Revista Española de Documentación Científica
42(2), abril-junio 2019, e230
ISSN-L:0210-0614. https://doi.org/10.3989/redc.2019.2.1602

ESTUDIOS / *RESEARCH STUDIES*

Sourcing Research Papers on Small- and Medium-Sized Enterprises' Competitiveness: An approach based on authors' networks

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Received: 10-07-2018; 2nd version: 11-09-2018; Accepted: 24-09-2018.

Citation/Cómo citar este artículo: Benitez Nara, E. O.; Schaefer, J. L.; de Moraes, J.; Tedesco, L. P. C.; Furtado, J. C.; Baierle. I. C. (2019). Sourcing Research Papers on Small- and Medium-Sized Enterprises' Competitiveness: An approach based on authors' networks. *Revista Española de Documentación Científica*, 42 (2), e230. https://doi.org/10.3989/redc.2019.2.1602

Abstract: This study aims to present a scientometric analysis, based on author's network maps, to determine the most influential and relevant authors with papers published about the subject Small- and medium-sized enterprises, competitiveness and its measurement, including the use of key performance indicators. Academic research relies on the prospection to retrieve the most relevant research studies and establishing links to authors from key international research groups. To facilitate this study, we used the *Scopus* and *Web of Science* databases research results, due to the significant number of indexed scientific articles. The extracted data were compiled and analysed through author's networks using the statistical software *Sci2 Tool*, which supports temporal, geospatial, topical, and networks analysis. This study also attempts to point out the research trends and gaps in this area. Results obtained are illustrated by maps of author's networks that reveal the main authors and research subject groups, thereby enhancing access to information from a scientific approach.

Keywords: competitiveness; small and medium-sized enterprises; key performance indicators; authors network; Sci2 Tool.

Obtención de documentos de investigación sobre la competitividad de las pequeñas y medianas empresas: un enfoque basado en las redes de autores

Resumen: Este estudio tiene como objetivo presentar un análisis cientométrico, basado en mapas de redes de autores, para determinar los autores más influyentes y relevantes con trabajos publicados sobre el tema Pequeñas y medianas empresas, la competitividad y su medición, incluido el uso de indicadores clave de rendimiento. La investigación académica se basa en la prospección para recuperar los estudios de investigación más relevantes y establecer vínculos con autores de grupos de investigación internacionales clave. Para facilitar este estudio, utilizamos los resultados de la investigación de las bases de datos *Scopus* y *Web of Science*, debido a su número significativo de artículos científicos indexados. Los datos extraídos fueron compilados y analizados a través de redes de autores utilizando el software estadístico Sci2 Tool, que es compatible con el análisis temporal, geoespacial, tópico y de redes. Este estudio también intenta señalar las tendencias de investigación y las brechas en esta área. Los resultados obtenidos se ilustran mediante mapas de redes de autores, que revelan los principales autores y grupos de temas de investigación, mejorando así el acceso a la información de una manera científica.

Palabras clave: competitividad; pequeñas y medianas empresas; indicadores clave de rendimento; red de autores; Sci2 Tool.

1. INTRODUCTION

The scientific production begins with an internal cycle of personal contacts in informal work situations, becoming formal in its external cycle, and validated through publications available in public database files accessed by the Web (Liberman and Wolf, 2015). To analyse and understand scientific development in certain areas, many studies deal with the quantity and impact of published papers (Garousi and Fernandes, 2017). However, these analyses are not always efficient in answering certain questions related to the scientific advance.

Scientometrics can be defined as the science of measuring and analyzing Science quantitatively (Abramo, 2018; Sassmannshausen and Volkmann, 2018) and it has been used to evaluate the performance of researchers and science areas, pointing out growing trends and patterns (Kumar and Kaliyaperumal, 2015). Egghe et al. (2008) state that the development of science occurs more quickly when collaborative networks are formed among researchers of the same area, enabling knowledge sharing and the production of qualified articles. According to these authors, the increase in scientific production in networks is explained as follows: researchers invited to collaborate as co-authors have more time to produce other articles; therefore, the collaboration is greater among the most renowned researchers and in areas with the best laboratories.

Scientific research that seeks a greater detail of science, responding to more specific questions, can be subdivided into four types, each one related to a given question: when, where, what and who (Light et al., 2014). According to the authors, the researches that answer the question "When?" are temporal studies that make scientific analyses in chronological order. Geospatial studies based on cartographic analyses answer the question "Where?". Language analyses elucidate "What?" questions. Maps of networks that employ algorithms and techniques of information science answer the question "Who?". The choice in which the questions will be answered depends solely on the purpose of the study in question.

Research based on maps helps us identify the players who have contributed to science, homogeneity vs. heterogeneity, cause and effect, and speed of advancement of knowledge; this makes it possible to monitor the evolution of and identify the most promising areas for further scientific research (Börner et al*.,* 2012). An author should be understood as part of a complex network with interconnections, where each author interacts directly with a very limited number of fellow authors and documents (Börner et al., 2004).

Competitiveness for SMEs

The competitiveness of companies is determined by institutions, policies and other factors, determining their continued presence in the market, profitability and ability to adapt production to demand (Chao et al., 2015) while reducing vulnerability to competition and being resistant to erosion by substitute products (Porter, 1999; Subramanian et al., 2014). The resource-based view emphasizes that internal resources and productive capacity are crucial to maintaining organizational performance (Huang, 2016). The strength of organizations is determined by their competitiveness and the strategies they adopt to gain competitive advantage and strengthen their positions in the market (Nara et al., 2013). The potential of a resource to be widespread can be decisive for a company to sustain its competitive advantage (Liao et al., 2015) that may still be directly linked to demands and work-related stress and how to deal with them (Dijkhuizen et al., 2016). In SMEs (Small and Medium Sized Enterprises) focused on high technology launching new products is an important way to maintain their competitive advantage (Pan et al., 2018). It can be noticed that several factors influence in the competitiveness of companies and it is important to determine these factors and the areas in which they can gain competitive advantage.

Competitiveness data

In 2016, SMEs accounted for 99.8% of all companies, 57.4% of added value, and 66.8% of jobs generated in the European Union (European Union, 2016). This fact evidences how these companies are crucial to the global economy. SMEs are characterized by close relationships with customers, employees and suppliers (Mayr et al., 2017) and this proximity allied to entrepreneurship favors the long-term competitiveness of these companies (Pérez-Luño et al., 2016). SMEs operate under more difficult conditions with less access to modern solutions, that leads them to seek new paths with innovative solutions to be competitive (Staniewski et al., 2016) and to take certain risks with proactivity and external links being key factors in moving SMEs to success through innovative attitudes (Gunawan et al., 2016). The strength of SMEs is in faster responses to situations through decision making that results in better product quality and innovation, while their weaknesses are in the areas of marketing, capital generation, technology, and finance (Gunasekaran et al., 2011). Another area of weakness results from SMEs' failure to implement strategies and systems to measure organizational performance (Taylor and

Taylor, 2014). Despite the difficulties, SMEs need to interact with those in their business environment to eliminate weaknesses and obtain improved competitiveness, as well as to establish strategies according to the market where they operate. For that purpose, it might be advantageous to propose the monitoring of the competitiveness level by measuring it.

Why measure it?

The measurement of competitiveness is an important strategic and motivational tool in management that enables organizations to monitor and optimize actual performance (Kozená and Chládek, 2012). Such evaluation should be guided by the use of uniform and reliable benchmarks (Zinnes et al., 2001). To enable the measurement of competitiveness, the adoption and use of key performance indicators (KPIs) is suggested.

KPIs enable managers to assess realistically how far goals and objectives have been achieved (Rebelo et al., 2014; Personal et al., 2014) and should be defined according to the objectives to be achieved by the companies (Andres and Poler, 2016). KPIs are a set of metrics that help companies to manage and seek continuous improvement in productivity, quality assurance, operational performance, and efficiency (Kang et al., 2016). Thus, KPIs provide benchmarks and fundamental information to gauge companies' competitiveness, assist in analysis and decision on strategies to be adopted, to enable companies to adjust to evolving environments.

However, SMEs often experience difficulties in translating knowledge into opportunities, mostly due to a lack of research activity and systematic development (Agostini and Nosella, 2017). In SMEs, most decisions are based on the capacity and expertise of its owners (Roy and Dangayach, 2015), and this makes the subject competitiveness important for the academy, because it is from the academy that studies arise to facilitate organizations management.

Network analysis

Networks formed by relationships between words can involve both relations between words that form a phrase, and the network of words in a dictionary, for example. The first complex networks to be studied were the networks of citations (Newman, 2001a; Newman, 2001b). Networks can be represented by electrical networks, links between web pages, representation of integrated circuits, road and rail networks. A social network can also be considered as a group of people interacting with each other (Scott, 2000). They are characterized by having a broad user base with various differences, with participation rates that vary widely and therefore have a high degree of uncertainty. This needs to be considered when modelling a large-scale decision-making process (Herrera-Viedma et al., 2017; Dong et al., 2018; Liu et al., 2016b; Zhang et al., 2018).

The networks and the relationships between them present two problems that merit attention. The first is that the large number of agents and background can lead to uncertainty or even inconsistency of information, making it difficult to assess the quality and the union of the information provided. The second problem is that it is desirable, and even indispensable, to achieve a solution that is accepted by the majority of the members or at least to assess the degree of agreement between the parties. One of the great challenges in any decision-making scenario within SME is precisely to obtain a complete and unanimous solution agreement between all those involved (Pérez et al., 2010; Urena et al., 2019). In this article we tried to present that there are several authors that research on the same theme, forming a network, and that through network analysis it is possible to find the most appropriate author in each subject.

Academic production overview

Among the articles published that make use of statistical software for the study and analysis of science, the following can be highlighted: Bornmann and Ozimek (2012) made use of the Stata commands to import bibliometric data and processes of information about authors. Elango et al. (2013) used *Sci2 Tool* and *Ucinet* to perform a scientometric analysis on nanotribology research. Jamali (2013) used *Pajek, HisCite, Sci2 Tool* and *VOSViewer* for analysis and visualization of the citations on the human behavior information theories. Wood and Khan (2015) used the technique of social network analysis to understand the semantic and knowledge networks related to international trade. Badar et al. (2015) used *Publish or Perish* software tool in addition to social network analysis, and Poisson regression techniques to explore a network of co-authorship in chemistry, in Pakistan. Liu et al. (2016a) have built networks of co-citations and co-occurrences of keywords in the area of magnetic nanoparticles using *CiteSpace III* software tool. Bernabò et al. (2016) conducted geospatial and temporal analyses using *Citespace* and *Sci2 Tool* software tool in the area of reproductive biology. Biglu et al. (2016) applied *Sci2 Tool* and *CiteSpace* to create co-autorship networks and co-organizations using

breast cancer as the theme. Boyack (2017) created synonym terms maps in the area of Astronomy with the help of the Public Library of Science (PLOS) and *Pajek* software tool. Guan et al. (2017) constructed knowledge networks through *Sci2 Tool.* Yao et al. (2017) used *Sci2 Tool* for geospatial, topical and collaborative analysis of neuroimaging initiatives of Alzheimer´s disease. Baier-Fuentes et al. (2018) presented an overview of Academic Research on International Entrepreneurship using VOSViewer.

Nerur et al. (2008) traced the evolution of the intellectual structure of the area of strategic management, using a co-citation analysis and a Pathfinder analysis of the main authors of the field. For Abbasi et al. (2012), scholars with more co-authors and those who exhibit higher levels of distance centrality perform better in terms of research. So, it is possible to notice the use of statistical software such as *Sci2 Tool* to study and map Science, but its use for mapping authors' networks in certain areas of Science, which becomes the proposal of this article, is still an unexplored area.

This study aims to present a scientometric analysis, based on authors' network maps made by *Sci2 Tool* software, used to detect who are the main authors, their research networks and interconnections in published articles, on topics such as competitiveness, and its measurement, key performance indicators (KPIs) and small- and medium-sized enterprises (SMEs). From this analysis, it will be possible to identify research gaps to be explored. Additionally, the knowledge about the main authors and research networks will facilitate the search on what has already scientifically produced with respect to the searched areas and authors.

2. METHODOLOGICAL PROCEDURES

To provide an overview of the developed work, the presentation of results concerning publications used two approaches: one employing quantitative bibliometric indicators, and the other employing scientometric analysis based on maps of authors' networks, drawn up using a computational tool. Computational tools may be helpful in circumstances such as extending collaborations toward less familiar areas or in interdisciplinary research (Rons, 2018). Quantitative bibliometric indicators, such as number of articles published, number of citations and *h-index* allow the analysis of scientific performance of authors and their works (Cobo et al., 2015; Baier-Fuentes et al., 2018). On the other hand, scientometric analysis brings a relevant approach to the development of certain research areas (Kim and Chen, 2015).

For this research, *Scopus* and *Web of Science (WoS)* databases were used. Created by *Elsevier*, *Scopus* is the largest abstract and citation database of peer-reviewed literature including books, conference papers, and scientific journals (*Scopus,* 2018). *WoS* indexes the world's leading academic journals, books and annals in the sciences, social sciences, arts and humanities (*Web of Science,* 2018).

In the first stage, to scientifically quantify available knowledge from studies on SMEs in the areas of competitiveness and its measurement and KPIs, data were collected by taking into consideration all publications in *Scopus* and *WoS* databases. In this stage of research, characterized as quantitative temporal bibliometric, the search filters in each database were limited with respect to each term as shown in Table I.

Each term was searched to be retrieved individually, and in combination with other terms by using the Boolean operator "*and*" to search for articles in which two terms occurred together.

In the second stage of research, an approach is presented, based on *Sci2 Tool*, which is a set of computational tools arranged in a modular set and designed to study science (Guler et al., 2016). It supports analysis of a temporal, geospatial, topical, and network analysis and visualization of datasets at the micro, meso, and macro levels

Table I. Search filters

SEARCH FILTERS	*SCOPUS*	*WOS*
DOCUMENT TYPE	Articles	Articles
SEARCH IN	Title, abstract or keywords	Topic
SUBJECT AREA	Decision Sciences; Engineering; Business, Management and Accounting; Economics, Econometrics and Finance	Management; Business; Economics; Operations Research Management Science; Engineering Industrial; Engineering Manufacturing
YEAR	All years	All years
SEARCH TERMS	measurement; competitiveness; SME; key performance indicator	measurement; competitiveness; SME; key performance indicator

(Light et al., 2014; Sci2 Tool, 2017). This article analyses in micro and meso levels networks of co-authors with up to 10,000 records. *Sci2 Tool* supports data import from files in the following formats: networks, scientometric, other formats, special algorithms, or structured database.

To construct maps of authors' networks through *Sci2 Tool* the start point was the bibliometric search result. However, it was necessary to establish the yardstick of minimum number of articles that an author should have published to make the resulting maps of authors' networks scientifically relevant, and to avoid loading the networks with too much, or unnecessary information. Minimum amounts were established according to the following Table II. No authors' networks were mapped for the search term "*measurement*" because the term requires search with other terms to obtain results relevant to the research. Maps for the search terms *"SME"* and *"measurement"* combined was also not carried, because simple measurement of something in SME does not have any significance for this research.

The results were exported into the scientometric file format "*Scopus csv*" for *Scopus* database and "*Other file formats – Plain text"* for *WoS*, which could then be imported into the *Sci2 Tool*. Once imported into the *Sci2 Tool*, data were prepared using the "*Extract Co-Occurrence Network*" algorithm to allow the analyses by authors, and analysed using the "*Network Analysis Toolkit*" algorithm. For the visualization of authors' networks, the "*Network – GUESS*" tool was used. The elaboration and interpretation of the maps of authors' networks, was based on the data collection carried out in the *Scopus* and *WoS* databases from August 30-31, 2018. In the elaborated maps, only the authors' names with the largest nodes of each map are presented, in order not to pollute the visualization and understanding of the formed networks. Fig. 1 presents a methodological flowchart.

3. RESULTS AND DISCUSSION

3.1 Quantitative bibliometrics results

To obtain a quantitative overview of articles already published on the subjects of relevance, two bibliometric surveys were carried out, taking into consideration articles from the publications indexed to *Scopus* and *WoS* databases. Table III presents the results from the bibliometric survey of *Scopus* database held on August 30 and 31, 2018. Table IV presents the results from the bibliometric survey of *WoS* database held on August 30 and 31, 2018.

The initial bibliometric analysis revealed that while retrieving individual search terms, especially the search term "*measurement,"* from *Scopus* and *WoS* databases, the number of resulting articles was large. However, when combinations of search terms were used, the number of published articles decreased discernibly. It can be seen that the number of articles that deal with KPIs related to SMEs and competitiveness is very small.

3.2 Authors' networks maps

The next stage of this study is the construction of authors' networks maps. In these maps, the nodes represent the authors and the bigger and the darker the black colour is, the larger the number of articles published by the author. The edges present the relations of co-authorship of articles and, the thicker and darker the edge, the greater the co-authorship relation between the authors interconnected. The number of records retrieved in each database to elaborate the authors' networks, considering the respective search terms and the minimum number of articles an author should have published, are presented in Table V.

Table II. Minimum number of articles an author should have published, according to the search terms used for the construction of maps of authors' networks

SEARCH TERM OR COMBINATION OF TERMS	MINIMUM NUMBER OF ARTICLES PER AUTHOR – *SCOPUS*	MINIMUM NUMBER OF ARTICLES PER AUTHOR – *WOS*
"competitiveness"	11	9
"SME"	10	5
"key performance indicator"	4	1
"competitiveness" and "measurement"	3	2
"competitiveness" and "SME"	2	2
"key performance indicator" and "measurement"	2	1

Fig. 1. Methodological flowchart

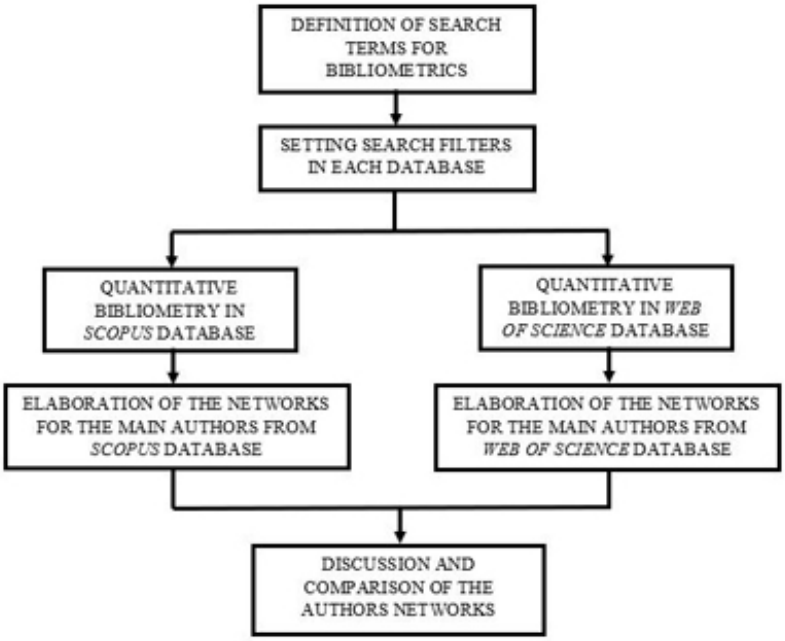


Table III. Initial bibliometric survey of Scopus database

SEARCH TERM	*Competitiveness*	*SME*	*Key Performance Indicator*	*Measurement*
Competitiveness	22,695			
SME	308	5,678		
Key Performance Indicator	48	12	1,610	
Measurement	753	241	333	817,750

Table IV. Initial bibliometric survey of WoS database

SEARCH TERM	*Competitiveness*	*SME*	*Key Performance Indicator*	*Measurement*
Competitiveness	8,733			
SME	120	2,178		
Key Performance Indicator	2	0	68	
Measurement	318	82	18	30,451

Table V. Number of records retrieved for authors' networks

SEARCH TERM OR COMBINATION OF TERMS	RECORDS RETRIEVED *SCOPUS*	RECORD RETRIEVED *WoS*
"competitiveness"	416	230
"SME"	271	173
"key performance indicator"	106	68
"competitiveness" and "measurement"	50	62
"competitiveness" and "SME"	48	8
"key performance indicator" and "measurement"	54	18

Fig. 2 shows a map with networks of authors with more than 10 articles published, indexed by *Scopus* database, retrieved using the search term "*competitiveness*". This image shows fourteen large independent networks of authors, two of them interlinked: the networks with the authors Phusavat K. and Takala J. at the center, and the networks with the authors Gunasekaran A. and Skitmore M. Also seen are smaller networks interlinked with networks of other more influential authors.

Fig. 3 presents a map with networks of authors with more than 8 articles indexed by *WoS* database, retrieved using the search term "*competitiveness*". This image shows twelve large independent networks of authors, two of them interlinked: the networks with the authors Mazzanti M. and Costantini V., and the networks with Gunasekaran A. and Cheng T.C.E.

The size of the resulting node in the networks elaborated from the *Sci2 Tool* correctly reflects the importance of the authors on the topic, since they also have high h-index and a considerable number of articles published on the topic. Table VI presents a ranking with the 5 authors with the highest node size in the authors' networks maps on competitiveness. It can be seen that only Gunasekaran A. is present as one of the 5 main authors in both maps. This shows the importance of carrying out surveys covering more than one database, given the diversity of research present in each of them.

Fig. 2. Authors' networks formed using the search term "competitiveness" from Scopus database

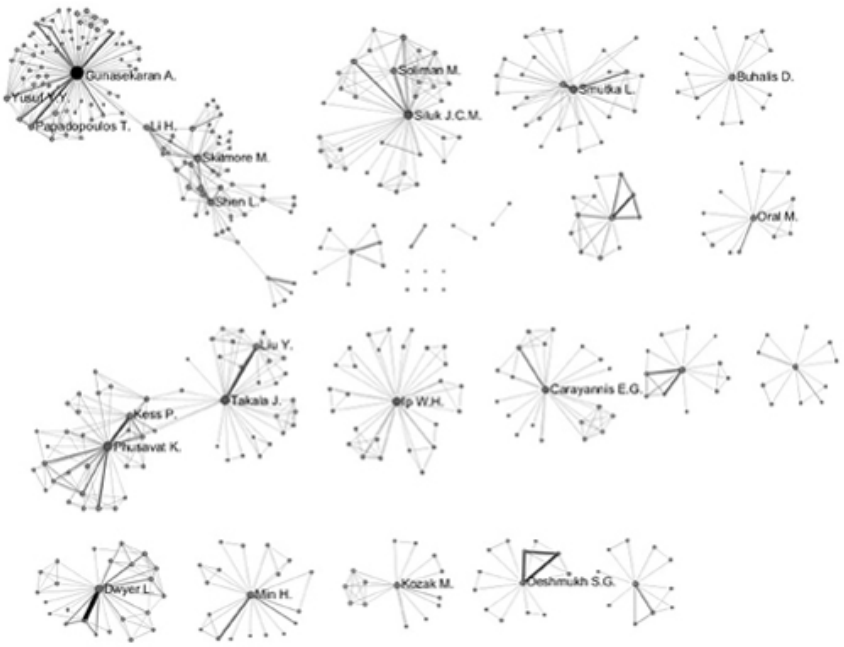


Fig. 3. Authors' networks formed using the search term "competitiveness" from WoS database

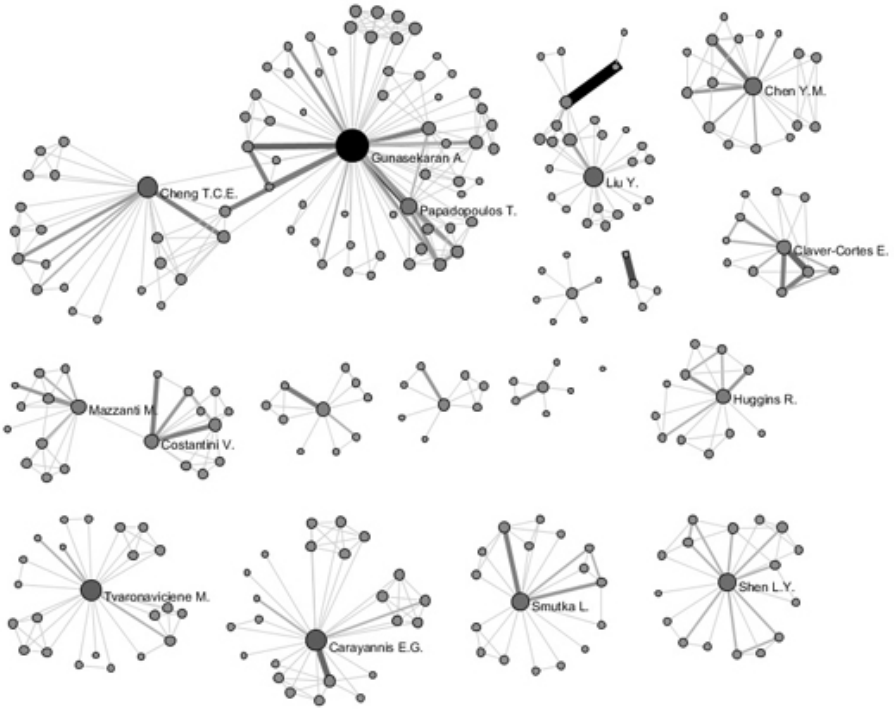


Table VI. Ranking of the 5 authors with the highest node size on competitiveness

Rank	Scopus authors' network				Web of Science authors' network		
	Author	Node size	Scopus h-index	Number of articles	Author	Node size	Number of articles
1º	Gunasekaran A.	72	54	52	Gunasekaran A.	58	39
2º	Siluk J.C.M.	31	3	13	Caravannis E.G.	23	14
3º	Phusavat K.	30	15	20	Tvaronavicience M.	22	13
4º	Takala J.	30	15	14	Cheng T.C.E.	21	10
5º	Ip W.H.	26	28	11	Liu Y.	20	9

Fig. 4 presents networks of authors on SMEs from Scopus database.

It is evident from Fig. 4 that there are seven networks of authors with significant research work on SMEs. Four of them are made up of interconnected networks, showing that there are several related research groups researching together on SMEs. Fig. 5 presents the map of authors' network on SME from *WoS* database.

It can be seen that the map originating from *Scopus* is larger than that of *WoS,* and the authors with more relevance are not the same. Table VII presents the data of these authors.

Fig. 6 illustrates the networks map of the main authors constructed from data retrieved using the search string "key performance indicator" from *Scopus* and *WoS* databases. On the left side, from *Scopus* database, we can see one bigger network with more than 20 relevant authors interconnected, and five other networks with median relevance. On the right side is the map from *WoS* where Yin S. appears as one of the leading authors on the subject in both maps.

Fig. 4. Networks of authors of research papers on SMEs in **Scopus** database

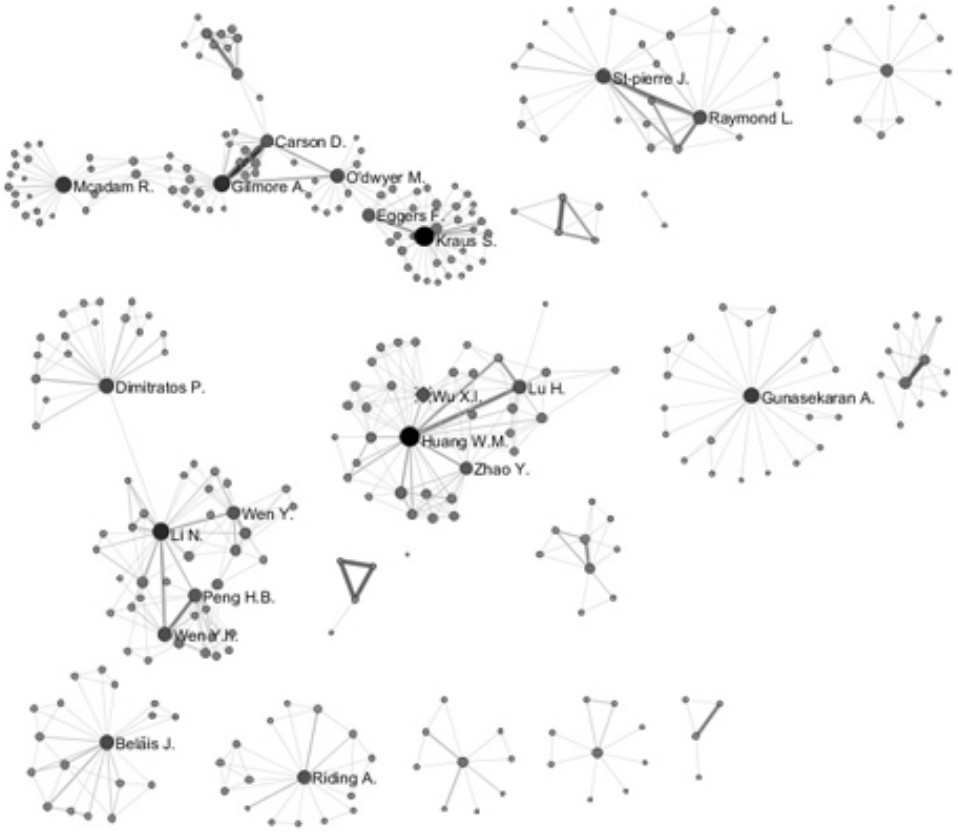


Fig. 5. Networks of authors of research papers on SMEs in WoS database

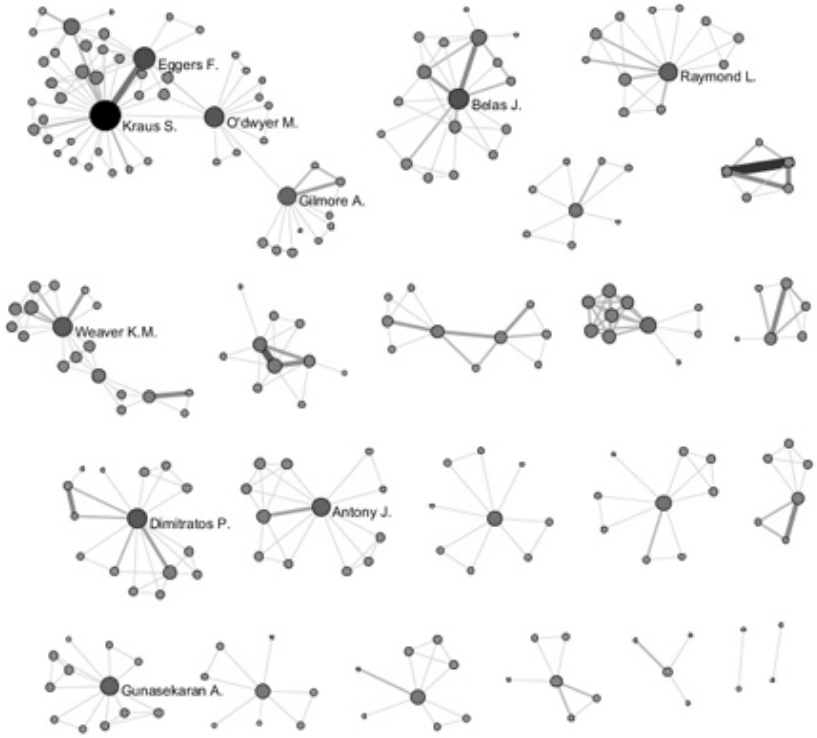


Table VII. Data concerning the author on the subject "SMEs"

	***Scopus* database**				***WoS* database**		
Rank	**Author**	**Node size**	***h-index Scopus***	**Number of articles**	**Author**	**Node size**	**Number of articles**
1º	Kraus S.	33	26	20	Kraus S.	29	15
2º	Huang W.M.	32	41	17	Eggers F.	15	6
3º	Li N.	24	81	15	Belas J.	14	10
4º	Gilmore A.	23	21	20	O'dwyer M.	13	6
5º	Mcadam R.	21	34	11	Dimitratos P.	13	8

Fig. 6. Authors' networks retrieved from "key performance indicator" from Scopus and WoS databases

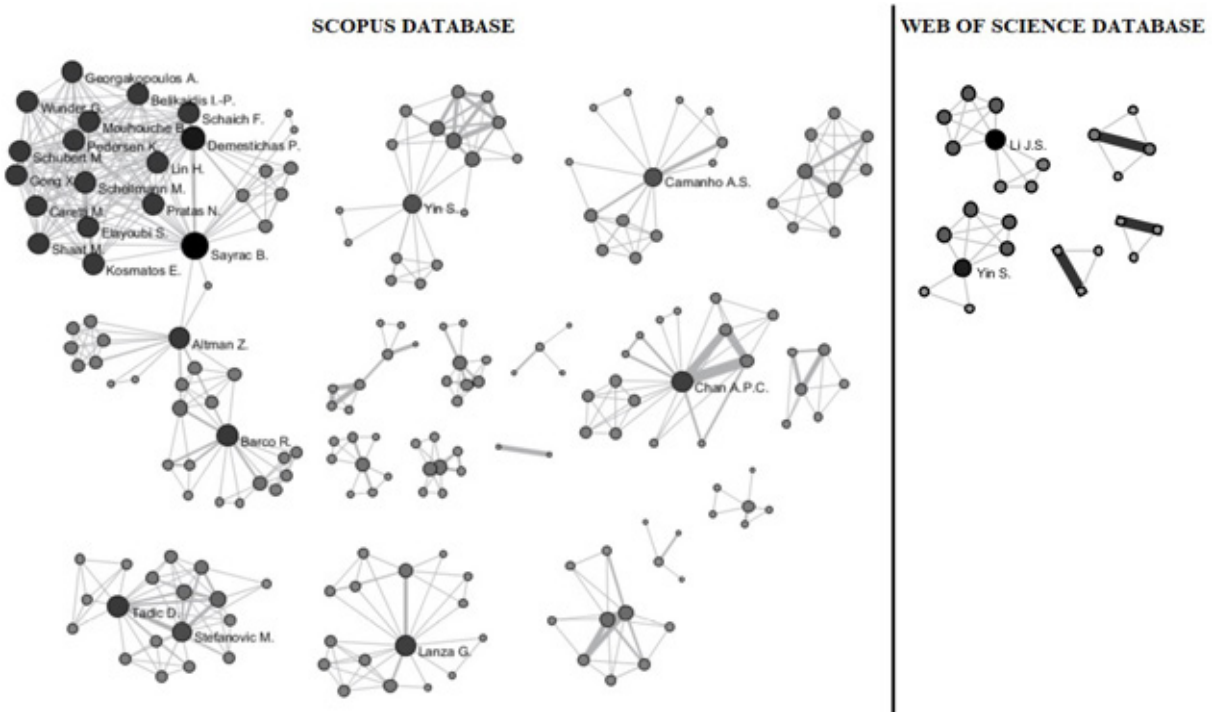


Table VIII presents data about the authors on the subject "key performance indicator" in both databases.

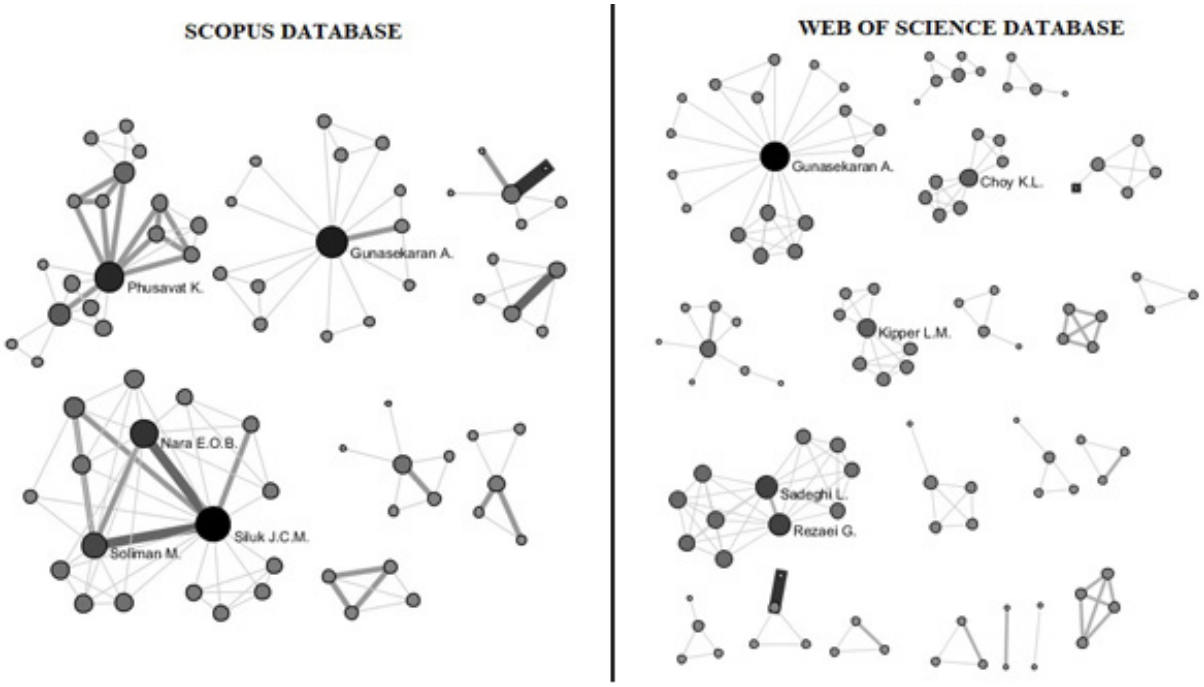
The next maps of authors' networks were drawn up using two search terms as a filter. Fig. 7 illustrates the maps of authors' networks obtained from the search terms "*measurement*" and "*competitiveness*" covering *Scopus* and *WoS* databases.

The presented image shows, from *Scopus* maps side, three large networks and other less influential ones. Again, Gunasekaran A., Phusavat K. and Siluk J.C.M. are at the center of three major networks of authors with published research work on competitiveness and measurement. However, in the map concerning published articles about these two themes, the nodes sizes are much smaller when compared to the map on the subject of competitiveness. Gunasekaran A., which had 72-size node, passes to a node 13-size, Phusavat K. moves from a node size 30 to 12, and Siluk J. C. M. which had 31-size node, passes to a node 16-size. Around Siluk J.C.M., are Nara E. O. B. with node size 11 and Soliman M. with node size 9, being this network composed by 17 authors in all. Considering this fact, it can be inferred that these researchers publish several articles on competitiveness, but few ones with aggregation to the "measurement" topic. On the map side with *WoS* data appear 4 larger

Table VIII. Data concerning the authors on the subject "key performance indicator

	Scopus database				*WoS database*		
Rank	**Author**	**Node size**	***h-index Scopus***	**Number of articles**	**Author**	**Node size**	**Number of articles**
1º	Sayraç B.	25	12	4	Li J.S.	7	2
2º	Demestichas P.	21	22	2	Yin S.	6	2
3º	Altman Z.	16	14	4	-	-	-
4º	Barco R.	16	15	5	-	-	-
5º	Tadic D.	16	9	4	-	-	-

Fig. 7. Authors' networks retrieved from "measurement" and "competitiveness" from Scopus and WoS databases



networks: the first one centralized by Gunasekaran A. with node size 17; the second with the authors Sadeghi L. and Rezaei G. with nodes size 10; the third with Kipper L.M. with node size 7 and composed by the authors of the network centralized by Siluk J.C.M. on the Scopus map; the fourth network centralized by Choy K.L. with node size 7.

On Fig. 8 are presented the authors' networks using the search terms "*competitiveness*" and "*SME"* extracted from *Scopus* (left side) and *WoS* (right side) databases.

Fig. 8 shows, on the left side, 4 networks of research that address competitiveness and SMEs from *Scopus* database: the first centered by Mahmood A. K. with a node size 10; the second formed by Tudisca S., Di Trapani A. M., Sgroi F. and Testa R., all of them with node size 6; the third network with Gunasekaran A. as the central author; and the fourth with Martinez-Martinez D. with node size 6. There are other smaller networks complementing the map. On the right side it can be seen the authors' network from *WoS* and the name of Martinez-Martinez D. appears, since it is the only node greater than 4. This reflects his importance for the themes addressed in this article.

For the next map, presented in Fig. 9, the authors with two or more articles published on "key performance indicator" and "measurement" indexed to the database *Scopus* were used.

Fig. 8. Authors' networks retrieved using the search terms "competitiveness" and "SME" from Scopus and WoS databases

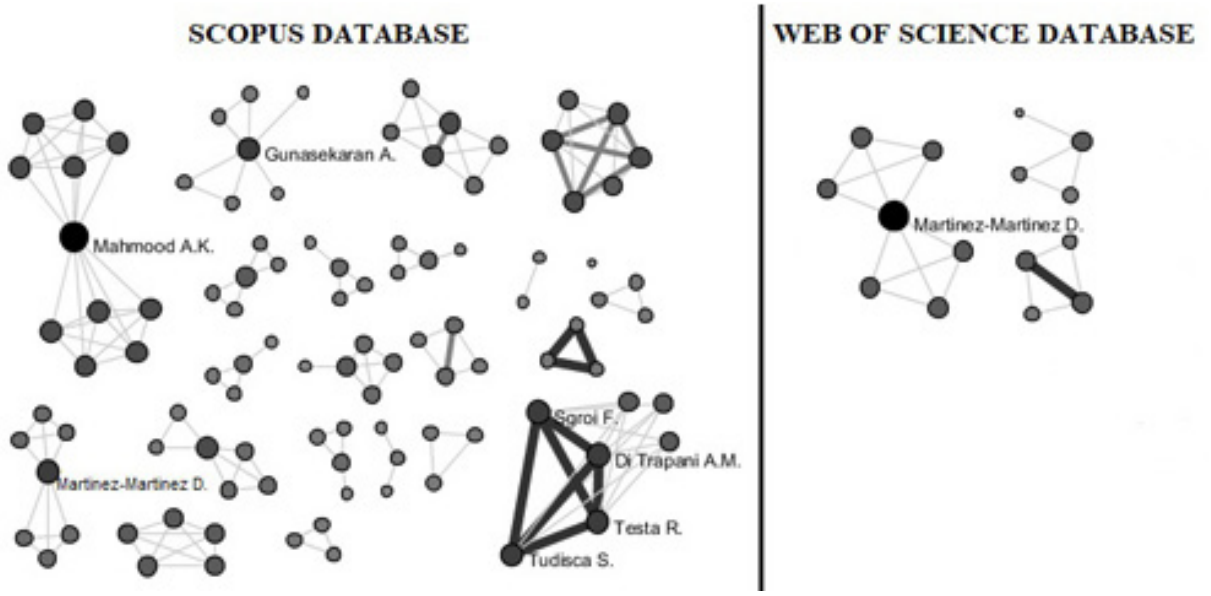
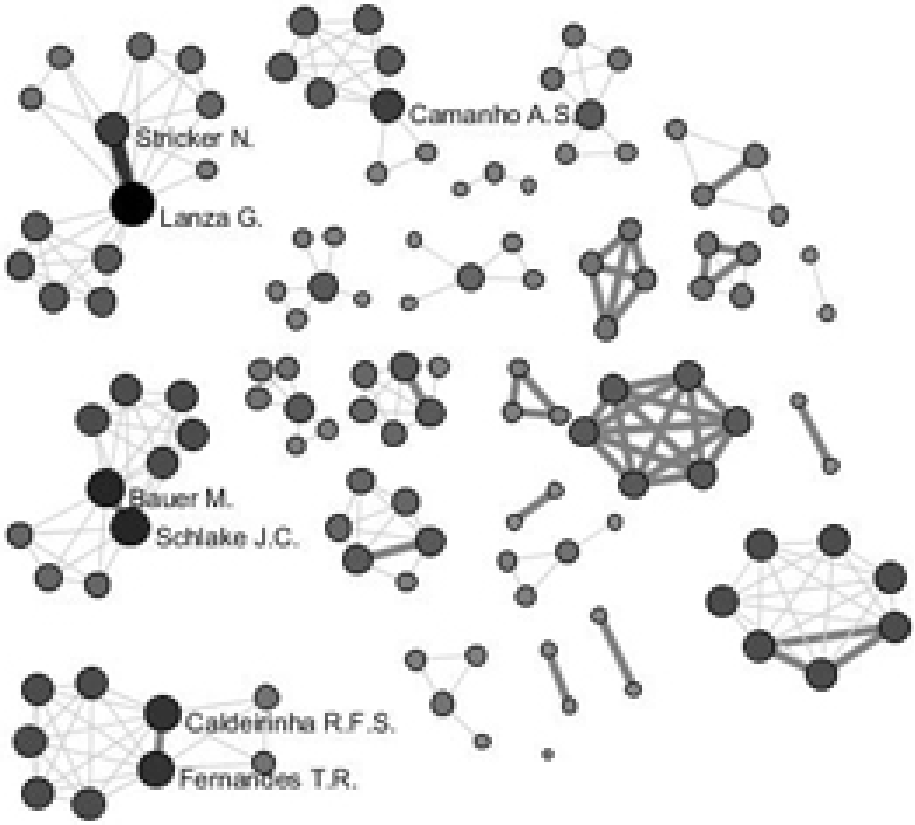


Fig. 9. Authors' networks retrieved using the search terms "key performance indicator" and "measurement" from Scopus database



The use of KPIs as an appraisal tool is a topic addressed by several authors and, as shown in Fig. 9, was represented by the formation of four major and several smaller networks. Of the larger networks, one is centered around Lanza G. with node size 12; the second is centered around Bauer M. and Schalke J. C., both with node size 9; the third around Camanho A. S. with node size 7; the fourth around Fernandes T.R. and Caldeirinha R.F.S. with node size 8; and several smaller networks. The records retrieved from *WoS* did not map authors' network with relevant information, given the low number of authors' indexed articles.

The search terms "*key performance indicator*" and "*SME,"* when used together for all the research papers indexed in *Scopus* database, retrieved 12 articles. Searching on *WoS* no articles were retrieved. As such, the creation of network maps to show most relevant authors was not possible, which reveals an area that offers scope for research and a gap that should be exploited. Another combination of search terms that retrieved a dwindling number of articles was "*key performance indicator*" and "*competitiveness*". Searches using this combination, retrieved 48 research papers from *Scopus* database, 2 papers from *WoS,* and all articles retrieved were written by different researchers, not allowing the creation of maps of relevant authors.

4. CONCLUSION

The results obtained presented the most relevant authors as well as their research networks on subjects as competitiveness and its measurement; KPIs and SMEs. We can cite Gunasekaran A. from California State University Bakersfield, USA, Phusavat K. from Kasetsart University, Thailand, and Siluk J.M.C. from Universidade Federal de Santa Maria, Brazil, as prominent among the authors on subjects of competitiveness and measurement. Kraus S. from University of Liechtenstein, Liechtenstein, Huang W.M. from Nanyang Technological University, Singapore, and Eggers F. from Menlo College, USA, on the theme SMEs; and Sayraç B. from Orange Gardens, France, Demestichas P. from Panepistimion Pireos, Greece, and Li J.S. from University of Wisconsin Madison, USA, as prominent among the authors on the subject KPIs. In the results section it can be seen that there are other authors with considerable relevance in the subjects researched.

Differences could be noted between the maps obtained from the *Scopus* and *WoS* databases: *Scopus* maps were larger than *WoS* maps; another difference is that in most cases of this article the main authors in each of the maps were different.

The formatting of authors' networks alone does not provide enough information to conclude whether an author is relevant in his or her research area. For this analysis to be complete and close to reality, it is necessary to verify other information, such as the number of publications and the authors h-index. In our analyses it was possible to observe that there are authors with node size larger, but with fewer articles published on a topic than other authors with smaller nodes. For example, in the map on the subject "SME", Eggers F. has node size 15 with 6 articles published on the topic, while Belas J. has node size 14 with 10 articles published. This can be explained by the breadth and reach of the authors' research networks, the wider their network, the more influence the author has and the more relevant the subject will be. Thus, with the information obtained through maps of authors' networks, researchers can make sure that the reference they are using comes from an influential research group and with strong research on the subject.

As can be seen from this study, the use of KPIs as a tool to measure the competitiveness of SMEs is a subject that is still considered scientifically incipient, presenting a gap in scientific research that can be exploited by researchers, who can publish their findings and obtain citations.

The computational tool *Sci2* was of great value in preparing maps of the main authors' networks on the subjects covered by this study and helped introduce the world's top researchers and interconnections in research networks. We recommend application of computational tools in the preparation of maps of authors' networks in other areas of science to facilitate identification of research groups and key researchers in a scientific manner.

5. ACKNOWLEDGMENTS

The authors want to thank Coordenação de Aperfeiçoamento de Pessoal de Nível Superior for granting them scholarships, to Editage for traducing this article, and the Programa de Pós-Graduação em Sistemas e Processos Industriais – Mestrado from the Universidade de Santa Cruz do Sul.

AGRADECIMIENTOS

Los autores desean agradecer a la Coordenação de Aperfeiçoamento de Pessoal de Nível Superior por otorgarles becas, a Editage por traducir este artículo, y al Programa de Pós-Graduação em Sistemas e Processos Industrais – Mestrado de la Universidade de Santa Cruz do Sul.

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