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Systematic Literature Review on Academic Entrepreneurship by Bibliometric Metadata Analysis

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Abstract

The purpose of this article is to map the field of Academic Entrepreneurship focusing on the search for models that evaluate the viability of intellectual property as a product. The study was based on articles retrieved from the Web of Science database covering the period from 1988 to 2020, where the metadata data analysis was carried out using the RStudio software, bibliometrix package, and the web interface Biblioshiny, and a systematic review was conducted following the PRISMA protocol, Extension for Scoping Reviews. The findings revealed that the main objectives of studies on academic entrepreneurship are related to the analysis of human (training, leadership, and motivation), physical and management resources, as they are pointed out as the most necessary incentives to improve universities AE. Therefore, it was concluded that most models on AE are for the evaluation of the development of entrepreneurship in the academic environment and there is a research gap to develop models aiming at the commercialization of intellectual property.

Keywords: academic entrepreneurship, technology transfer, systematic review, metadata, bibliometrics

1. Introduction

Given the efforts of universities to improve their productivity and stimulate the capitalization of scientific knowledge, the issues of academic entrepreneurship have been the center of several theoretical and empirical research. Such importance of this subject can be perceived by the number of documents indexed in scholarly databases, only in the Web of Science database the search for "academic entrepreneurship", in all fields, results in 9526 documents. In that regard, due to the extensive literature, when it is necessary to identify, evaluate, and interpret the available papers to address a determined question on the subject, the manipulation of efficient tools to guide the systematic literature review is extremely useful. Without setting a reproducible method, with a clear protocol, the credibility of the findings can be compromised, which leads to biased and inefficient outcomes.

In recent years, health-related areas have sought to improve their review processes to become more systematic, transparent, and replicable, developing systematic review procedures that are being adopted by other areas, e.g., engineering. Those methods first include the formulation of a clear research question, the development of search strategies, description of inclusion and exclusion criteria, and a quality assessment of selected documents. Guides and protocols to conduct a systematic literature review are presented by Brereton et al (2007) e Kitchenham et al (2007; 2002) on the engineering field and by Tranfield, Denye and Smart (2003), Sampaio e Mancini (2007), Moher et al. (2009), and Page et al. (2021) on health fields.

To study the forms of measuring information and scientific knowledge, Vanti (2002) proposed to analyze the quantitative metric methods of bibliometrics, scientometrics, informatics, and webometrics under a theoretical conceptual discussion to explore and extend these concepts, while revising and discussing their main applications. The study stated some of the similarities and differences linking those subfields, showing that each one can be more adequate to obtain a reliable base

for the different types of literature review, and reviewed their theoretical history, revealing that the term bibliometrics was first introduced in literature by Paul Otlet (1934) and popularized by Alan Pritchard (1969).

Within the application of quantitative methods, the bibliometric analysis presented by multiple authors has as objects of study: books, documents, journals, papers, authors, or users; as variables: number of circulations and citations or sentence length frequency; as methods: ranking or distribution frequency; as others (Munim et al., 2020; Roldan-Valadez et al., 2019; Teles et al., 2020; Zhang et al., 2016). In addition, can be reported Lotka's Law of author productivity (Lotka, 1926), Zipf's Law of Word Occurrence (Zipf, 1949), and Bradford's law of Scattering of Scientific papers (Brandford, 1948) and citation analyses, that comprises: Most Cited Authors, Most Productive Authors, Author Impact, Corresponding Author's Country, Author Institutional Affiliation, Most Influential Authors on the specific research field, Most Common Document Type, Mean Age of References, Obsolescence of the literature, Geographic origin of the bibliography, Institutional Affiliations of the Bibliography, Most Cited Journals, and set of journals in a specific area of knowledge.

In that context, the indicators measured by bibliometrics are best suitable for covering the purpose of the present work, which is to develop a systematic literature review searching for evidence of models that evaluate the viability of products generated from academic intellectual property. The paper proposes to use the metadata analysis to clarify or answer the question of what documents should compose the theoretical framework in a literature review on EA, besides suggesting secondary questions on AE related to main research information and its evolution over time, who is leading the research, most relevant authors and current limitations on the topic.

2. Methods

The study was carried out using the PRISMA protocol recommendation, Extension for Scoping Reviews (PRISMA-ScR), an extension of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009; Page et al., 2021; A. C. Tricco et al., 2018) and bibliometric analysis followed as suggested by (Aria & Cuccurullo, 2019, p. 38) (Table 1).

Table 1. Bibliometric Analysis for Systematic Literature Reviews focused on the domain

| <i>Main data results</i> | <i>Level of analysis</i> | <i>Metrics</i> |
|---|--------------------------|-------------------------------------|
| <i>Time span</i> | <i>Sources</i> | <i>Bradford's law</i> |
| <i>Sources Types</i> | | <i>H index</i> |
| | | <i>Source dynamics</i> |
| | | <i>Most relevant sources</i> |
| <i>Author Appearances</i> | <i>Authors</i> | <i>Most relevant authors</i> |
| <i>Authors of single-authored documents</i> | | <i>Annual production per author</i> |
| <i>Authors of multi-authored documents</i> | | <i>Loka's Law</i> |
| <i>Authors per Document</i> | | <i>h index</i> |
| <i>Co-Authors per Documents</i> | | <i>Most relevant affiliations</i> |
| <i>Collaboration Index</i> | <i>Documents</i> | <i>Countries</i> |
| <i>Document Types</i> | | <i>Most cited documents</i> |
| <i>Document Contents</i> | | <i>Cited references</i> |
| <i>References</i> | | <i>Words: Keywords Plus®,</i> |
| <i>Documents per Author</i> | | <i>Author Keywords,</i> |
| <i>Single-authored documents</i> | | <i>Document Title, Abstract</i> |

Source: Adapted from (Aria & Cuccurullo, 2019).

The data used for this work was retrieved from the Core Collection of the database Web of Science (WoS), which among the databases supported in Bibliometrix provides better data quality to export to package biblioshiny in "plain text" format (Aria & Cuccurullo, 2017, p. 17). The WoS database was accessed from CAPES/MEC Journal Portal via Federal University of Sergipe, then the search was performed by employing the term "academic entrepreneurship" and selecting the field "TOPIC", which includes title, authors keywords, and Keywords Plus.

Based on the eligibility criteria defined by Tricco, Lillie, Zarin, O'Brien, Colquhoun, Levac, et al., 2018, p. 22), this study searched for documents in all sources of the database WoS, covering the whole period up to 2020 and selecting only articles published in English from scientific peer-reviewed journals in the areas of "Business economics" and "Operations research management science".

The workflow to export the data from WoS to Biblioshiny can be described in four stages: (1) refining the results by applying the search strategy to export them in the form of Plain text file; (2) completing the record of cited references with the variables necessary for analysis; (3) exportation of txt files; and (4) uploading metadata from files to biblioshiny interface.

3. Results and Discussion

As initial results, from the conducted search on academic entrepreneurship in the database Web of Science, by using the

predefined keywords and filters, it was found 882 records. For extracting the files with consolidated data, without duplicates (certified by the individual analysis of each document), the data were exported to biblioshiny for bibliometricx and filtered from 1988 to 2020, which results in 848 as bases documents. Then, the main results were synthesized into three groups: (1) Main data information; (2) Document information; (3) Author information (Table 2).

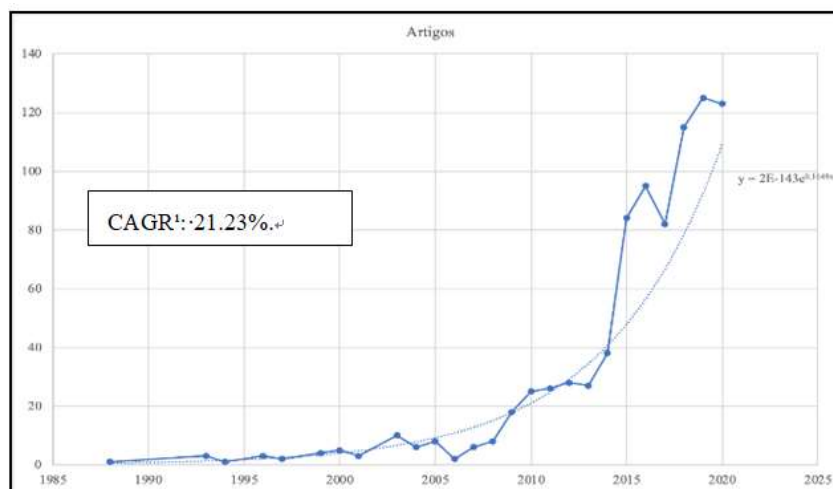
For the period covered in the research, it was observed that from 1988, the year of the first publication with the keyword AE, to the next 21 years (2008), the annual scientific production was not superior to ten per year, having had only 13 productive years and a total of 62 publications over that time. On the other hand, the following period of 9 years, from 2009 to 2017, and the last 3 consolidated years (2018-2020) ended up, respectively, with 423 and 363 published articles. For the selected period, a constant growth rate of 21.23% per year was measured by the Compound Annual Growth Rate (CAGR), while the exponential growth, which better represents the trend of the curve, is described by the expression $y = 2E-143e^{0.1649}$ (Figure 1 and Table 3).

Table 2. Main collection information from searching the keyword "academic entrepreneurship", WoS database

| Information | Results |
|---------------------------|--|
| | Period 1988:2020 |
| | Sources (journals) 228 |
| | Articles 848 |
| (1) Main data information | Average Years since Published 5.49 |
| | Average Citations per Paper 31.03 |
| | Average Citations per Year per Paper 3.079 |
| | References 37.614 |
| (2) Document information | Articles 848 |
| | Keywords Plus 1371 |
| | Author's keywords 2186 |
| (3) Author's information | Authors 1.911 |
| | Authorship Appearances 2.231 |
| | Authors of single-authored papers 149 |
| | Authors of multiple-authored papers 1.762 |
| | Single-authored paper 162 |
| | Multi-authored paper 0.444 |
| | Authors per documents 2.25 |
| | Co-authors per paper 2.63 |
| | Collaborative Index 2.57 |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometricx, **Dataset/Main Information about the collection.**

Figure 1. Profile and trend of annual scientific production on AE, WoS database



Source: Elaborated by the authors from data generated by biblioshiny for bibliometricx. Dataset/Annual Scientific Production Compound Annual Growth Rate.

Table 3. Annual scientific production on AE, WoS database

| | Year | Articles | Year | Articles | Year | Articles | Year | Articles |
|----|------|----------|---------|----------|---------|----------|-------|----------|
| 1 | 1988 | 1 | 1999 | 4 | 2009 | 18 | 2018 | 115 |
| 2 | 1989 | | 2000 | 5 | 2010 | 25 | 2019 | 125 |
| 3 | 1990 | | 2001 | 3 | 2011 | 26 | 2020 | 123 |
| 4 | 1991 | | 2002 | | 2012 | 28 | | |
| 5 | 1992 | | 2003 | 10 | 2013 | 27 | | |
| 6 | 1993 | 3 | 2004 | 6 | 2014 | 38 | | |
| 7 | 1994 | | 2005 | 8 | 2015 | 84 | | |
| 8 | 1995 | | 2006 | 2 | 2016 | 95 | | |
| 9 | 1996 | 3 | 2007 | 6 | 2017 | 82 | | |
| 10 | 1997 | | 2008 | 8 | | | | |
| 11 | 1998 | | | | | | | |
| | | | Total 1 | 62 | Total 2 | 423 | Total | 363 |
| | | | | | | | Total | 848 |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix, Dataset/Annual Scientific Production.

Analyzing the Average Citations Per Year present in Table 4, it is possible to observe that, together, the five articles published in 2000 have recorded the highest average of 28.72 citations per year since their publication, a clear indication that those articles should compose the theoretical framework on AE. Further, the papers from the following years were also heavily cited by other authors, for which was found an average of 13.86 in 2004, 12.75 in 2003, and 12.10 in 2005. Therefore, the outcomes revealed the beginning of the 00s as an important period for the solidification of AE knowledge. Another highlight is the only single publication of 1994 that has been cited 299 times.

Table 4. Average Citations per Year on AE, WoS database

| Year | TC ¹ | Art ² | TC/Art | ⁴ TC/Year | ⁵ CY | Year | TC | TC ¹ | Art ² | TC/Art | ⁴ TC/Year |
|------|-----------------|------------------|--------|----------------------|-----------------|------|------|-----------------|------------------|--------|----------------------|
| 1988 | 36 | 1 | 36.00 | 1.09 | 33 | 2005 | 1549 | 8 | 193.63 | 12.10 | 16 |
| 1989 | 0 | 0 | 0.00 | 0.00 | 32 | 2006 | 94 | 2 | 47.00 | 3.13 | 15 |
| 1990 | 0 | 0 | 0.00 | 0.00 | 31 | 2007 | 749 | 6 | 124.83 | 8.92 | 14 |
| 1991 | 0 | 0 | 0.00 | 0.00 | 30 | 2008 | 843 | 8 | 105.38 | 8.11 | 13 |
| 1992 | 0 | 0 | 0.00 | 0.00 | 29 | 2009 | 1743 | 18 | 96.83 | 8.07 | 12 |
| 1993 | 371 | 3 | 123.67 | 4.42 | 28 | 2010 | 928 | 25 | 37.12 | 3.37 | 11 |
| 1994 | 299 | 1 | 299.00 | 11.07 | 27 | 2011 | 2194 | 26 | 84.38 | 8.44 | 10 |
| 1995 | 0 | 0 | 0.00 | 0.00 | 26 | 2012 | 1122 | 28 | 40.07 | 4.45 | 9 |
| 1996 | 144 | 3 | 48.00 | 1.92 | 25 | 2013 | 1251 | 27 | 46.33 | 5.79 | 8 |
| 1997 | 268 | 2 | 134.00 | 5.58 | 24 | 2014 | 1629 | 38 | 42.87 | 6.12 | 7 |
| 1998 | 0 | 0 | 0.00 | 0.00 | 23 | 2015 | 1848 | 84 | 22.00 | 3.67 | 6 |
| 1999 | 264 | 4 | 66.00 | 3.00 | 22 | 2016 | 1574 | 95 | 16.57 | 3.31 | 5 |
| 2000 | 3016 | 5 | 603.20 | 28.72 | 21 | 2017 | 749 | 82 | 9.13 | 2.28 | 4 |
| 2001 | 458 | 3 | 152.67 | 7.63 | 20 | 2018 | 775 | 115 | 6.74 | 2.25 | 3 |
| 2002 | 0 | 0 | 0.00 | 0.00 | 19 | 2019 | 558 | 125 | 4.46 | 2.23 | 2 |
| 2003 | 2295 | 10 | 229.50 | 12.75 | 18 | 2020 | 144 | 123 | 1.17 | 1.17 | 1 |
| 2004 | 1414 | 6 | 235.67 | 13.86 | 17 | | | | | | |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix Dataset/Average Citations per Year.

¹Total Citations; ²Number of Articles; ³Mean TC/Article; ⁴Mean TC/year; ⁵Citable years.

Academic entrepreneurship has been reported in documents from different sources, such as journals, books, proceedings papers, and others, however, for this work, all the 848 documents selected were articles published in peer-reviewed journals. The 248 document sources (journals) were evaluated in terms of relevance and impact, measured by the number of publications (NP), the h-index (Hirsch, 2005), the analysis of Bradford's Law (1948), and publication growth dynamics.

The descending order of sources by the number of citations in Table 5, showed that the top 20 journals, 8.77% of the total, account for 80% of total citations, wherein the Research Policy and Journal of Business Venturing, first and second respectively, stand out with the highest h-indices and 41.91% of cumulative citations. In addition, the highest numbers of publications were 61 from Research Policy and 45 from Small Business Economics.

The 848 retrieved articles were divided into 3 groups (analyzes zones), each one containing approximately 1/3 of the documents: Zone1, with 288 articles distributed in 12 journals; Zone 2 with 283 articles distributed in 44 journals; and Zone 3, with 277 articles distributed in 177 journals. The journals in Zone 1 (Table 6) represent only 5.26% of total journals but cumulate 33.96% of the whole cited articles, therefore, according to Bradford's Law (1948), when considering the analysis of main journals on AE, zone 1 contains the most significant group of sources available on WoS.

Regarding the authors' analysis, the metrics used were: Most Relevant Authors, Most Cited Authors in the field of AE,

Authors' Production Per Year, Lotka's law, Author Impact (h-index), Most Relevant Affiliations, and Corresponding Author's Country. In terms of productivity, the Most Relevant Authors were: Wright with 10 articles, Meoli and Vismara with 8 articles, and Braunerhjelm with 7 articles (Table 7); while the Most Cited Authors were: Wright with 244 citations, Siegel with 110 citations, and Grimaldi with 100 citations (Table 8).

Table 5. Classification of articles' sources on academic entrepreneurship, WoS database

| Source | <i>h_index</i> | <i>g_index</i> | <i>m_index</i> | <i>TC</i> ¹ | <i>NP</i> ² | <i>PY_start</i> ³ | <i>TC_c</i> ⁴ | <i>Par_c</i> ⁵ |
|---|----------------|----------------|----------------|------------------------|------------------------|------------------------------|--------------------------|---------------------------|
| 1 <i>Research Policy</i> | 39 | 61 | 2.05263 | 5970 | 61 | 2003 | 5970 | 22.69% |
| 2 <i>Journal of Business Venturing</i> | 22 | 25 | 0.75862 | 5059 | 25 | 1993 | 11029 | 41.91% |
| 3 <i>Small Business Economics</i> | 22 | 43 | 0.84615 | 1886 | 45 | 1996 | 12915 | 49.08% |
| 4 <i>Entrepreneurship Theory and Practice</i> | 11 | 15 | 0.64706 | 1146 | 15 | 2005 | 14061 | 53.43% |
| 5 <i>Academy of Management Journal</i> | 5 | 5 | 0.22727 | 902 | 5 | 2000 | 14963 | 56.86% |
| 6 <i>R & D Management</i> | 10 | 11 | 0.29412 | 822 | 11 | 1988 | 15785 | 59.98% |
| 7 <i>International Entrepreneurship and Management Journal</i> | 11 | 25 | 0.91667 | 639 | 26 | 2010 | 16424 | 62.41% |
| 8 <i>Strategic Entrepreneurship Journal</i> | 5 | 8 | 0.38462 | 621 | 8 | 2009 | 17045 | 64.77% |
| 9 <i>Strategic Management Journal</i> | 2 | 2 | 0.11111 | 607 | 2 | 2004 | 17652 | 67.08% |
| 10 <i>Organization Science</i> | 5 | 6 | 0.35714 | 463 | 6 | 2008 | 18115 | 68.84% |
| 11 <i>International Small Business Journal-Researching Entrepreneurship</i> | 13 | 21 | 0.92857 | 453 | 21 | 2008 | 18568 | 70.56% |
| 12 <i>Journal of Business Research</i> | 8 | 16 | 0.47059 | 432 | 16 | 2005 | 19000 | 72.20% |
| 13 <i>Industrial and Corporate Change</i> | 8 | 11 | 0.61538 | 386 | 11 | 2009 | 19386 | 73.67% |
| 14 <i>Management Decision</i> | 6 | 19 | 0.50000 | 362 | 19 | 2010 | 19748 | 75.04% |
| 15 <i>Journal of Small Business Management</i> | 7 | 7 | 0.53846 | 308 | 7 | 2009 | 20056 | 76.22% |
| 16 <i>International Business Review</i> | 5 | 7 | 0.35714 | 289 | 7 | 2008 | 20345 | 77.31% |
| 17 <i>California Management Review</i> | 2 | 2 | 0.25000 | 266 | 2 | 2014 | 20611 | 78.32% |
| 18 <i>British Journal of Management</i> | 4 | 4 | 0.57143 | 243 | 4 | 2015 | 20854 | 79.25% |
| 19 <i>Family Business Review</i> | 2 | 2 | 0.15385 | 218 | 2 | 2009 | 21072 | 80.08% |
| 20 <i>European Management Journal</i> | 4 | 6 | 0.33333 | 214 | 6 | 2010 | 21286 | 80.89% |

Source: Elaborated by the authors. ¹Total Citations; ²Number of publications; ³Year of the first publication; ⁴Cumulative Total Citations; ⁵Cumulative participations

Table 6. Sources (peer-reviews journals) aggregated to Zone 1, according to Bradford's Law for AE articles, WoS database

| Sources | Classification | Freq | CFreq |
|--|----------------|------|-------|
| <i>Research Policy</i> | 1 | 61 | 61 |
| <i>Small Business Economics</i> | 2 | 45 | 106 |
| <i>International Entrepreneurship and Management Journal</i> | 3 | 26 | 132 |
| <i>Journal of Business Venturing</i> | 4 | 25 | 157 |
| <i>International Small Business Journal-Researching Entrepreneurship</i> | 5 | 21 | 178 |
| <i>Management Decision</i> | 6 | 19 | 197 |
| <i>International Journal of Entrepreneurial Behavior & Research</i> | 7 | 18 | 215 |
| <i>Jour. of Enterprising Communities-People and Places in The Global Economy</i> | 8 | 17 | 232 |
| <i>Journal of Business Research</i> | 9 | 16 | 248 |
| <i>Entrepreneurship Theory and Practice</i> | 10 | 15 | 263 |
| <i>Journal of International Entrepreneurship</i> | 11 | 13 | 276 |
| <i>Entrepreneurship Research Journal</i> | 12 | 12 | 288 |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix, Sources/Bradford's Law ¹ Frequency; ²Cumulative frequency.

Table 7. Authors with the highest production of articles on AE up to 2020, WoS database

| Authors | Art ¹ | Art.F ² | Authors | Art | Art.F |
|------------------|------------------|--------------------|------------------|-----|-------|
| 1 Wright M | 10 | 3.50 | 10 Cunningham JA | 5 | 1.83 |
| 2 Meoli M | 8 | 2.75 | 11 Czarnitzki D | 5 | 1.87 |
| 3 Vismara S | 8 | 2.92 | 12 Grimaldi R | 5 | 1.67 |
| 4 Braunerhjelm P | 7 | 2.50 | 13 Guerrero M | 5 | 1.70 |
| 5 Fini R | 6 | 1.92 | 14 Klofsten M | 5 | 1.78 |
| 6 Link An | 6 | 2.50 | 15 Rasmussen E | 5 | 2.33 |
| 7 Urbano D | 6 | 2.03 | 16 Siegel DS | 5 | 1.58 |
| 8 Buenstorf G | 5 | 3.50 | 17 Toole Aa | 5 | 1.87 |
| 9 Carlsson B | 5 | 2.42 | | | |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix, *Authors/Most Relevant Authors*.

Number of articles; Fractionated articles represent the average participation of other authors in articles authorship; for single author paper = 1.

Table 8. Most Local Cited Authors on AE up to 2020, WoS database

| Position | Author | Citations | Position | Author | Citations |
|----------|--------------|-----------|----------|---------------|-----------|
| 1 | Wright M | 244 | 11 | Rasmussen E | 58 |
| 2 | Siegel DS | 110 | 12 | Fini R | 58 |
| 3 | Grimaldi R | 100 | 13 | Shane S | 57 |
| 4 | Kenney M | 95 | 14 | Guerrero M | 57 |
| 5 | Klofsten M | 74 | 15 | Etzkowitz H | 56 |
| 6 | Feldman M | 72 | 16 | Tartari V | 52 |
| 7 | Bercovitz J | 72 | 17 | Jones-Evans D | 52 |
| 8 | Mosey S | 66 | 18 | Carsrud AL | 51 |
| 9 | Mcdougall PP | 66 | 19 | Reilly MD | 49 |
| 10 | Urbano D | 58 | 20 | Krueger NF | 49 |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix,

Authors/Most Local Cited Authors.

When analyzing the authors' production over time, it was noticed that Wright besides being one of the first authors to address AE, has also been demonstrated as one of the most constant producers (Figure 2): Clarysse et al., 2007; Estrin & Wright, 1999; Fini et al., 2019; Fryges & Wright, 2014; Grimaldi et al., 2011; Huyghe et al., 2016; Knockaert et al., 2011; Lockett et al., 2003; Lockett & Wright, 2005; Markman et al., 2008; Mosey & Wright, 2007; Mustar & Wright, 2010; Rasmussen et al., 2014; Rasmussen & Wright, 2015; Siegel & Wright, 2015; Wennberg et al., 2011; Wright, 2017; Wright et al., 2007. Other consistent authors are Klofsten, that started his production in 1999, the same year as Wright, and is: de Cleyne et al., 2015; Etzkowitz & Klofsten, 2005; Guerrero et al., 2016; Jones-Evans et al., 1999; Klofsten & Jones-Evans, 2000), and Grimaldi, that started his production four years later, in 2003 (Fini et al., 2009, 2011, 2020; Greco et al., 2013; Grimaldi et al., 2011; Grimaldi & Grandi, 2001; Kochenkova et al., 2016; Nosella & Grimaldi, 2009; Perkmann et al., 2013; Villani et al., 2018).

To examine author productivity and publications, Lotka (1926) developed the mathematical relation $y=C/x^n$, named Lotka's law, where: x is the number of publications, y is the relative frequency of authors with x publications, and n and C are constants. From its generalized form, where n is approximately 2, the law is known as the 'inverse square law of scientific productivity' and means that nearly 60% of all contributors will make only a single publication.

In the 848 selected records, there was the occurrence of 1911 authors who appeared 2231 times in the collection. The empirical productivity patterns of authors predicted by Lotka's law obtained fitted values of $C=1408.8$ and $n=3.334$ and equation $y=1408.8x^{-3.334}$, with correlation coefficient R^2 of 0.9738. Hence, the frequency distribution was ranked from 1708 authors (about 89.38%) making one contribution in the field to a single author credited in 10 articles. On the basis of Lotka's inverse square law with $C=1708$ and $n=2$, was found that 2647 authors appeared 5003 times, wherein the theoretical frequency distribution ranged from 1708 authors (64.53% of participation contraction) making one contribution to 1708 authors credited in 10 articles. Therefore, the difference between empirical and generated data indicates different values of n when applying Lotka's Law (Figure 3 and Table 9). The 15 authors who wrote 5 or more articles have cumulative participation of 0.89% in the collection, whereas when calculated by Lotka's law the most relevant authors represent 8.14%, being then considered as the most important authors for this study.

The author-level academic impact can be measured by the citations metric of published articles calculating the h-, g-, and m- indices, as they reflect the contribution and recognition of the author within the academic community. The h-index was proposed by Hirsch (2005) to quantify the author's scientific production, an author has index h when h of the total number of papers published (N_p) have at least h citations each and the others ($N_p - h$) papers have a number of citations $\leq h$ each. The g-index was designed by Leo Egghe (2006) aiming to improve the h-index to measure the performance of a series of articles. Based on the number of citations ranked in descending order of numbers of citations that have been received, the g-index is the highest number such that the top of g articles received together at least g^2 citations. Considering the citation scores of the main articles is possible to produce a better distinction within the order of the scientists from the point of view of visibility. The m-index, also proposed by Hirsch (2005), known as m-quotient, is defined by the linear correlation $h \approx mn$ or $m = h/n$, where h is the h-index and n is the number of years since the author's first publication, and its useful to compare the authors' production from different periods.

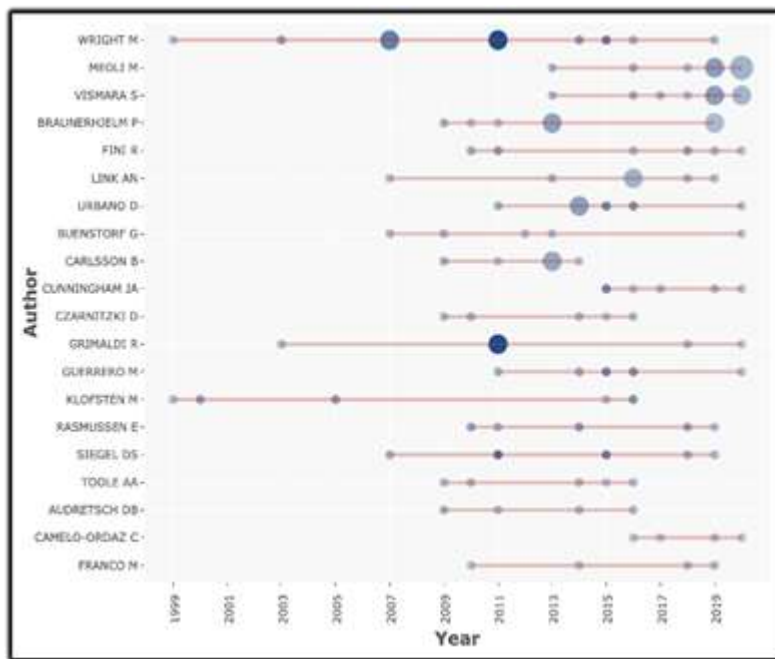


Figure 2. Top-Authors' Production on AE over Time, WoS database

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix. Authors/Top- Authors' Production over Time.

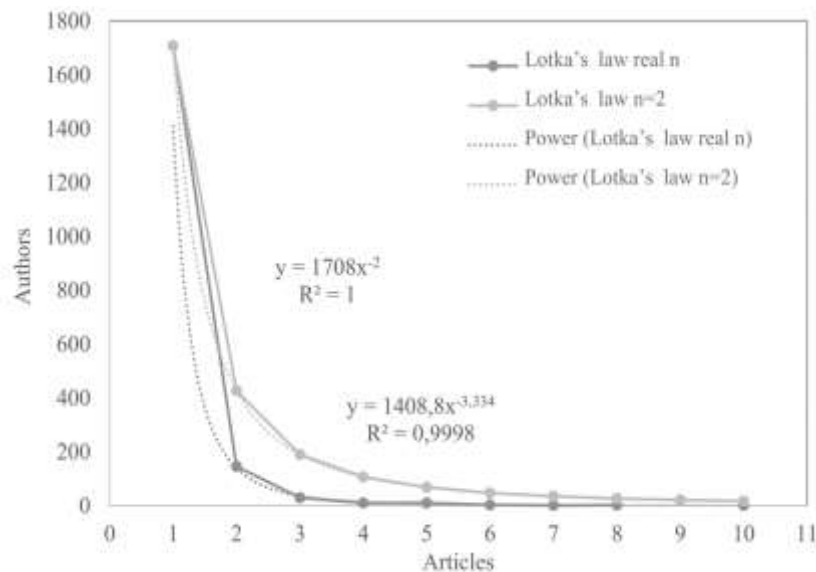


Figure 3. Frequency distribution of scientific productivity based on the AE collection from WoS (n real) and by Lotka's Law (theoretical n=2)

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix. Authors/Author Productivity through Lotka's Law.

Table 9. The frequency distribution of scientific productivity: comparison of values obtained from the collection and by Lotka's Law for articles on AE, WoS database

| Values obtained for the collection | | | | | Values calculated by Lotka's Law | | | |
|------------------------------------|----------------|-----------------------|-----------|---------|----------------------------------|-----------------------|----------|---------|
| No. of articles | No. of authors | Total No. of articles | Contr. 1% | Cum. 2% | No. of authors | Total No. of articles | Contr. % | Cum. % |
| 1 | 1708 | 1708 | 89.38% | 100.00% | 1708.0 | 1708.0 | 64.53% | 100.00% |
| 2 | 146 | 292 | 7.64% | 10.62% | 427.0 | 854.0 | 16.13% | 35.47% |
| 3 | 30 | 90 | 1.57% | 2.98% | 189.8 | 569.3 | 7.17% | 19.34% |
| 4 | 10 | 40 | 0.52% | 1.41% | 106.8 | 427.0 | 4.03% | 12.17% |
| 5 | 10 | 50 | 0.52% | 0.89% | 68.3 | 341.6 | 2.58% | 8.14% |
| 6 | 3 | 18 | 0.16% | 0.37% | 47.4 | 284.7 | 1.79% | 5.56% |
| 7 | 1 | 7 | 0.05% | 0.21% | 34.9 | 244.0 | 1.32% | 3.77% |
| 8 | 2 | 16 | 0.10% | 0.16% | 26.7 | 213.5 | 1.01% | 2.45% |
| 9 | | | | 0.05% | 21.1 | 189.8 | 0.80% | 1.44% |
| 10 | 1 | 10 | 0.05% | 0.05% | 17.1 | 170.8 | 0.65% | 0.65% |
| Total | 1911 | 2231 | 100.00% | | 2647 | 5003 | 100.00% | |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix. *Authors/Author Productivity through Lotka's Law.* ¹Contribution percentage; ²Cumulative percentage.

In the studied collection, the authors were ranked first by h-index, then by g- and m- indices (Table 10). The highest h index of h =10 was found for the author Wright, whereas all your 10 articles had been cited more than 10 times each, followed by Vismara, Meoli e Link, h = 6, Urbano, Fini, Rasmussen, Siegel, e Klofsten, h=5. Given the most relevant authors, Wright, Vismara, Meoli, Link, Urbano, and Fini R, it was observed that, except for Wright, they do not belong to the oldest contributors.

Regarding the affiliation institutions, the most relevant were: Univ Beira Interior with 19 articles, Univ Bergamo with 18 articles, Katholieke Univ Leuven with 15 articles, Indiana Univ with 14 articles, and Linkoping Univ with 14 articles (Figure 4). The country relevance was measured by the total of published articles by authors affiliated with that country, considering both Single Country Publication (SCP) when researchers' affiliations were from the same country, and Multiple Countries Publication (MCP) when researchers from multiple countries are collaborating. The top five countries ranked by the number of publications were: USA, 159 articles, United Kingdom, 88 articles, Italy, 70 articles, and Spain, 55 articles.

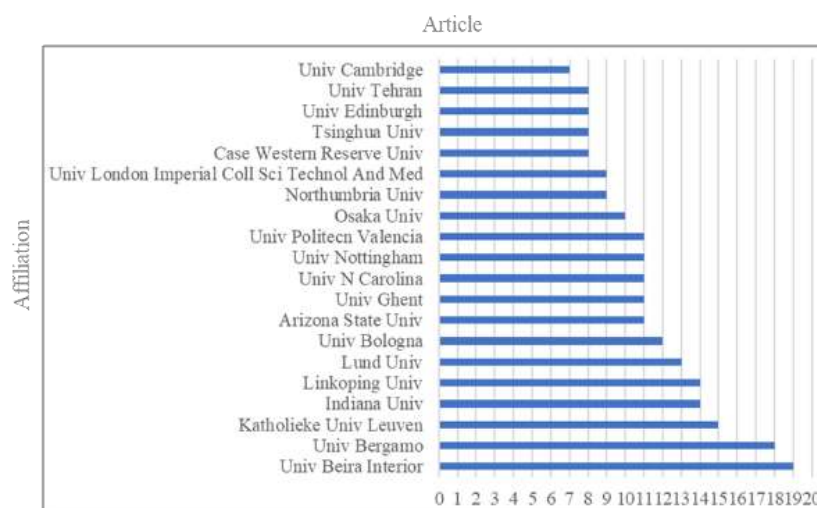


Figure 4. Most Relevant Affiliations of Authors on AE, WoS database

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix. *Authors/Most Relevant Affiliations.*

Table 10. Authors on AE articles ranked based on Author Local Impact, WoS database

| <i>CL</i> ¹ | <i>Author</i> | <i>h_index</i> | <i>g_index</i> | <i>m_index</i> | <i>TC</i> ² | <i>NP</i> ³ | <i>PY_start</i> ⁴ |
|------------------------|----------------|----------------|----------------|----------------|------------------------|------------------------|------------------------------|
| 1 | Wright M | 10 | 10 | 0.435 | 1545 | 10 | 1999 |
| 2 | Vismara S | 6 | 8 | 0.667 | 168 | 8 | 2013 |
| 3 | Meoli M | 6 | 8 | 0.667 | 145 | 8 | 2013 |
| 4 | Link A N | 6 | 6 | 0.400 | 145 | 6 | 2007 |
| 5 | Urbano D | 5 | 6 | 0.455 | 466 | 6 | 2011 |
| 6 | Fini R | 5 | 6 | 0.417 | 322 | 6 | 2010 |
| 7 | Rasmussen E | 5 | 5 | 0.417 | 370 | 5 | 2010 |
| 8 | Siegel D S | 5 | 5 | 0.333 | 702 | 5 | 2007 |
| 9 | Klofsten M | 5 | 5 | 0.217 | 740 | 5 | 1999 |
| 10 | Braunerhjelm P | 4 | 7 | 0.308 | 231 | 7 | 2009 |
| 11 | Guerrero M | 4 | 5 | 0.364 | 425 | 5 | 2011 |
| 12 | Czarnitzki D | 4 | 5 | 0.308 | 160 | 5 | 2009 |
| 13 | Toole A A | 4 | 5 | 0.308 | 160 | 5 | 2009 |
| 14 | Buenstorf G | 4 | 5 | 0.267 | 161 | 5 | 2007 |
| 15 | Grimaldi R | 4 | 5 | 0.211 | 624 | 5 | 2003 |
| 16 | Ramadani V | 4 | 4 | 0.571 | 41 | 4 | 2015 |
| 17 | Tartari V | 4 | 4 | 0.364 | 376 | 4 | 2011 |
| 18 | Franco M | 4 | 4 | 0.333 | 40 | 4 | 2010 |
| 19 | Audretsch D B | 4 | 4 | 0.308 | 188 | 4 | 2009 |
| 20 | Cunningham J A | 3 | 5 | 0.429 | 191 | 5 | 2015 |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix.

Authors/Author Local Impact. ¹Classification; ²Total Citations; ³Number of publications; ⁴Year of the first publication.

The MCP ratios, which means the MCP proportion of the total number of publications, were determined to evaluate the collaboration between countries. Among the top 20 productive countries, France, Netherlands, Denmark, Australia, and Canada, showed the highest degree of international collaboration, while Brazil, India, Iran, Spain e South Africa were identified with little inter-country collaboration (Table 11 and Figure 5). The country's scientific production, presented in Table 12, showed that the major numbers of authors with published articles on AE come from the **USA, UK, Italy, Sweden, and Spain**, representing 70.9% of total citations (Table 13).

Table 11. Authors' collaboration in the publication of articles on AE, WoS database

| | Country | Articles | Frequency | SCP ¹ | MCP ² | MCP_Ratio |
|----|----------------|----------|-----------|------------------|------------------|-----------|
| 1 | USA | 159 | 0.18817 | 121 | 38 | 0.2390 |
| 2 | United Kingdom | 88 | 0.10414 | 50 | 38 | 0.4318 |
| 3 | Italy | 70 | 0.08284 | 45 | 25 | 0.3571 |
| 4 | Spain | 55 | 0.06509 | 45 | 10 | 0.1818 |
| 5 | Germany | 41 | 0.04852 | 29 | 12 | 0.2927 |
| 6 | Sweden | 34 | 0.04024 | 23 | 11 | 0.3235 |
| 7 | China | 27 | 0.03195 | 18 | 9 | 0.3333 |
| 8 | Canada | 25 | 0.02959 | 13 | 12 | 0.4800 |
| 9 | Australia | 21 | 0.02485 | 9 | 12 | 0.5714 |
| 10 | Poland | 20 | 0.02367 | 15 | 5 | 0.2500 |
| 11 | Brazil | 19 | 0.02249 | 18 | 1 | 0.0526 |
| 12 | France | 18 | 0.02130 | 6 | 12 | 0.6667 |
| 13 | Portugal | 18 | 0.02130 | 14 | 4 | 0.2222 |
| 14 | India | 17 | 0.02012 | 16 | 1 | 0.0588 |
| 15 | Netherlands | 13 | 0.01538 | 5 | 8 | 0.6154 |
| 16 | South Africa | 11 | 0.01302 | 9 | 2 | 0.1818 |
| 17 | Denmark | 10 | 0.01183 | 4 | 6 | 0.6000 |
| 18 | Finland | 10 | 0.01183 | 6 | 4 | 0.4000 |
| 19 | Iran | 10 | 0.01183 | 9 | 1 | 0.1000 |
| 20 | Ireland | 10 | 0.01183 | 6 | 4 | 0.4000 |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix. *Authors/Corresponding Author's Country* ¹Single Country Publication; ²Multiple Country Publication.

Table 12. Country Scientific production on AE, WoS database

| Region | Freq ¹ | Region | Freq | Region | Freq | Region | Freq |
|----------------|-------------------|-------------------|------|------------------|------|----------------------|-------------|
| 1 USA | 359 | 21 Denmark | 17 | 41 Pakistan | 7 | 61 Cambodia | 2 |
| 2 UK | 212 | 22 South Africa | 17 | 42 Nigeria | 6 | 62 Ecuador | 2 |
| 3 Italy | 160 | 23 Finland | 16 | 43 Slovakia | 6 | 63 Ethiopia | 2 |
| 4 Spain | 121 | 24 Austria | 15 | 44 Vietnam | 6 | 64 Ghana | 2 |
| 5 Germany | 100 | 25 Malaysia | 15 | 45 Bangladesh | 5 | 65 Yemen | 2 |
| 6 Sweden | 89 | 26 Romania | 14 | 46 Macedonia | 5 | 66 Argentina | 1 |
| 7 Canada | 65 | 27 Colombia | 13 | 47 Singapore | 5 | 67 Bulgaria | 1 |
| 8 China | 58 | 28 Switzerland | 13 | 48 Slovenia | 5 | 68 Costa rica | 1 |
| 9 Portugal | 57 | 29 Mexico | 12 | 49 Croatia | 4 | 69 Georgia | 1 |
| 10 France | 43 | 30 Russia | 11 | 50 Hungary | 4 | 70 Jordan | 1 |
| 11 Belgium | 41 | 31 Ukraine | 11 | 51 Lithuania | 4 | 71 Kazakhstan | 1 |
| 12 Brazil | 40 | 32 Greece | 10 | 52 Saudi Arabia | 4 | 72 Kosovo | 1 |
| 13 Australia | 37 | 33 Israel | 10 | 53 Serbia | 4 | 73 Kuwait | 1 |
| 14 India | 33 | 34 South Korea | 10 | 54 Thailand | 4 | 74 Latvia | 1 |
| 15 Netherlands | 32 | 35 Turkey | 10 | 55 Belarus | 3 | 75 Luxembourg | 1 |
| 16 Ireland | 28 | 36 New zealand | 9 | 56 Cyprus | 3 | 76 Malta | 1 |
| 17 Poland | 28 | 37 Indonesia | 8 | 57 Estonia | 3 | 77 Oman | 1 |
| 18 Iran | 24 | 38 Chile | 7 | 58 Lebanon | 3 | 78 Zambia | 1 |
| 19 Japan | 23 | 39 Czech republic | 7 | 59 Liechtenstein | 3 | 79 N ão identificado | 1 |
| 20 Norway | 18 | 40 Egypt | 7 | 60 Morocco | 3 | | |
| Total | | | | | | | 1911 |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix.

Authors/ Country Scientific Production. ¹Frequency.

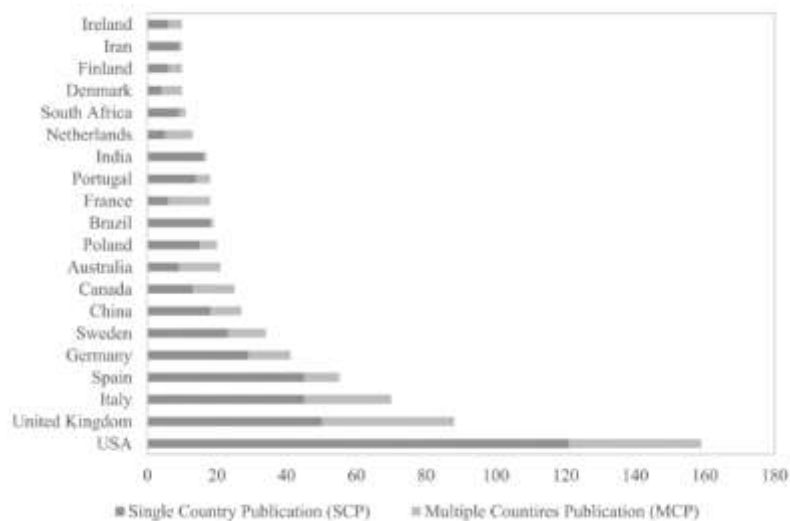


Figure 5. Number of articles on AE published as Single Country Publication and Multiple Countries Publication , WoS database

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix. *Authors/Corresponding Author's Country.*

Mapping the top best-cited publications, in terms of global citations, 6 from the 848 articles selected had over 500 citations: *Competing models of entrepreneurial intentions* (Krueger et al., 2000), *International entrepreneurship: the intersection of two research paths* (McDougall & Oviatt, 2000), *Research groups as 'quasi-firms': The invention of the entrepreneurial university* (Etzkowitz, 2003), *Research in social entrepreneurship: past contributions and future opportunities*, *Science as a map in technological search* (Fleming & Sorenson, 2004) *The chronology and intellectual trajectory of American entrepreneurship education: 1876–1999* (Katz, 2003) (Table 14).

Table 13. Most Cited Countries on AE, WoS database

| | Country | TC ¹ | AAC ² | Part. ³ | | Country | TC | AAC | Part. |
|----|-------------|-----------------|------------------|--------------------|----|----------------|----|------|-------|
| 1 | U S A | 11106 | 69.8 | 42.7% | 21 | Malaysia | 93 | 9.3 | 0.4% |
| 2 | U K | 3238 | 36.8 | 12.4% | 22 | Poland | 82 | 4.1 | 0.3% |
| 3 | Italy | 1634 | 23.3 | 6.3% | 23 | Liechtenstein | 64 | 64.0 | 0.2% |
| 4 | Sweden | 1268 | 37.3 | 4.9% | 24 | India | 61 | 3.6 | 0.2% |
| 5 | Spain | 1203 | 21.9 | 4.6% | 25 | Brazil | 59 | 3.1 | 0.2% |
| 6 | Canada | 1160 | 46.4 | 4.5% | 26 | Switzerland | 56 | 9.3 | 0.2% |
| 7 | Germany | 1000 | 24.4 | 3.8% | 27 | Romania | 52 | 5.8 | 0.2% |
| 8 | Ireland | 740 | 74.0 | 2.8% | 28 | Korea | 42 | 8.4 | 0.2% |
| 9 | Norway | 728 | 104.0 | 2.8% | 29 | Colombia | 40 | 8.0 | 0.2% |
| 10 | Belgium | 571 | 71.4 | 2.2% | 30 | South Africa | 38 | 3.5 | 0.1% |
| 11 | Australia | 533 | 25.4 | 2.0% | 31 | Georgia | 33 | 16.5 | 0.1% |
| 12 | France | 300 | 16.7 | 1.2% | 32 | Greece | 32 | 8.0 | 0.1% |
| 13 | Finland | 299 | 29.9 | 1.1% | 33 | Iran | 30 | 3.0 | 0.1% |
| 14 | Portugal | 274 | 15.2 | 1.1% | 34 | Pakistan | 27 | 5.4 | 0.1% |
| 15 | Israel | 201 | 33.5 | 0.8% | 35 | Malta | 26 | 26.0 | 0.1% |
| 16 | Netherlands | 196 | 15.1 | 0.8% | 36 | Belarus | 25 | 25.0 | 0.1% |
| 17 | Denmark | 155 | 15.5 | 0.6% | 37 | Egypt | 25 | 5.0 | 0.1% |
| 18 | China | 148 | 5.5 | 0.6% | 38 | Macedonia | 25 | 8.3 | 0.1% |
| 19 | Chile | 114 | 22.8 | 0.4% | 39 | Austria | 23 | 3.3 | 0.1% |
| 20 | New Zealand | 109 | 27.3 | 0.4% | 40 | Czech Republic | 22 | 4.4 | 0.1% |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix.

Authors/Most Cited Countries. ¹Total citations; ²**Average Article Citations**; ³% of participation.

Table 14. Most Global Cited Documents on AE, WoS database

| | Paper | TC ¹ | TC per Year | Normalized TC |
|----|--------------------------------------|-----------------|-------------|---------------|
| 1 | Krueger N F., 2000. J Bus Venturing | 1765 | 80.227 | 2.9261 |
| 2 | Mcdougall P P., 2000. Acad Manage J | 773 | 35.136 | 1.2815 |
| 3 | Etzkowitz H., 2003. Res Policy | 685 | 36.053 | 2.9847 |
| 4 | Short J. C., 2009. Strateg Entrep J | 542 | 41.692 | 5.5972 |
| 5 | Fleming L., 2004. Strategic Manage J | 533 | 29.611 | 2.2617 |
| 6 | Katz J. A., 2003. J Bus Venturing | 501 | 26.368 | 2.1830 |
| 7 | Martin B. C., 2013. J Bus Venturing | 409 | 45.444 | 8.8273 |
| 8 | Bercovitz J., 2008. Organ Sci | 404 | 28.857 | 3.8339 |
| 9 | Gulbrandsen M., 2005. Res Policy | 381 | 22.412 | 1.9677 |
| 10 | Grimaldi R., 2011. Res Policy | 368 | 33.455 | 4.3610 |
| 11 | Powers J B., 2005. J Bus Venturing | 319 | 18.765 | 1.6475 |
| 12 | Linan F., 2015. Int Entrep Manag J | 310 | 44.286 | 14.0909 |
| 13 | George G., 2011. Entrep Theory Pract | 308 | 28.000 | 3.6500 |
| 14 | Robinson P B., 1994. J Bus Venturing | 299 | 10.679 | 1.0000 |
| 15 | Klofsten M., 2000. Small Bus Econ | 284 | 12.909 | 0.4708 |
| 16 | Jain S., 2009. Res Policy | 280 | 21.538 | 2.8916 |
| 17 | Mosey S., 2007. Entrep Theory Pract | 277 | 18.467 | 2.2190 |
| 18 | Etzkowitz H., 2005. R&D Manage | 259 | 15.235 | 1.3376 |
| 19 | Goldfarb B., 2003. Res Policy | 258 | 13.579 | 1.1242 |
| 20 | Crane A., 2014. Calif Manage Rev | 254 | 31.750 | 5.9251 |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix. *Documents/Most Global Cited Documents*. ¹Total Citations.

As in terms of local citations in the collection, the highest scores, with over 40 citations were from *Academic entrepreneurs: organizational change at the individual level* (Bercovitz & Feldman, 2008), *30 years after Bayh-Dole: reassessing academic entrepreneurship* (Grimaldi et al., 2011), *Competing models of entrepreneurial intentions* (Krueger et al., 2000), *Comparing Academic Entrepreneurship in Europe - The Case of Sweden and Ireland* (Klofsten & Jones-Evans, 2000) *Research groups as 'quasi-firms': the invention of the entrepreneurial university* (Etzkowitz, 2003), *University start-up formation and technology licensing with firms that go public: a resource-based view of academic entrepreneurship* (Powers & McDougall, 2005), *From human capital to social capital: a longitudinal study of technology-based academic entrepreneurs* (Mosey & Wright, 2007), *Academic entrepreneurship: time for a rethink?* (Siegel & Wright, 2015) (Table 15).

Table 15. Most Cited Articles on AE collection, WoS database

| | Paper | Year | LC | GC | LC/GC (%) | NLC ¹ | NGC ² |
|----|-------------------------------------|------|----|------|-----------|------------------|------------------|
| 1 | Bercovitz J., 2008. Organ Sci | 2008 | 72 | 404 | 17.82 | 6.19 | 3.83 |
| 2 | Grimaldi R., 2011. Res Policy | 2011 | 60 | 368 | 16.30 | 5.84 | 4.36 |
| 3 | Krueger N F., 2000. J Bus Venturing | 2000 | 49 | 1765 | 2.78 | 2.09 | 2.93 |
| 4 | Klofsten M., 2000. Small Bus Econ | 2000 | 49 | 284 | 17.25 | 2.09 | 0.47 |
| 5 | Etzkowitz H., 2003. Res Policy | 2003 | 48 | 685 | 7.01 | 2.61 | 2.98 |
| 6 | Powers J B., 2005. J Bus Venturing | 2005 | 47 | 319 | 14.73 | 4.18 | 1.65 |
| 7 | Mosey S., 2007. Entrep Theory Pract | 2007 | 44 | 277 | 15.88 | 3.07 | 2.22 |
| 8 | Siegel D S., 2015. Brit J Manage | 2015 | 44 | 184 | 23.91 | 31.06 | 8.36 |
| 9 | Clarysse B., 2011. Res Policy | 2011 | 39 | 179 | 21.79 | 3.80 | 2.12 |
| 10 | Lockett A., 2003. Small Bus Econ | 2003 | 37 | 240 | 15.42 | 2.01 | 1.05 |
| 11 | Jain S., 2009. Res Policy | 2009 | 37 | 280 | 13.21 | 4.90 | 2.89 |
| 12 | Kenney M., 2004. Res Policy | 2004 | 35 | 192 | 18.23 | 2.19 | 0.81 |
| 13 | Haeussler C., 2011. Res Policy | 2011 | 32 | 137 | 23.36 | 3.12 | 1.62 |
| 14 | Murray F., 2004. Res Policy | 2004 | 30 | 247 | 12.15 | 1.88 | 1.05 |
| 15 | Abreu M., 2013. Res Policy | 2013 | 30 | 169 | 17.75 | 9.53 | 3.65 |
| 16 | Fini R., 2011. Res Policy | 2011 | 29 | 149 | 19.46 | 2.82 | 1.77 |
| 17 | Gulbrandsen M., 2005. Res Policy | 2005 | 28 | 381 | 7.35 | 2.49 | 1.97 |
| 18 | Wennberg K., 2011. Res Policy | 2011 | 28 | 153 | 18.30 | 2.73 | 1.81 |
| 19 | Krabel S., 2009. Res Policy | 2009 | 25 | 125 | 20.00 | 3.31 | 1.29 |
| 20 | Shane S., 2004. J Bus Venturing | 2004 | 23 | 203 | 11.33 | 1.44 | 0.86 |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix.

Documents/Most Local Cited Documents. Local Citation; \bar{G} Global Citation.

With 37588 references identified over the 848 records imported from WoS, 8 references stood out with 60 or more citations: *A general theory of entrepreneurship: the individual-opportunity nexus* (Shane, 2003), *University entrepreneurship: a taxonomy of the literature* (Rothaermel et al., 2007), *The promise of entrepreneurship as a field of research* (Shane & Venkataraman, 2000), *Why do some universities generate more start-ups than others?* (di Gregorio & Shane, 2003), *Academic entrepreneurs: organizational change at the individual level* (Bercovitz & Feldman, 2008), *Entrepreneurial orientation, technology transfer and spinoff performance of U. S. universities* (O'Shea et al., 2005), *Resources, capabilities, risk capital, and the creation of university spin-out companies* (Lockett & Wright, 2005), *30 years after Bayh-Dole: reassessing academic entrepreneurship* (Grimaldi et al., 2011) (Table 16).

Table 16. Most Local Cited References on AE collection, WoS database

| | Cited References | Citations | | Cited References | Citations |
|----|----------------------------|-----------|----|------------------------------|-----------|
| 1 | Shane, 2003 | 109 | 11 | Stuart & Ding, 2006 | 56 |
| 2 | Rothaermel et al., 2007 | 102 | 12 | Vohora et al., 2004 | 54 |
| 3 | Shane & Venkataraman, 2000 | 81 | 13 | Etzkowitz et al., 2000 | 53 |
| 4 | di Gregorio & Shane, 2003 | 79 | 14 | Ajzen, 1991 | 51 |
| 5 | Bercovitz & Feldman, 2008 | 72 | 15 | Siegel et al., 2003 | 50 |
| 6 | O'Shea et al., 2005 | 66 | 16 | Klofsten & Jones-Evans, 2000 | 49 |
| 7 | Lockett & Wright, 2005 | 63 | 17 | Krueger et al., 2000 | 49 |
| 8 | Grimaldi et al., 2011 | 60 | 18 | Lumpkin & Dess, 1996 | 49 |
| 9 | Perkmann et al., 2013 | 59 | 19 | Etzkowitz, 2003 | 48 |
| 10 | Eisenhardt, 1989 | 58 | 20 | Jensen & Thursby, 2001 | 47 |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix. *Documents/Most Local Cited References.*

Concerning the Most Frequent Words, it was noted that using the keyword 'academic entrepreneurship' in the basic search on the field 'Title, Abstracts, Author's keywords and Keywords Plus®', there was a single occurrence in the abstract and no occurrence in titles. The 10 most frequent words in *Author's Keywords* were: *entrepreneurship*, *academic entrepreneurship*, *innovation*, *technology transfer*, *social entrepreneurship*, *entrepreneurship education*, *entrepreneurial university*, *university*, *higher education*, *entrepreneurial orientation*, and *entrepreneurship*, which the first and second ones appeared 176 and 135 times, respectively (Table 17). In the Keywords Plus® field, the 10 Most Frequent Words were *performance*, *entrepreneurship*, *innovation*, *knowledge*, *impact*, *firms*, *Science*, *technology-transfer*, *university*, and *academic entrepreneurship*, which AE appeared in the 10^o position with 58 times. Therefore, the analysis indicates that AE is part of a major subject, entrepreneurship, and is often associated with performance, innovation, technology transfer, knowledge, university, education, and others (Figure 6). In addition, it should be pointed the KeyWords Plus®: management (55), model (51) and commercialization (49), as words references used to analyze the results of this work.

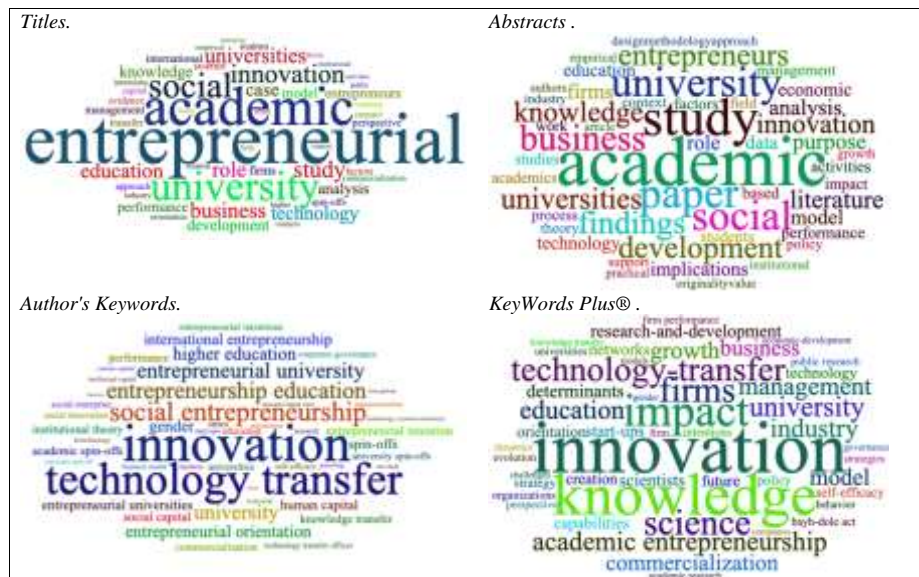


Figure 6. Top words in Titles, Abstracts, Author's Keywords, and KeyWords Plus®, represented by Word Cloud, WoS database

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix. Documents/ **Word Cloud**.

Table 17. Most Frequent Words in the AE literature over the years, WoS database

| N | Author's keywords | Oc. ¹ | N | KeyWords Plus® | Oc. |
|----|--------------------------------|------------------|----|---------------------------|-----|
| 1 | entrepreneurship | 176 | 1 | performance | 195 |
| 2 | academic entrepreneurship | 135 | 2 | entrepreneurship | 166 |
| 3 | innovation | 58 | 3 | innovation | 156 |
| 4 | technology transfer | 50 | 4 | knowledge | 127 |
| 5 | social entrepreneurship | 30 | 5 | impact | 98 |
| 6 | entrepreneurship education | 26 | 6 | firms | 77 |
| 7 | entrepreneurial university | 24 | 7 | science | 77 |
| 8 | university | 23 | 8 | technology-transfer | 74 |
| 9 | higher education | 20 | 9 | university | 61 |
| 10 | entrepreneurial orientation | 19 | 10 | academic entrepreneurship | 58 |
| 11 | gender | 18 | 11 | education | 57 |
| 12 | international entrepreneurship | 17 | 12 | industry | 57 |
| 13 | entrepreneurial universities | 15 | 13 | management | 55 |
| 14 | human capital | 15 | 14 | growth | 52 |
| 15 | spin-offs | 15 | 15 | model | 51 |
| 16 | entrepreneurial intention | 14 | 16 | business | 50 |
| 17 | social capital | 14 | 17 | commercialization | 49 |
| 18 | academic spin-offs | 13 | 18 | determinants | 40 |
| 19 | institutional theory | 13 | 19 | research-and-development | 38 |
| 20 | knowledge transfer | 13 | 20 | scientists | 38 |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix.

Documents/Most Frequent Words/Author's Keywords. ¹Occurrences.

The investigation of dynamics in the use of words related to AE, within the retrieved articles by using the keyword academic entrepreneurship, allowed us to link the frequency of words and the discussion development over time. The word *management* was first used in 2005 and has two peak moments, in articles produced in 2015 and 2019; the words *model* or *models* first appeared in 2004 and had a maximum peak in 2019, although they were still high in 2020 productions; the word *commercialization*, that was early used in 2010 and keep growing ever since, reaching 9 articles in 2020 (Figure 7). Therefore, could be identified the recent discussion on AE and issues related to management models and their commercialization.



Figure 7. Frequency of words associated with AE, WoS database

Source: Elaborado pelo autor. dados gerados no biblioshiny for bibliometrix. Documents/Word Dynamics/Field – Keywords Plus

In the investigation of the tendency of the most discussed topics in the last 10 years (2011-2010), it was detected as the most used keywords by the authors, minimum frequency of 5 occurrences: start-up and academic spin-offs in 2020, academic spin-offs in 2017, academic entrepreneurship and spin-offs in 2016, commercialization in 2014 (Table 18).

Table 18. *Trend Topics* in the Academic entrepreneurship literature over the years, WoS database

| Item | Freq | Year | Item | Freq | Year |
|--------------------------------|------|------|-----------------------------|------|------|
| patenting | 7 | 2011 | spin-offs | 15 | 2016 |
| entrepreneurialism | 7 | 2012 | entrepreneurship | 176 | 2017 |
| licensing | 6 | 2012 | academic spin-offs | 13 | 2017 |
| university-industry relations | 6 | 2012 | education | 11 | 2017 |
| biotechnology | 7 | 2013 | smes | 11 | 2017 |
| intellectual property rights | 5 | 2013 | innovation | 58 | 2018 |
| commercialization | 12 | 2014 | social entrepreneurship | 30 | 2018 |
| corporate governance | 10 | 2014 | entrepreneurship education | 26 | 2018 |
| born globals | 6 | 2014 | entrepreneurial orientation | 19 | 2019 |
| technology transfer | 50 | 2015 | knowledge transfer | 13 | 2019 |
| human capital | 15 | 2015 | performance | 13 | 2019 |
| r&d | 6 | 2015 | start-ups | 8 | 2020 |
| academic entrepreneurship | 135 | 2016 | entrepreneurial education | 6 | 2020 |
| international entrepreneurship | 17 | 2016 | academic spinoffs | 5 | 2020 |
| entrepreneurial universities | 15 | 2016 | knowledge translation | 5 | 2020 |

Source: Elaborated by the authors from data generated by biblioshiny for bibliometrix. Documents/ *Trend Topics*/Field – Keywords Plus.

A set of studies were selected according to the described by Tricco (2018, p. 2), evaluated for eligibility, and included in the review, which the reasons for exclusions at each stage are illustrated as a flowchart in Figure 8. The aim of the 112 articles was examined considering the data extracted from the fields: AU-Authors, TI-Document Title, DE-Author Keywords, ID-Keywords Plus®, AB-Abstract, PY-Year Published. Then, among them, it was identified models that deal with the development of entrepreneurship in the academic environment, whereas no models for evaluating intellectual property as products to be commercialized were found. Else, it was noted objectives related to the role of resources (physical, human and managerial) available at the university to collaborate with the development of entrepreneurship activities, the role of technology transfer offices, the training of professors, and the commercialization capacity necessary to generate economic resources for both university and professors. The results were aggregated by the contribution of each author in the comprehension of the themes: (1) model development, (2) management, and (3) commercialization of intellectual property (Table 19).

4. Conclusion

Through this literature review, within the documents available on *Web of Science* database and covering the whole period up to 2020, it was possible to verify that the main objectives of the selected studies on academic entrepreneurship are related to the analysis of resources, human (training, leadership, and motivation), physical and management.

The models found in the scientific articles were mainly related to the assessment of entrepreneurship development in the academic environment, then it was identified a gap for models that evaluate intellectual property as products to be commercialized, being, therefore, pointed as a research opportunity. Also, it was detected indication of research space to develop models to evaluate the intellectual property registered in technology transfer offices, as a basis for products to be commercialized.

Table 19. Analysis of articles' objectives on AE retrieved from the WoS base

| Subject | Article | Objective |
|--|--|--|
| 1. Models development | Krueger et al., 2000 | Compares two intention-based models in terms of their ability to predict entrepreneurial intentions |
| | Etzkowitz & Klofsten, 2005 | Sets forth a model of knowledge-based regional development conceived as a set of multi-linear dynamics, based on alternative technological paradigms |
| | O'Shea et al., 2007 | Develop a systematic model of the entrepreneurial university |
| | Kirby et al., 2011 | Development of a model to make universities more entrepreneurial |
| | George & Bock, 2011 | Review prior research and reframe the business model with an entrepreneurial lens |
| 2. Management | Guerrero et al., 2016 | Improve the understanding of the theoretical, empirical, managerial and political implications of emerging models of entrepreneurial universities in the new social and economic landscape |
| | Heaton et al., 2019 | Propose the dynamic capabilities framework to guide how universities might manage their innovation ecosystems |
| 3. Intellectual property commercialization | Klofsten & Jones-Evans, 2000 | Examine the activities of academics involved with industry and the influence of gender, age, previous entrepreneurial experience, work experience and university environment on the entrepreneurship activities; and discuss and contrast the extent to which academic entrepreneurship has developed. |
| | Goldfarb & Henrekson, 2003 | Evaluate the efficiency of national policies in promoting the commercialization of university-generated knowledge |
| | Shane, 2004 | Examine the effect of one U.S. public policy initiative (the Bayh-Dole Act in the U.S.) on one aspect of technology commercialization (university patenting) |
| | Powers & McDougall, 2005 | Investigate the effects of particular internal and external resource factors on the performance of universities |
| | Toole & Czarnitzki, 2009 | Analyze how the depth of the scientists' scientifically and commercially oriented academic human capital contributes to the firm performance when they start or join for-profit firms |
| | Grimaldi et al., 2011 | Describe the evolving role of universities in the commercialization of research considering the rationale for academic entrepreneurship on the 30th anniversary of enactment of the Bayh-Dole Act in the U.S. and discuss and appraise the effects of legislative reform in several OECD countries relating to academic entrepreneurship |
| | Buenstorf & Geissler, 2012) - | Explore the way in which inventor, technology, and licensee characteristics affect the commercialization of academic inventions |
| | Buenstorf & Schacht, 2013 | Analyze how the probability and magnitude of commercial success are affected by geographic distance between licensors and licensees |
| | O'Kane et al., 2017 | Examine what factors publicly funded principal investigators perceive as inhibiting their involvement in commercialization activities |
| | Fini et al., 2018 | Outlines a research agenda on the societal impacts of science commercialization by extending current theories, data, and methods and exploring the need to consider ethical concerns and who is benefiting from these impacts. |
| | Fini et al., 2019 | Shows how research on science commercialization may yield conceptual contributions to the field of management |

Source: Elaborated by the authors

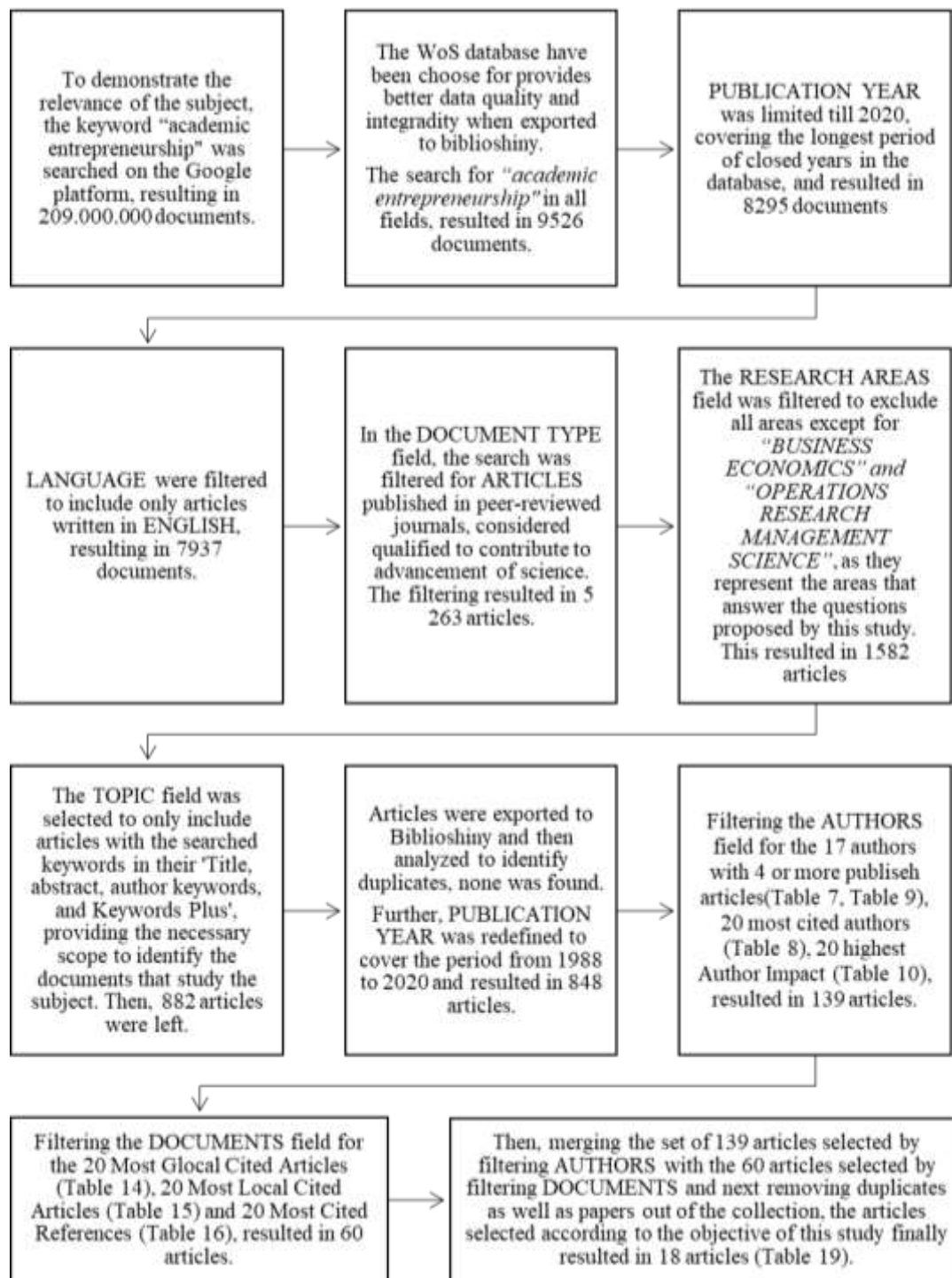


Figure 8. Flowchart of studies selected, evaluated for eligibility and included in the review ¹

Source: Elaborated by the authors. ¹Each flowchart step indicates the reasons for document exclusions considering the systematic literature review on academic entrepreneurship.

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