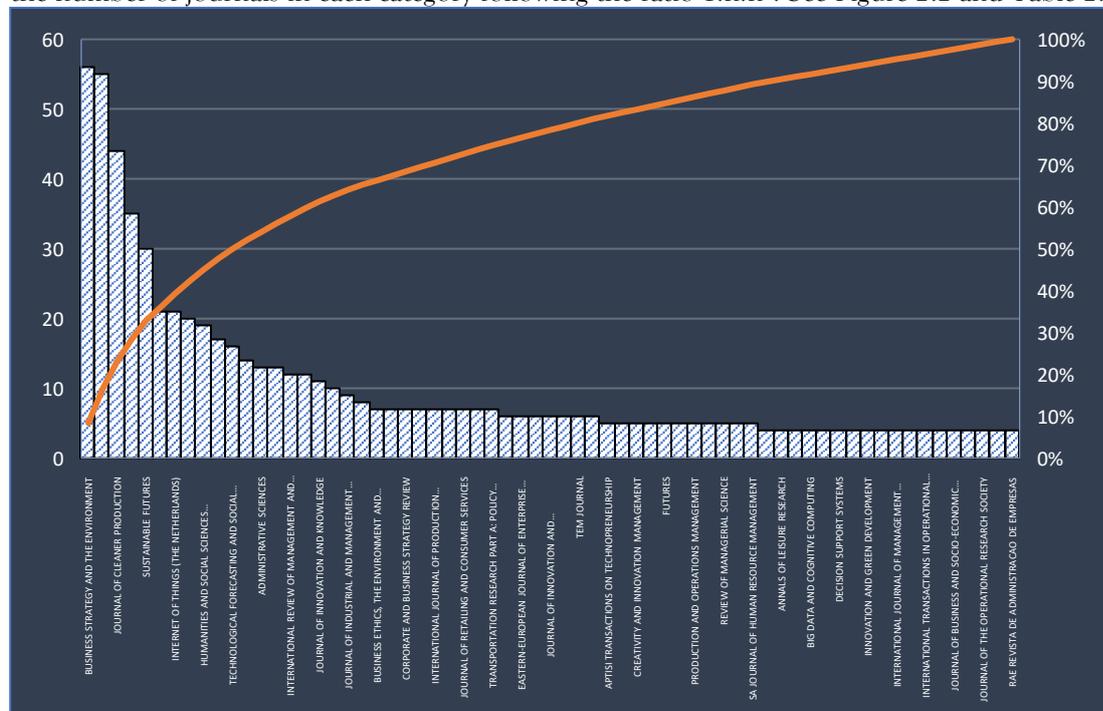

Figure 2.2: Bradford laws

Table 2.1: Bradford Law

SO	Rank	Zone
BUSINESS STRATEGY AND THE ENVIRONMENT	1	Zone 1
CORPORATE SOCIAL RESPONSIBILITY AND ENVIRONMENTAL MANAGEMENT	2	Zone 1
JOURNAL OF CLEANER PRODUCTION	3	Zone 1
COGENT BUSINESS AND MANAGEMENT	4	Zone 1
SUSTAINABLE FUTURES	5	Zone 1
CITIES	6	Zone 1
INTERNET OF THINGS (THE NETHERLANDS)	7	Zone 1
INTERNATIONAL JOURNAL OF COMPUTING AND DIGITAL SYSTEMS	8	Zone 1
HUMANITIES AND SOCIAL SCIENCES COMMUNICATIONS	9	Zone 1
PROBLEMS AND PERSPECTIVES IN MANAGEMENT	10	Zone 1
TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	11	Zone 1
JOURNAL OF BUSINESS ETHICS	12	Zone 1
ADMINISTRATIVE SCIENCES	13	Zone 1
JOURNAL OF RISK AND FINANCIAL MANAGEMENT	14	Zone 1
INTERNATIONAL REVIEW OF MANAGEMENT AND MARKETING	15	Zone 2
TOURISM AND HOSPITALITY	16	Zone 2
JOURNAL OF INNOVATION AND KNOWLEDGE	17	Zone 2
LOGISTICS	18	Zone 2
JOURNAL OF INDUSTRIAL AND MANAGEMENT OPTIMIZATION	19	Zone 2

RESEARCH IN INTERNATIONAL BUSINESS AND FINANCE	20	Zone 2
BUSINESS ETHICS, THE ENVIRONMENT AND RESPONSIBILITY	21	Zone 2
CLEANER LOGISTICS AND SUPPLY CHAIN	22	Zone 2
CORPORATE AND BUSINESS STRATEGY REVIEW	23	Zone 2
ECONOMICS - INNOVATIVE AND ECONOMICS RESEARCH JOURNAL	24	Zone 2
INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS	25	Zone 2
JOURNAL OF BUSINESS RESEARCH	26	Zone 2
JOURNAL OF RETAILING AND CONSUMER SERVICES	27	Zone 2
JOURNAL OF SUSTAINABLE TOURISM	28	Zone 2
TRANSPORTATION RESEARCH PART A: POLICY AND PRACTICE	29	Zone 2
CLEAN TECHNOLOGIES AND ENVIRONMENTAL POLICY	30	Zone 2
EASTERN-EUROPEAN JOURNAL OF ENTERPRISE TECHNOLOGIES	31	Zone 2
IBIMA BUSINESS REVIEW	32	Zone 2
JOURNAL OF INNOVATION AND ENTREPRENEURSHIP	33	Zone 2
JOURNAL OF PROJECT MANAGEMENT (CANADA)	34	Zone 2
TEM JOURNAL	35	Zone 2
TRANSPORTATION RESEARCH PART E: LOGISTICS AND TRANSPORTATION REVIEW	36	Zone 2
APTISI TRANSACTIONS ON TECHNOPRENEURSHIP	37	Zone 2
ASIA PACIFIC MANAGEMENT REVIEW	38	Zone 2
CREATIVITY AND INNOVATION MANAGEMENT	39	Zone 2
FRONTIERS IN SPORTS AND ACTIVE LIVING	40	Zone 2
FUTURES	41	Zone 2
JOURNAL OF CULTURAL HERITAGE MANAGEMENT AND SUSTAINABLE DEVELOPMENT	42	Zone 2
PRODUCTION AND OPERATIONS MANAGEMENT	43	Zone 2
PRODUCTION PLANNING AND CONTROL	44	Zone 2
REVIEW OF MANAGERIAL SCIENCE	45	Zone 2
REVISTA VENEZOLANA DE GERENCIA	46	Zone 2
SA JOURNAL OF HUMAN RESOURCE MANAGEMENT	47	Zone 2
ACTA COMMERCII	48	Zone 2
ANNALS OF LEISURE RESEARCH	49	Zone 2
ASIAN ECONOMIC AND FINANCIAL REVIEW	50	Zone 2
BIG DATA AND COGNITIVE COMPUTING	51	Zone 2
BUSINESS STRATEGY AND DEVELOPMENT	52	Zone 2
DECISION SUPPORT SYSTEMS	53	Zone 2
EAI ENDORSED TRANSACTIONS ON INTERNET OF THINGS	54	Zone 2
INNOVATION AND GREEN DEVELOPMENT	55	Zone 2
INTERNATIONAL JOURNAL OF CONSTRUCTION MANAGEMENT	56	Zone 2
INTERNATIONAL JOURNAL OF MANAGEMENT EDUCATION	57	Zone 2
INTERNATIONAL JOURNAL OF SYSTEM ASSURANCE ENGINEERING AND MANAGEMENT	58	Zone 2
INTERNATIONAL TRANSACTIONS IN OPERATIONAL RESEARCH	59	Zone 2
INVESTMENT MANAGEMENT AND FINANCIAL INNOVATIONS	60	Zone 2
JOURNAL OF BUSINESS AND SOCIO-ECONOMIC DEVELOPMENT	61	Zone 2

JOURNAL OF THE INTERNATIONAL COUNCIL FOR SMALL BUSINESS	62	Zone 2
JOURNAL OF THE OPERATIONAL RESEARCH SOCIETY	63	Zone 2
OMEGA (UNITED KINGDOM)	64	Zone 2
RAE REVISTA DE ADMINISTRACAO DE EMPRESAS	65	Zone 2
RESEARCH IN TRANSPORTATION BUSINESS AND MANAGEMENT	66	Zone 2
RESEARCH POLICY	67	Zone 2
REVISTA BRASILEIRA DE MARKETING	68	Zone 2
TOTAL QUALITY MANAGEMENT AND BUSINESS EXCELLENCE	69	Zone 2
TOURISM MANAGEMENT	70	Zone 2
BRITISH JOURNAL OF MANAGEMENT	71	Zone 2
BUSINESS AND SOCIETY REVIEW	72	Zone 2
CONTADURIA Y ADMINISTRACION	73	Zone 2
ENGINEERING MANAGEMENT IN PRODUCTION AND SERVICES	74	Zone 2
FINANCIAL ACCOUNTABILITY AND MANAGEMENT	75	Zone 2
FINANCIAL AND CREDIT ACTIVITY: PROBLEMS OF THEORY AND PRACTICE	76	Zone 2
FINANCIAL INNOVATION	77	Zone 2
HERITAGE AND SUSTAINABLE DEVELOPMENT	78	Zone 2
HUMANITIES AND SOCIAL SCIENCES LETTERS	79	Zone 2
INDUSTRIAL MARKETING MANAGEMENT	80	Zone 2
INNOVATION: THE EUROPEAN JOURNAL OF SOCIAL SCIENCE RESEARCH	81	Zone 2
INTERNATIONAL JOURNAL OF ADVERTISING	82	Zone 2
INTERNATIONAL JOURNAL OF FINANCE AND ECONOMICS	83	Zone 2
INTERNATIONAL JOURNAL OF PRECISION ENGINEERING AND MANUFACTURING - GREEN TECHNOLOGY	84	Zone 2
INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH	85	Zone 2
JOURNAL OF ASSET MANAGEMENT	86	Zone 2
JOURNAL OF COMMON MARKET STUDIES	87	Zone 3
JOURNAL OF FAMILY BUSINESS MANAGEMENT	88	Zone 3
JOURNAL OF GOVERNANCE AND REGULATION	89	Zone 3
JOURNAL OF INDUSTRIAL ENGINEERING AND MANAGEMENT	90	Zone 3
JOURNAL OF NETWORK AND SYSTEMS MANAGEMENT	91	Zone 3
JOURNAL OF STRATEGIC MARKETING	92	Zone 3
JOURNAL OF THE GEOGRAPHICAL INSTITUTE JOVAN CVIJIC SASA	93	Zone 3
JOURNAL OF THEORETICAL AND APPLIED ELECTRONIC COMMERCE RESEARCH	94	Zone 3
JOURNAL OF TRAVEL RESEARCH	95	Zone 3
MANAGEMENT REVIEW QUARTERLY	96	Zone 3
MANAGEMENT SYSTEMS IN PRODUCTION ENGINEERING	97	Zone 3
MANAGING SPORT AND LEISURE	98	Zone 3
QUBAHAN ACADEMIC JOURNAL	99	Zone 3
SMALL BUSINESS ECONOMICS	100	Zone 3

Word Cloud: Word-cloud analysis has emerged as an innovative tool in bibliometric research, offering a visual representation of the frequency and importance of terms within a body of academic literature. Word clouds provide the swift identification of prevailing themes and patterns through graphical representations of textual data, functioning as a crucial instrument for studying the vast and complex

datasets typical of bibliometric research. The most often occurring keywords are sustainability, sustainable development, circular economy, sustainable development goals, innovation, decision making, supply chain management, environmental economics, stakeholder, green economy, case studies, consumption behavior, technology adoption, block-chain, business development, and so on. See Figure 2.3 and Figure 2.4.

Figure 2.3: Word Cloud

Figure 2.4: Tree-map

Country Scientific Production: The bibliometric study of a country's scientific production refers to the quantitative evaluation of its academic output, based on published research articles, citations, and diverse scientific indicators. This study enables the comparison of research performance among nations and highlights global trends in scientific output. Bibliometric analyses may identify leading nations across several disciplines and reveal the extent of their contributions to global knowledge by assessing metrics such as total publications, h-index, and citation impact. These measurements further illustrate how national investment in research and development translates into academic output. The most productive countries in the operation stream are: ITALY, UK, INDONESIA, SPAIN, INDIA, CHINA, AUSTRALIA, USA, GERMANY, PORTUGAL, SWEDEN. See Figure 2.5 and Table 2.2.
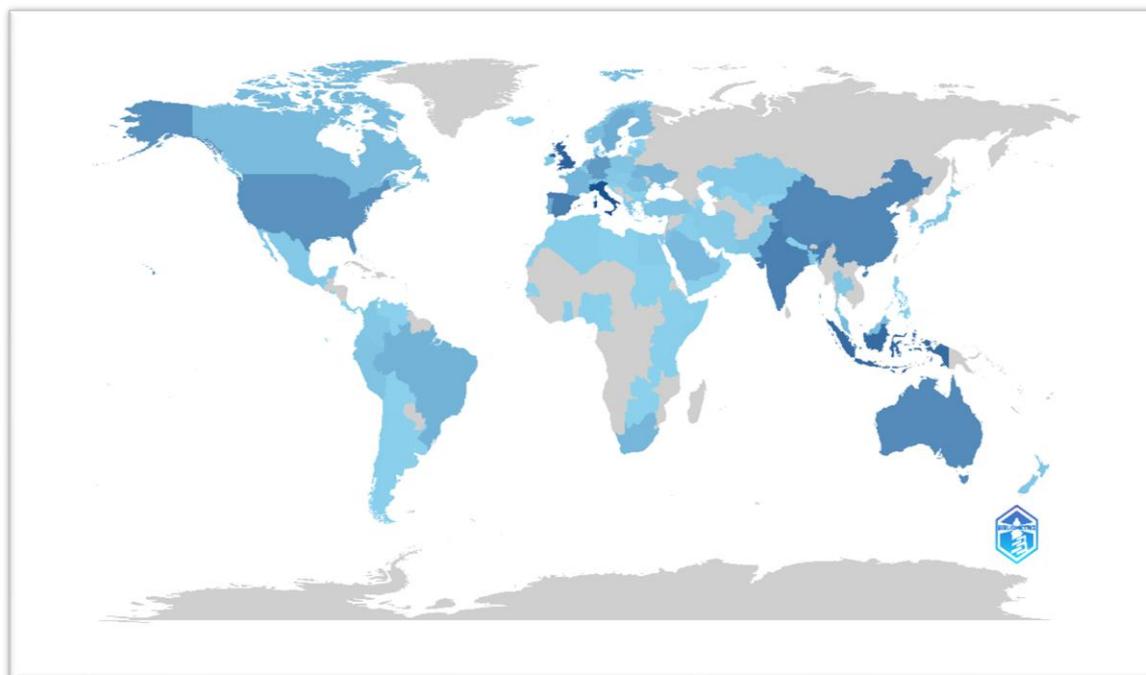

Figure 2.5: Country Scientific Production

Table 2.2: Country Scientific Production

Region	Freq
ITALY	326
UK	279
INDONESIA	255
SPAIN	205
INDIA	201
CHINA	183
AUSTRALIA	174
USA	154
GERMANY	137
PORTUGAL	90
SWEDEN	86
NETHERLANDS	78
BRAZIL	73
UKRAINE	69
FRANCE	68
SOUTH AFRICA	64
FINLAND	58
SAUDI ARABIA	55
CANADA	54
MALAYSIA	54
NORWAY	47
ROMANIA	47

SOUTH KOREA	38
JORDAN	37
PERU	34
ECUADOR	32
PAKISTAN	32
POLAND	32
UNITED ARAB EMIRATES	32
DENMARK	30
TURKEY	30
COLOMBIA	27
LITHUANIA	27
NEW ZEALAND	27
THAILAND	27
CZECH REPUBLIC	26
SWITZERLAND	26
GREECE	25
JAPAN	24
AUSTRIA	23
BANGLADESH	23
IRELAND	22
KAZAKHSTAN	22
HUNGARY	19
MEXICO	19
BELGIUM	18
IRAN	18
EGYPT	15
SLOVAKIA	15
QATAR	11
TUNISIA	10
ALGERIA	9
CROATIA	9
GHANA	9
LEBANON	9
MOROCCO	9
SOMALIA	9
IRAQ	8
SERBIA	8
SLOVENIA	8
CHILE	6
PHILIPPINES	6
ARGENTINA	5
AZERBAIJAN	5
BULGARIA	5
NIGERIA	5
TANZANIA	5
UGANDA	5
ETHIOPIA	4
NEPAL	4
OMAN	4
ALBANIA	3
KENYA	3
MALTA	3
YEMEN	3

BAHRAIN	2
ESTONIA	2
KUWAIT	2
LATVIA	2
LIBYA	2
SENEGAL	2
SUDAN	2
ZIMBABWE	2
BOLIVIA	1
BOTSWANA	1
BURUNDI	1
CAMEROON	1
COSTA RICA	1
CYPRUS	1
DJIBOUTI	1
EL SALVADOR	1
ICELAND	1
KYRGYZSTAN	1
PANAMA	1
SAN MARINO	1
SINGAPORE	1
URUGUAY	1
UZBEKISTAN	1
VENEZUELA	1
ZAMBIA	1

Thematic Map: Theme map analysis is a powerful visualisation instrument in bibliometrics that offers a comprehensive perspective of the intellectual framework and theme progression within a study domain. It classifies study themes according to their significance and progression, enabling academics to discern fundamental domains, nascent subjects, and prospective research voids. Thematic maps are extensively utilised for trend analysis, strategic research planning, and promoting interdisciplinary collaboration. A thematic map visually illustrates the relationships among study subjects by categorising them into quadrants. The quadrants are often delineated by two axes: density, which signifies the internal cohesiveness of a subject, and centrality, which denotes the theme's significance within the wider academic domain. This method facilitates the classification of subjects into four primary categories. See Figure 2.6.

Niche themes: in this quadrant, we represent the extremely developed themes, but not essential to Chiller Sustainability and Predictive maintenance strategies, such as linear programming, energy, supply chain.

Motor themes: in this quadrant, we demonstrate the most developed themes in the Chiller Sustainability and Predictive maintenance strategies, such as Sustainability, environmental economics, and stakeholders.

Basic themes: in this quadrant, we display not developed themes in Chiller Sustainability and Predictive maintenance strategies, such as sustainable development, innovation, and decision making.

Declining themes: in this fourth quadrant, we represent not relative and not developed themes to the Chiller Sustainability and Predictive maintenance strategies, such as life cycle assessment.
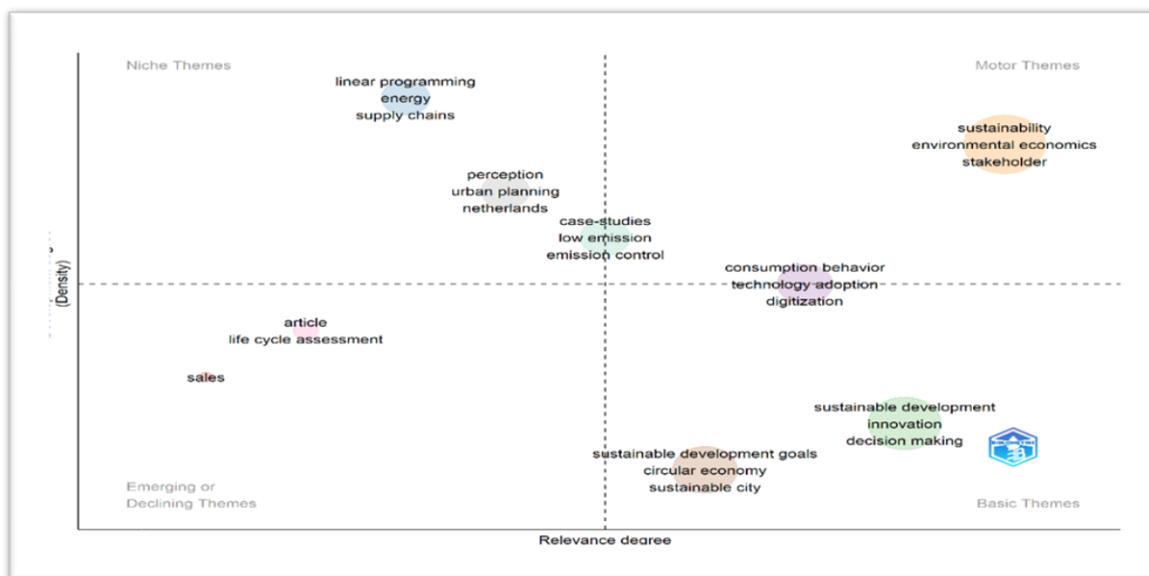
Figure 2.6: Thematic Map

Citation: Citation analysis is a fundamental method in bibliometric analysis that assesses the scientific impact, relevance, and influence of scholarly publications by analysing the frequency and context of citations from other researchers to a certain document, author, or journal. It offers quantitative insights into the knowledge transfer within a subject and assists in identifying pivotal contributions, foundational works, and emerging trends in a research area. Through the analysis of citation patterns, researchers may delineate intellectual frameworks, identify prominent authors or organisations, and evaluate the progression of scientific ideas across time. Citation analysis is extensively employed to assess academic achievement, particularly in research assessments, institutional rankings, and journal impact measures. Resources like Web of Science, Scopus, and Google Scholar are frequently utilised to get citation data, whilst specialised software such as VOSviewer or CiteSpace facilitates the visualisation of citation networks and co-citation clusters. Moreover, citation analysis underpins co-citation and bibliographic coupling methodologies, elucidating the interconnections among academic publications through common citations. Citation analysis provides useful insights; nevertheless, it requires careful interpretation, as citation counts can be affected by factors such as publication age, self-citation, linguistic bias, or the popularity of specific research areas. Notwithstanding these constraints, citation analysis continues to be a fundamental component of bibliometric research, significantly contributing to the comprehension of scientific impact, facilitating literature reviews, and aiding in strategic research planning. There exists a citation in the UK, Italy, the USA, India, and others. See Figure 2.7.
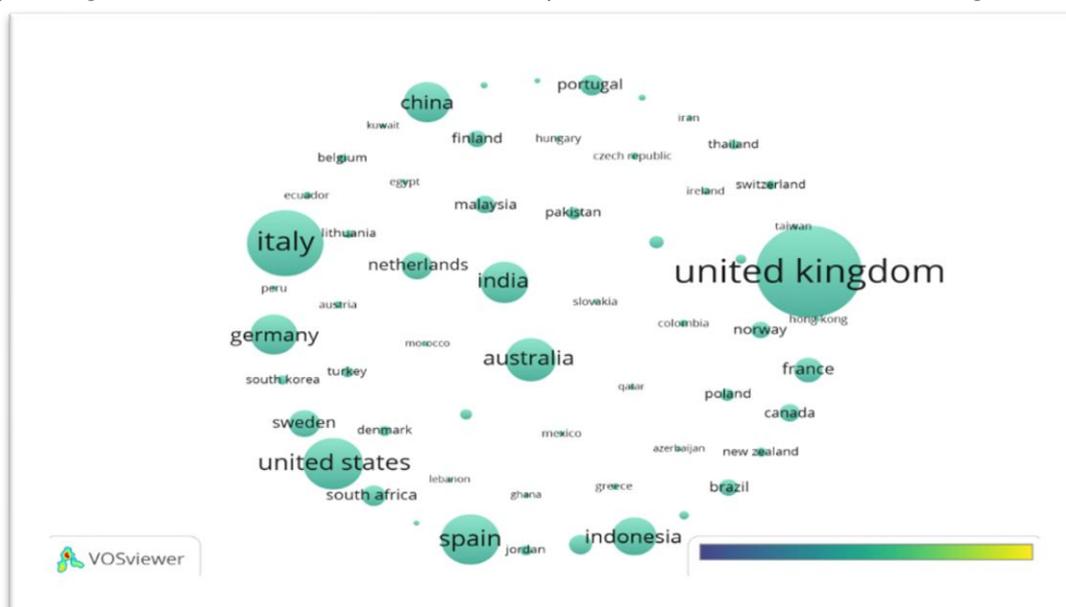

Figure 2.7: Citation

Co-occurrence: Co-occurrence analysis is a key technique in bibliometrics employed to examine and illustrate the links among concepts, terms, or entities in academic literature. By analysing the co-occurrence frequency of certain entities (such as words, authors, or nations) within a dataset, researchers can identify patterns and correlations that elucidate the conceptual framework of a field. This method has gained popularity for its capacity to elucidate knowledge domains, research trends, and the interconnections among concepts. This research has several fundamental nodes, each representing distinct colours, with every node indicating the frequency of the phrase within the context of operational performance themes. As we can observe, their high levels of co-occurrences between sustainability, sustainability reporting, digital transformation, and so on. See Figure 2.8.

Figure 2.8: Co-occurrence

Bibliographic coupling: Bibliographic coupling is a crucial analytical method in bibliometrics that elucidates the conceptual connections between academic publications. It examines the degree of interrelation among various works, providing insights into their thematic or intellectual linkages. Bibliographic coupling has emerged as an essential instrument for delineating the structure of research domains, monitoring scientific progress, and pinpointing clusters of connected activities. Bibliographic coupling asserts that two publications are cognitively linked if they cite the same set of sources. A rising quantity of shared references correlates with enhanced coupling strength. In contrast to citation analysis, which investigates how a document is referenced by others, bibliographic coupling is a retrospective approach that assesses common references across prior publications, offering a static representation of relationships at the time of production. Several countries, like the UK, India, Italy, and so on. See Figure 2.9.

Figure 2.9: Bibliographic coupling

DISCUSSION:

A bibliometric analysis of Chiller Sustainability and Predictive Maintenance Strategies in Operations Management offers essential practical insights for facility operators, energy managers, and industrial decision-makers. Through thorough analysis of trends, frequently referenced publications, and prominent authors or institutions, the research allows practitioners to discern the most successful and widely implemented predictive maintenance technologies and sustainable frameworks. This facilitates evidence-based decision-making in the selection of tools such as IoT sensors, AI-driven diagnostics, and condition-based monitoring systems. Moreover, the study's findings assist organisations in synchronising their chiller operations with energy efficiency requirements and green building certifications, facilitating adherence to laws such as ISO 50001 or LEED, while minimising operational expenses and carbon emissions (Utiyama et al., 2023).

The bibliometric analysis improves benchmarking and competitive intelligence for enterprises at a strategic level. By identifying the nations, industries, or corporate sectors that excel in research output or innovation, firms may more effectively evaluate their position relative to global best practices. The study promotes the establishment of new research-industry partnerships by mapping collaborations between academia and industry, which might foster innovation in sustainable HVAC operations. Predictive maintenance, guided by academic trends, may assist companies in minimising chiller downtime, prolonging asset lifespan, and shifting from reactive to proactive maintenance strategies, hence enhancing overall operational performance and dependability (Dubey et al., 2017).

The bibliometric review theoretically advances new conceptual and analytical frameworks by identifying rising topics, co-citation clusters, and research gaps. It enables researchers to track the development of concepts such as energy optimisation, total productive maintenance, and digital transformation in facility management. These findings present potential to enhance or broaden current theories in operations management by including sustainability, intelligent maintenance, and lifecycle considerations into more holistic models. The analysis identifies underexplored research domains, particularly the synergistic effects of predictive analytics and environmental outcomes in tropical climates, thereby facilitating future empirical investigations that can expand upon this theoretical framework and enhance comprehension of sustainable operations (Dehghani et al., 2021).

CONCLUSION:

This study aims to explore the topic trends in Chiller Sustainability and Predictive maintenance strategies, to define the gap in Chiller Sustainability and Predictive maintenance strategies, and to define the relationship between all the themes related to Chiller Sustainability and Predictive maintenance strategies.

This study demonstrates that the most often occurring keywords are sustainability, sustainable development, circular economy, sustainable development goals, innovation, decision making, supply chain management, environmental economics, stakeholder, green economy, case studies, consumption behaviour, technology adoption, block-chain, business development, and so on. additionally, the most productive countries in the operation stream are: ITALY, UK, INDONESIA, SPAIN, INDIA, CHINA, AUSTRALIA, USA, GERMANY, PORTUGAL, SWEDEN. Furthermore, this research has several fundamental nodes, each representing distinct colours, with every node indicating the frequency of the phrase within the context of operational performance themes. As we can observe, their high levels of co-occurrences between sustainability, sustainability reporting, digital transformation, and so on.

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