

ISO 14001 management systems: comparing past and recent scientific production

Abstract

Business has a range of answer options in order to face environmental issues and implementing environmental management systems according to ISO 14001 is one of these options. Currently its use is spread worldwide and there is still debate on which are the real benefits of implementing it. A bibliometric study was conducted to describe the evolution of publication in this field and discuss key features such as main authors, countries of origin of articles, main institutions involved, main journals and the keywords. Production has been divided in two subsets – from 1996 through 2009 and from 2009 through 2013. The analysis of differences between more recent and earlier production showed that there has been little change in the countries of origin, institutions of origin of articles and knowledge areas. The results show also that Journal of Cleaner Production is the journal that publishes more articles in the studied subject. In the studied period there was very different main authors, showing a shift in the interest of researchers on the theme. The analysis of keywords and index words showed that some details that the ISO 14001 standards contains are not probably given much attention because they either did not show up in the research or are present in very little frequency.

Keywords

Environmental management systems, bibliometry, ISO 14001

Introduction

Several years ago, the environmental issues entered the companies challenges agenda. During the 1950', the pacifist movements, which started also to get into the environmental matters. This pressure lead in the 1970's and 80's to a ramp in legal and other requirements. Focus of

these legal requirements were almost all what is known as “end of pipe” control, that means, putting abatement equipment in place as the main tool to face environmental regulations. However, major accidents that occurred in the 1980’s taught industries that this might not be enough. Accidents such as methyl-isocyanate leak at Bhopal (India), Exxon Valdez (oil leak from a ship) showed that equipment abatement was enough to assure pollution control. Chemical Industries have then started Responsible Care programs and ISO (International Organization for Standardization) launched, in 1996, the first of their environmental standard, namely ISO 14001. Currently, many companies still look for ISO 14001 as a way to face their environmental issue.

The standard was originally launched with a lot of excitement in many business branches as tool with great potential to bring benefits. Nowadays there is still room for debate on the extent of benefits achieved by the companies and the society as a whole when companies go for ISO 14001 certification. This is a hard field to research on, first because companies do not usually like to talk about difficulties, and second they frequently refuse to give quantitative information that allows research on a “companies’ population” level. Although the standard itself does not use the wording “green economy”, there was a strong expectation that its implementation could be part of support to a greener economy. How to measure this result? This could probably be done by comparing green economy performance of certified and non-certified companies.

Once the standard is now 18 years old, 10 years from the second edition, it might be a good time to look at the scientific production on this theme, and particularly on the evolution on some specific features.

Literature Review

Environmental management systems and ISO 14001

In order to face stakeholders and client pressures, business has a range of answer options and implementing environmental management systems according to ISO 14001 is one of the options. ISO 14001 is a standard which determines requirements for establishing an environmental management system. The proposed model is based upon the PDCA continuous improvement cycle, and serves to organizations that wish to have an environmental management system in place, in order to assure its environmental policy and its results are delivered, and to demonstrate conformance to stakeholders (ISO, 2004). The standard does not establish performance parameters.

ISO 14001 was first issued in 1996, then revised in 2004. According to ISO (2013), there were more than 280 thousand ISO 14001 certified business units around the world in 158 countries. Figure 1 shows the growth of certification numbers.

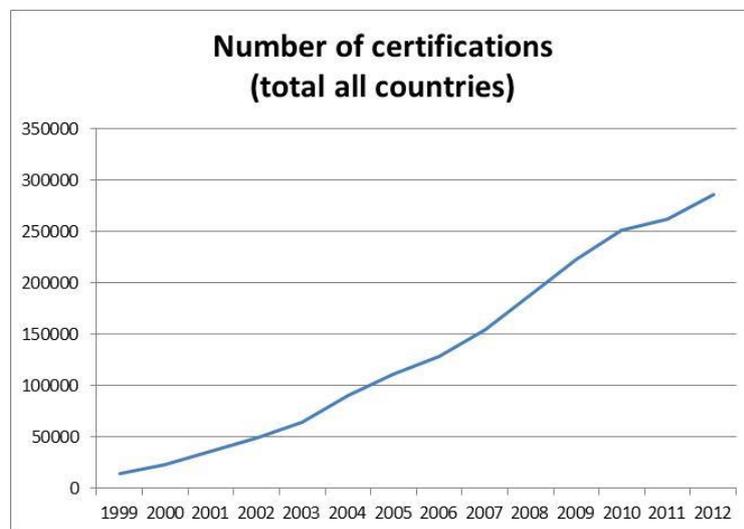


Figure 1. Total number of ISO 14001 existing certifications in each year. Source: ISO (2013)

Delmas & Montiel (2008) studied the international diffusion of ISO 14001 in the chemical industry and concluded that previous business experience in other voluntary standards and management models such as ISO 9000 and Responsible Care, and the existence of international nongovernmental organizations in the countries affected positively the number of ISO 14001 certifications. Delmas & Monte-Sancho (2011) argue also that the business

context and that regulative forces were more important in early phases of adoption of the standard, and that normative factors such as trade related factors and the diffusion of other standards gain importance. On the other hand, Heras-Saizarbitoria, Landín & Molina-Azorín (2011) concluded that internal driving forces play a more important role in effectiveness and results than the external ones. Marimon, Casadesus & Heras (2010) studied the standards deployment in some countries using what they called *certification intensity level*, linking a country's economy to the number of certifications.

Effectiveness of ISO 14001 systems remain a non-consensus topic in scientific literature. Some research confirms that certified companies have a better performance than non-certified companies, such as Potoski and Prakash (2005) regarding to compliance with legal requirements and (2005b) that confirmed reduced emissions; and Babakri et al (2004) found that recycling performance was better among certified companies. On the other hand, other researches brought doubts on the effectiveness of the standardized management systems or at least confirm that results vary according to implementation style. Darnall et al (2008) drew to the conclusion that results are influenced by the implementation motivation and by internal factors for a broader sense of environmental management and involvement of research and development. Link and Haifa (2006) and Yin and Schmeidler (2009) found that environmental performance is better among certified companies when environmental management is included in the company's daily activities.

Bibliometry and bibliometric studies

There is a growing concern in measuring scientific production, being common to use terms such as scientometrics , informetrics , webometrics , netometrics, cybermetrics, all of them embraced by bibliometry (De Bellis, 2009). The bibliometry uses a series of scientific and statistical methodologies to measure the number of publications that have certain characteristics, also checking the productivity of an author or group of authors, the impact

caused by certain publications and draw knowledge maps which shows the areas of research or production of authors (Huang, Zhang, Guo, Zhu, & Porter, 2014; Markscheffel, 2011; Woon, Henschel, & Madnick, 2009). As a result, Bornmann (2013) considers that bibliometry has become an indispensable tool in the evaluation of institutions and has been used in evaluation reports of teachers, institutions, areas of research and scientific publications.

Bibliometric techniques has been used, for example, to measure the performance of scientific publications (Sanni, Zainab, Raj, & Abrizah, 2014), its impact factor (Marx & Bornmann, 2013; Abramo, D'Angelo, & Di Costa, 2010) and to set up strategies to improve their performance (Zainab, Abrizah, & Raj, 2013). It has also been used in the productivity analysis of knowledge areas in relation to received funds (Wainer & Vieira, 2013), in assessing the productivity of researchers (Bornmann & Marx, 2013), in the construction of scientific collaboration networks (Catalá-López, et al., 2012), in measuring the productivity of countries (Schoeneck, Porter, Kostoff, & Berger, 2011) or in the internationalization of research groups (Abramo, D'Angelo, & Solazzi, 2011). There are also studies that assess the impact of new media (Thelwall, Haustein, Larivière, & Sugimoto, 2013; Woszezenki, et al., 2013; Thelwall, 2008).

The bibliometry uses some statistical tools (De Bellis, 2009; DeSolla Price, 1976), as the Lotka's Law and Bradford's Law, as well as Zipf distribution. The Lotka's Law allows evaluating the degree of maturity of the scientific production of a particular group or area. In more established areas of knowledge, with a more mature and consolidated scientific production, there is a tendency that a small group of authors focus a high academic production, while a larger group of researchers represents a relatively lower production.

The Bradford's Law assists the researcher to identify the publications that concentrate more articles on specific topics, making it easier to conduct literature searches (De Bellis, 2009;

DeSolla Price, 1976; Thelwall, 2008; Zhao & Xu, 2010). According to the Bradford's Law, considering a specific scientific area, a small number of journals concentrate a high number of articles. This is the main core of journals of this area. The Zipf's Law investigates the frequency distribution of words in a text, with implications for indexing scientific articles, for example. Whereas the articles on a given topic, some words occur at a high frequency, while others appear only sporadically. The Zipf's Law contributes to this process, allowing the identification of more useful words for the selection of articles (De Bellis, 2009; DeSolla Price, 1976; Thelwall, 2008; Zhao & Xu, 2010).

OBJECTIVES

METHODS

The research is descriptive and prospective in nature, and bibliometric from the techniques point of view

Data collection

Information on articles have been got from the Scopus base, which is provided by Elsevier B.V. and can be accessed online. The search using expression "environmental management systems" returned originally 66849 documents. The search has then been restricted to "ISO 14001", and returned a total of 1374 documents, that have been further restricted to articles and to exclude publications dated year 2014, resulting 878 articles, which is the set that has been studied in this paper.

Scopus scientific base makes it available tools that allow researchers to collect bibliographic information. Information was exported into comma separated value files and then was imported into Microsoft Excel® for better presentation and formatting. Data has been checked for different spelling of same names of authors, institutions and sources, and also for inconsistent information, e.g. when the contents did not match the information category.

Data on ISO 14001 certifications has been taken from ISO Survey, including 176 countries, which is an annual database provided by ISO. According to ISO, information comes from certification bodies.

Economic information on countries have been obtained from the World Bank Website, which contains information from 215 countries.

Data analysis

The papers have been separated in two periods: 2009-2013 (371 documents) and 1996-2008 (507 documents). This was done in order to try to identify differences among older and newer papers, then trying to capture changes and trends.

Keywords and index words have been analyzed using the online tool available on <http://linguistica.insite.com.br/corpus.php>, created and provided by a research group coordinated by Insite software and systems company.

In order to better establish authorship profile, Lotka's law equation has been derived using bivariate regression (Hair, 2005) with support of software SPSS 13.

In order to deepen the study on the articles publication by country origin, the following correlation hypothesis (Hair, 2005) have been tested:

- H1: countries that have more ISO 14001 certified companies produce more articles
- H2: countries that have a larger economy produce more articles on ISO 14001
- H3: countries that have a higher ISO 14001 certifications intensity produce more articles
- H4: countries that have experienced a higher percentual growth in ISO 14001 certifications produce more articles.

The results have been considered significant when p-value $<0,05$. Tests have also been done with support of software SPSS 13.

RESULTS

Figure 1 shows the total papers production on ISO 14001 in the studied period.

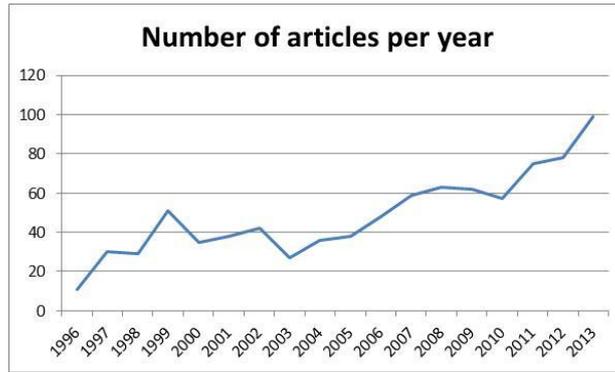


Figure 2. Number of articles published in each year. Created by the authors with data from Scopus.

The total number of articles has been relatively constant, varying around an average between 20 and 50 articles per year from 1997 till 2007. 2008 can be probably a transition year, and from 2009 the general trend is the growth in the number of publications that deals with ISO 14001 environmental management systems.

Most productive authors

First the number of papers per author has been subject to the Lotka's law to determine the maturity of production on ISO 14001 management systems. Figure 3 shows the regression results.

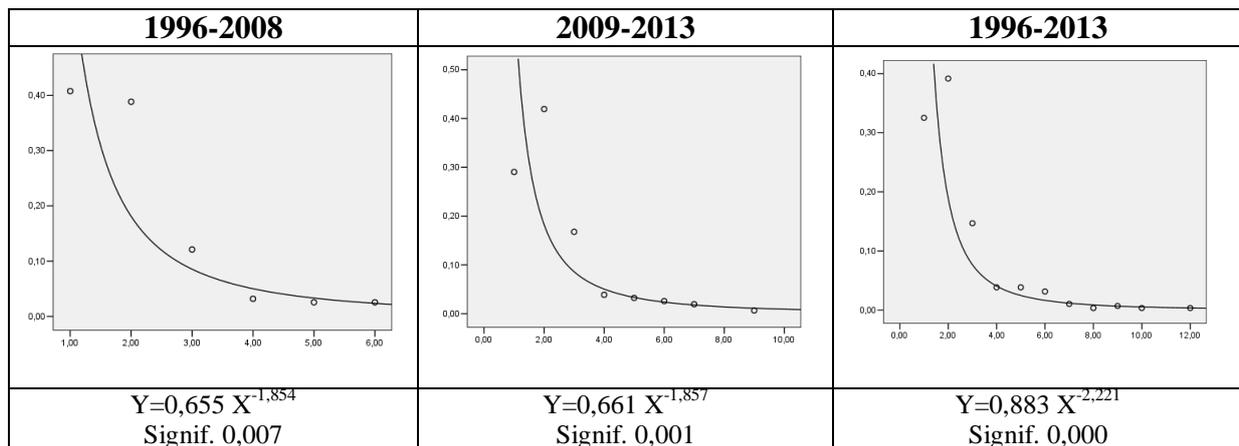


Figure 2. Regression results for the Lotka's law.

Figure 2 shows that there has been a maturing process from the earlier period 1996-2008 to the later period 2009-2013, because the curve's shape is more elbow-like.

Then, it is important to study which are the main authors in the field. Figure 3 shows the 15 main authors for each period. It is clear that there has been change in the main authors.

Period 1996-2008		Period 2009-2013	
AUTHOR NAME	Number of articles	AUTHOR NAME	Number of articles
Hui, I.K.	6	Casadesus, M.	9
Wilkinson, G.	6	Heras, I.	7
Hjelm, O.	6	Karapetrovic, S.	7
Dale, B.G.	6	Comoglio, C.	7
Fryxell, G.E.	5	Matuszak-Flejszman, A.	6
Sarkis, J.	5	Botta, S.	6
Pun, K.F.	5	De Oliveira, O.J.	6
Karapetrovic, S.	5	Nishitani, K.	6
Melnyk, S.A.	4	Molina-Azorin, J.F.	5
Willborn, W.	4	Jabbour, C.J.C.	5
Zutshi, A.	4	Chan, E.S.W.	5
Anon,	4	Marimon, F.	5
Darnall, N.	4	Bernardo, M.	5
Emilsson, S.	3	Zeng, S.X.	4
Sohal, A.S.	3	Awang, A.	4

Figure 3. Most productive authors in the field of ISO 14001 environmental management systems

Only one author remained in the top 15 authors in the studied periods, namely S. Karapetrovic. This is a significant turnover. Identifying the reasons for that fact goes beyond our objectives, but it could be interesting to study what happened in the academic conditions or in the ISO 14001 market that lead to this significant change.

In the period 2009-2013, the three top authors are publishing frequently as co-authors: 2 articles with all of the three and five articles including two out of the three.

Article productions per countries

In the case of articles origin by country, although the position of each country can vary, the Figure 4 shows that the main countries remained approximately the same along the time. In total 70 countries have originated at least one paper since 1996.

Period 1996-2008		Period 2009-2013	
COUNTRY (total countries = 53)	Number of articles	COUNTRY (total countries = 60)	Number of articles
United States	98	Spain	51
United Kingdom	48	United States	51
Canada	35	Brazil	33
Sweden	34	Canada	29
Germany	33	United Kingdom	23
Australia	23	Italy	18
Hong Kong	22	Australia	15
Spain	22	China	15
Japan	21	Hong Kong	14
Italy	16	Germany	13
India	14	Malaysia	13

Netherlands	13	Sweden	12
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Figure 4 – Main countries that originated articles on management systems and ISO 14001.

The production of articles per country has been submitted to correlations tests, as previously described in the methods description. Table 1 shows the results.

		Average GNIPPP 2004-2012	Average GNIPPP 2004-2008	Average GNIPPP 2009-2012	Total certifications per country - year 2007	Total certifications per country - year 2012	Average Certification intensity 2004 - 2008	Average Certification Intensity 2009-2012	Average Certification Intensity 2009-2012	% certification variation 2002-2012	% certification variations 2009-2012	% certification variations 2002-2009
Total number of articles per country	Pearson Correlation	0,747	0,773	0,715	0,375	0,264	0,019	0,085	0,074	0,250	-0,112	-0,159
	Sig. (2-tailed)	0,000	0,000	0,000	0,002	0,033	0,881	0,501	0,557	0,044	0,382	0,225
	N	65	65	65	63	65	65	65	65	65	63	60
Articles per country 2009-2013	Pearson Correlation	0,620	0,636	0,599	0,403	0,308	0,118	0,164	0,155	0,298	-0,064	-0,092
	Sig. (2-tailed)	0,000	0,000	0,000	0,001	0,013	0,351	0,193	0,216	0,016	0,617	0,484
	N	65	65	65	63	65	65	65	65	65	63	60
Articles per country 1999-2008	Pearson Correlation	0,766	0,796	0,729	0,319	0,208	-0,053	0,021	0,010	0,193	-0,135	-0,191
	Sig. (2-tailed)	0,000	0,000	0,000	0,011	0,096	0,676	0,868	0,939	0,124	0,291	0,143
	N	65	65	65	63	65	65	65	65	65	63	60

Table 1. Results of correlation tests.

It can be noticed that there is strong correlation between number of articles and GNIPPP, showing that countries with bigger economies produce more articles in the ISO 14001 themes. Correlation was also positive in some cases when taking ISO 14001 certifications, however the correlation is weak.

It can also be noticed that total certifications in year 2007 has also a weak correlation with articles production in both periods and in total, showing that probably earlier adopters of the standards are producing more articles. Correlation also showed up between the percentual certification variation 2002-2012 and more recent articles production, what means that countries that have grown more in the 10-year period also produced more articles.

Institutions

The analysis of institutions showed that none of the top ten institutions in the first period remained on top in the second period, as shows Figure 5. Total number of institutions in the whole period (1996-2013) was 286.

Period 1996-2008		Period 2009-2013	
INSTITUTION (total number = 160)	Nr of articles	INSTITUTION (total number = 160)	Nr of articles
Hong Kong Polytechnic University	14	UNESP-Universidade Estadual Paulista	12
Linköpings universitet	10	Universitat de Girona	10
City University of Hong Kong	7	Universidad del Pais Vasco - Euskal Herriko Unibertsitatea	8
The University of North Carolina at Chapel Hill	6	Akademia Ekonomiczna w Poznaniu	7

University of Manchester	6	Hong Kong Polytechnic University	7
Clark University	5	Politecnico di Torino	7
Dalhousie University	5	University of Alberta	7
George Mason University	5	School of Hotel and Tourism Management, Hong Kong	6
Monash University	5	Shanghai Jiaotong University	6
Universidad de Oviedo	5	Universidade de Sao Paulo	6
University of Manitoba	5	Universitat d'Alicante	6
		Universitat de Barcelona	6
		Universitat Politècnica de Catalunya	6

Figure 5. Main institutions involved in the ISO 14001 articles publication

This shows a high level of turnover in the institutions, once only 17 out of 286 institutions showed up in both lists.

Main Sources of publications

Although there has been some variation, it can be seen that one journal publishes most papers: Journal of Cleaner Production has been on top for the entire period of study, as shown in Figure 6. Other journals have also been on the high places although places vary, and some journals that appeared only once.

Period 1996-2008		Period 2009-2013	
SOURCE (total = 208 sources)	Nr of articles	SOURCE (total = 270 sources)	Nr of articles
Journal of Cleaner Production	43	Journal of Cleaner Production	51
Greener Management International	18	Journal of Environmental Management	12
Business Strategy and the Environment	16	Business Strategy and the Environment	10
Corporate Environmental Strategy	15	International Journal of Life Cycle Assessment	7
Corporate Social Responsibility and Environmental Management	11	Corporate Social Responsibility and Environmental Management	6
Management of Environmental Quality	10	Quality Access to Success	6
Environmental Management	9	Journal of Business Ethics	5
International Journal of Quality and Reliability Management	9	International Journal of Production Economics	5
TQM Magazine	8	Ecological Economics	5
Journal of Environmental Management	7	Management of Environmental Quality	5
Quality Progress	6	Metalurgia International	5
European Management Journal	5	TQM Journal	5

Figure 6. Main journals publishing articles on ISO 14001.

Knowledge areas

Top five areas that have published papers on ISO 14001 environmental management systems remained the same in from the beginning.

Period 1996-2008		Period 2009-2013	
KNOWLEDGE AREA	Nr of articles	KNOWLEDGE AREA	Nr of articles
Environmental Science	211	Environmental Science	173
Business, Management and Accounting	133	Business, Management and Accounting	161
Engineering	100	Engineering	105
Social Sciences	98	Social Sciences	65
Energy	58	Energy	58
Chemical Engineering	40	Economics, Econometrics and Finance	41
Materials Science	29	Decision Sciences	27
Decision Sciences	24	Agricultural and Biological Sciences	21
Agricultural and Biological Sciences	23	Materials Science	9
Economics, Econometrics and Finance	20	Computer Science	8

Figure 7. Main knowledge areas of publishing articles on ISO 14001.

In contrast with other themes, there has been little turnover in the set of main areas of publications remained the same throughout the period.

Keywords

Period 1996-2008		Period 2009-2013		Period 1996-2008		Period 2009-2013	
Keywords	%	Keywords	%	Index words	%	Index words	%
environmental	12,14	management	10,29	environmental	8,95	environmental	9,06
management	11,34	environmental	9,87	management	8,25	management	8,18
iso	5,03	iso	4,29	systems	2,66	systems	2,27
system	3,34	system	3,23	iso	1,54	industry	1,32
systems	2,88	systems	2,84	industry	1,29	iso	1,32
ems	1,78	performance	1,81	quality	1,13	quality	1,22
performance	1,52	sustainable	1,42	performance	1,12	performance	1,11
quality	1,18	quality	1,23	development	0,99	development	1,00
standards	1,10	ems	1,10	impact	0,96	impact	1,00
sustainable	1,06	development	0,94	sustainable	0,96	analysis	0,96
environment	1,02	sustainability	0,84	system	0,95	sustainable	0,93
assessment	0,97	supply	0,81	control	0,84	control	0,90
development	0,93	corporate	0,77	analysis	0,83	assessment	0,85
industry	0,85	chain	0,74	industrial	0,77	supply	0,83
sustainability	0,85	industry	0,74	assessment	0,75	system	0,82
certification	0,72	certification	0,68	supply	0,72	policy	0,72
health	0,68	integrated	0,68	waste	0,70	construction	0,70

life	0,68	manufacturing	0,68	engineering	0,65	industrial	0,67
chain	0,59	assessment	0,65	construction	0,64	waste	0,60
construction	0,59	standards	0,65	policy	0,64	certification	0,57

Most keywords and index words are present in the top 20 words. Eleven are present in all sets. Some are present only in indexes, e.g. control and policy; others are present only in keywords, e.g. certification and sustainability, although sustainable is present in all sets. There is no trend that is clear as a time evolution of the words.

However, it is remarkable that some wording generally associated with system's elements do not show up on top, indeed there is only a few occurrences. Wording such as audits, training, awareness, emergency plan, responsibility and corrective actions do not show up in the top words. Indeed "corrective" and emergency do not show up at no instance. For example, wording related to audits sums up to 0,76% till 2008 and 0,32 in the most recent period, showing that it is a potentially less interesting theme. This is likely to be related to the confidentiality issues involved in auditing, making it difficult to get objective information on the process. In the same way.

The results suggest that the scientific production on ISO 14001 environmental management systems is not focusing its internal working, but could be focusing more motivations, strategies and results.

CONCLUSIONS

The results show that scientific production on ISO 14001 management systems has been increasing since 2009. The analysis of differences between more recent and earlier production showed that there has been little change in the countries of origin, institutions of origin of articles and knowledge areas.

It was also an unexpected result that production on ISO 14001 does not necessarily comes from the countries that have a higher number of certifications. This could be reason for future research.

The results show also that Journal of Cleaner Production is the journal that publishes more articles in the studied subject. Other journals that were among top ones are Corporate Environmental Responsibility, Journal of Environmental Management and Corporate Social Responsibility and Environmental Management.

It has also been shown that in the studied period there was very different main authors, showing a shift in the interest of researchers on the theme.

The analysis of keywords and index words showed that some details that the ISO 14001 standards contains are not probably given much attention because they either did not show up in the research or are present in very little frequency.

Research limitations are due to the fact that specific contents such as type of research, objectives, type of sampling, were not treated and could be treated in future studies.

Future studies could focus on:

- Comparing articles with other kinds of production
- Comparing research methods and contents of articles (case studies, surveys, and so on)
- Exploring the causes for authorship and institutions turnover

REFERENCES

- Abramo, G., D'Angelo, C. A., & Di Costa, F. (2010). Citations versus journal impact factor as proxy of quality: Could the latter ever be preferable? *Scientometrics*, *84*, 821-833.
- Abramo, G., D'Angelo, C. A., & Solazzi, M. (2011). The relationship between scientists research performance and the degree of internationalization of their research. *Scientometrics*, *86*, 629-643.
- Babakri, K. A., Bennett, R. A., Rao, S., & Franchetti, M. (2004). Recycling performance of firms before and after adoption of the ISO 14001 standard. *Journal of Cleaner Production*, *12*(6), 633-637.
- Bornmann, L. (2013). The problem of citation impact assessments for recent publication years in institutional evaluations. *Journal of Informetrics*, *7*, 722-729.
- Bornmann, L., & Marx, W. (2013). Evaluating individual researchers performance. *European Science Editing*, *39*, 39-40.

- Catalá-López, F., Alonso-Arroyo, A., Aleixandre-Benavent, R., Ridao, M., Bolaños, M., García-Altés, A., . . . Peiró, S. (2012). Coauthorship and institutional collaborations on cost-effectiveness analyses: a systematic network analysis. *PloS one*, 7.
- De Bellis, N. (2009). *Bibliometrics and citation analysis : from the Science citation index to cybermetrics*. Plymouth: Scarecrow Press.
- Delmas, M. A., & Montes-Sancho, I. M. J. (2011). An Institutional Perspective on the Diffusion of International Management System Standards: The Case of the Environmental Management Standard ISO 14001. *Business Ethics Quarterly*, 21(1).
- Delmas, M., & Montiel, I. (2008). The diffusion of voluntary international management standards: responsible care, ISO 9000, and ISO 14001 in the chemical industry. *Policy Studies Journal*, 36(1), 65-93.
- DeSolla Price, D. (1976). General Theory of Bibliometric and other Cumulative Advantage Processes. *Journal of the American Society for Information Science*, 27, 292-306.
- HAIR, JR. J.F; BABIN, B.; MONEY, A.H.; SAMOUEL, P. (2005). *Fundamentos de Métodos de Pesquisa em Administração*. Porto Alegre: Bookman, 2005.
- Heras-Saizarbitoria, I., Landín, G. A., & Molina-Azorín, J. F. (2011). Do drivers matter for the benefits of ISO 14001?. *International Journal of Operations & Production Management*, 31(2), 192-216.
- Huang, L., Zhang, Y., Guo, Y., Zhu, D., & Porter, A. L. (2014). Four dimensional Science and Technology planning: A new approach based on bibliometrics and technology roadmapping. *Technological Forecasting and Social Change*, 81, 39-48.
- ISO, INTERNATIONAL ORGANIZATION FOR STANDARTIZATION. (2004). Environmental management systems - Requirements with guidance for use. Geneve.
- Link, S., & Naveh, E. (2006). Standardization and discretion: does the environmental standard ISO 14001 lead to performance benefits?. *Engineering Management, IEEE Transactions on*, 53(4), 508-519.
- Markscheffel, B. (2011). An ontology based visualization approach for the joined interpretation of bibliometrics and webometrics data. *Proceedings of the International Conference on Management of Emergent Digital EcoSystems, MEDES11*, (pp. 163-168).
- Marx, W., & Bornmann, L. (2013). Journal impact factor: the poor mans citation analysis and alternative approaches. *European Science Editing*, 39, 62-63.
- Potoski, M., & Prakash, A. (2005). Covenants with weak swords: ISO 14001 and facilities' environmental performance. *Journal of policy analysis and management*, 24(4), 745-769.
- Potoski, M., & Prakash, A. (2005). Green clubs and voluntary governance: ISO 14001 and firms' regulatory compliance. *American Journal of Political Science*, 49(2), 235-248.
- Sanni, S. A., Zainab, A. N., Raj, R. G., & Abrizah, A. (2014). Measuring journal diffusion using periodic citation counts. *Malaysian Journal of Library and Information Science*, 19, 23-36.
- Schoeneck, D. J., Porter, A. L., Kostoff, R. N., & Berger, E. M. (2011). Assessment of Brazils research literature. *Technology Analysis and Strategic Management*, 23, 601-621.
- Thelwall, M. (2008). Bibliometrics to webometrics. *Journal of Information Science*, 34, 605-621.

- Thelwall, M., Haustein, S., Larivière, V., & Sugimoto, C. R. (2013). Do Altmetrics Work? Twitter and Ten Other Social Web Services. *PLoS ONE*, 8.
- Wainer, J., & Vieira, P. (2013). Correlations between bibliometrics and peer evaluation for all disciplines: The evaluation of Brazilian scientists. *Scientometrics*, 96, 395-410.
- Woon, W. L., Henschel, A., & Madnick, S. (2009). A framework for technology forecasting and visualization. *2009 International Conference on Innovations in Information Technology, IIT 09*, (pp. 155-159).
- Woszezenki, C. R., Freitas Junior, V., Anderle, D. F., Steil, A. V., Dandolini, G., & De Souza, J. A. (2013). Twitter® as an object of empirical quantitative research: A bibliometric review. *Espacios*, 34.
- Yin, H., & Schmeidler, P. J. (2009). Why do standardized ISO 14001 environmental management systems lead to heterogeneous environmental outcomes?. *Business Strategy and the Environment*, 18(7), 469-486.
- Zainab, A. N., Abrizah, A., & Raj, R. G. (2013). Adding value to scholarly journals through a citation indexing system. *Program*, 47, 239-262.
- Zhao, R., & Xu, L. (2010). Visualization analysis of evolution from bibliometrics to webometrics. *Wuhan Daxue Xuebao (Xinxi Kexue Ban)/Geomatics and Information Science of Wuhan University*, 35, 97-101.
- Marimon, F., Casadesús, M., & Heras, I. (2010). Certification intensity level of the leading nations in ISO 9000 and ISO 14000 standards. *International Journal of Quality & Reliability Management*, 27(9), 1002-1020.