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Rossetto, Dennys Eduardo; Carvalho, Fábio Câmara Araújo de; Bernardes, Roberto Carlos; Borini, Felipe Mendes

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Absorptive Capacity and Innovation: An Overview of International Scientific Production of Last Twenty-Five Years

Dennys Eduardo Rossetto professor@dennyseduardo.com.br

ESPM - Escola Superior de Propaganda e Marketing, Brasil

Fábio Câmara Araújo de Carvalho

fabiocamara@kmbusiness.net

Centro Universitário FEI, Brasil

Roberto Carlos Bernardes bernardes@fei.edu.br

ESPM - Escola Superior de Propaganda e Marketing, Brasil

Felipe Mendes Borini fborini@espm.br

ESPM - Escola Superior de Propaganda e Marketing, Brasil

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Abstract: This work aims to achieve an overview of international scientific production on absorptive and innovation capacities in order to mapping the academic contributions already made between 1990 and 2015 (last 25 years). Bibliometric methods, and social network analysis were used to understand the behavior of 1,693 published articles and analysis of key works cited. Most notably, the growing publication with related topics, in approximate exponential growth, concentration of work into five groups and six co-citation periodic coupling groups, indicating possible fields for publication related to the themes absorptive capacity and innovation. The analysis of the key articles cited identifies the themes and methods used, as well as understand the context of the themes absorptive capacity and innovation.

Keywords: Absorptive Capacity, Innovation, Innovation Capacities, Review.

Resumo: O presente trabalho tem por objetivo realizar um panorama das publicações científicas internacionais sobre capacidades absorptivas e inovação, de modo a mapear as contribuições acadêmicas já realizadas entre 1990 e 2015 (25 anos). Foram utilizados métodos bibliométricos e de análise de redes sociais para entendimento do comportamento de 1.693 artigos publicados, bem como análise dos principais trabalhos citados. Como destaque, a crescente publicação com os temas relacionados, em crescimento aproximado ao exponencial, concentração de trabalhos em quatro grupos de cocitação e seis grupos de acoplamento de periódicos, indicando os campos possíveis para publicação relacionadas com os temas capacidade absorptiva e inovação. A análise dos principais artigos citados permite identificar os temas e métodos utilizados, bem como entender a contextualização dos temas capacidade absorptiva e inovação.

Palavras-chave: Capacidade Absortiva, Inovação, Bibliometria, Produção Acadêmica.

INTRODUCTION

The aim of this study is to provide an overview of the scientific publications on "absorptive capacities" and "innovation", in order to map the academic contributions already made. This work offers academic contributions presenting the panorama of international publications in 1990-2015 (25 years), identifying gaps and possible trends for the orientation of future academic production, as well as mapping the main

works published in the area, serving as a guide for future studies and for relevant inquiries in the field.

This work is organized as follows, in the following sections: methodological procedures used to carry out this study, discussion, and analysis of results, implications and contributions of the main articles cited. Finally, the final considerations, research limitations and suggestions for future work are presented.

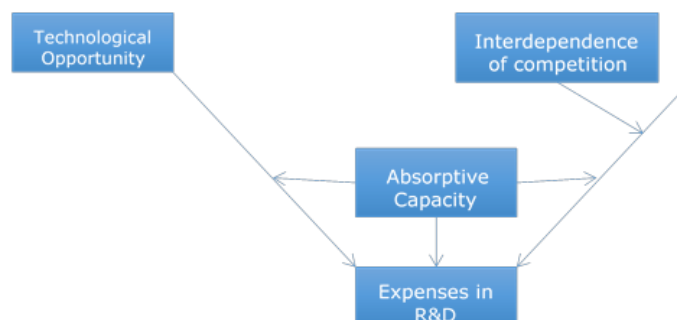
Theoretical background

Publications related to absorptive capacity, transfer of knowledge and/or technology have undergone a substantial increase since 1990 when Cohen and Levinthal (1990) published a seminal paper on absorptive capacities and the impact on innovation. The premise of the absorptive capacities is anchored in Penrose (1959), which underlies a theory of the firm, in which it is an innovative agent, which accumulates skills in an environment of permanent mutation. In this sense, organizations accumulate skills and knowledge in order to improve technology that allows performance gains, in order to maintain and expand a position within the market, that is, being competitive.

The need to maximize productivity and reduce costs means that companies share knowledge in the supply chain links by investing in inter-organizational knowledge transfer processes. These processes include investment in absorptive capacity.

Cohen and Levinthal (1990) describe that firms must invest in the absorptive capacity to recognize the value of new, external information, to assimilate it and to apply it for commercial purposes. In this way, the absorptive capacity is defined as the ability to identify, assimilate and exploit the knowledge to promote innovation and performance that allow the competitive advantage in their markets.

This occurs at both the individual and organizational levels. The authors also highlight the figure of the Research and Development (R&D) department associated with the appropriation capacity, as shown in Figure 1.



Innovation capacity can be driven by R&D efforts, from the technological opportunities, the interdependence of the competitors and the capacity of appropriation of the technology. Cohen and Levinthal

(1990) pioneered the importance of absorptive capacity in learning and innovation processes.

There are many applications to Absorptive Capacity listed in the literature, like some authors (Oliveira, Echeveste, Cortimiglia, & Gonçalves, 2017) relating the linking of the absorptive capacity in the networks relationships showing the companies can use the external resources of knowledge to integrating with its research and development activities. Another application realized (Soares & Mazon, 2016) is for a self-evaluation and institutional change based in absorptive capacities.

Methodological procedures

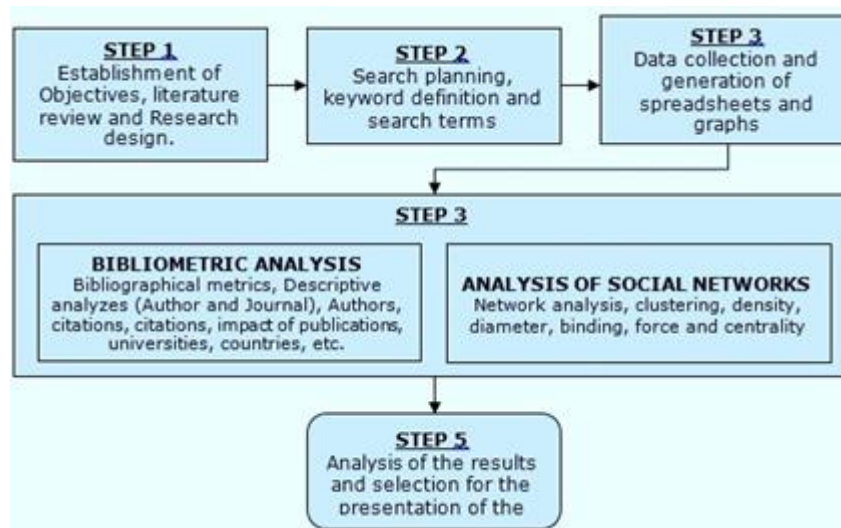
Among the sciences for the measurement of academic productivity, bibliometry (Andrés, 2009; Chueke & Amatucci, 2015), and Social Network Analysis (Kleinberg, 1999) is gaining more and more supporters (Otte & Rousseau, 2002).

Bibliometric studies, since the work of Pritchard (1969), have been consolidated as a quantitative and statistical method used to measure the production and dissemination indexes of scientific knowledge (Araújo, 2006), solid and mature, able to offer relevant information (Borgman & Furner, 2002; De Bellis, 2009; Diodato & Gellatly, 2013; Hood & Wilson, 2001; Ikpaahindi, 1985; Pendlebury, 2008) to guide new research efforts, as pointed out by several studies using this method, As in the studies of Carvalho, Fleury, and Lopes (2013), Janssens, Glänzel, and De Moor (2008), Narin (1976), Radošević and Yoruk (2014).

Social network analysis has gained increasing importance in recent years (Otte & Rousseau, 2002), becoming a differentiated method for analyzing social structures and how they behave (Wellman & Berkowitz, 1988).

The contributions of the use of the analysis of social networks are evidenced by Wetherell, Plakans, and Wellman (1994, p. 645) in order to meet the objectives of the present work by providing a means for the analysis of how authors and institutions are related to academic production, especially the production of knowledge related to absorptive capacities in the context of innovation in emerging countries.

Thus, this study was designed to provide a broad understanding of scientific production on "absorptive capacities" in the context of "innovation", to provide an analysis following the process presented in Figure 2:



Criteria for choosing the database

For the bibliometric analysis was chosen the Web of Science indexed search engine provided by Reuters (2015). It was chosen because it is a database of scientific production indexed and credited internationally, gathering in its searches scientific articles of other databases like Scopus, ProQuest, and Wiley, among others. Another criterion for selecting this database is that all the journals available at its base have their JCR index with its impact factor calculated by JCR (Journal Citation Reports).

In addition, the Web of Science database, in addition to having a wide range of areas of knowledge and scientific production with international recognition, also provides a set of metadata that was necessary for the bibliometric analysis and construction of social network analysis, Such as the complete data of the publication, the periodical, the authors and other information such as the number of citations, references cited, institutions, countries, development agencies, among others (Carvalho et al., 2013).

Defining search criteria

The first step in defining the search criteria was the determination of the keywords. For this, a general search for a better understanding of the words was carried out in the light of the orientations indicated in the work of Bhalotia, Hulgeri, Nakhe, Chakrabarti, and Sudarshan (2002) and based on the work of Goerzen, Asmussen, and Nielsen (2013) were made a general search in order to enhance the comprehension of the words commonly used for "absorptive capacity" and "innovation".

Although the search results in words like "absorptive capacity", "absorptive capacities" or "absorption capacities", we chose to use only the word "absorptive capacit*" as the main keyword associated with the word "innovat*", Has seen the large number of studies that have emerged

that use the term "absorptive capacity" associated with the absorption properties of substances in the digestive system.

In this way, the searches were made associating "absorptive capacity" and "innovation" in order to limit the results within the scope of this work.

The main objective of this work is to analyze the academic production on the absorptive capacity in the context of the innovation, in order to map the main trends for new academic contributions in the area, so the search criteria were broad, without any restriction when the areas.

The scope is the core of the "Web of Science" Core Collection" (Reuters, 2015), which covers the "Science Citation Index Expanded (SCI-EXPANDED) - 1945-present" and the "Social Sciences Citation Index (SSCI) 1956-present", both containing the scientific production in the Social Sciences.

A temporal cut was made between 1990 and June 2015. In addition, it was determined that the search would only be for the scientific production of "articles", excluding other types of documents such as "Abstracts, Abstract of Published Item, Art Exhibit Review, Bibliography, Bibliographical Item, Books, Book Reviews, Chronology, Correction, Discussion "among others, besides the academic production available only in the English language, since it understands that the scientific content is only of domain and global access if made available in English.

Based on Hristidis and Papakonstantinou (2002) and Felizardo et al. (2011) (TS=Innovat*) AND LANGUAGE: (TS=Absorptive Capacit*) and the "Field Tags" of the "Web of Science" for the search, the following term was used: English) AND DOCUMENT TYPES: (Article) Indexes = SCI-EXPANDED, SSCI Timespan = All years.

After the search results, the data were collected for all 1,693 articles, generating tables and graphs and other analyzes in order to contextualize the academic production on "Absorptive Capacity" in the context of innovation in emerging countries.

Metrics and bibliographic analysis criteria

(Microsoft, 2013) and bibliometric software Publish the data collections described above, it was possible or Perish (Harzing, 2007) and from the obtained in to obtain the following metrics indicated in Table 1. Table 1: Bibliometric metrics of the results Basic Metrics Results Total of articles obtained 1.693 Total sum of citations 44.760 Total sum of non-self-citing cited 35.476 Average number of citations per author 24.160,85 Total of cited articles 21.905 Total of articles cited without self-citation 20.261 Average citations per article 26.44 Mode of citation by article 5,0 Citations per year of searched terms 1.790,40 Average number of authors per article 2.44 Average citations per author per year 966.43 Time lapse 25 anos Contemp. ac=7.06 Indexes Results h_index 86 (61%) g_index 182 (74%) hc_index 55 hI_index 38,32 hI_norm 62 AWCR 5.337,02 AW_index 73,05 AWCRpA 2.771,20 e_index 141,63 hm_index 66,40 hI_annual 2.48 h_coverage 61 g_coverage 74 Source: Survey data with results obtained with the Publish or Perish software (Harzing, 2007).

From the main metrics presented with the data, it is important to highlight the Hirsch Index, also known as "index h", or h-Index is

an academic evaluation metric proposed by Hirsch (2005) and widely discussed (for example, Braun, Glänzel, & Schubert, 2005; Egghe, 2006; Hirsch, 2010; Schubert & Glänzel, 2007) with the purpose of quantifying the productivity and impact of scientists and academics based on the cited articles.

A scientist has index h if his number of publications has at least h citations each and in other publications ($N-h$) he has $\leq h$ citations each (Andrés, 2009, p. 61).

Social metrics and analysis criteria

For the social networks analysis was used the VOSviewer software v.1.6.1 (Van Eck & Waltman, 2009) together with Gephi v.0.8.2 (Contributors, 2008) where it was possible to analyze the data Collected in the previous stages and generate the maps of the networks using as type of analysis of the bibliographic coupling and using as unit of analysis based on documents, periodicals, authors and educational institutions. For the type of co-citation analysis, the references cited by each paper, periodicals and author (in this case, considering only the first author) were used as the unit of analysis. And for the type of co-authorship analysis was used as unit of analysis by author, and by institution. As method of counting nodes and vertices, the fractional counting method was used so that the weight of a link is fractionated by how it contributes to each reference, citation or article in general (Van Eck & Waltman, 2013).

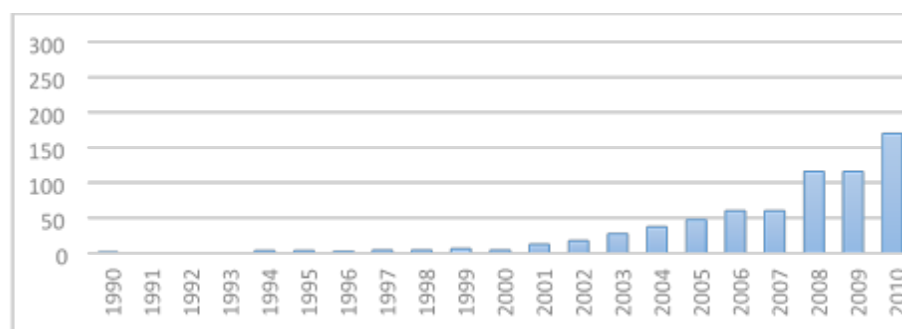
After the generation of the maps of the network, density, and cluster, we evaluated the potential contribution of each map to the understanding of the relations under analysis in this work, so that we present here only the results considered relevant or that contribute to the contribution of the context to which this article is proposed.

Presentation and analysis of results

Since the paper published by Cohen and Levinthal (1990), 31% of papers were published by 2009. That is, more than two-thirds of the publications on absorptive capacity and innovation occurred as of

2010, as shown in Figure 3.

As this research was carried out in early July 2015, same year. In this case, the curve is closer to the a number of publications this year tends to maintain exponential behavior, compared to the number of the growth rate perceived by Figure 3 during the publications.



Eleven authors have more than nine publications, Although it is still a question of authors, it is among the 1,693 publications surveyed, representing possible to observe in Figure 4 the graph that shows 7.75% of the cases, as shown in Table 2.

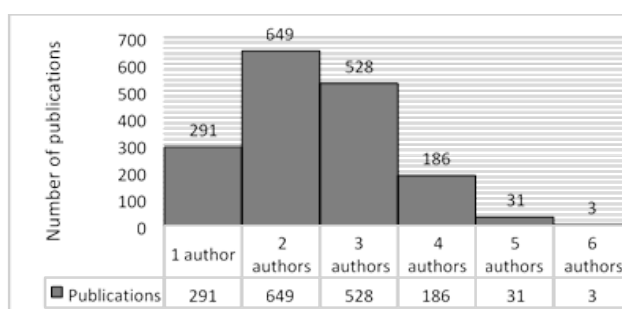


Figure 4: Author's number by publication
Source: Research Data (Reuters, 2015).

In the data presented it is possible to observe that the great majority of the 1,693 articles published are published with two authors, with the articles with three authors being the most usual, that is, almost 70% of the 1,693 articles published have two or three authors, making clear that the figuration of three or the number of authors per article, among the results obtained.

Table 3: Top 10 countries

more authors in an article falls outside the norm in publications carried out in the social sciences.

Table 3 highlights the main countries of the authors of the publications, of which they have more than 3% of the registrations.

Nº	Countries	Freq.	% of 1693
1º	United States	454	26.8
2º	England	219	12.9
3º	Spain	203	11.9
4º	China	154	9.1
5º	Germany	147	8.7
6º	Holand	123	7.3
7º	Taiwan	117	6.9
8º	Italy	94	5.5
9º	Canada	90	5.3
10º	Denmark	68	4.0

The US stands out first, with more than double the The main areas of research are indicated in Table percentage of second place. Of the eighteen listed, 4. The percentage values are related to areas above twelve are European, three are Asian, in addition to 01 register, totaling 29 areas. Canada and Australia.

Nº	Research's Areas	Freq.	% of 1693
1	Business Economics	1475	87.1
2	Engineering	282	16.6
3	Public Administration	221	13.0
4	Operations Research Management Science	172	10.1
5	Information Science Library Science	127	7.5
6	Environmental Sciences Ecology	95	5.6
7	Geography	92	5.4
8	Computer Science	77	4.5
9	Science Technology Other Topics	39	2.3
10	Urban Studies	26	1.5
11	Outros	125	2,9

The business area is highlighted as the main area, with 87% of the publications records. However, even with the filters applied, 21% of the publications come from other areas, indicating that the theme is related to different areas and a varied degree of interdisciplinary. The database indicated 114 journals that hold more than one publication. Table 5 shows the main journals that present more than 20 records.

Nº	Journal's list	Freq.	% of 1693
1	Research Policy	110	6.5
2	Technovation	64	3.8
3	Strategic Management Journal	60	3.5
4	International Journal of Technology Management	54	3.2
5	Journal of Knowledge Management	43	2.5
6	Journal of Business Research	41	2.4
7	R&D Management	39	2.3
8	Journal of Product Innovation Management	38	2.2
9	Technology Analysis Strategic Management	37	2.2
10	Technological Forecasting And Social Change	30	1.8
11	Organization Science	29	1.7
12	Industrial Marketing Management	27	1.6
13	Regional Studies	26	1.5
14	IEEE Transactions on Engineering Management	26	1.5
15	Journal of Management Studies	25	1.4
16	Journal of Engineering And Technology Management	25	1.4
17	European Planning Studies	25	1.4
18	Journal of Technology Transfer	24	1.4
19	Industry And Innovation	24	1.4
20	International Business Review	21	1.2

Table 6 presents the 45 main publications, organized by total citations. In addition, the average of citations per year and the citations of the last 25 years is also presented.

[illegible]

A total of 536 organizations were listed in the presents the ranking of the main organizations, which search results. Only eight (0.5%) of

the records are published over 20 articles within the scope of this not associated with any organization. Table 7 research.

Table 7: Top 20th universities that most publish papers about Innovation and Absorptive Capacity.

Nº	Universities	Freq.	% of 1693
1	Copenhagen Business School	36	2.1
2	University System Of Georgia	32	1.9
3	Imperial College London	31	1.8
4	Erasmus University Rotterdam	31	1.8
5	University Of London	29	1.7
6	Universitat Politecnica De Valencia	28	1.6
7	Pennsylvania Commonwealth System	27	1.6
8	Universitat Jaume I	26	1.5
9	Zhejiang University	24	1.4
10	University Of Minnesota Twin Cities	24	1.4
11	University Of Minnesota System	24	1.4
12	University Of Manchester	23	1.3
13	Tilburg University	23	1.3
14	Ku Leuven	22	1.3
15	Xi An Jiaotong University	20	1.2
16	University Of Sussex	19	1.1
17	University Of Toronto	18	1.1
18	Lappeenranta University Of Technology	18	1.1
19	Georgia Institute Of Technology	18	1.1
20	Florida State University System	18	1.1

The research data also pointed to publications incentive. Table 8 presents the ranking of the main with financing from development agencies. Of the agencies. 1,693 articles, only 142 (8.5%) received this type of

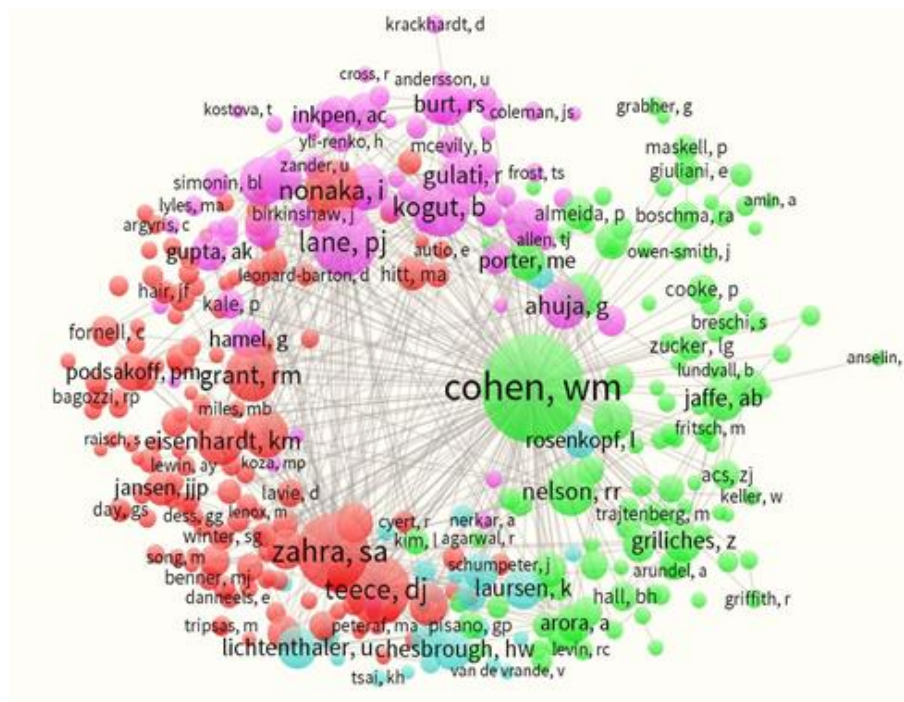
Table 8: Main scientific research funding agencies in the study area

Nº	Funding Agencies	Freq.	% of 1693
1	National Natural Science Foundation Of China	15	0.9
2	Spanish Ministry Of Science And Innovation	7	0.4
3	Spanish Ministry Of Economy And Competitiveness	4	0.2
4	Fundamental Research Funds For The Central Universities	4	0.2
5	National Science Foundation Of China	3	0.2
6	National Science Council In Taiwan	3	0.2
7	Hong Kong Polytechnic University	3	0.2
8	European Union	3	0.2
9	European Commission	3	0.2
10	Uk Economic And Social Research Council Esrc	2	0.1

With the social networks analysis, it was possible to generate some maps that demonstrate the relationships between the main actors of this study, being presented by the nodes in the network, and their relationship making the connection through the vertices. Both the map nodes and the vertices that link them reflect the state of their relationships, indicating

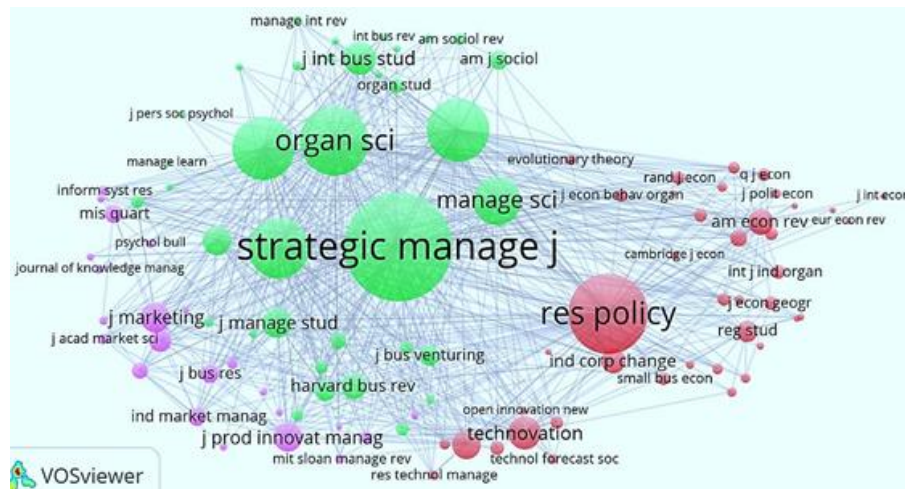
the strength of the relationships, intensity, centrality among other things, how their size represents their importance or representativeness in the network, as well as the thickness of their links also indicate a link between the nodes that may be weaker or stronger, as well as may indicate the direction, giving clues as to where the relationship departs and where it goes, or who gets. Other relevant information to be inferred from the maps presented is their groupings, usually indicating that clustering nodes, forming a "cluster" that unites them by some common feature, either by the cooperation in academic production, by the citations or periodicals in which they publish or are cited.

Figure 5 shows the relationships between the most cited authors and their relation based on the articles produced, so that the more cited the author is, the greater he is represented. And their grouping occurs by uniting the works that refer to each other, presenting clusters based on related themes of publication that produce articles in the theme and cocitation between them. Thus, it is possible to observe that the authors belonging to cluster 1 have a higher concentration in publications related to dynamic capacities and grouped by having a higher frequency of citation among them. In the same way occurs in cluster 2 with Absorptive Capacities, cluster 3 with Knowledge Management and cluster 4 with innovation.



In the same way, it is also possible to identify works belonging to the same author, but in different groups, also indicating the scope of the author's production that can have his work framed in different groups. Just below in the Figure 6, a bibliographic coupling network map is presented below, where it brings together the most cited journals as a unit of analysis according to the bewilderments of publications, in order to highlight the importance and representativeness of certain journals in the

volume of articles published in the theme, as is the case of Research Policy, a journal focused on innovation, research, and technology publications.



Implications and contributions: analysis of the main authors cited

The work of the seminal authors Cohen and Levinthal (1990) is the most cited with 7,058 citations, almost three and a half times higher than the second place, of Szulanski (1996) with 2,041 citations. Was selected the top ten articles most cited after the paper of Cohen and Levinthal (1990), according to what was presented in Table 3. From this, we investigated the themes of the articles, the methodological approaches, as well as the treatment of concepts and theories of capacity and innovation, as shown in Table 9.

Table 9: Analysis of the most cited articles.

Authors	Theme	Approach - Methods	Relation with Absorptive Capacity	Relation with Innovation
Szulanski, G	Transfer of best practice knowledge between enterprises	Quantitative - canonical correlation analysis	Independent variable of the model	Only cited in the article
Zahra, SA; George, G	Revision, reconceptualization and extension of the concept of absorptive capacity	Qualitative - literature review	Conceptual proposal	Integrates the analysis model
Lane, PJ; Lubatkin, M	Absorptive capacity and organizational learning	Quantitative - regression analysis	Independent variable of the model	Only cited in the article
Bathelt, H; Malmberg, A; Maskell, P	Learning and knowledge creation	Qualitative - literature review	Integrates the analysis model	Integrates the analysis model
Tsai, WP	Knowledge Transfer in Inter Organizational Networks	Quantitative - regression analysis	Independent variable of the model	Independent variable of the model
Reagans, R; McEvily, B	Knowledge transfer and network structure	Quantitative - regression analysis	Base for independent model variables	No conceptual treatment
Lane, PJ; Salk, JE; Lyles, MA	Absorptive capacity, learning and performance	Quantitative - regression analysis	Base for independent model variables	No conceptual treatment
Rothaermel, FT; Deeds, DL	Alliances for development of new products	Quantitative modeling of structural equations and regression	No conceptual treatment	Only cited in the article
Ahuja, G; Katila, R	Technological Acquisition and Innovation Performance	Quantitative - Poisson regression	Base for independent model variables	Variable dependent on the model
Jansen, Justin J. P.; Van den Bosch, Frans A. J.; Volberda, Henk W.	Organizational performance from exploitation of innovation	Quantitative - regression analysis	No conceptual treatment	Dependent and model independent variable

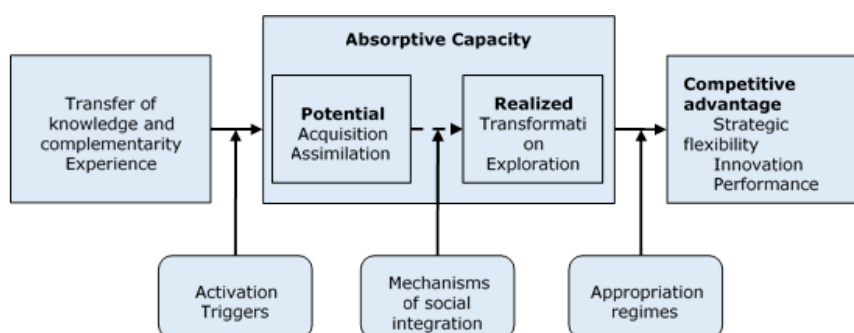
Thus, eight of the ten analyzed articles use quantitative models, predominantly the use of regression analysis. The absorptive capacity is

the basis for the independent variables of three article models, directly as the independent variable of other three models and not considered directly in other two articles.

Innovation is used as a dependent and/or independent variable in three articles, only quoted verbatim in three other articles and receives no textual consideration in two other articles.

Failure to consider the concepts of absorptive capacity and innovation means that theories are not explored in the text, only related to the bibliographical references of the articles. In this sense, it is verified that the relation between absorptive capacity and innovation is not necessarily the focus of most of the articles most cited by Table 3 and focus of the research of this work.

Two of the articles use qualitative models, where the proposal is based on literature review. In both works, the absorptive capacity and innovation integrate the analysis model and proposals. However, it is understood that only Zahra and George (2002) have advanced the concept of absorptive capacity, indicating four dimensions: acquisition, assimilation, transformation and exploitation of knowledge, as shown in Figure 7.



In this sense, it is possible to affirm that of the eleven most cited works of Table 3, Cohen and Levinthal (1990) introduced the concept of absorptive capacity and innovation and Zahra and George (2002) advanced in the academic theory.

Final considerations

This paper presents an overview of the international scientific production of the last 25 years on the themes of absorptive capacity and innovation from the seminal publication of Cohen and Levinthal (1990). It is possible to highlight the relevance of the contribution of authors and their article to the whole development related to learning and knowledge management and its impact on innovation processes in the following years.

The methodological procedures and researches in the Web of Science allowed to obtain 1,693 published works with association of the themes, allowing bibliometric analyses and social networks, such as: evolution of publications per year, authors that published the most, number of authors per publication, most cited publications by year and periodical,

authors' countries, research areas, journals with the largest amount of publications, major organizations associated with the works and funding agencies providing a detailed overview of what has been published in the area and serving as a guide for future research on the theme.

The analysis of social networks allowed us to analyze and understand how the authors relate and refer, providing an overview of the main groups of authors and how they are grouped according to the affinity shown by the cocitation between them. In the author relationship map, five main cocitation groups were identified, with seminal authors at the center.

On the other hand, it was possible to identify three major groups, highlighting the Research Policy, as the main journal, but not totally connected with the other groups.

In addition to the seminal work, eight were quantitative (using regression as the main method used) and two qualitative ones. In this sense, there was no direct association between absorptive capacity and innovation. In addition, the work of Zahra and George (2002) has advanced the concept of absorptive capacity and the implications for innovation as a result of the promotion of competitive advantage of organizations.

As limitations of the research, we can highlight: analyses considering only half of the year 2015, analysis restrictions with more depth of the work. It is suggested for future work the analysis of the works of authors who have published more articles about the subjects, more in-depth understanding of the cited groups of social networks (authors and periodicals), verification of the relation between absorptive capacity and innovation in the most recently published works.

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