Using structural equation modeling: patterns and trends of publications in Brazilian journals

Jorge Ramón D'Acosta Rivera
Centro Universitário FEI, São Paulo, Brazil
Rafael Ricardo Jacomossi
Centro Universitário FEI, São Bernardo do Campo, Brazil
Alcides Barrichello
Mackenzie Presbyterian University, São Paulo, Brazil, and
Rogerio Scabim Morano
Federal University of São Paulo, São Paulo, Brazil

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Abstract

Purpose – The purpose of this paper is to analyze patterns and trends of articles that present the use of structural equation modeling (SEM) and that were published in several Brazilian journals. In addition, this paper maps the institutions where the authors of the identified articles are affiliated, and discusses aspects of searching the articles in journals' archives and other scientific databases.
Design/methodology/approach – The work used bibliometrics, which is one of the forms of evaluation and measurement of information flows in scientific knowledge, using mathematical and statistical methods.
Findings – The study showed an exponential growth in using SEM in several areas in recent years, with predominance in marketing. Most of the publications were produced by authors from institutions such as USP, FGV and UFRGS, but most authors published only one article using SEM. Almost all published articles used one of the three most common software, especially AMOS®. Surprisingly, many articles did not mention the software used, indicating methodological flaw.
Practical implications – Weaknesses were found regarding the search for articles in the different sources used, indicating that, for literature reviews, the research should be conducted in several databases in a complementary way and not alternatively. This fact becomes critical especially when expressions in languages other than Portuguese were used. This situation suggests an aggravating lack of visibility for the Brazilian scientific community since the articles are less likely to be found.
Originality/value – The paper shows that among the various techniques of multivariate data analysis used in the field of administration, SEM has gained prominence being operationalized using specific software.

Keywords Structural equations, Quantitative methods, Bibliometrics

Paper type Literature review

Introduction

Complexity is one of the characteristics of modern society, requiring researchers to learn and improve in multivariate techniques of data analysis to get a proper answer about the phenomena studied. In addition to that, the use of microcomputers and statistical software facilitates the task of data analysis (Pilati and Laros, 2007).

One of the techniques of multivariate data analysis that is gaining prominence and that can be operationalized using specific software is structural equation modeling (SEM), including confirmatory factor analysis (CFA). CFA is driven by theory, thus consolidating

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itself as a technique for testing explicit hypotheses in a given theoretical model (Albright and Park, 2009; Baumgartner and Homburg, 1996; Byrne, 2009; Hair *et al.*, 2009; Nunnally and Bernstein, 1994).

In a general way, studies that use SEM in the field of Administration have been developed worldwide with more emphasis since the 1980s. In Brazil, the technique began to be used in the 1990s. Both, in Brazil and internationally, SEM has been more widely used in studies in the area of marketing (Brei and Liberali Neto, 2006).

Considering the evolution of SEM in studies in Administration in Brazil, this research aims to understand the patterns and trends of publications that rely on the use of this technique, as well as to map the institutions where the authors of the identified articles are affiliated, and to discuss aspects of searching the articles in journals' archives and other scientific databases. Therefore, a bibliometric study was carried out to evaluate quantitatively the production, dissemination and use of SEM in the field of administration in Brazil.

The contribution of this research is to provide an understanding about the evolution of using SEM in Administration in Brazil, the areas in which it is applied, identify trends, tools (software) used, authors and the institutions they are affiliated with. In addition, this research contributes by evaluating the agreement of results from different databases and the ease of searching in each one.

This article is organized in this introduction, followed by a literature review on SEM, a presentation of the methodology used, an analysis of the results and the conclusion.

SEM: definition, application and authors

SEM is a statistical method used to confirm theoretical models, originated in the field of psychometrics (Kaplan, 2000). Psychometrics consists in techniques to measure mental processes, and its most widespread use is in the fields of education and psychology (Nunnally and Bernstein, 1994).

The use of SEM in research in the field of administration in Brazil has been growing (Frezatti *et al.*, 2015; Maciel and Camargo, 2013; Mazzon and Hernandez, 2013). According to Pasquali (2009), this technique intends to understand the meaning of the responses given by individuals to certain statements. For Pilati and Laros (2007), this technique not only allows the confirmatory test of the psychometric structure of measurement scales but can also be used to analyze explanatory relationships between multiple variables simultaneously, whether latent or observed. For Anderson and Gerbin (1982), the development of analysis methods for linear models of structural equations with latent variables provides researchers with considerable means to construct, test and modify theories.

The jargon used in the context of the technique is still profuse. Ullman (2007), for example, names it "causal modeling," "causal analyses," "simultaneous equation modeling" and "analysis of covariance structures." As for Nunnally and Bernstein (1994), the technique is known as "analysis of covariance structures" and "linear structural relations."

Historically, SEM has a hybrid origin, used initially in psychometrics as result of seminal works developed by Pearson, Spearman and Thurstone at the beginning of the twentieth century (Kaplan, 2000). The technique is based on the measurement of human latent characteristics or cognitive abilities through behavioral tasks, which cannot be directly measured. This technique – also known as a latent trait model (Pilati and Laros, 2007) – uses assertions, and for each of them the respondent establishes a degree of intensity. The structure is measured by the interrelationships between the assertions.

Regarding the software most commonly used for SEM, it is possible to point out AMOS®, LISREL®, Sas/Stat/Calis® and SmartPLS®. According to Albright and Park (2009), AMOS® and LISREL® are the friendliest products, while Sas/Stat/Calis® presents a systematic

grammatical structure in an integrated environment, but their output reports are confusing and do not support models with missing values.

According to Ringle *et al.* (2014), the software SmartPLS® is gaining notoriety because it can be used with smaller samples, it is free in its basic version and because it does not require that the variables have a normal distribution. In this case, the software uses variance-based estimation methods, whereas the others mentioned above use methods based on covariance.

Byrne (2009, 2010) developed theoretical and practical guides for the use of LISREL® and AMOS®, which are an important reference for the construction and analysis by using structural equations. No less important is the article by Iacobucci (2009), which presents a guide on how to construct covariance matrices, which helps the researcher in the specification of the structural model, especially in LISREL®. Although there are several available options in terms of software, the researcher must choose, according to Clayton and Pett (2008), based on their knowledge on programming and based on the research questions being addressed. These authors compared the results of the same research with the use of different softwares and the differences were little significant.

Another important point about the use of SEM is the possibility of testing effects of moderation, mediation, moderation–mediation and indirect effects. For Vieira (2009), one of the advantageous factors of SEM is the introduction of the concept of latent variables, generating a differential treatment of the (M)ANOVA for the moderation test and of the regression analysis for the mediation test, corroborating Iacobucci *et al.* (2007), who present empirical evidence showing that performing such tests with SEM is better than with the use of regression analysis.

The work by Hair *et al.* (2009) is widely referenced as supporting research on multivariate data analysis and SEM. Among the several techniques discussed by the authors are those on factor loading and reliability assays (such as Cronbach's α and KMO test) that represent the latent variables in the structural models studied. The authors also discuss the size and reliability of the samples used in the research, determining the minimum number of respondents according to the number of variables studied and the ranges of values of the model's various fit indicators found in the analyses.

Reinforcing these points, Marôco (2014) discusses the main methods and indicators traditionally used in the analysis of SEM. The author focuses on a small set of fit indicators, between 5 and 10, which may characterize the adequacy of the structural model studied. Another contribution is the possibility of comparing structural models with different mediations, moderations and causal relations through relations χ^2/df (χ^2 divided by degrees of freedom).

Churchill (1979) presents several aspects of the process of measuring latent variables that potentially generate bias and may impair the reliability of the results obtained. These aspects are: momentary physical or emotional factors of the respondent, situational factors, variations of application, problems in defining the sample, problems of the measuring instruments used, among others. To mitigate the problems raised and improve the measurement process, the author proposes a procedure for the application of measurement and data collection instruments with steps to be followed, which is applicable to variables with multi-assertions.

Bagozzi (2010) proposes a new perspective on the use and interpretation of SEM to deepen the studies and discussions based on the contributions by Iacobucci (2009, 2010). According to Bagozzi (2010), such models require complex procedures, with many assumptions, details and traps. In addition, the author proposes that the best methodological approach for research projects is the use of SEM as a procedure to be carried out together with other techniques, such as analysis of variance, multiple regression and qualitative methods.

Methodology

This work used bibliometrics, which is one of the forms of evaluation and measurement of information flows in scientific knowledge (Caldas *et al.*, 2003). Bibliometrics is intended for quantitative study of production, dissemination and use of published information, using mathematical and statistical methods (Spinak, 1996).

As part of information science (Guedes, 2012; Guedes and Borschiver, 2005), bibliometrics consolidated from the work of Pritchard (1969). Within the diverse possibilities of bibliometrics application (Vanti, 2002), this work seeks: to identify the authors that use SEM in their research; identify the journals and periodicals where these research pieces were published; quantify the evolution of publications that use SEM; and identify trends in the use of SEM in Brazil.

This research analyzed articles published in Brazilian journals. The articles led to the identification of the main journals, the authors and the institutions the authors were affiliated with, as well as the evolution, in terms of number of articles, of publications using the SEM approach. Following the criteria proposed by Mazzon and Hernandez (2013), this work selected Brazilian journals in Administration with a generalist editorial agenda, and that are submitted to classification by Capes/Qualis criteria. The selection of the journals took into consideration the Capes/Qualis classification of 2014. In addition, other journals identified in the national scenario were included, adopting similar criteria. Therefore, articles containing the theme "structural equations" were researched and found in the following journals: *Revista de Administração de Empresas* (*RAE*, Qualis A2); *Revista de Administração Contemporânea* (*RAC*, Qualis A2); *Revista Brasileira de Gestão de Negócios* (*RBGN*, Qualis A2); *Brazilian Business Review* (*BBR*, Qualis B1); *Cadernos da EBAPE* (*Cadernos EBAPE.BR*, Qualis A2); *Revista de Administração da USP* (*FEA-USP*, Qualis A2); *Revista de Administração Mackenzie* (*RAM*, Qualis B1); B*razilian Journal of Public Administration* (*RAP*, Qualis A2); and *Brazilian Administration Review* (*BAR*, Qualis A2).

As source of data, the EBSCO and PROQUEST databases were used, as well as the search engines of the journal's websites. Some of the journals publish articles in other languages (mainly English and Spanish), which made it necessary to cover the search in those languages. Regardless of the publication's language, they contain abstracts and keywords in Portuguese and English, sometimes also in Spanish. Thus, the search criteria were the expressions "equações estruturais" for Portuguese, "structural equations" for English and "ecuaciones estructurales" for Spanish. The search focused on the period from 1996-2015, covering 20 years of publications.

After the selection, the articles were qualitatively evaluated after careful reading of the titles, abstracts, keywords and methodologies used, to validate whether the criterion in the first analysis was fulfilled. Such a process was necessary since the interest of the study focused on the application of the structural equations technique in empirical research.

At the end of the evaluation, the research obtained the information about title in the main language of the article, year of publication, author's name, first institutional affiliation of each author, research area, SEM tool used and databases used in the research.

The information extracted allowed for a subsequent quantitative analysis of the data with results related to the number of publications over the period studied, number of publications per magazine, number of publications per area, number of publications per author, number of publications by affiliation and frequency of use of modeling instruments.

Result analysis

In the survey conducted in the period between March and April 2016, 164 articles were obtained, fitting the selection criteria adopted. *RAC* magazine accounted for almost a third

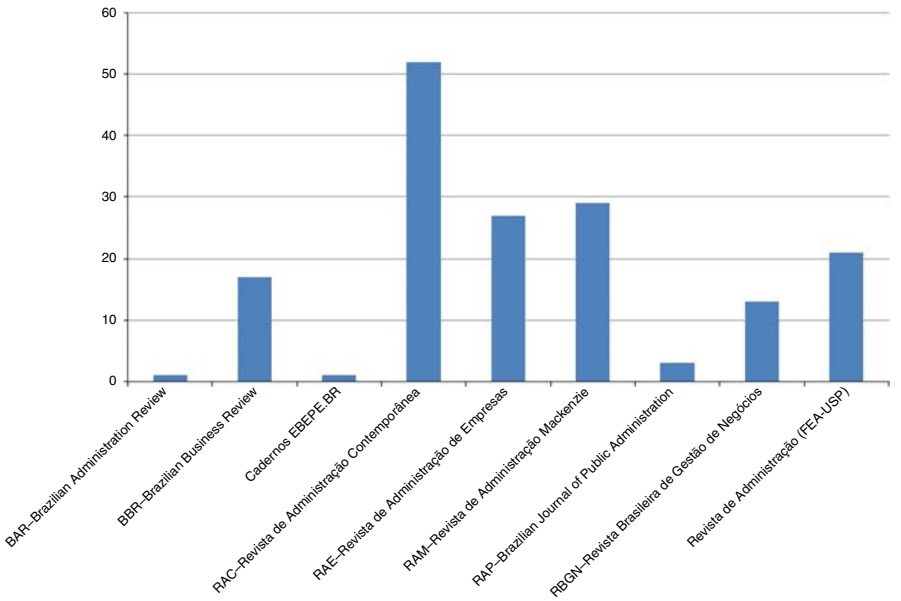
of the publications (32 percent), with *RAM* and *RAE* accounting for 18 and 16 percent, respectively. Figure 1 shows the graph with the number of publications per journal in the period studied.

Figure 2 shows, stratified by area, the evolution of using SEM, and a growing trend in the use of the technique is observed. Although the search was focused on the period of the last 20 years (1996–2015) articles using SEM were only found after 1999. After 2003, it is possible to observe the intensification of the use of SEM, and the curve of theoretical trend (dashed line) indicates a significant increase over the years. The sharp drop from 2014-2015 is possibly attributable to the fact that the survey was conducted in a period in which some of the journals of 2015 had not yet been issued. However, this seems not to invalidate the growing trend of the use of SEM.

The thematic areas commonly adopted at the Annual Meeting of the National Association of Postgraduate and Research in Administration (EnANPAD) were used to define the areas of Administration covered in the articles selected. As shown in Figure 3, most publications are concentrated in the marketing area, with almost a third of the total (32 percent), more than double the second rank (organizations), corroborating Brei and Liberali Neto (2006). This fact is probably justified because marketing, especially regarding consumer behavior, has a strong relationship with psychology, where there are many published works since the 1970s using SEM (Nunnally and Bernstein, 1994). This gives an opportunity for more discussion about what leads marketing publications to stand out in comparison to the others.

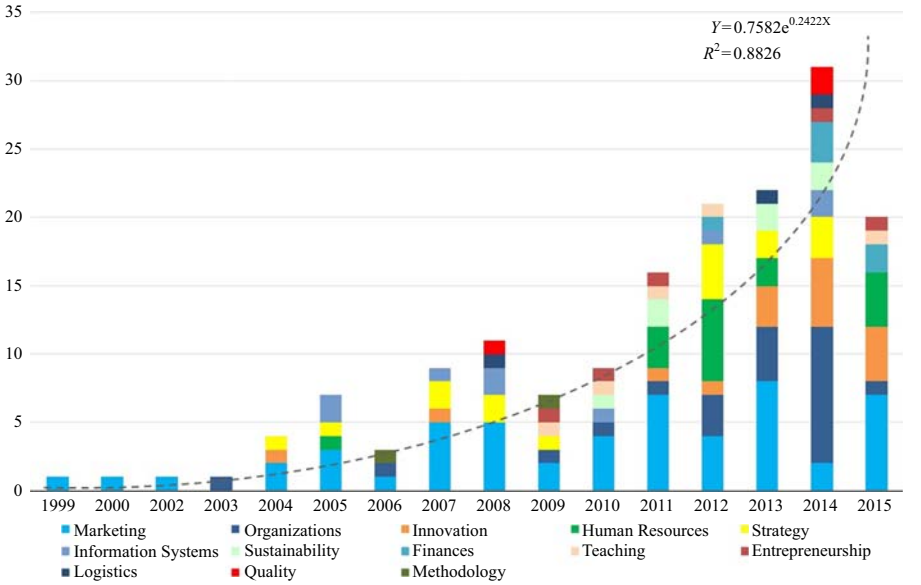
Table I presents the distribution of publications per area for each of the analyzed journals. Marketing is the area with more publications, concentrated in the journals *RAC*, followed by *RAM* and *RAE*.

Some other areas of administration (sustainability, innovation, organizations and human resources) stand out for presenting most of their publications employing SEM in the last five years of the analyzed period, which may be an indication that the use of the technique began to be accepted in other areas, besides marketing, suggesting a possible trend for the next years.



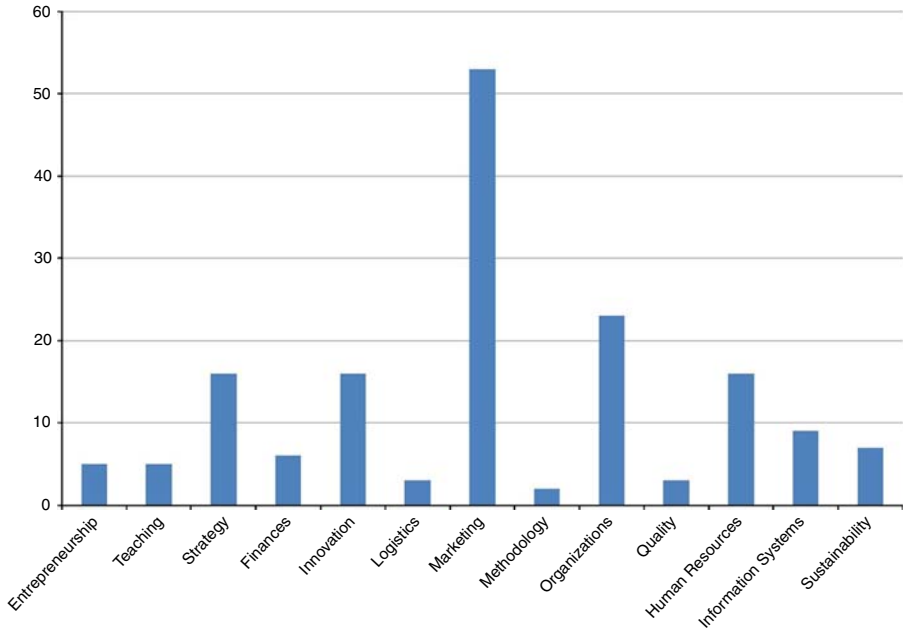
Source: Elaborated by the authors

Figure 1.
Number of publications per journal



Source: Elaborated by the authors

Figure 2.
Number of publications for the research period



Source: Elaborated by the authors

Figure 3.
Number of publications per area

Table I. Publications per area per journal

	Entrepreneurship	Teaching	Strategy	Finances	Innovation	Logistics	Marketing	Methodology	Organizations	Quality	Human resources	Information systems	Sustainability	Total
BAR – Brazilian Administration Review											1			1
BBR – Brazilian Business Review		1	2		4		4		5		1			17
Cadernos EBAPE.BR			1											1
RAC – Revista de Administração Contemporânea	3	2	4	2	4	1	17	1	6		5	6	1	52
RAE – Revista de Administração de Empresas			3		3	1	10		6	1		2	1	27
RAM – Revista de Administração Mackenzie	2	1	2	1	2		10		3		4	1	3	29
RAP – Brazilian Journal of Public Administration							1			1	1			3
RBGN – Revista Brasileira de Gestão de Negócios			3	1	1		5		1	1	1			13
Revista de Administração (FEA-USP)		1	1	2	2	1	6	1	2		3		2	21
Total	5	5	16	6	16	3	53	2	23	3	16	9	7	164

Source: Elaborated by the authors

Almost 60 percent of the authors in the analyzed sample had only one publication, while 15 percent published two or three articles. Only five authors had four or more publications. The ranking of these authors is presented in Table II.

As for the authors' affiliation, just over three quarters of them are concentrated in three institutions, USP, FGV and UFRGS, with a relative balance between them. Almost 20 percent of affiliations appeared once, twice or thrice and less than 4 percent appeared four to seven times. The ranking presented in Table II details the affiliations that have appeared eight or more times. In addition to USP and FGV, which present a large number of authors publishing articles in administration with the use of SEM, it is possible to observe a strong contribution of public institutions, as well as some private institutions (Pontific Catholic Universities – PUCs – and Mackenzie).

Table II also presents the tools used in the published research. Half of the publications used AMOS® and almost 30 percent between the SmartPLS® and LISREL®. About 17 percent of the articles surveyed did not mention the tool used, which can be seen as a methodological failure, since the tool and the method are strongly related and influence the results and the analysis performed, as indicated by Albright and Park (2009) and Marôco (2014). Regarding the high use of AMOS®, it is possible to assume that its compatibility with IBM SPSS Statistics® facilitates the research, due to the synergy of the two softwares in terms of database sharing, menus, terminology and report results.

Ranking of authors

Author	Publications
Bido, D.S.	6
Maciel, O.C.	5
Mazzon, J.A.	4
Santos, C.P. dos	4
Joia, A.L.	4

Ranking of affiliations

Affiliation	Frequency
USP	47
FGV	43
UFRGS	36
UnB	16
PUC-RJ	16
UFPR	15
MACKENZIE	13
PUC-PR	11
PUC-RS	11
FURB	9
UFMG	9
UECE	8

SEM tools used

Tool	Publications	%
AMOS	82	50.0
PLS	31	18.9
LISREL	19	11.6
STATA	1	0.6
DEA Warwick	1	0.6
EBTs	1	0.6
EQS	1	0.6
No information	28	17.1

Source: Elaborated by the authors

Table II.
Ranking of authors/ affiliations and SEM tools used

The results of the search for articles in the databases and directly in the journals are presented in Figure 4. By using the keywords "equações estruturais," less than a quarter of a total of 164 articles were found in the journals archives. When the search used the keywords in English and Spanish ("structural equations" and "ecuaciones estructurales"), these figures fell to less than 5 and 8 percent, respectively.

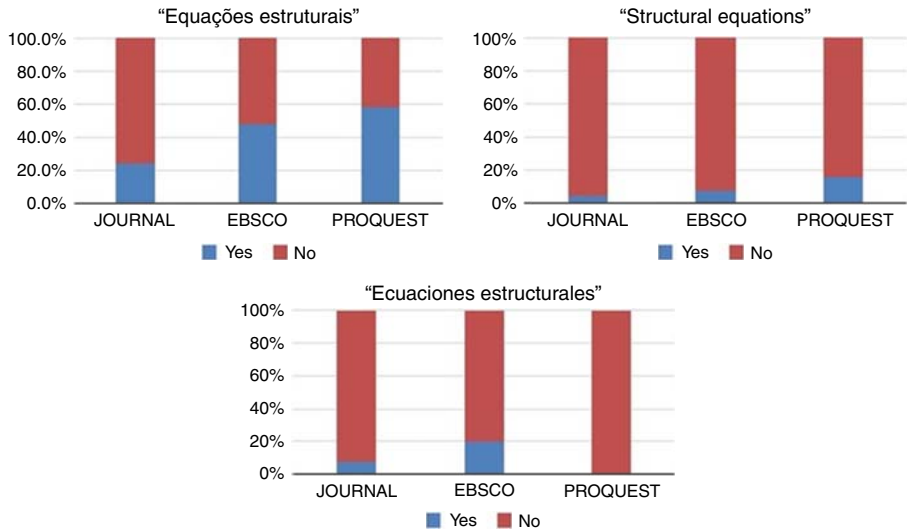
In the EBSCO database, the keywords in Portuguese resulted in almost half of the total articles selected, and in the case of the other languages the result was well below this (6.7 percent for English and 19.5 percent for Spanish). On the other hand, the search in the PROQUEST database presented slightly higher results than the EBSCO database for the keywords in Portuguese and English, and lower for Spanish.

Although all articles have abstract and keywords in Portuguese and in English, the search results, both directly in the journals archives and in EBSCO and PROQUEST databases, fell far short of the total volume of articles selected. It is interesting to notice that the EBSCO database found more articles with the search in Spanish than in English and, in the case of PROQUEST, the result did not present any article when the search was in Spanish. Although many articles lacked abstract and keywords in Spanish, a better result was expected.

This result reinforces the importance of being careful when using search mechanisms of the three sources used (journals' archives, EBSCO and PROQUEST), as can be seen in Figure 5.

The 164 articles were identified using the keywords in Portuguese, but less than 5 percent of them (8 articles) appeared in the three databases. The articles found in the databases EBSCO and PROQUEST were usually different from the ones found on the journal's archives, which indicates the need to use the three bases in a complementary and non-alternative way when reviewing the literature. The expectation was that the articles found with the direct search in the journals' archives would comprehend the universe of the 164 articles.

For the keywords in English and Spanish, the results of the search fell far short when compared with the search in Portuguese. The intersection of the three sources did not bring any article, which indicates that searching in other languages results in a much lower number than the existing one.



Source: Elaborated by the authors

Figure 4.
Search results per article

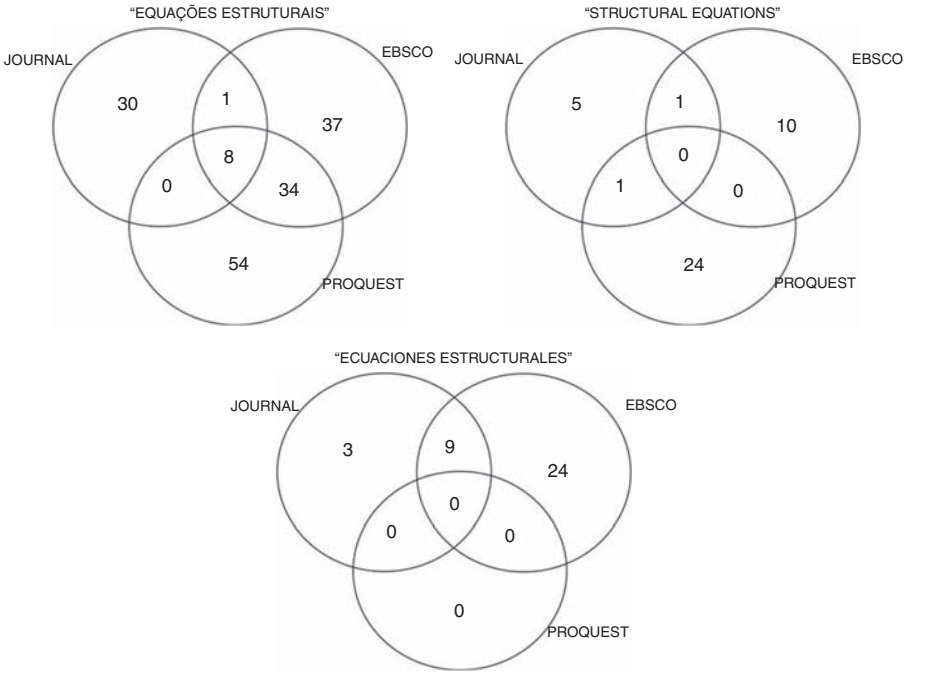


Figure 5.
Intersection of search results of the articles

Source: Elaborated by the authors

Conclusion

This paper presented a bibliometric study that quantitatively evaluated, the production, dissemination and use of SEM in the field of administration in Brazil, using prominent journals known nationwide. The study contributed to understand the development in the use of SEM, the areas where it is applied, the tools used, the authors and the institutions the authors are affiliated with. Complementarily, it was possible to evaluate the convergence of results and the ease of searching in the journals archives or in the databases EBSCO and PROQUEST.

It was observed that in recent years, there has been a substantial increase in the number of publications using SEM, which indicates its acceptance and dissemination in the scientific community in the field of administration in Brazil. The predominance of such publications is in the area of marketing although the use of the technique is increasing in other areas.

The search resulted in a large number of authors, which can be seen as positive and indicate an interest in the technique, although many of these authors have few publications. When it comes to the institutions, however, there is a certain degree of concentration in the publications. The expectation is that the dissemination of SEM leads to a change in this picture with a higher number of publications per author and a lower concentration of institutions the authors are affiliated with.

In the development of the work, there was a great disparity in the results of the searches: the articles that were extracted from the journals' archives are different from those extracted from the other databases, which makes it difficult to conduct a deeper literature review. Although the work carried out here has focused on the field of administration, specifically in publications with SEM, this problem possibly occurs in other fields of knowledge. Thus, it is recommended for this type of work to carry out surveys in different databases, including the ones used here. The idea is to use databases in a complementary way to each other.

Most of the articles found were in Portuguese, which may make it difficult to disseminate them in the international context. In addition, research with keywords in other languages has resulted in a much lower number of articles, which makes it even more difficult to see the work of the Brazilian community, since articles are not found in search engines.

In general, the growth and strengthening of the technique in the administration field in the Brazilian context was evident, following the international scenario. In this direction, the schools of administration should intensify the teaching of the technique as part of the methodology to be used in scientific works in the field. As a contribution, this study allows Brazilian authors to direct their publication efforts to journals that dialogue with their themes and methodology, as well as indicating that the technique could be incorporated by other areas of administration that currently do not use it at all.

Regarding the search for articles, it is suggested that similar research be carried out in other areas of science, to verify the findings of this work and promote further investigation.

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Corresponding author
Jorge Ramón D'Acosta Rivera can be contacted at: jorge.ramon.dacosta@gmail.com