Trends in Environmental Management Systems Research. A Content Analysis

Filippo Fiume FAGIOLI1*, Luisa PAOLOTTI2, Antonio BOGGIA3

1Department of Economics, Society, Politics, University of Urbino Carlo Bo, Via A. Saffi, 42, 61029 Urbino, Italy
2,3Department of Agricultural, Environmental and Food Sciences, University of Perugia, Borgo XX Giugno 74, 06121 Perugia, Italy

Abstract – Environmental Management Systems (EMS) represent a solid opportunity for companies that voluntarily undertake a path towards the adoption of environmental protection policies. Many studies investigated the link between EMS and improvement of environmental performance, demonstrating how the adoption of an international standard as ISO 14000 or EMAS guarantees the company an improvement in its performance and an increase in transparency towards stakeholders. However, scientific research in this field reflects the strong variability due to the breadth and diversity of sectors in which the two international standards can be adopted. The aim of this work is to analyse, through textual statistics and text mining methods, the trends that characterize scientific production, highlighting most debated topics useful for developing new research perspectives in this research field.

Keywords – EMAS; Environmental Management Systems (EMS); ISO 14000; text mining; textual statistics

1. INTRODUCTION

By the end of the 1980s, there has been a growing interest in environmental issues, not only by government institutions and consumers, but also by the private economic sector. The industry began to recognize the complexity of the environmental problems connected to its business and implications for the business management of the environmental issue, starting to question on possible perspectives to reconcile the economy of its business with the environmental impact of its activities [1].

Many companies, trying to anticipate the rapidly evolving environmental regulations, began to adopt voluntary pollution prevention practices, with the aim of reducing or eliminating pollutant emissions. These initiatives were based on the control of production processes and on the control of polluting sources that were introduced into the production cycle. This phenomenon represented one of the first steps towards the development of a preventive approach to the environmental issue, with respect to the vision previously considered of control of harmful substances released into nature [2].

The birth of environmental management systems is therefore attributable to a variation of the inspiring principles of the American and European environmental policy, which since the 1990s has seen the progressive affirmation of a new approach to environmental protection in
relation to the rules of the market, and the conjugation between the environment and the competitiveness of businesses according to the principles of Sustainable Development.

Since then, there has been a strong evolution of voluntary environmental management systems. Nowadays, both ISO and EMAS, represent a solid and voluntary approach to guarantee environmental protection beyond strict compliance of the law, within a framework characterized by an increased transparency towards stakeholders who interact with the organization itself (customers, suppliers, employees, citizens, public administrations, credit institutions, etc.).

Due to its mostly practical connotation, the scientific debate surrounding EMS has simultaneously focused on a broad set of diverse aspects which characterize voluntary standards. For example, Wang et al. [3] and Campos et al. [4] investigated the application of EMS in specific sectors, while other authors as Stevens et al. [5], focused on the types of organizations which adopt an EMS and on the reasons that lead these organizations to undertake a voluntary path of environmental management [6]. Some authors dealt more specifically with businesses, and in particular with small and medium-sized enterprises [7], and in this context, Vásquez-Berna [8], through an academic review, analysed the impacts which affect companies adopting an EMS.

However, these reviews analysed a limited number of papers. For this reason, using the methodology of text mining, this work aims to adopt a broader approach, which takes into consideration most of the scientific production in the EMS - without distinction of sectors, types of organizations or specific aspects of the phenomenon - analysing trends, underlining the most debate topics, to develop new pathways for future research in EMS.

The paper is organized as following: section 2.1. and 2.2. describe data collected for the constitution of a corpus on which to carry out the analyses, while the methods are described in section 2.3. The results are explained in section 3, followed by discussion in section 4 and conclusions in section 5.

2. MATERIAL AND METHODS

2.1. Data Collection

According to Feldman and Sanger [9], data collection is represented by a set of processes aimed at identifying a corpus, related to the topic to be analysed. In this case we used SCOPUS database, one of the largest abstract and citation databases for academic literature. Thanks to the database functions it was possible to select the types of contributions, such as articles, reviews and conference papers and the reference period, that was selected from 1995 to today.

Preliminarily, the query with the term ‘Environmental Management System’ was used, which resulted in 3440 documents. The research was further refined with the introduction of other similar and commonly used terms for the definition of the topic, as well as the specific terms of the two major certification standards. Primary subject areas were also progressively added in order to achieve a corpus of 401 documents that could be numerically significant and at the same time qualitatively centred with the subject of investigation. Table 1 shows the steps and queries applied for the search.
TABLE 1. QUERIES ON SCOPUS DATABASE – MARCH 2021

| Keywords                              | Boolean Operator | Subject Areas                  | No. Documents |
|---------------------------------------|------------------|--------------------------------|--------------|
| **Query 1**                           |                  |                                | 3440         |
| Environmental Management Syst*        | –                | –                              |             |
| **Query 2**                           |                  | Environmental Sciences         | 1525         |
| Environmental Management Syst*        | –                | —                              |             |
| **Query 3**                           |                  | Environmental Sciences         | 1411         |
| EMS                                   | OR               | Environmental Sciences         |             |
| Environmental Management Syst*        |                  | Social Science                 |             |
| **Query 4**                           |                  | Environmental Sciences         | 203          |
| EMS                                   | AND              | Social Science                 |             |
| Environmental Management Syst*        |                  | Business, Management Accounting|             |
|                                       |                  | Economics, Econometrics        |             |
|                                       |                  | and Finance                    |             |
| **Query 4**                           |                  | Environmental Sciences         | 401          |
| EMS                                   | AND              | Environmental Sciences         |             |
| Environmental Management Syst*        | AND              | Social Science                 |             |
| ISO 14001                             | OR               | Business, Management Accounting|             |
| EMAS                                  |                  | Economics, Econometrics        |             |
|                                       |                  | and Finance                    |             |

A dataset was therefore created containing the abstract, author’s keywords and source of each article. It was also possible to download each contribution to create the corpus on which to apply the methods for this analysis.

2.2. Overview of Articles

Over the considered period (1995–2020), the number of published researches shows a growing trend, with the exception of 2015 in which scientific production (8) was less than the annual average of 14 published articles (Fig. 1).
An overview of the journals in which the selected articles were published shows a correspondence between the corpus and the object of investigation, since they all deal with clean production, environmental issues, sustainability, management and business strategy (Table 2).

**TABLE 2. SCIENTIFIC PRODUCTION BY SOURCE**

| Ranking | Journal title                                           | Published research |
|---------|--------------------------------------------------------|--------------------|
| 1       | Journal Of Cleaner Production                           | 57                 |
| 2       | Environmental Quality Management                       | 14                 |
| 3       | Sustainability                                         | 14                 |
| 4       | International Journal of Life Cycle Assessment         | 12                 |
| 5       | Corporate Social Responsibility and Environmental Management | 11                 |
| 6       | Business Strategy and The Environment                  | 10                 |
| 7       | Greener Management International                       | 10                 |
| 8       | Corporate Environmental Strategy                       | 9                  |
| 9       | Journal of Environmental Management                    | 8                  |
| 10      | Environmental Management                               | 6                  |

**2.3. Methods**

The methodologies used in this work were Textual Statistics and Text Mining methods. These methods were chosen in order to analyse the real scope of the Environmental Management Systems, to focus the investigation on the central elements of their discussion and on the trends that characterized scientific production in that field.

Textual statistics is defined as the mathematical study of texts meant as a collection of distinct items which can be compared through the analysis of their frequency [10]. It is widely used, especially in linguistic research [11], [12], and it employs a variety of methods, ranging from procedural processing, in which the texts are not exposed to any prior analysis, to cases in which linguistic knowledge can be used to classify textual types with precise meaning [13].

The first step of this study was to analyse the frequencies of author’s keywords in the selected corpus. The analysis has been carried out with ATLAS.ti [14], [15] a data analysis software.
software for qualitative research that allows to carry out various investigations on the data constituting the corpus showing in a graphic form the properties and relationships between the information in order to give meaning and structure to the data.

All keywords with a frequency higher than 4 have been categorized into five different argumentative dimensions (Table 3).

**Table 3. Keywords Categories**

| Argumentative dimensions | Keywords |
|--------------------------|----------|
| Management               | ems, eco-management, policy, benefit, strategy, barrier, innovation, control, change, ecological, improvement, organization |
| Standards                | ISO, EMAS, certification, quality, scheme, model, integration, audit |
| Assessment               | Assessment, performance, lca, indicator, evaluation, implementation, drivers, integration, material, factors, accounting, impact |
| Application              | Product, production, energy, pollution, waste, design, process |
| Business                 | Industry, business, sme, sector, company, enterprise, corporate, financial, local, china, malaysia, intentional, manufacturing, supply |

The second phase of the study was the investigation on the elements that characterize scientific output related to EMS. The method chosen for this analysis was text mining [16], through which it is possible to explore and analyse vast volumes of textual data in order to define, themes, templates, and other attributes. According to Feldman and Sanger [9], the use of text mining to probe documents, includes three distinct phases:

1. Constitution of corpus;
2. Pre-processing and cleaning;
3. Review and assessment of information.

At this stage, some information contained in the corpus may be irrelevant for the analysis [17]. For this reason, pre-processing and cleaning phase removes from the corpus all the insignificant words that commonly appear in the language, such as prepositions, conjunctions, pronouns, and punctuation. It was also necessary to clean up data from the characteristic terms of scientific articles, such as the words ‘journal’, ‘review’, ‘paper’, but also ‘DOI’.

According to Bazeley [18], the argumentative dimensions and the relative keywords (Table 3) have been used to code the corpus. Coding is a basic ability for qualitative research, because it offers access to evidence that can be used to question results, verify hypotheses, and draw conclusions. At the most basic level, naming a code creates a mark that connects data to the concept, and the idea to all the data relating to that idea [19]. The codification of the articles contained in the corpus allowed us to extract from it all sentences which contained those words.

An analysis of co-occurrence codes [20], [21] was carried out for each argumentative dimension (for more detailed information see Annex), to highlight the codes that were applied to the same quotation and to find out which topics are mentioned simultaneously and how often. This approach allows to analyse the trend topics of a very high number of papers concerning EMS, but at the same time, thanks to the analysis of the co-occurrence tables, to address the analysis towards the study of specific aspects of interest.

In this case, the next phase was represented by the analysis of the quotations extracted selecting the pair of codes with the highest frequency. To visualize the results, we chose the
Word Clouds approach. This style of representation is utilized in a variety of scenarios to provide a clear summary of the most commonly occurring terms in a text. Moro et al. [22], for example, used this methodology to determine the scope of the literature and define the notion of ethnic marketing, which is characterized by considerable heterogeneity. Other applications can be found in the biomedical field, as well as in the rapidly growing fields of Big Data and computer science [23]. It is also defined as a useful summary for determining the amount and type of subjects present in a body of text [24], [25] and it is obtained by positively correlating the font size of the represented words with its frequency in the text.

3. RESULTS

The corpus, consisting of over 120 000 words, was analysed using the ATLAS.ti software. For each argumentative dimension it was possible to establish the main topics covered and give a selection of most representative articles on topics results. It was also possible to choose minimum threshold values, excluding words less frequently used and focusing attention on the most used words. What derives from this is a clear sign of the most discussed issues in every single dimension.

3.1. Management

Fig. 2 relates to the argumentative dimension of Management (see Annex 1 – Table 6)

The relationship between the EMS and the corporate organizational structure is evident. The goal of EMS adoption is to help organizations in improving its environmental performances, complying with laws and managing major environmental risks, liabilities, and impacts, which should be identified and minimized [26]. In this sense, the adoption of an EMS mainly depends on company culture, nature of business, extent of internal environmental maturity, and the actual organization situation and conditions [27], [28]. In the extracted scientific articles, the implementation of EMS is declined in several aspects, among which the most relevant are the environmental policy development [29]–[31], employee and management training [32]–[34], management review [35], auditing practice [36], [37] and corrective action [38].
3.2. Standards

Fig. 3 relates to the argumentative dimension of Standards (see Annex – Table A7). The topics most treated are related to the characteristics of the two international environmental management standards and their diffusion [39]–[44].

Both certifications have been the subject of studies on their effectiveness in terms of environmental performance, in which a better result was found compared to companies that do not adopt an environmental management system [45]. Particular emphasis is given to issues related to motivational factors which influence decisions on the adoption of EMS standards by organizations and companies [46]–[50].

3.3. Assessment

The third argumentative dimension (see Annex – Table A8) is related to Assessment issues (Fig. 4). The most significative evaluation carried out in this dimension is represented by environmental performance assessment. Some articles consider the evaluation of company performance as a valid tool to identify the cause of their environmental impacts along the entire value chain, in order to improve the environmental performance itself [51]–[54]. At the same time, research investigate firms which adopt an EMS from an economic and social performance point of view [55]–[58]. Another issue is quality and how it impacts on the environmental performance of companies [59], [60].
3.4. Application

Fig. 5 shows the Application word cloud (see Annex – Table A9). All results are related to physical materials and energy which intervene in the whole industrial process as for extracting, processing, and consuming. Main arguments are in fact materials, product/process, waste generation, energy consumption but also design.

Many authors point out how the implementation of an EMS can increase productivity, in terms of refined processes, cost savings, waste reduction or reduction in raw material and energy consumption [61]–[63]. Adopting an EMS typically entails the monitoring of a wide range of production processes, as well as the implementation of pollution, energy and waste management systems [64]. Companies with environmental management systems are more likely to implement technical innovations that change their production process [30], [65] as well as product design with life cycle analysis has a considerable positive effect on environmental product and process innovations [66].
3.5. Business

The last result of the analysis concerns the topic of business implementing EMS (see Annex – Table A10). In the word cloud, the terms that define industry and companies are evident, but also the main sectors, which scientific production has dealt with. Many authors analysed the adoption of EMS in the food sector [67]–[70]. For example, Salim et al. [71] examined factors determining EMS adoption within the food and beverage industry, while Ormazabal et al. [72] pointed out how food companies with an environmental management standard tend to have a more developed system and a greater presence of environmental tools and actions.

The second main field of study is the chemical industry [27], [73]. In this context, Evangelinos et al. [74] examined the ways in which various factors affect the choice of the chemical industry in their adoption of an EMS, while Yaqoob et al. [75] underlined the role of legislation enforcement and strategic environmental assessments to encourage chemical industry to adopt an effective EMS.

Thanks to the word cloud it is also possible to note that one of the main aspects of this argumentative dimension is waste production, which is considered by several authors to be one of the main reasons that lead companies to adopt an EMS [76]–[80].

4. DISCUSSION

The approach of text mining for the analysis of Environmental Management Systems research allowed to build a framework useful for in-depth investigations in this field. The definition of argumentative dimensions based on the author’s keywords allowed the coding of the corpus and the construction of co-occurrence tables useful for tracing not only the trends, but to identify connections between all the defined topics, and to develop new research perspectives in this research field.

It should also be noted that in all the word clouds, with the exception of the specific argumentative dimension of the standards, the word clouds “ISO” is present, while the EMAS
is not. This peculiarity derives mainly from the diffusion of the two standards. The international scope of the former is therefore reflected into the scientific production.

Of the five argumentative dimensions that characterize the corpus, the one that had the greatest response, in terms of quotation, is Application with 1253 extracted quotations. This result gives a clear indication of how scientific research focuses more on aspects related to relationship between EMS and productivity, reduction of waste and energy consumption. However the aspects related to performances assessment, both environmental, economic, and social, of companies which adopt a management system, receives less attention.

In the corpus made up of over 400 scientific papers the second main indication is represented by Management dimension. This result allows us to highlight how aspects such as company culture, environmental policy development, employee and management training, auditing practice and corrective action appear to be of great interest to researchers in this field. In addition, there is also strong feedback on topics related to standards and their attributes (1078 quotations), while the arguments related to the specific characteristics of the companies that adopt an EMS arouse less interest (632 quotations).

5. Conclusion

The analysis made it possible to arrive to a clear definition of the most debated issues in the context of Environmental Management Systems. If from a managerial point of view the adoption of an EMS depends on the organizational structure of business, the two standards ISO and EMAS allow a clear improvement in the environmental performance of companies. At the same time, many studies focus on the strong need of a broad environmental assessment linked to production processes, as well as pollution, energy consumption and waste management issues.

This study achieved the objective of providing a picture of the current research in the field of EMS, testing a research tool useful for subsequent more detailed analyses and debates on this research topic.

References

[1] Zilahy G. Environmental Management Systems-History and New Tendencies. In Encyclopedia of Sustainable Technologies. Elsevier, 2017. https://doi.org/10.1016/B978-0-12-409548-9.10529-9
[2] Morrow D., Rondinelli D. Adopting Corporate Environmental Management Systems: Motivations and Results of ISO 14001 and EMAS Certification. European Management Journal 2002:20(2):159–171. https://doi.org/10.1016/S0263-2373(02)00026-9
[3] Wang X. H., Wu W. A Review of Environmental Management Systems in Global Defence Sectors. American Journal of Environmental Sciences 2013:9(2):164–181. https://doi.org/10.3844/ajessp.2013.164.181
[4] Campos L. M. S., Trierweiller A., de Carvalho D. N. Environmental management systems in the construction industry: a review. Environmental Engineering and Management Journal 2016:15:453–460. https://doi.org/10.30638/eemj.2016.048
[5] Stevens P. A., Batty W. J., Longhurst P. J., Drew G. H. A Critical Review of Classification of Organisations in Relation to the Voluntary Implementation of Environmental Management Systems. Journal of Environmental Management 2012:113:206–212. https://doi.org/10.1016/j.jenvman.2012.08.037
[6] Tourais P., Videira N. Why, How and What Do Organizations Achieve with the Implementation of Environmental Management Systems? – Lessons from a Comprehensive Review on the Eco-Management and Audit Scheme. Sustainability (Switzerland) 2016:8(3):283. https://doi.org/10.3390/su8030283
[7] Ferenhof H. A., et al. Environmental Management Systems in Small and Medium-Sized Enterprises: An Analysis and Systematic Review. Journal of Cleaner Production 2014:74:44–53. https://doi.org/10.1016/j.jclepro.2014.03.027
[8] Vásquez-Bernal O. A., Castillo-Castellanos M. P. Exploratory Review of the State of the Art on the Impact of Implementation in SMEs: Case Study in the Environmental Management System. Proceedings of the International Conference on Industrial Engineering and Operations Management 2018:773–778.
9. Feldman R., Sanger J. *The Text Mining Handbook*. 1st ed. Cambridge: Cambridge University Press, 2007. [https://doi.org/10.1017/CBO9780511546914](https://doi.org/10.1017/CBO9780511546914)

10. Lebart L. L., Salem A., Barry L. *Exploring Textual Data*. 1st ed. Springer Netherlands, 1998. [https://doi.org/10.1007/978-94-017-1525-6_1](https://doi.org/10.1007/978-94-017-1525-6_1)

11. Kosmajac D., Keselj V. *Twitter User Profiling: Bot and Gender Identification*. In Arampatzis A. et al. (eds) Experimental IR Meets Multilinguality, Multimodality, and Interaction. CLEF 2020. Lecture Notes in Computer Science, vol 12260. Springer, Cham. [https://doi.org/10.1007/978-3-030-58219-7_13](https://doi.org/10.1007/978-3-030-58219-7_13)

12. Savoy J. *Lexical Analysis of US Political Speeches*. *Journal of Quantitative Linguistics* 2010:17(2):123–141. [https://doi.org/10.1080/092961703643205](https://doi.org/10.1080/092961703643205)

13. Lucidi F., Alivernini F., Pedon A. *Metodologia Della Ricerca Qualitativa (Qualitative Research Methodology).* 1st ed. Bologna: Il Mulino, 2019. (in Italian)

14. Friese S. *Qualitative Data Analysis with ATLAS.Ti*. 3rd ed. London: SAGE Publications Ltd., 2019.

15. Hwang S. *Utilizing Qualitative Data Analysis Software: A Review of Atlas.Ti.* *Social Science Computer Review* 2007:26:519–527. [https://doi.org/10.1177/0894439307312485](https://doi.org/10.1177/0894439307312485)

16. Berry M. W., Kogan J. *Text Mining*. Chichester: John Wiley & Sons, 2010. [https://doi.org/10.1002/9780470689646](https://doi.org/10.1002/9780470689646)

17. Cegan J. C., et al. *Trends and Applications of Multi-Criteria Decision Analysis in Environmental Sciences: Literature Review*. *Environment Systems and Decisions* 2017:37:123–133. [https://doi.org/10.1017/s10669-17-9642-9](https://doi.org/10.1017/s10669-17-9642-9)

18. Bazeley P. *Qualitative Data Analysis: Practical Strategies*. 1st ed. London: SAGE Publications Ltd, 2013.

19. Morse J. M., Richards L. *Readme First for a Guide to Qualitative Methods*. 1st ed. London: SAGE Publications, 2002.

20. Canzonetti A. *Semantic Classification and Co-Occurrences: A Method for the Rules Production for the Information Extraction from Textual Data*. In *Data Analysis and Classification*. Berlin: Springer, 2010:209–216. [https://doi.org/10.1007/978-3-642-03739-9_24](https://doi.org/10.1007/978-3-642-03739-9_24)

21. Martinez W., et al. *Au-delà de la cooccurrence binaire… Poly-co-occurrences et trames de cooccurrence (Beyond binary co-occurrence… Poly-co-occurrences and co-occurrence frames).* *Corpus* 2012:11. [https://doi.org/10.4000/corpus.2262](https://doi.org/10.4000/corpus.2262)

22. Moro S., et al. *A Text Mining and Topic Modelling Perspective of Ethnic Marketing Research*. *Journal of Business Research* 2019:103:275–285. [https://doi.org/10.1016/j.jbusres.2019.01.053](https://doi.org/10.1016/j.jbusres.2019.01.053)

23. Sinclair J., Cardew-Hall M. *The Folksonomy Tag Cloud: When Is It Useful?* *Journal of Information Science* 2008:34(1):15–29. [https://doi.org/10.1177/0165551506078083](https://doi.org/10.1177/0165551506078083)

24. Feinberg J. *Wordle. Beautiful Visualization: Looking at Data through the Eyes of Experts.* Sebastopol: O'Reilly Media, 2010:37–58.

25. Kuo B. Y. L., et al. *Tag Clouds for Summarizing Web Search Results*. *Proceedings of the 16th International World Wide Web Conference* 2007:1203–1204. [https://doi.org/10.1145/1242572.1242766](https://doi.org/10.1145/1242572.1242766)

26. Darnall N., et al. *Environmental Management Systems: Opportunities for Improved Environmental and Business Strategy?* *Environmental Quality Management* 2000:9:1–9. [https://doi.org/10.1002/1520-6483(2000219).3<1::AID-TQEM1>3.0.CO;2-L](https://doi.org/10.1002/1520-6483(2000219).3<1::AID-TQEM1>3.0.CO;2-L)

27. Zutshi A., Sohal A. S. *A Framework for Environmental Management System Adoption and Maintenance: An Australian Perspective.* *Management of Environmental Quality* 2005:16(5):464–475. [https://doi.org/10.1108/14777830510614330](https://doi.org/10.1108/14777830510614330)

28. Fonseca L. M., Domingues J. P. *Exploratory Research of ISO 14001:2015 Transition among Portuguese Organizations. Sustainability* 2018:10(3):789. [https://doi.org/10.3390/su10030789](https://doi.org/10.3390/su10030789)

29. McFarland M. J., et al. *Complying with Executive Order 13148 Using the Enterprise Environmental Safety and Occupational Health Management Information System.* *Journal of the Air & Waste Management Association* 2005:55:302–308. [https://doi.org/10.1080/10473289.2005.10464168](https://doi.org/10.1080/10473289.2005.10464168)

30. Martín-de Castro G., Amores-Salvador J., Navas-López J. E. *Environmental Management Systems and Firm Performance: Improving Firm Environmental Policy through Stakeholder Engagement.* *Corporate Social Responsibility and Environmental Management* 2016:23(4):243–256. [https://doi.org/10.1002/csr.1377](https://doi.org/10.1002/csr.1377)

31. Turki M., Medhioub E., Kallel M. *Effectiveness of EMS in Tunisian Companies: Framework and Implementation Process Based on ISO 14001 Standard.* *Environment, Development and Sustainability* 2017:19:479–495. [https://doi.org/10.1007/s10545-015-9741-z](https://doi.org/10.1007/s10545-015-9741-z)

32. Chin K.-S. *Factors Influencing ISO 14000 Implementation in Printed Circuit Board Manufacturing Industry in Hong Kong.* *Journal of Environmental Planning and Management* 1999:42:123–134. [https://doi.org/10.1080/09640569911334](https://doi.org/10.1080/09640569911334)

33. Matthews D. H., Christini G. C., Hendrickson C. T. *Five Elements for Organizational Decision-Making with an Environmental Management System.* *Environmental Science & Technology* 2004:38:1927–1932. [https://doi.org/10.1021/es0351239](https://doi.org/10.1021/es0351239)

34. Soroshian S., Ting K. C. *Reasons for Implementing ISO 14001 in Malaysia.* *Environmental Quality Management* 2018:27:125–133. [https://doi.org/10.1002/tqem.21561](https://doi.org/10.1002/tqem.21561)

35. Todaro N. M., et al. *Antecedents of Environmental Management System Internalization: Assessing Managerial Interpretations and Cognitive Framings of Sustainability Issues.* *Journal of Environmental Management* 2019:247:804–815. [https://doi.org/10.1016/j.jenvman.2019.06.106](https://doi.org/10.1016/j.jenvman.2019.06.106)
[36] Ben-Zvi-Assaraf O., Ayal N. Harnessing the Environmental Professional Expertise of Engineering Students-The Course: “Environmental Management Systems in the Industry.” Journal of Science Education and Technology 2010:19:532–545. https://doi.org/10.1007/s10956-010-9219-6

[37] Soyka P. A. Designing Environmental Management Systems to Create Financial Value: A Benefit-Cost Estimation Methodology. Environmental Quality Management 2006:16(2):7–23. https://doi.org/10.1002/tqem.20118

[38] Yiridoe E. K., et al. ISO 14001 EMS Standard Registration Decisions among Canadian Organizations. Agribusiness 2003:19(4):439–457. https://doi.org/10.1002/agr.10069

[39] Boronat-Navarro M., Garcia-Joerger A. Ambidexterity, Alliances and Environmental Management System Adoption in Spanish Hotels. Sustainability 2019:11(20):8515. https://doi.org/10.3390/su11208515

[40] Chan E. S. W., Hawkins R. Application of EMSS in a Hotel Context: A Case Study. International Journal of Hospitality Management 2012:31(2):405–418. https://doi.org/10.1016/j.ijhm.2011.06.016

[41] Ardente F., et al. Application Of Environmental Management Systems (EMS) To Natural Parks And Reserves. Management of Natural Resources, Sustainable Development and Ecological Hazards. Southampton: WIT Press, 2006-99. https://doi.org/10.2495/RAV060171

[42] Tessitore S., et al. Isomorphic or Dissimilar Implementation among Environmental Management Scheme Adopters? Empirical Evidence from the European Context. Business Strategy & Development 2019:2(4):290–302. https://doi.org/10.1002/bsd2.61

[43] Neugebauer F. EMAS and ISO 14001 in the German Industry - Complements or Substitutes? Journal of Cleaner Production 2012:37:249–256. https://doi.org/10.1016/j.jclepro.2012.07.021

[44] Murmura F., et al. Evaluation of Italian Companies’ Perception About ISO 14001 and Eco Management and Audit Scheme III: Motivations, Benefits and Barriers. Journal of Cleaner Production 2017:184:691–700. https://doi.org/10.1016/j.jclepro.2017.10.337

[45] Lannelongue G., et al. Time Compression Diseconomies in Environmental Management: The Effect of Assimilation on Environmental Performance. Journal of Environmental Management 2015:147:203–212. https://doi.org/10.1016/j.jenvman.2014.04.035

[46] Nawrocka D., Parker T. Finding the Connection: Environmental Management Systems and Environmental Performance. Journal of Cleaner Production 2009:17:601–607. https://doi.org/10.1016/j.jclepro.2008.10.003

[47] Santos G., et al. Implementing and Certifying ISO 14001 in Portugal: Motives, Difficulties and Benefits after ISO 9001 Certification. Total Quality Management & Business Excellence 2016:27:1211–1223. https://doi.org/10.1080/14783363.2015.1065176

[48] Puente-Rodríguez D., et al. Knowledge Co-Production in Practice: Enabling Environmental Management Systems for Ports through Participatory Research in the Dutch Wadden Sea. Environmental Science & Policy 2016:55(part3):456–466. https://doi.org/10.1016/j.envsci.2015.02.014

[49] Gawaikar V., Bhole A., Lakhe R. R. Measuring the Impact of ISO 14001 Implementation. Polish Journal of Environmental Studies 2018:27:637–646. https://doi.org/10.15244/pjoes/76035

[50] Testa F., et al. Public Regulatory Relief and the Adoption of Environmental Management Systems: A European Survey. Journal of Environmental Planning and Management 2016:59:2231–2250. https://doi.org/10.1080/09640568.2016.1139491

[51] Darnall N., Jolley G. J., Handfield R. Environmental Management Systems and Green Supply Chain Management: Complements for Sustainability? Business Strategy and the Environment 2008:17(1):30–45. https://doi.org/10.1002/bse.557

[52] Matuszak-Flejszman A., Szyszka B., Jóhannsdóttir L. Effectiveness of EMAS: A Case Study of Polish Organisations Registered under EMAS. Environmental Impact Assessment Review 2019:74:86–94. https://doi.org/10.1016/j.eiar.2018.09.005

[53] Yang Y., et al. Efficacy of China’s Strategic Environmental Management in Its Institutional Environment. International Journal of Operations & Production Management 2019:39:138–163. https://doi.org/10.1108/IJOPM-11-2017-0695

[54] Muduli K., et al. Barriers to Green Supply Chain Management in Indian Mining Industries: A Graph Theoretic Approach. Journal of Cleaner Production 2013:47:335–344. https://doi.org/10.1016/j.jclepro.2012.10.030

[55] Psomas E. L., Fotopoulos C. V., Kafetzopoulos D. P. Motives, Difficulties and Benefits in Implementing the ISO 14001 Environmental Management System. Management of Environmental Quality 2011:22:502–521. https://doi.org/10.1108/14777831111136090

[56] Gupta S., Innes R. Private Politics and Environmental Management. Journal of Environmental Economics and Management 2014:68:319–339. https://doi.org/10.1016/j.jeem.2014.05.002

[57] Merli R., Preziosi M., Acampora A. Sustainability Experiences in the Wine Sector: Toward the Development of an International Indicators System. Journal of Cleaner Production 2018:172:3791–3805. https://doi.org/10.1016/j.jclepro.2017.06.129

[58] Younis H., Sundarakani B. The Impact of Firm Size, Firm Age and Environmental Management Certification on the Relationship between Green Supply Chain Practices and Corporate Performance. Benchmarking: An International Journal 2020:27(1):319–346. https://doi.org/10.1108/BJI-11-2018-0363

[59] Shah S. A. R., et al. Integrated Quality Environmental Management Implementation in Food Processing SMEs. The TQM Journal 2019:31:740–757. https://doi.org/10.1108/TQM-11-2018-0166
[60] Curkovic S., Vickery S., Dröge C. Quality-Related Action Programs: Their Impact on Quality Performance and Firm Performance. Decision Sciences 2000;31:885–902. https://doi.org/10.1111/1540-5915.2000.b60947.x

[61] Nishitani K., et al. Are Firms' Voluntary Environmental Management Activities Beneficial for the Environment and Business? An Empirical Study Focusing on Japanese Manufacturing Firms. Journal of Environmental Management 2012;105:121–130. https://doi.org/10.1016/j.jenvman.2012.03.054

[62] Schmidt J.-S., Osebold R. Environmental Management Systems as a Driver for Sustainability: State of Implementation, Benefits and Barriers in German Construction Companies. Journal of Civil Engineering and Management 2017;23(1):150–162. https://doi.org/10.3846/13923730.2014.946441

[63] Phan T. N., Baird K. The Comprehensiveness of Environmental Management Systems: The Influence of Institutional Pressures and the Impact on Environmental Performance. Journal of Environmental Management 2015;160:45–56. https://doi.org/10.1016/j.jenvman.2015.06.006

[64] Frondel M., Krätschell K., Zwick L. Environmental Management Systems: Does Certification Pay? Economic Analysis and Policy 2018;59:14–24. https://doi.org/10.1016/j.eap.2018.02.006

[65] Henriques I., Sadorsky P. Environmental Technical and Administrative Innovations in the Canadian Manufacturing Industry. Business Strategy and the Environment 2007;16(2):119–132. https://doi.org/10.1002/bse.475

[66] Könnölä, T., Unruh G. C. Really Changing the Course: The Limitations of Environmental Management Systems for Innovation. Business Strategy and the Environment 2007;16:525–537. https://doi.org/10.1002/bse.487

[67] Länsihioto, A., Järvenpää M. Environmental and Performance Management Forces. Qualitative Research in Accounting & Management 2008;5(3):184–206. https://doi.org/10.1108/11766090810910218

[68] Stanisikis J.K., Stasiskiene, Z. Environmental Management Accounting in Lithuania: Exploratory Study of Current Practices, Opportunities and Strategic Intents. Journal of Cleaner Production 2006;14(14):1252–1261. https://doi.org/10.1016/j.jclepro.2005.08.009

[69] Campos L. M. S., de Melo Heizen D. A., Verdinelli M. A., Cauchick Miguel P. A. Environmental Performance Indicators: A Study on ISO 14001 Certified Companies. Journal of Cleaner Production 2015;99:286–296. https://doi.org/10.1016/j.jclepro.2015.03.019

[70] Demirel P., Iatridis K., Kesidiou E. The Impact of Regulatory Complexity upon Self-Regulation: Evidence from the Adoption and Certification of Environmental Management Systems. Journal of Environmental Management 2018;207:80–91. https://doi.org/10.1016/j.jenvman.2017.11.019

[71] Salim H. K., Padfield R., Lee C. T., Syayuti K., Papargyropoulou E., Tham M.H. An Investigation of the Drivers, Barriers, and Incentives for Environmental Management Systems in the Malaysian Food and Beverage Industry. Clean Technologies and Environmental Policy 2018;20:529–538. https://doi.org/10.1007/s10098-017-1436-8

[72] Ormazabal M., Viles E., Santos J., Jaca C. An Overview of Environmental Management in the Spanish Food Sector: A Survey Study. Management of Environmental Quality: An International Journal 2018;29:49–62. https://doi.org/10.1108/MEQ-10-2016-0072

[73] Hera-Saizarbitoria I., Arana G., Boiral O. Outcomes of Environmental Management Systems: The Role of Motivations and Firms’ Characteristics. Business Strategy and the Environment 2016;25:545–559. https://doi.org/10.1002/bse.1884

[74] Evangelinos K. I., Nikolaou I. E., Karagiannis A. Implementation of Responsible Care in the Chemical Industry: Evidence from Greece. Journal of Hazardous Materials 2010;177:822–828. https://doi.org/10.1016/j.jhazmat.2009.12.107

[75] Yaqoob M. E., Naser H. A., Elkanzi E. M., Janahi E. M. Towards an Effective Environmental Impact Assessment (EIA) in the Industrial Sector of Bahrain, Arabian Gulf. Arab Journal of Basic and Applied Sciences 2019;26:113–124. https://doi.org/10.1080/25765299.2019.1570621

[76] Schylander E., Martinuzzi A. ISO 14001 – Experiences, Effects and Future Challenges: A National Study in Austria. Business Strategy and the Environment 2007;16(2):119–132. https://doi.org/10.1002/bse.487

[77] Mokhtar N., Jusoh R., Zulkifli N. Corporate Characteristics and Environmental Management Accounting (EMA) Implementation: Evidence from Malaysian Public Listed Companies (PLCs). Journal of Cleaner Production 2016;136(A):111–122. https://doi.org/10.1016/j.jclepro.2016.01.085

[78] Ghisellini A., Thurston D. L., Decision Traps in ISO 14001 Implementation Process: Case Study Results from Illinois Certified Companies. Journal of Cleaner Production 2005;13(8):763–777. https://doi.org/10.1016/j.jclepro.2004.02.042

[79] Von Malmberg F. Environmental Management Systems: What Is in It for Local Authorities? Journal of Environmental Policy & Planning 2003;5:3–21. https://doi.org/10.1080/15239080305605

[80] Snäkin J.-P. A., Korhonen J. Industrial Ecology in the North Karelia Region in Finland — Scenarios for Heating Energy Supply. International Journal of Sustainable Development & World Ecology 2002;9:9–21. https://doi.org/10.1080/13504500209470098
## ANNEX

### TABLE A1. MANAGEMENT CO-OCCURRENCE.

|          | barrier | benefit | change | eco-management | ems | improvement | innovation | organization | policy | strategy |
|----------|---------|---------|--------|----------------|-----|-------------|------------|--------------|--------|----------|
| barrier  | 0       |         |        |                |     |             |            |              |        |          |
| benefit  | 30      | 0       |        |                |     |             |            |              |        |          |
| change   | 50      | 16      | 0      |                |     |             |            |              |        |          |
| eco-management | 5  | 0       | 1      | 0              |     |             |            |              |        |          |
| ems      | 309     | 235     | 381    | 61             | 0   |             |            |              |        |          |
| improvement | 28   | 36      | 156    | 3              | 702 | 0           |            |              |        |          |
| innovation | 23   | 7       | 100    | 4              | 262 | 57          | 0          |              |        |          |
| organization | 67  | 103     | 323    | 18             | 1147| 257         | 127        | 0            |        |          |
| policy   | 18      | 11      | 126    | 6              | 494 | 149         | 61         | 195          | 0      |          |
| strategy | 58      | 33      | 164    | 4              | 464 | 130         | 155        | 389          | 162    | 0        |

### TABLE A2. STANDARD CO-OCCURRENCE.

|          | audit | certification | emas | integration | iso | model | quality | scheme |
|----------|-------|---------------|------|-------------|-----|-------|---------|--------|
| audit    | 0     |               |      |             |     |       |         |        |
| certification | 38  | 0             |      |             |     |       |         |        |
| emas     | 284   | 53            | 0    |             |     |       |         |        |
| integration | 9   | 2             | 20   | 0           |     |       |         |        |
| iso      | 212   | 490           | 1077 | 103         | 0  |       |         |        |
| model    | 11    | 22            | 31   | 34          | 291 | 0    |         |        |
| quality  | 30    | 48            | 29   | 61          | 361 | 101  | 0       |        |
| scheme   | 316   | 12            | 363  | 4           | 167 | 8    | 15      | 0      |

### TABLE A3. ASSESSMENT CO-OCCURRENCE.

|          | accounting | assessment | driver | evaluation | factor | impact | implementation | indicator | lea | material | performance |
|----------|-------------|------------|--------|------------|--------|--------|----------------|-----------|-----|----------|-------------|

59
### Table A4. Application Co-Occurrence.

| design | energy | pollution | process | product | waste |
|--------|--------|-----------|---------|---------|-------|
|        | 0      |           |         |         |       |
| energy | 32     | 0         |         |         |       |
| pollution | 11   | 110       | 0       |         |       |
| process | 230    | 179       | 144     | 0       |       |
| product | 339    | 415       | 210     | 1253    | 0     |
| waste  | 55     | 443       | 222     | 282     | 483   |

### Table A5. Business Co-Occurrence.

| business | business | china | company | corporate | enterprise | financial | industry | local | malaysia | sector | sme | supply |
|----------|----------|-------|---------|-----------|------------|-----------|----------|-------|----------|--------|-----|--------|
| business | 0        |       |         |           |            |           |          |       |          |        |     |        |
| china    | 35       | 0     |         |           |            |           |          |       |          |        |     |        |
| company  | 434      | 36    | 0       |           |            |           |          |       |          |        |     |        |
| corporate| 203      | 45    | 323     | 0         |            |           |          |       |          |        |     |        |
| enterprise| 99    | 26    | 120     | 42        | 0          |           |          |       |          |        |     |        |
| financial| 26       | 1     | 48      | 39        | 9          | 0         |          |       |          |        |     |        |
| industry | 238      | 113   | 629     | 207       | 134        | 31        | 0        |       |          |        |     |        |
| local    | 54       | 13    | 150     | 37        | 38         | 4         | 107      | 0     |          |        |     |        |
| malaysia | 19       | 10    | 53      | 12        | 6          | 1         | 47       | 1     | 0        |        |     |        |
| sector   | 127      | 22    | 401     | 52        | 52         | 9         | 546      | 56    | 23       | 0      |     |        |
| sme      | 14       | 0     | 28      | 7         | 32         | 3         | 8        | 4     | 5        | 15     | 0   |        |
| supply   | 72       | 34    | 173     | 79        | 26         | 8         | 155      | 25    | 14       | 74     | 4  | 0      |
### TABLE A6. MANAGEMENT WORD CLOUD – FREQUENCIES

| Word         | Frequency |
|--------------|-----------|
| ems          | 1357      |
| organizations| 525       |
| iso          | 315       |
| implementation| 219     |
| system       | 149       |
| performance  | 142       |
| activities   | 89        |
| aspects      | 85        |
| practices    | 81        |
| improve      | 71        |
| adoption     | 69        |
| policy       | 69        |

### TABLE A7. STANDARD WORD CLOUD – FREQUENCIES

| Word         | Frequencies |
|--------------|-------------|
| iso          | 1242        |
| emas         | 1204        |
| ems          | 328         |
| standards    | 161         |
| certification| 142         |
| companies    | 128         |
| european     | 117         |
| scheme       | 112         |
| audit        | 96          |
| performance  | 87          |
| implementation| 85        |
| international| 82          |
| adoption     | 79          |
| corporate    | 78          |
| organizations| 69          |

### TABLE A8. ASSESSMENT WORD CLOUD – FREQUENCIES

| Word         | Frequencies |
|--------------|-------------|
| performance  | 923         |
| impact       | 684         |
| ems          | 238         |
## Table A9. Application Word Cloud – Frequencies

| Word            | Frequencies |
|-----------------|-------------|
| process         | 615         |
| production      | 457         |
| product         | 452         |
| ems             | 164         |
| quality         | 157         |
| waste           | 141         |
| innovation      | 137         |
| which           | 132         |
| design          | 115         |
| iso             | 115         |
| performance     | 110         |
| system          | 110         |
| innovations     | 105         |
| materials       | 102         |
| development     | 99          |
| green           | 98          |
| energy          | 96          |
| improvement     | 93          |
### Table A10. Business Word Cloud – Frequencies

| Word             | Frequencies |
|------------------|-------------|
| companies        | 539         |
| industry         | 325         |
| for              | 227         |
| iso              | 133         |
| ems              | 111         |
| performance      | 96          |
| sector           | 56          |
| factors          | 49          |
| implementation   | 48          |
| production       | 46          |
| sustainability   | 40          |
| standard         | 36          |
| waste            | 36          |
| chemical         | 32          |
| activities       | 29          |
| business         | 29          |
| food             | 28          |