Bibliometric analysis of innovation in Mexico

Abstract

This article aims to use bibliometric techniques to analyze the production of scientific documents related to innovation research carried out in the territory of Mexico. The study focuses on a period of thirty-eight years, from 1980 to 2019. Knowing the direction that innovation takes in Mexico during this period is what motivates its implementation. The main source of information for this study is the "Web of Science" database. The results show an exponential increase in publications starting in 2010, with the participation of Spanish- or English-speaking authors; more research on innovation in the areas of health; the adoption of a broader concept of innovation; and language as a limiting factor for collaborations.

Key Words: Bibliometrics, Innovation, Mexico, Web of Science.

JEL codes: O32, Y10, Z00

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Análisis bibliométrico de la innovación en México

Resumen
Este artículo tiene como objetivo utilizar técnicas bibliométricas para analizar la producción de documentos científicos relacionados a la investigación en innovación realizada en el territorio de México. El estudio se enfoca en un periodo de treinta y ocho años, comprendido desde el año 1980 a 2019. Conocer la dirección que toma la innovación en México durante este periodo es lo que motiva su realización. La principal fuente de información de este estudio es la base de datos "Web of Science". Los resultados muestran un aumento exponencial en las publicaciones a partir del año 2010, con participación de autores de habla hispana o inglesa; mayor investigación sobre innovación en las áreas de la salud, la adopción de un concepto más amplio de innovación y el idioma como limitante para realizar colaboraciones.

Palabras Clave: Bibliometría, Innovación, México, Web of Science.

Códigos JEL: O32, Y10, Z00

1. INTRODUCCIÓN

Currently, one of the factors to which the economic growth of countries is linked is innovation, arising from its new products that are generated, or different or more efficient uses that are found for products that already exist (Independent Evaluation Group, 2013). Over time, the interest of researchers in innovation has been reflected not only in the increase in research centers for new products, but also in the increase in scientific articles published on the subject (Cancino et al., 2017). Similarly, other types of innovation have been formally considered, including process, marketing and organizational innovation. Currently, innovation is understood as a “new or improved product or process (or a combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or positions in use by the unit (process)”. (OECD/Eurostat, 2018). As the subject of innovation acquires more importance for the growth of nations, it is necessary to know more about the trends of researchers’ works. Although there are currently published works on the subject (Cancino et al., 2017; Fagerberg et al., 2012; Linton, 2004; Shañque, 2013; Yang and Tao, 2012), they do not perform individual analyses on development of research on the subject of innovation in Mexico.

This article aims to apply bibliometric tools to analyze the development of research on innovation in Mexico to observe its evolution over time, trends and key information on productivity and the influence of the various actors linked to the subject. The period covered for this study ranges from 1980 to 2018, considering the scientific articles contained in the "Web of Science" database, with the search performed with the word "innovation", filtering only for articles, reviews, notes and letters. Finally, the search was narrowed to the country Mexico, and articles published by Mexican
authors or by foreign authors related to Mexican institutions were obtained.

In the “Methodology” section, bibliometric methods are briefly reviewed. The "Results" section presents the evolution of publications by universities, a citation structure and an analysis of universities. The “Conclusions” section summarizes the main findings and conclusions of the study.

Over time, bibliometric studies have become very common in the literature, since through the application of mathematics and statistics, quantitative studies of bibliographic units published physically or electronically are carried out to understand the nature and course of a discipline (Broadus, 1987; Cancino et al., 2017; Prithchard, 1969).

However, over time, bibliometric studies have been used to explore, organize and analyze large amounts of historical information to find patterns that can help researchers to make decisions to understand previously analyzed information in different disciplines, including several in the area of economics (Bonilla et al., 2015; Carvalho et al., 2013; Chun-Hao and Jian-Min, 2012; Daim et al., 2006; Neely, 2005; Wagstaff and Culyer, 2012).

Specifically concerning innovation research, it is already possible to find studies that have based their analysis on bibliometric methodologies (Martin, 2012). Around the world, though the topic was previously overlooked, networks of researchers are now interacting and collaborating on innovation research. One of the recent studies belongs to Cancino et al., (2017). In their results, they show a greater concentration of publications on this subject from American universities, which are published in leading management magazines. In addition, Fagerberg et al., (2012) describes the increase in innovation studies from the 1950s, which is divided into three stages in which each one of them shows a different degree of evolution in field research, going from conducting studies focused on economic and social aspects to the association of specialized professionals for the development of the discipline. Now, the studies generated around the topic of innovation involve the particularities of the region and have multidisciplinary natures (Cancino et al., 2017).

2. METHODOLOGY

Some bibliometric studies have focused on counting numbers of publications, which measures the productivity of authors and universities; however, an optimal analysis implies the evaluation of the influence of groups of articles written by authors or universities through a citation analysis. The h-index is an indicator that shows the number of studies that received a certain number of citations, which allows a study to be carried out while jointly considering the parameters of the number of articles and the number of citations (Cancino et al., 2017).

The development of specialized databases such as the Web of Science (WoS) allows the acquisition of research information in a simple way, which has made bibliometric studies more popular in the literature (Merigó et al., 2015). For this work, the WoS database was used to collect information on research on innovation in Mexico, the authors and universities conducting these studies, as well as the journals that publish the studies. This tool is used due to the vast content of articles available, which are classified into 250 categories and 150 research areas (Cancino et al., 2017).
The information for this work was collected during January and February 2019, considering all the articles published in academic journals registered in the WoS. The use of WoS facilitates the curation of the information by providing filtering tools, which allow data to be obtained on indexed scientific publications with specific characteristics. This filtering allows the establishment of relationships and identification of relevant information on a research topic. The data collection process in this study was carried out as follows. Initially, the data were filtered by the word innovation; additionally, a series of filters was generated, first for a range of time between 1980 and 2018, and later limiting studies only to those with production related to Mexico, either as first authors, co-authors, Mexican universities or foreign universities with Mexican collaborators. This was achieved by choosing only "Mexico" in the filter by country option of the database. Once the required data had been obtained, the information was arranged in tables. VosViewer software was also used to graphically analyze the information through the construction of a heat map where the words are shown most frequently in the articles related to the topic of innovation and a relationship map that shows the groups of authors of articles with less than ten co-authored researchers. This process is summarized in a flow chart (Figure 1).

**Figure 1 Flow chart of the process for obtaining the results.**

![Flow chart](image)

3. Results

This section presents the results of the work. First, the behavior of publications related to Mexico on the subject of innovation was analyzed. According to the results obtained, it is observed that there has been a gradual increase in scientific production around the subject of innovation in Mexico, gaining strength from the year 2010, the year in which increases began to be noted, and a particular increase was observed from 2014 to 2018 (Figure 2). During this period of time, a total of 1749 articles were written, of which 1476 were published after 2010; however, only 22% of articles had 10 citations or more (Table 1).

The citations of the documents published during this period of time began in 1995 and reached a very high number in 2004, representing a boom in the subject within the academic field and reaching the highest number of citations during 2012.
FIGURE 2. NUMBER OF ANNUAL PUBLICATIONS IN THE WoS FROM 2010 TO 2018.

Source: Own elaboration from the information obtained in the WoS. Number of annual posts in the WoS from 2010 to 2018

TABLE 1. GENERAL STRUCTURE OF CITATIONS IN THE WoS QUANTITATIVE RESEARCH

| Citations | Full period of time | 2010-2018 |
|-----------|---------------------|-----------|
|           | Number of articles  | %Articles | Number of articles | %Articles |
| >100      | 34                  | 2%        | 16                  | 1%        |
| >50       | 74                  | 4%        | 41                  | 3%        |
| >10       | 389                 | 22%       | 256                 | 17%       |
| <10       | 1360                | 78%       | 1220                | 83%       |
| Total     | 1749                | 100%      | 1476                | 100%      |

Source: Own elaboration from the information obtained in the WoS. Citations: Base number under which the number of articles that have that number of citations are counted. Number of articles: number of articles that have the number of citations indicated in the group. % Articles: Percentage of articles that represents the number of articles contained in the indicated group.

However, according to the number of citations of the articles in proportion to the number of articles published in a year, the year 2004 had the best ratio, while there was a considerable drop in 2018.

The above shows a clear production of literature with a low level of impact within the academic world (Table 2). Among the most cited articles, it is found that most were produced after 2010 and dealt with topics in the area of natural sciences. The article with the highest number of citations was published in 2012 and currently has an average of 309 citations per year. It should be noted that most of the articles that occupy the first places on this list were written in collaboration with more than five authors, and when moving down the table, the number of collaborators is reduced to a maximum of two or three (Table 3).

Of the total articles published, the most productive authors on the subject of innovation were analyzed, and it is found that groups of authors formed research teams who continually publish together. It is also observed that only five authors reported a production greater than 10 articles, while the rest of the 25 most productive had only 8 articles on average. It is observed that the first five authors with the highest number of publications belong to the American continent, to Mexico mostly, while the next five are from the European continent.
The lack of relationship between the number of publications and the authors' h-index is shown since the author with the highest number of published articles is not the one with the highest impact index (Table 4).

Of the most productive universities, the National Autonomous University of Mexico stands out, with more than 200 articles, followed by the Tecnológico de Monterrey, with more than 100; the first is the main public university in the country, and the second is its counterpart among the private

### Table 2. Annual Analysis of Publications Related to Innovation in Mexico According to the WoS Quantitative Analysis

| Year | TP  | TC  | Avg. CP | ≥100 | ≥50 | ≥10 |
|------|-----|-----|---------|------|-----|-----|
| 1980 | 1   | 0   | 0       | 0    | 0   | 0   |
| 1991 | 1   | 0   | 0       | 0    | 0   | 0   |
| 1992 | 2   | 0   | 0       | 0    | 0   | 0   |
| 1993 | 2   | 0   | 0       | 0    | 0   | 0   |
| 1994 | 3   | 0   | 0       | 0    | 0   | 0   |
| 1995 | 4   | 89  | 22.25   | 0    | 1   | 2   |
| 1996 | 4   | 93  | 23.25   | 0    | 0   | 3   |
| 1997 | 5   | 146 | 29.20   | 1    | 0   | 3   |
| 1998 | 8   | 81  | 10.13   | 0    | 1   | 2   |
| 1999 | 8   | 83  | 10.38   | 0    | 0   | 3   |
| 2000 | 8   | 237 | 29.63   | 0    | 2   | 7   |
| 2001 | 9   | 479 | 53.22   | 2    | 0   | 4   |
| 2002 | 10  | 363 | 36.30   | 1    | 2   | 3   |
| 2003 | 16  | 949 | 59.31   | 2    | 0   | 6   |
| 2004 | 17  | 1416| 83.29   | 3    | 5   | 13  |
| 2005 | 23  | 539 | 23.44   | 2    | 3   | 11  |
| 2006 | 26  | 679 | 26.12   | 2    | 5   | 13  |
| 2007 | 35  | 870 | 24.86   | 1    | 6   | 19  |
| 2008 | 43  | 712 | 16.56   | 2    | 3   | 17  |
| 2009 | 48  | 981 | 20.44   | 2    | 5   | 27  |
| 2010 | 54  | 838 | 15.52   | 1    | 3   | 20  |
| 2011 | 75  | 1567| 20.89   | 5    | 9   | 37  |
| 2012 | 89  | 3291| 36.98   | 2    | 6   | 33  |
| 2013 | 96  | 1932| 20.13   | 5    | 7   | 31  |
| 2014 | 102 | 1470| 14.41   | 2    | 0   | 28  |
| 2015 | 201 | 1894| 9.42    | 1    | 7   | 41  |
| 2016 | 258 | 1423| 5.52    | 0    | 4   | 46  |
| 2017 | 290 | 829 | 2.86    | 0    | 4   | 15  |
| 2018 | 311 | 288 | 0.93    | 0    | 1   | 5   |
| Total| 1749| 21249| 595.01 | 34   | 74  | 389 |
| %   | 100.00% |       |         | 1.94% | 4.23% | 22.24% |

Sources: Own elaboration from the information obtained in WoS. Year: year of publication, TP: Total publications, TC: Total citations, Avg. CP: Average citations per publication.
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institutes (Table 5). Moreover, in this table, most of the universities included are Mexican; thus, it is concluded that foreign authors are those who are linked to Mexican institutions.

Table 3. The 15 most cited articles in quantitative research in the WoS.

| Title                                                                 | Author       | TC  | Year | C/Y  |
|----------------------------------------------------------------------|--------------|-----|------|------|
| 1 “Guidelines for the use and interpretation of assays for monitoring autophagy” | DJK, et al.  | 2163 | 2012 | 309.00 |
| 2 “Phylogenomics resolves the timing and pattern of insect evolution” | MB, et. al.  | 749  | 2014 | 149.80 |
| 3 “Recent advances in removing phosphorus from wastewater and its future use as fertilizer (1997-2003)” | LEB, et al.  | 717  | 2004 | 47.80 |
| 4 “Beans (Phaseolus spp.) - model food legumes” | WJB, et al.   | 533  | 2003 | 33.31 |
| 5 “The IPBES Conceptual Framework - connecting nature and people” | DS, et al.    | 383  | 2015 | 95.75 |
| 6 “A randomised, double-blind, parallel-group study to demonstrate equivalence in efficacy and safety of CT-P13 compared with innovator infliximab when coadministered with methotrexate in patients with active rheumatoid arthritis: the PLANETRA study” | DHY, et al.  | 317  | 2013 | 52.83 |
| 7 “Predicting distributions of known and unknown reptile species in Madagascar” | CJR, et al.  | 309  | 2003 | 19.31 |
| 8 “A randomised, double-blind, multicentre, parallel-group, prospective study comparing the pharmacokinetics, safety, and efficacy of CT-P13 and innovator infliximab in patients with ankylosing spondylitis: the PLANETAS study” | WP, et al.   | 293  | 2013 | 48.83 |
| 9 “The conservation status of the world’s reptiles” | BM, et al.    | 292  | 2013 | 48.67 |
| 10 “Integrating seaweeds into marine aquaculture systems: A key toward sustainability” | TC, et al.    | 282  | 2001 | 15.67 |
| 11 “Business Model Innovation through Trial-and-Error Learning The Naturhouse Case” | SM, et al.    | 238  | 2010 | 26.44 |
| 12 “Exactly integrable nonlinear Schrodinger equation models with varying dispersion, nonlinearity and gain: Application for soliton dispersion managements” | VNS, et al.  | 199  | 2002 | 11.71 |
| 13 “Transportation of heavy and extra-heavy crude oil by pipeline: A review” | RMP, et al.  | 194  | 2011 | 24.25 |
| 14 “Revision of Begomovirus taxonomy based on pairwise sequence comparisons” | JKB, et al.  | 188  | 2015 | 47.00 |
| 15 “Conservation Agriculture and Soil Carbon Sequestration: Between Myth and Farmer Reality” | GB, et al.    | 186  | 2009 | 18.60 |

Source: Own elaboration from the information obtained in the WoS. Title: article title, Author: article author, TC: Total Citations, Year: year of publication, C/Y: reason for citations per year.
## Table 4. The 50 authors with the highest production in quantitative research in the WoS

| Author                  | University | Country | TP | TC | TC ws | Avg. TC | Avg. TC ws | H | ≥100 | ≥50 | ≥10 |
|-------------------------|------------|---------|----|----|-------|---------|------------|----|------|-----|-----|
| Dutrenit G              | UAM        | MEX     | 16 | 182| 168   | 11.38   | 10.50      | 7  | 0    | 1   | 4   |
| Frenk J                 | UM         | EUA     | 12 | 164| 654   | 55.33   | 54.50      | 10 | 3    | 6   | 11  |
| Reynoso J               | ITC        | MEX     | 12 | 186| 168   | 15.50   | 14.00      | 6  | 0    | 1   | 4   |
| Castaneda-Hernandez G  | IPN        | MEX     | 11 | 73 | 65    | 6.46    | 5.91       | 5  | 0    | 0   | 2   |
| Hellín J                | CIMMYT     | MEX     | 10 | 295| 291   | 29.50   | 29.10      | 6  | 2    | 3   | 5   |
| Castano Vm              | UNAM       | MEX     | 9  | 60 | 59    | 6.67    | 6.56       | 4  | 0    | 0   | 1   |
| Bachert C               | UDG        | BEL     | 8  | 288| 267   | 36.00   | 33.38      | 8  | 0    | 2   | 7   |
| Bousquet J              | ICN2       | ESP     | 8  | 288| 267   | 36.00   | 33.38      | 8  | 0    | 2   | 7   |
| Demoly P                | UHA        | FRA     | 8  | 288| 267   | 36.00   | 33.38      | 8  | 0    | 2   | 7   |
| Kuna P                  | UL         | POL     | 8  | 288| 267   | 36.00   | 33.38      | 8  | 0    | 2   | 7   |
| Mullol J                | UB         | ESP     | 8  | 288| 267   | 36.00   | 33.38      | 8  | 0    | 2   | 7   |
| Park W                  | UI         | KOR     | 8  | 831| 817   | 103.88  | 102.13     | 6  | 2    | 5   | 6   |
| Passalacqua G           | UGEN       | ITA     | 8  | 288| 267   | 36.00   | 33.38      | 8  | 0    | 2   | 7   |
| Rosales-Mendoza S       | UASLP      | MEX     | 8  | 90 | 86    | 11.25   | 10.75      | 8  | 0    | 0   | 4   |
| Samolinski B            | UW         | POL     | 8  | 288| 267   | 36.00   | 33.38      | 8  | 0    | 2   | 7   |
| Yoo Dh                  | HYU        | KOR     | 8  | 831| 817   | 103.88  | 102.13     | 6  | 2    | 5   | 6   |
| Zermeño Mgg             | ITC        | MEX     | 8  | 0  | 0     | 0.00    | 0.00       | 0  | 0    | 0   | 0   |
| Zuberbier T             | CI         | GER     | 8  | 288| 267   | 36.00   | 33.38      | 8  | 0    | 2   | 7   |
| Aguilar-Avilá J         | CIESTAAM   | MEX     | 7  | 24 | 20    | 3.43    | 2.86       | 2  | 0    | 0   | 1   |
| Canonica Gw             | IUHI       | ITA     | 7  | 277| 261   | 39.57   | 37.29      | 7  | 0    | 2   | 6   |
| Chavannes Nh            | RUL        | NLD     | 7  | 275| 259   | 39.29   | 37.00      | 7  | 0    | 2   | 6   |
| Cruz Aa                 | UFB        | BRA     | 7  | 275| 259   | 39.29   | 37.00      | 7  | 0    | 2   | 6   |
| Fonseca J               | UPORTO     | PRT     | 7  | 275| 259   | 39.29   | 37.00      | 7  | 0    | 2   | 6   |
| Gil-Garcia Jr           | CIDÉ       | MEX     | 7  | 142| 141   | 20.29   | 20.14      | 4  | 1    | 0   | 2   |
| Husted Bw               | ITC        | MEX     | 7  | 218| 217   | 31.14   | 31.00      | 4  | 1    | 1   | 3   |
| Iqbal Hmn               | ITC        | MEX     | 7  | 121| 118   | 17.29   | 16.86      | 3  | 0    | 1   | 2   |
| Klimek L                | CRA        | GER     | 7  | 243| 228   | 34.71   | 32.57      | 7  | 0    | 2   | 6   |
| Knaul Fm                | HU         | MEX     | 7  | 362| 359   | 51.71   | 51.29      | 6  | 1    | 3   | 6   |
| Lozano R                | INSP       | MEX     | 7  | 211| 211   | 30.14   | 30.14      | 5  | 1    | 2   | 4   |
| Muraro A                | UP         | ITA     | 7  | 279| 263   | 39.86   | 37.57      | 7  | 0    | 2   | 7   |
| Price D                 | ABERD      | GBR     | 7  | 277| 261   | 39.57   | 37.29      | 7  | 0    | 2   | 6   |
| Sheikh A                | EDIN       | GBR     | 7  | 277| 261   | 39.57   | 37.29      | 7  | 0    | 2   | 6   |
| Valulis A               | VU         | LTU     | 7  | 275| 259   | 39.29   | 37.00      | 7  | 0    | 2   | 6   |
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| # | Name                  | University | Country | TP | TC | TC ws | Avg. TC | Avg. TC ws |
|---|----------------------|------------|---------|----|----|-------|---------|------------|
| 34 | Valovirta E         | UTU        | FIN     | 7  | 275| 259   | 39.29   | 37.00      |
| 35 | Wickman M           | UU         | SWE     | 7  | 275| 259   | 39.29   | 37.00      |
| 36 | Arnavelhe S         | KYOINN     | FRA     | 6  | 199| 187   | 33.17   | 31.17      |
| 37 | Bedbrook A          | UMONTE     | FRA     | 6  | 199| 187   | 33.17   | 31.17      |
| 38 | Bergmann Kc         | HUB        | GER     | 6  | 199| 187   | 33.17   | 31.17      |
| 39 | Bewick M            | IQ4U       | GRB     | 6  | 167| 155   | 27.83   | 25.83      |
| 40 | Custovic A          | UMAN       | GRB     | 6  | 167| 155   | 27.83   | 25.83      |
| 41 | De Fuentes C        | MSMU       | CAN     | 6  | 118| 113   | 19.67   | 18.83      |
| 42 | De Sousa Jc         | UMI        | PRT     | 6  | 230| 219   | 38.33   | 36.50      |
| 43 | Devillier P         | UFR        | FRA     | 6  | 201| 189   | 33.50   | 31.50      |
| 44 | Fokkens Wj          | KYOINN     | FRA     | 6  | 199| 187   | 33.17   | 31.17      |
| 45 | Hahtaeta T          | HY         | FIN     | 6  | 199| 187   | 33.17   | 31.17      |
| 46 | Hellings Pw         | UCL        | BEL     | 6  | 167| 155   | 27.83   | 25.83      |
| 47 | Just J              | APHP       | FRA     | 6  | 167| 155   | 27.83   | 25.83      |
| 48 | Keil T              | FUB        | GER     | 6  | 199| 187   | 33.17   | 31.17      |
| 49 | Larenas-Linnemann D | CEAA       | MEX     | 6  | 288| 267   | 48.00   | 44.50      |
| 50 | Lee Sj              | SNU        | KOR     | 6  | 713| 706   | 118.83  | 117.67     |

Source: Own elaboration from the information obtained in WoS. University: University to which the author belongs (U.), Country: Country of collaboration of the author, TP: Total articles published, TC: Total citations published, TC ws: Total citations without self-citations, Avg. TC: Reason of total citations per article, Avg. TC ws: Ratio of total citations without self-citation H: h-index. APHP: Paris Public Assistance Hospital, CEAA: Center for Asian and African Studies, CI: Cumberland Infirmary, CID: Center for Economic Research and Teaching, CIESTAAM: Center for Economic, Social and Economic Research Technologies of Agribusiness and World Agriculture, CIMMYT: International Maize and Wheat Improvement Center, CRA: Clinical Research Association, EDIN: University of Edinburgh, FUB: Free University of Berlin, HABERD: University of Aberdeen, HU: Harvard University, HUB: University of Humbolt, HY: Hanyang University, ICN2: Catalan Institute of Nanoscience and Nanotechnology, INS: National Institute of Public Health, IPN: National Polytechnic Institute, IQ4U: IQ4U Consultores, ITESM: Technological and Higher Studies Institute of Monterrey, IUHI: Instituto Universitario Hospital Italiano, KYOINN: KYomed Innovation, MSMU: Mount St. Mary’s University, RUL: University of Leiden, SNU: National University 1 of Seoul, UAM: Metropolitan Autonomous University, UASLP: Autonomous University of San Luis Potosí, UB: University of Barcelona, UCL: Catholic University of Leuven, UDG: University of Genth, UFB: Federal University of Brazil, UFR: University of Paris - Sclay, UGEN: University of Genoa, UHA: Humanist University of the Americas, UI: INHA University, UJ: University of Lodz, UM: University of Michigan, UMAN: University of Manchester, UMI: University of Milão, UMONTE: University of Montpellier, UNAM: National Autonomous University of Mexico, UP: University of Padua, UPORTO: University of Porto, UTU: University of TURKU, UU: University of Uppsala, UW: University of Warsaw, VU: University of Vilna.
### Table 5. The 44 Universities with the Highest Production in Quantitative Research in the WoS.

| Institution | Country | TP  | TC  | H   | C/P | ≥100 | ≥50  | ≥25 | ARWU 2018 | QS 2018 |
|-------------|---------|-----|-----|-----|-----|------|------|-----|-----------|---------|
| 1 UNAM      | MEX     | 266 | 3567| 23  | 13.41 | 5    | 13   | 23  | 201-300   | 122     |
| 2 ITESM     | MEX     | 139 | 855 | 13  | 6.15  | 2    | 3    | 9   | -         | 199     |
| 3 IPN       | MEX     | 84  | 2563| 10  | 30.51 | 1    | 2    | 4   | -         | 651-700 |
| 4 UDEG      | MEX     | 56  | 975 | 9   | 17.41 | 1    | 2    | 2   | -         | 801-1000|
| 5 UAEM      | MEX     | 46  | 318 | 9   | 6.91  | 1    | 0    | 5   | -         | 801-1001|
| 6 UASLP     | MEX     | 33  | 312 | 9   | 9.45  | 0    | 1    | 3   | -         | -       |
| 7 UABC      | MEX     | 31  | 338 | 5   | 10.90 | 1    | 1    | 1   | -         | -       |
| 8 NIPH      | MEX     | 28  | 433 | 11  | 15.46 | 1    | 3    | 4   | -         | -       |
| 9 UANL      | MEX     | 28  | 265 | 10  | 9.46  | 0    | 0    | 3   | -         | 801-1000|
| 10 INSP     | MEX     | 27  | 310 | 9   | 11.48 | 0    | 2    | 4   | -         | -       |
| 11 UAM      | MEX     | 24  | 79  | 4   | 3.29  | 0    | 0    | 0   | -         | 751-800 |
| 12 UG       | MEX     | 23  | 80  | 5   | 3.47  | 0    | 0    | 0   | -         | -       |
| 13 UADY     | MEX     | 22  | 160 | 5   | 7.27  | 0    | 1    | 3   | -         | -       |
| 14 USP      | BRA     | 21  | 3401| 12  | 161.95| 4    | 8    | 9   | 151-200   | 121     |
| 15 UV       | MEX     | 21  | 87  | 6   | 4.14  | 0    | 0    | 0   | -         | -       |
| 16 UAMI     | MEX     | 19  | 132 | 5   | 6.94  | 0    | 1    | 1   | -         | -       |
| 17 UAMX     | MEX     | 19  | 161 | 7   | 8.47  | 0    | 0    | 3   | -         | -       |
| 18 UAQ      | MEX     | 19  | 315 | 7   | 16.57 | 1    | 2    | 4   | -         | -       |
| 19 CIMMYT   | MEX     | 18  | 674 | 10  | 37.44 | 2    | 4    | 8   | -         | -       |
| 20 CINVESTAV| MEX     | 18  | 249 | 5   | 13.83 | 1    | 1    | 1   | -         | -       |
| 21 IMWIC    | MEX     | 18  | 363 | 6   | 20.17 | 2    | 3    | 4   | -         | -       |
| 22 UAEH     | MEX     | 18  | 27  | 3   | 1.50  | 0    | 0    | 0   | -         | -       |
| 23 UNISON   | MEX     | 18  | 56  | 4   | 3.11  | 0    | 0    | 0   | -         | -       |
| 24 CIDE     | MEX     | 17  | 203 | 4   | 11.94 | 1    | 2    | 2   | -         | -       |
| 25 UH       | USA     | 17  | 2855| 11  | 167.94| 2    | 5    | 7   | 1         | 3       |
| 26 UDLAP    | MEX     | 17  | 115 | 6   | 6.76  | 0    | 0    | 1   | -         | 801-1000|
| 27 UA       | MEX     | 17  | 2763| 13  | 162.52| 2    | 4    | 7   | -         | -       |
### Bibliometric analysis of innovation in Mexico

|  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| 28 | UACH | MEX | 17 | 48 | 3 | 2.82 | 0 | 0 | 1 | - | - |
| 29 | COLPOS | MEX | 16 | 80 | 4 | 5.00 | 0 | 0 | 1 | - | - |
| 30 | UAEMOR | MEX | 16 | 142 | 7 | 8.87 | 0 | 0 | 1 | - | - |
| 31 | BUAP | MEX | 15 | 223 | 4 | 14.87 | 1 | 1 | 1 | - | 801-1000 |
| 32 | UB | ESP | 15 | 2427 | 8 | 161.8 | 1 | 3 | 4 | 151-200 | 156 |
| 33 | ITAM | MEX | 14 | 104 | 4 | 7.42 | 0 | 1 | 1 | - | 651-700 |
| 34 | UDEC | MEX | 14 | 70 | 3 | 5.00 | 0 | 0 | 1 | - | - |
| 35 | UMSNH | MEX | 14 | 37 | 3 | 2.64 | 0 | 0 | 0 | - | - |
| 36 | UO | GBR | 14 | 2897 | 9 | 206.92 | 2 | 6 | 7 | 7 | 6 |
| 37 | ININ | MEX | 13 | 79 | 6 | 6.07 | 0 | 0 | 0 | - | - |
| 38 | IK | SWE | 13 | 2606 | 11 | 200.46 | 1 | 4 | 7 | 44 | - |
| 39 | US | AUS | 13 | 2910 | 9 | 223.84 | 2 | 6 | 7 | 68 | 50 |
| 40 | IMSS | MEX | 12 | 256 | 7 | 21.33 | 0 | 2 | 4 | - | - |
| 41 | UCL | BEL | 12 | 2583 | 9 | 215.25 | 2 | 3 | 5 | 86 | 71 |
| 42 | USDC | USA | 12 | 2373 | 6 | 197.75 | 1 | 3 | 3 | 15 | 38 |
| 43 | UL | CAN | 12 | 3147 | 8 | 262.25 | 2 | 4 | 5 | 201-300 | 378 |
| 44 | UPV | ESP | 12 | 94 | 4 | 7.83 | 0 | 2 | 2 | 401-500 | 373 |

Source: Own elaboration from the information obtained in WoS. TP: Total articles published, TC: Total citations published, H: h-index, C/P: Reason of citations per article. BUAP: Meritorious Autonomous University of Puebla, CIDE: Center for Economic Research and Teaching, CIMMYT: International Center for Corn and Wheat Improvement, CINVESTAV: Center for Research and Studies Avanzados del Instituto Politécnico Nacional, COLPOS: Colegio de Postgraduados, HU: Harvard University, IK: Instituto Karlinska, IMSS: Instituto Mexicano del Seguro Social, IMWIC: International Maize and Wheat Improvement Center, ININ: Instituto Nacional de Investigaciones Nucleares, INSP: National Institute of Public Health, IPN: National Polytechnic Institute, ITAM: Instituto Tecnológico Autónomo de México, ITESM: Instituto Tecnológico y de Estudios Superiores de Monterrey, NIPH: National Institute of Public Health, UA: University of Arizona, UABC: Autonomous University of Baja California, UACH: Universidad Autónoma de Chapingo, UADY: Universidad Autónoma de Yucatán, UAEM: Autonomous University of the State of Mexico, UAEMOR: Autonomous University of the State of Morelos, UAM: Metropolitan Autonomous University, UAMI: Iztapalapa Metropolitan Autonomous University, UAMX: Xochimilco Metropolitan Autonomous University, UAQ: Nuevo León Autonomous University, UASLP: Autonomous University of San Luis Potosí, UB: University of Barcelona, UCL: Catholic University of Leuven, UDEC: University of Colima, UDEG: University of Guadalajara, UDLAP: University of the Americas Puebla, UG: University of Guanajuato, UL: Laval University, UMSNH: Michoacan University of San Nicolás de Hidalgo, UNAM: National Autonomous University of Mexico, UNISON: University of Sonora, UO: University of Oxford, UPV: Polytechnic University of Valencia, US: University from Sydney, USDC: University of San Diego California, USP: University of Sao Paulo, UV: Universidad Veracruzana.
The most cited article of the first fifteen authors is shown in the following table (Table 6). According to the titles of the publications, it is also notable that most of them correspond to the medical field. Bousquet is also present in five of these publications over a period of two years between 2015 and 2017, which places him as the author with the highest production and with the highest number of highly cited articles. Similarly, it stands out that the most cited articles by the authors with the highest production are concentrated between the years 2012 and 2017. When relating this period with the information presented in Figure 1, a possible coincidence between the increase in interest in the innovation theme and the number of citations observed in the articles is observed. This possible relationship should be studied in future works. The nationalities of these researchers are diverse; however, the most productive associations are with groups from the United States, Spain and England (Table 7). It is likely that this situation is due to linguistic barriers with the rest of the countries since speaking English as a second language is a requirement for Mexican researchers. Countries such as Denmark and Lithuania stand out as having fairly high proportions of papers per inhabitant, and the fact that they are small countries stands out. Both countries have articles with more than fifty citations, which indicates that scientific production in the area of innovation has an impact on the academic environment.

**Table 6. The most cited articles of the 15 authors with the most production.**

| Article                                                                 | Author/Year                                      |
|-------------------------------------------------------------------------|--------------------------------------------------|
| 1  | “Best channels of academia-industry interaction for long-term benefit” | C De Fuentes y Dutrenit, 2012                    |
| 2  | “Health system reform in Mexico 1 - Comprehensive reform to improve health system performance in Mexico” | Frenk et al., 2006                               |
| 3  | “Shaping, organizing, and rethinking service innovation: a multidimensional framework” | Rubalcaba et al., 2012                           |
| 4  | “Biopharmaceuticals for rheumatic diseases in Latin America, Europe, Russia, and India: Innovators, biosimilars, and intended copies” | Castaneda-Hernandez et al., 2014                 |
| 5  | “Improving market access and agricultural productivity growth in Africa: what role for producer organizations and collective action institutions?” | Shiferaw et al., 2011                            |
| 6  | “Covalently Bonded Chitosan on Graphene Oxide via Redox Reaction” | Bustos-Ramirez et al., 2013                      |
| 7  | “Information networks that generate economic value: A study on clusters of adopters of new or improved technologies and practices among oil palm growers in Mexico” | Aguilar-Gallegos et al., 2015                    |
| 8  | “Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines-2016 revision” | Brozek et al., 2017                              |
| 9  | “MACVIA-ARIA Sentinel NetworK for allergic rhinitis (MASK-rhinitis): the new generation guideline implementation” | Bousquet et al., 2015                            |
| 10 | “MACVIA clinical decision algorithm in adolescents and adults with allergic rhinitis” | Bousquet, Schunemann, et al., 2016               |
| 11 | “ARIA 2016: Care pathways implementing emerging technologies for predictive medicine in rhinitis and asthma across the life cycle” | Bousquet, Hellings, et al., 2016                 |
| 12 | “Scaling up strategies of the chronic respiratory disease programme of the European Innovation Partnership on Active and Healthy Ageing (Action Plan B3: Area 5)” | Bousquet, Farrell, et al., 2016                  |
| 13 | “A randomised, double-blind, parallel-group study to demonstrate equivalence in efficacy and safety of CT-P13 compared with innovator infliximab when coadministered with methotrexate in patients with active rheumatoid arthritis: the PLANETRA study” | Yoo et al., 2013                                 |
| 14 | “CHRODIS criteria applied to the MASK (MACVIA-ARIA Sentinel NetworK) Good Practice in allergic rhinitis: a SUNFRAIL report” | Bousquet et al., 2017                            |
| 15 | “Over-expression of Dof-type transcription factor increases lipid production in Chlamydomonas reinhardtii” | Ibanez-Salazar et al., 2014                      |

Source: Own elaboration from the information obtained in the WoS. Article: Most cited article, Author/Year: Author and year of publication.
TABLE 7. THE MOST PRODUCTIVE COUNTRIES INVOLVED ACCORDING TO THE WoS QUANTITATIVE RESEARCH.

| Country | TP  | TC   | H   | C/P | ≥250 | ≥100 | ≥50   | Population | P/Po | C/Po |
|---------|-----|------|-----|-----|------|------|-------|------------|------|------|
| MEX     | 1749| 21551| 64  | 12.32| 10   | 35   | 82    | 129.16     | 13.54| 166.85|
| USA     | 306 | 10641| 42  | 34.78| 9    | 17   | 37    | 325.72     | 0.94 | 32.67|
| SPA     | 206 | 5605 | 28  | 27.21| 3    | 8    | 21    | 46.57      | 4.42 | 120.35|
| ENG     | 92  | 5231 | 23  | 56.86| 4    | 6    | 13    | 54.79      | 1.68 | 95.47|
| FRA     | 88  | 4435 | 23  | 50.39| 3    | 4    | 14    | 67.12      | 1.31 | 66.08|
| CAN     | 82  | 5592 | 26  | 68.19| 5    | 6    | 19    | 36.71      | 2.23 | 152.34|
| BRA     | 72  | 4179 | 19  | 58.04| 3    | 5    | 12    | 209.29     | 0.34 | 19.97|
| GER     | 69  | 5552 | 24  | 80.46| 6    | 6    | 17    | 82.69      | 0.83 | 67.14|
| COL     | 55  | 1962 | 17  | 35.67| 3    | 4    | 9     | 49.07      | 1.12 | 39.99|
| ITA     | 51  | 3832 | 18  | 75.14| 3    | 3    | 10    | 60.55      | 0.84 | 63.29|
| SWI     | 47  | 4845 | 26  | 103.09| 4  | 5    | 16    | 8.47       | 5.55 | 572.29|
| ARG     | 40  | 3442 | 15  | 86.05| 3    | 3    | 6     | 44.27      | 0.90 | 77.75|
| NET     | 40  | 3005 | 17  | 75.13| 1    | 1    | 6     | 4.81       | 8.31 | 624.27|
| PEO     | 40  | 4612 | 18  | 115.30| 4  | 5    | 11    | 138.639    | 0.03 | 3.33|
| AUS     | 39  | 4755 | 19  | 121.92| 4  | 6    | 14    | 24.59      | 1.59 | 193.30|
| CHI     | 36  | 4317 | 21  | 119.92| 5  | 6    | 14    | 18.06      | 1.99 | 239.11|
| SWE     | 32  | 3798 | 14  | 118.69| 4  | 4    | 9     | 10.07      | 3.18 | 377.24|
| BEL     | 31  | 3738 | 15  | 120.58| 3  | 4    | 7     | 11.37      | 2.73 | 328.70|
| DEN     | 28  | 4320 | 14  | 154.29| 4  | 4    | 11    | 5.77       | 4.85 | 748.75|
| IND     | 25  | 3451 | 11  | 138.04| 3  | 4    | 7     | 1339.18    | 0.02 | 2.58|
| POL     | 25  | 3842 | 15  | 153.68| 4  | 4    | 10    | 37.98      | 0.66 | 101.17|
| AUS     | 24  | 3654 | 13  | 152.25| 3  | 3    | 5     | 8.81       | 2.72 | 414.79|
| SOU     | 24  | 4032 | 16  | 168.00| 4  | 5    | 12    | 51.47      | 0.47 | 78.34|
| FIN     | 21  | 2900 | 13  | 138.09| 2  | 2    | 6     | 5.51       | 3.81 | 526.19|
| JAP     | 21  | 4516 | 15  | 215.05| 4  | 6    | 11    | 126.79     | 0.17 | 35.62|
| POR     | 21  | 2639 | 11  | 125.67| 1  | 1    | 4     | 10.29      | 2.04 | 256.37|
| SCO     | 21  | 3261 | 14  | 155.29| 2  | 3    | 8     | 5.37       | 3.91 | 606.92|
| VEN     | 21  | 641  | 9   | 30.52| 1    | 1    | 3     | 31.98      | 0.66 | 20.05|
| GRE     | 17  | 3733 | 13  | 219.59| 3  | 3    | 7     | 10.76      | 1.58 | 346.92|
| SOU     | 17  | 3574 | 13  | 210.24| 3  | 5    | 8     | 56.72      | 0.30 | 63.01|
| TUR     | 17  | 3294 | 11  | 193.77| 3  | 3    | 6     | 80.75      | 0.21 | 40.80|
| CZE     | 16  | 2790 | 10  | 174.38| 2  | 2    | 4     | 10.59      | 1.51 | 263.42|
| PAK     | 15  | 562  | 8   | 37.47| 0    | 1    | 4     | 197.02     | 0.08 | 2.85|
| SIN     | 15  | 2593 | 9   | 172.87| 1  | 2    | 4     | 5.61       | 2.67 | 462.02|
| UKR     | 15  | 3316 | 11  | 221.07| 3  | 3    | 9     | 44.83      | 0.33 | 73.97|
| URU     | 15  | 537  | 6   | 35.80| 1    | 1    | 3     | 3.46       | 4.34 | 155.35|
| PER     | 14  | 1023 | 8   | 73.07| 2    | 2    | 4     | 32.166     | 0.44 | 31.80|
| RUS     | 14  | 2879 | 11  | 205.64| 2  | 2    | 5     | 144.49     | 0.10 | 19.92|
| ISR     | 13  | 3140 | 10  | 241.54| 3  | 4    | 6     | 8.71       | 1.49 | 360.41|

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The area with the highest production in the subject of innovation is business research, followed by engineering (Table 8). This suggests that research on product innovation contained in the area of engineering is not actually the most important.

Table 8. The 25 research areas with the greatest production in quantitative research in the WoS.

| Research Area                              | Total Studies |
|--------------------------------------------|---------------|
| 1.  Business Economics                      | 284           |
| 2.  Engineering                             | 187           |
| 3.  Education Educational Research          | 155           |
| 4.  Environmental Sciences Ecology          | 127           |
| 5.  Science Technology Other Topics         | 88            |
| 6.  Agriculture                             | 85            |
| 7.  Computer Science                        | 85            |
| 8.  Social Sciences Other Topics            | 85            |
| 9.  Public Administration                   | 68            |
| 10. Public Environmental Occupational Health| 59            |
| 11. Chemistry                               | 57            |
| 12. Food Science Technology                 | 50            |
| 13. Materials Science                       | 47            |
| 14. Information Science Library Science     | 39            |
| 15. Biotechnology Applied Microbiology      | 38            |
| 16. Energy Fuels                            | 37            |
| 17. Pharmacology Pharmacy                   | 33            |
| 18. Plant Sciences                          | 33            |
| 19. General Internal Medicine               | 32            |
| 20. Government Law                          | 32            |
| 21. Biochemistry Molecular Biology          | 29            |
| 22. Physics                                 | 28            |
| 23. Development Studies                     | 25            |
| 24. Communication                           | 24            |
| 25. Water Resources                         | 24            |

Source: Own elaboration from the information obtained in the WoS. Research area: Study area to which the articles belong, Total studies: Number of published articles.
It is also observed that innovation research in government is in last place among the investigated areas, which reflects the reality of the country. Particularly for the area of Business Economics, the area with the highest number of publications on the topic of innovation in Mexico, once again, the author with the most publications is Dutrenit; however, only six of their twelve articles are classified in this category area, namely, “What hinders innovation performance or services and manufacturing firms in Mexico?”, “Determinants of Innovation and Productivity in the Service Sector in Mexico”, “Economic growth, innovation and inequality in Latin America: improvements, setbacks and pending issues post-Washington Consensus”, “Coevolution, emergence and economic development: some lessons from the Israeli and Mexican experience”, “Premises and Instruments of Innovation Policy: A Reflection from the Mexican Case” and “Technological profile of Mexican Industry and its dynamics of innovation during the eighties” (Claudia De Fuentes et al., 2015; G Dutrenit, 2009; G Dutrenit et al., 2014; G Dutrenit and Teubal, 2011; Gabriela Dutrenit and Capdevielle, 1993; Santiago et al., 2017).

The next four most productive authors are not in less important positions in the general table (Table 9); however, their works are the most relevant in the Business and Economics section. Husted stands out for his articles "Opportunity, Discovery and creation in social entrepreneurship: An exploratory study in Mexico", "Sustainability Strategy in Constrained Economic Times", "Value Creation Through Social Strategy", "Strategic corporate social responsibility and value creation among large firms - Lessons from the Spanish experience" and “Corporate social strategy in multinational enterprises: Antecedents and value creation” (Barnett et al., 2015; Gonzalez et al., 2017; Husted et al., 2015; Husted and Allen, 2007b, 2007a). Belausteguigoitia and De Clercq are located in the third and fourth positions of the ranking, coauthoring the articles “The Usefulness of Tenacity in Spurring Problem-Focused Voice: The Moderating Roles of Workplace Adversity”, “Perceptions of Adverse Work Conditions and Innovative Behavior: The Buffering Roles of Relational Resources”, “Intergenerational strategy involvement and family firms' innovation pursuits: The critical roles of conflict management and social capital” and “Entrepreneurial Initiative Selling within Organizations: Towards a More Comprehensive Motivational Framework” (De Clercq et al., 2011, 2016; De Clercq and Belausteguigoitia, 2015, 2017).

Corona is the fifth most productive author in this area, with four articles in the ranking, with the publications “The key elements of innovation infrastructure and the evolution of knowledge regions: a framework for analysis”, “US technology infrastructure and the development of regional innovation poles through incubation mechanisms”, “Mexico: the challenge to create regional innovative environments” and “Canada’s innovation poles and their role as technology incubation scapes” (Corona et al., 2006b, 2006c, 2006a; Corona and Doutriaux, 2006).
### Table 9. General Table of Published Articles on Innovation That Correspond to the Business and Economics Areas.

| Year | TP | Author                            | TP | Country | TP | Source | TP | Source |
|------|----|-----------------------------------|----|---------|----|--------|----|--------|
| 2018 | 42 | Dutrenit G                        | 6  | MEX     | 284| ETE    | 12 | UNAM   |
| 2017 | 36 | Husted Bw                         | 5  | ESP     | 39 | EG     | 9  | ITESM  |
| 2016 | 25 | Belausteguiogitiai                | 4  | USA     | 23 | IE     | 8  | IPN    |
| 2015 | 28 | Corona L                         | 4  | GBR     | 18 | TF&SC  | 7  | CIDE   |
| 2014 | 12 | De Clercq D                       | 4  | CAN     | 14 | ARLA   | 5  | ITAM   |
| 2013 | 6  | De Lema Dgp                      | 4  | COL     | 6  | DE     | 5  | EGADE  |
| 2012 | 9  | Doutriaux J                       | 4  | FRA     | 5  | JBR    | 5  | IEU    |
| 2011 | 8  | Guerrero M                       | 4  | ARG     | 3  | RBGN   | 5  | UDLAP  |
| 2010 | 4  | Mian Sa                          | 4  | DEU     | 3  | ECO RFID | 5 | UABC   |
| 2009 | 9  | Reynoso J                         | 4  | IRL     | 3  | BKRNA  | 4  | UDEG   |
| 2008 | 8  | Urbano D                         | 4  | ITA     | 3  | EP     | 4  | BANXICO |
| 2007 | 7  | Allen Db                          | 3  | PAN     | 3  | FIR    | 4  | BROCKU |
| 2006 | 4  | Cypher Jm                         | 3  | SWE     | 2  | JEI    | 4  | IE     |
| 2005 |   | De Fuentes C                     | 3  | IND     | 2  | MD     | 4  | SUNY   |
| 2004 | 1  | Kawalek P                        | 3  | CHE     | 2  | PORTES | 4  | UAM    |
| 2003 |   | Lloret A                         | 3  | BOL     | 1  | RCS    | 4  | UAMX   |
| 2002 | 1  | Lorenzo O                        | 3  | CHL     | 1  | U&E    | 4  | UC     |
| 2001 | 3  | Unger K                          | 3  | CRI     | 1  | WD     | 4  | UDEC   |
| 2000 |   | Wharton L                        | 3  | CZE     | 1  | AD     | 3  | UG     |
| 1999 | 1  | Aguilera-Avila J                 | 2  | ETH     | 1  | EIT    | 3  | UOTTAWA |
| 1998 | 1  | Bolivar Hr                       | 2  | IDN     | 1  | INNOVAR| 3  | ALLIANCEMBS |
| 1997 | 1  | Campos Hm                        | 2  | ISR     | 1  | KG&P   | 3  | UDBS   |
| 1996 | 1  | Castillo A                       | 2  | KEN     | 1  | LRP    | 3  | FOUR23 |
| 1995 |   | Diaz-Pichardo R                  | 2  | KWT     | 1  | REH    | 3  | IAE    |
| 1994 |   | Edvardsson B                     | 2  | NLD     | 1  | RF     | 3  | JEIA   |
| 1993 | 3  | Flores D                         | 2  | NOR     | 1  | 3C     | 2  | LYTI   |
| 1992 |   | Gajon E                          | 2  | CHN     | 1  | AGE    | 2  | LBORO  |
| 1991 |   | Gama A                           | 2  | SVK     | 1  | AE     | 2  | NU     |
| 1990 |   | Gras N                           | 2  | WAL     | 1  | AQLR   | 2  | MSMU   |
| 1989 |   | Herrera F                        | 2  | -       | -  | EE     | 2  | UB     |
| 1988 |   | Merino L                         | 2  | -       | -  | E&SE   | 2  | UACH   |
| 1987 |   | Michel Al                        | 2  | -       | -  | FUT    | 2  | UAT    |
| 1986 |   | Moreno-Brid Jc                   | 2  | -       | -  | JBE    | 2  | IBERO  |
| 1985 |   | Munoz-Rodriguez M                | 2  | -       | -  | JIK    | 2  | UPAN   |
| 1984 |   | Ochoa Jn                         | 2  | -       | -  | JISIB  | 2  | UPCT   |
| 1983 |   | Padilla-Perez R                  | 2  | -       | -  | JIK    | 2  | UNISON |

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| Source                                      | TP | 3C Company | AD | AE | AEZ | 3C |
|---------------------------------------------|----|-------------|----|----|-----|----|
| Own elaboration from the information obtained in WoS | 37 | 2           |    |    |     |    |
| TP: Total articles 3C: 3c Company, AD: Ad Minister, AE: Applied economics, AEZ: Agricultural economics-Zemedelska Ekonomika, AGE: Agricultural economics, AHTSI: Advances in hotel tourism and the service industry, AQLR: Application of quality of life Best research practices, ARLA: Academia Revista Latinoamericana de Administración, ARS: Annals of Regional Science, ASEIEG: Advances In The Study of Entrepreneurship Innovation and Economic Growth, BEJTE: BE Journal of Theoretical Economics, BH: Business Horizons, BHR: Business History Review, BIS: Business & Society, BKR: Building Knowledge Regions In North America Emerging Technology Innovation Poles, BRMJ: Business Process Management Journal, C&C: Competitiveness Change, CIRIEC: Ciriec España Revista de Economía Publica Social y Cooperativa, CJAS: Canadian Journal of Administrative Sciences Revue Canadienne des Sciences de la Administration, CR: Competitiveness Review, DE: Business dimension, ECORFAN: Ecofan Magazine, EE: Ecological Economics, EG: Management Studies, EIRSE: Best practices and implications for the quality of life of innovative and sustainable business ecosystems, EIJ&T: Business innovation and technology A Guide to Core Models and Tools, EP: Energy policy, ETE: Economic Quarter, FIR: Faedpyme International Review Fir, FUT: Futures, IE: Economic Research, INNOVATE: Innovate Revista de Ciencias Administrativas y Sociales, JBE: Journal of Business Ethics, JBR: Journal of Business Research, JEI: Journal of Economic Issues, JK: Journal of Knowledge Innovation, JISIB: Journal of Business Intelligence Studies, JKE: Knowledge Economy Journal, KG&P: Knowledge Generation and Protection, LRP: Long-Term Planning, MD: Management Decision, NISSI: National Systems of Innovation, Inclusion and Social Development The Latin American Experience, PORTES: Portes Mexican Journal of Studies on the Pacific Basin, RBGN: Brasileira Magazine de Gestao de Negocios, RCS: Social Science Magazine, REH: Business and Humanism Magazine, RF: Routledge Focus, TFSC: Technological Projection and Social Change, U&E: Business University Magazine, WD: World Development. ALLIANCEMBS: Alliance manchester business school, BANXICO: Banco de México, BROCKU: Brock University, BUAP: Benemérita Universidad Autónoma de Puebla, ECLAC: Economic Commission for Latin America and the Caribbean, CIDE: Center for Economic Research and Teaching, CIMMYT: International Center of Corn and Wheat Improvement, COLEF: Colegio de la Frontera Norte, COLMEX: Colegio México, EGADE: Egade Business School, FOUR23: FOUR23 Studio, GESCT: Groupe ESC Troyes en Champagne, IAE: IAE Bussines School, IBERO: Universidad Iberoamericana, IE: ie Business School, IESA: Instituto de Estudios Superiores de Administración, IEU: Instituto Empresa, IPN: Instituto Politécnico Nacional, ITAM: Instituto Tecnológico Autónomo de México, ITESM: Instituto Tecnológico y de Estudios Superiores de Monterrey, ITSON: Instituto Tecnológico de Sonora, NU: University No rhum bria, SUNY: State University of New York, UABC: Universidad Autónoma de Baja California, UACH: Universidad Autónoma de Chapingo, UAM: Universidad Autónoma Metropolitana, UAMX: Universidad Autónoma Metropolitana Xochimilco, UAT: Universidad Autónoma de Tamaulipas, UB: Universidad de Barcelona, UC: University of Cantabria, UDBS: Deusto Business School, UDEC: University of Colima, UDEG: University of Guadalajara, UDLAP: University of the Americas Puebla, UG: University of Guanajuato, UNAM: National Autonomous University of Mexico, UNISON: University of Sonora, UOTTAWA: University of Ottawa, UPAN: Universidad Panamericana, UPC: Universidad Politécnica de Cartagena. |
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**Table 10. The 25 Journals with the Most Publications According to Quantitative Research of the WoS within the JCR Catalog, Part 1.**

| No | Journal | TP | TC | H  | C/P | ≥100 | ≥50 | ≥25 | ≥10 | ≥5 | ≥1 | Country | Índice H | Quarteile | Total Citation |
|----|---------|----|----|----|-----|------|-----|-----|-----|----|----|----------|-----------|-----------|----------------|
| 1  | SPP     | 26 | 241| 9  | 2.77| 0    | 1   | 4   | 8   | 10 | 20 | MEX      | 46        | 3         | 1,787 |
| 2  | GPP     | 14 | 21 | 3  | 1.50| 0    | 0   | 0   | 0   | 10 | 6  | MEX      | 6         | 4         | 86   |
| 3  | JCP     | 14 | 135| 7  | 9.64| 0    | 0   | 0   | 5   | 8  | 14 | NLD      | 132       | 1         | 45,454 |
| 4  | ETE     | 12 | 11 | 2  | 0.92| 0    | 0   | 0   | 0   | 4  | 4  | MEX      | 9         | 4         | 124  |
| 5  | SUS     | 11 | 16 | 2  | 1.46| 0    | 0   | 0   | 0   | 1  | 5  | CHE      | 42        | 2         | 8904 |
| 6  | GMM     | 10 | 7  | 2  | 0.70| 0    | 0   | 0   | 0   | 0  | 5  | MEX      | 18        | 4         | 426  |
| 7  | INT     | 10 | 10 | 2  | 1.00| 0    | 0   | 0   | 0   | 0  | 6  | VEN      | 30        | 4         | 915   |
| 8  | RIC     | 9  | 25 | 3  | 2.78| 0    | 0   | 0   | 2   | 8  | 4  | MEX      | 24        | Q3        | 519   |
| 9  | RMCP    | 9  | 1  | 1  | 1.00| 0    | 0   | 0   | 0   | 1  | 3  | MEX      | 6         | 3         | 254   |
| 10 | AGS     | 8  | 77 | 4  | 9.63| 0    | 0   | 1   | 4   | 4  | 6  | NLD      | 88        | 1         | 5,624 |
| 11 | IE      | 8  | 4  | 1  | 0.50| 0    | 0   | 0   | 0   | 3  | 4  | MEX      | 6         | 4         | 90    |
| 12 | SCPP    | 8  | 98 | 4  | 12.25| 0    | 0   | 2   | 3   | 4  | 7  | GRB      | 51        | 3         | 1,730 |
| 13 | JSM     | 7  | 170| 5  | 24.29| 0    | 1   | 2   | 4   | 5  | 6  | GRB      | 40        | 1         | 1,479 |
| 14 | LAN     | 7  | 527| 6  | 75.29| 2    | 4   | 6   | 6   | 7  | 4  | GRB      | 670       | Q1        | 233,269 |
| 15 | RP      | 7  | 209| 6  | 29.86| 0    | 1   | 4   | 6   | 6  | 7  | NLD      | 191       | 1         | 20,135 |
| 16 | TF&SC   | 7  | 77 | 5  | 11.00| 0    | 0   | 1   | 2   | 5  | 7  | NLD      | 86        | 2         | 8,374 |
| 17 | CC      | 6  | 1  | 1  | 0.17| 0    | 0   | 0   | 0   | 1  | 3  | MEX      | 13        | Q4        | 313   |
| 18 | IJEE    | 6  | 24 | 4  | 4.00| 0    | 0   | 0   | 0   | 3  | 5  | IRL      | 41        | Q4        | 1,253 |
| 19 | IB      | 6  | 2  | 1  | 0.33| 0    | 0   | 0   | 0   | 1  | 3  | MEX      | 6         | Q4        | 108   |
| 20 | PI      | 6  | 32 | 4  | 5.33| 0    | 0   | 0   | 2   | 3  | 4  | USA      | 241       | Q1        | 582,878 |
| 21 | ARLA    | 5  | 7  | 1  | 1.40| 0    | 0   | 0   | 0   | 1  | 3  | COL      | 7         | Q4        | 106   |
| 22 | EP      | 5  | 240| 4  | 48.00| 1    | 2   | 2   | 3   | 4  | 5  | GRB      | 159       | 1         | 41,513 |
| 23 | GIQ     | 5  | 149| 3  | 29.80| 1    | 1   | 1   | 3   | 3  | 5  | USA      | 76        | 1         | 2,837 |
| 24 | PL      | 5  | 2  | 1  | 0.40| 0    | 0   | 0   | 0   | 0  | 1  | NLD      | 5         | Q4        | 180   |
| 25 | SR      | 5  | 30 | 3  | 6.00| 0    | 0   | 0   | 2   | 3  | 4  | GRB      | 122       | Q1        | 192,841 |

| Total | 216 | 4  | 10 | 23 | 48 | 70 | 147 |
|-------|-----|----|----|----|----|----|-----|
| %     | 100%| 2% | 5% | 11%| 22%| 32%| 68% |

Source: Own elaboration from the information obtained in WoS. TP: Total articles, TC: Total citations, H: H index in the innovation area, C / P: Reason of citations per article, Country: Country of origin of the publication, H Index: H index of the publication in general, Quartile: Quartile of the general publication. AGS: Agricultural Systems, ARLA: Academia Revista Latinoamericana de Administracion, CC: Cirujía y Cirujanos, EP: Energy Policy, ETE: Economic Quarter, GIQ: Government Information Quarterly, GMM: Gaceta Medica de Mexico, GPP: Gestion y Politica Publica, IB: Investigacion Bibliotecologica, IE: Investigacion Economica, IJEE: International Journal of Engineering Education, INT: Interciencia, JCP: Journal of Cleaner Production, JSM: Journal of Service Management, LAN: Lancet, PI: Plos One, PL: Latin American Profiles, RIC: Revista de Investigacion Clinica Clinical and Translational Investigation, RMCP: Revista Mexicana de Ciencias Pecuarias, RP: Research Policy, SCPP: Science and Public Policy, SPP: Salud Publica de Mexico, SR: Scientific Reports, SUS: Sustainability, TF&SC: Technological Forecasting and Social Change.
### Table 11. The 43 magazines with the most publications according to quantitative research of the WoS within the JCR catalog, Part 2.

| Journal | FI  | FIws | FIS | Im  | EC  | VmC | VmCR | Eig  | VIA  | % AEC | EigN | PPV  |
|---------|-----|------|-----|-----|-----|-----|------|------|-----|-------|------|------|
| 1       | SPP | 1.039| 0.751|1.423|0.238|84  | 7.8  | 7.0  | 0.002|0.372|95.24 | 0.257|23.248|
| 2       | GPP | 0.103|0.103 |0.228|0.000|20  | N/A  | 10.7 | 0.000|0.091|100.00| 0.000|3.191 |
| 3       | JCP | 5.651|3.809 |6.352|1.364|2.741|3.2   | 6.3  | 0.055|0.815|94.71 | 6.469|87.287|
| 4       | ETE | 0.211|0.211 |0.211|0.182|22  | 12.6 | 11.2 | 0.000|0.052|100.00| 0.012|3.258 |
| 5       | SUS | 2.075|1.364 |2.177|0.483|2.346|2.4   | 7.0  | 0.014|0.323|94.50 | 1.612|50.022|
| 6       | GMM | 0.342|0.320 |0.358|0.048|104 | 7.2  | 7.9  | 0.001|0.085|90.38 | 0.070|5.484 |
| 7       | INT | 0.258|0.218 |0.300|0.026|114 | 10.6 | 9.9  | 0.000|0.055|98.25 | 0.054|2.188 |
| 8       | RIC | 1.360|1.325 |0.818|0.128|39  | 7.2  | 5.9  | 0.001|0.193|79.49 | 0.087|43.548|
| 9       | RMCP| 0.768|0.695 |0.884|0.080|50  | 5.2  | 11.0 | 0.000|0.169|98.00 | 0.040|35.833|
| 10      | AGS | 3.004|2.562 |3.756|0.944|162 | 8.5  | 7.2  | 0.006|0.871|97.53 | 0.751|95.614|
| 11      | IE  | 0.390|0.341 |0.427|0.000|16  | N/A  | 9.9  | 0.000|0.056|100.00| 0.000|10.623|
| 12      | SCPP| 1.368|1.168 |2.067|0.309|68  | 7.6  | 8.5  | 0.000|0.509|100.00| 0.250|35.278|
| 13      | JSM | 3.414|2.957 |5.407|0.205|39  | 5.5  | 10.4 | 0.002|0.912|92.31 | 0.238|79.286|
| 14      | LAN | 53.254|51.896|52.665|13.030|302 |8.9   | 4.5  | 0.436|21.011|79.80 | 50.874|99.032|
| 15      | RP  | 4.661|4.261 |7.070|0.880|133 |10.5  | 11.2 | 0.018|1.877|99.25 | 2.101|94.442|
| 16      | TF&SC| 3.131|2.535 |3.683|0.872|337 |5.6   | 9.5  | 0.011|0.697|99.11 | 1.247|80.905|
| 17      | CC  | 0.427|0.415 |0.339|0.064|94  | 6.0  | 10.3 | 0.000|0.064|91.49 | 0.045|4.750 |
| 18      | IJEE| 0.575|0.323 |0.663|0.090|144 | 7.3  | 8.7  | 0.001|0.100|97.22 | 0.133|13.337|
| 19      | IB  | 0.212|0.173 |0.427|0.200|30  | 5.5  | 10.9 | 0.000|0.024|100.00| 0.005|6.250 |
| 20      | P1  | 2.766|2.599 |3.352|0.405|20.328|4.3 | 8.2  | 1.862|1.000|97.99 | 217.451|77.344|
| 21      | ARLA| 0.617|0.595 |0.623|0.030|33  | 4.5  | 10.7 | 0.000|0.080|93.94 | 0.014|6.012 |
| 22      | EP  | 4.039|3.297 |5.038|0.915|694 |6.7   | 5.6  | 0.047|0.994|98.99 | 5.448|84.144|
| 23      | GIQ | 4.009|2.784 |5.231|0.722|54  | 5.4  | 7.3  | 0.003|0.683|98.15 | 0.353|92.614|
| 24      | PL  | 0.537|0.219 |0.640|0.214|28  | 9.8  | 10.6 | 0.000|0.114|100.00| 0.016|25.000|
| 25      | SR  | 4.122|3.745 |4.609|0.576|24.809|2.2  | 7.5  | 0.719|1.356|99.99 | 83.931|82.031|

Source: Own elaboration from the information obtained in the WoS. FI: Impact factor, FIws: Impact factor without self-citations, FIS: Impact factor at 5 years, Im: Immediacy index, EC: Quotable elements, VmC: Average life of appointments, VmCR: Average life of appointments made, Eig: Eigenfactor, VIA: Item influence value, % AEC: Percentage of items in citable items, EigN: Normalized eigenfactor, PPV: Average percentile of life. AGS: Agricultural Systems, ARLA: Academia Revista Latinoamericana de Administracion, CC: Cirugía y Cirujanos, EP: Energy Policy, ETE: Economic Quater, GIQ: Government Information Quarterly, GMM: Gaceta Medica de Mexico, GPP: Gestion y Politica Publica, IB: Investigacion Bibliotecologica, IE: Investigacion Economica, IJEE: International Journal of Engineering Education, INT: Interciencia, JCP: Journal of Cleaner Production, JSM: Journal of Service Management, LAN: Lancet, P1: PLOS One, PL: Latin American Profiles, RIC: Revista de Investigacion Clinica Clinical and Translational Investigation, RMCP: Revista Mexicana de Ciencias Pecuarias, RP: Research Policy, SCPP: Science and Public Policy, SPP: Salud Publica de Mexico, SR: Scientific Reports, SUS: Sustainability, TF&SC: Technological Forecasting and Social Change.
Subsequently, the journals with the highest publication numbers on the subject of innovation registered within the “Journal Citation Report” (JCR) were analyzed. The journal that was the most productive stands out for belonging to the public health area,
followed by one belonging to the areas of administration and economics, both of Mexican origin. The above can be taken as proof that innovation in Mexico is now taking hold as a broader concept than the creation of a new technological tool. Similarly, it is notable that Mexican journals, despite having a large number of publications on innovation, do not achieve as high of an impact compared to journals from other countries, such as "Journal Cleaner" from the Netherlands or "Lancet" and "PLOS One" from the United Kingdom and the United States of America, respectively (Tables 10 and 11).

However, Mexican journals do have a high $h$-index compared to other journals when only those articles that refer to the subject of innovation in Mexico are considered for the calculation of said index. This information acquires greater importance if the conclusion raised above is taken, i.e., that if a publication is produced on the subject of innovation in Mexico in foreign journals with a high $h$-index, for which it is necessary to invest a greater amount of resources, it will not necessarily result in a high-impact article; conversely, if the same article is published in a Mexican journal with a lower $h$-index, there will be a greater possibility that the article will end up being cited the most. One reason for this behavior may be because the articles deal with very specific issues of the country, and Mexican researchers, who would ultimately have a greater interest in the subject, do not have access to specialized journals but do have access to Mexican journals, which would lead to a greater number of citations of articles published in Mexican magazines. Regarding the quartiles, it is again observed that foreign journals have very high $h$-index values; consequently, they are considered to be within the first quartile in terms of their publications in society.

Similarly, the behavior of scientific articles on innovation in Mexico published in journals that do not belong to the JCR was studied. In this list is the magazine “Innovación Educativa México”, whose $h$-index is even higher than the highest in the JCR list; however, it is observed that there are no citations of the articles that correspond to innovation in Mexico; thus, a null impact of the articles presented in them is assumed (Table 12).

Finally, with the support of VosViewer software, maps are constructed that allow visual analysis of the information. The heatmap contains those words that are most frequently present within the articles and are used to generate the results. The presence of words such as model, process, study, approach, and strategy stand out, which indicates a tendency for researchers to accept and use a broad concept of innovation and to not restrict it to the creation of a new product or service (Figure 3). However, words such as application, production and implementation are also found within the articles, where innovation works with a concept limited to the creation of new products. The presence of words such as need and challenge is observed, which suggests the use of innovation for solving applied problems. The presence of words such as strategy and process allude to the existence of a set of higher-order elements, of which innovation is part. Moreover, words such as change, effect and impact indicate a possible conception of innovation as an agent of change.
Finding words such as data and research within the articles points to the generation of innovation oriented in a conscious way, determining its use, application or role; these words are also present in the articles on innovation.

Similarly, a map is constructed where the relationship that exists between the authors at the time of publishing their articles is shown graphically. For the elaboration of this map, only those authors whose publications included ten coauthors or less were considered. Importantly, it is observed that there is a group of authors who coauthor publications on a regular basis. This is relevant because it is these same authors who are in the top places as those with the highest production in the area and manage to obtain h-indexes that are equal to each other, which also corresponds to one of the highest recorded h-indexes among the research, as shown in Figure 4. Within this map are those authors with the highest production of articles with less than ten coauthored researchers. It is observed that Dutrenit, the author who has the largest number of published articles, is not part of this group. However, Bousquet, the author with the highest number of the most cited articles, is part of this group. Notably, Bousquet is a member of a group of authors who generally participate in coauthorship, and all of them are closely ranked relative to one another in the general ranking of production in the area of Business and Economics (Table 9), with Bachert occupying the highest place (7), followed by Bousquet (8), Demoly (9), Kuna (10), Mullol (11), Samolinski (15) and Zuberbier (18).
4. CONCLUSIONS

This article presents a bibliometric overview of the production of research on the subject of innovation in Mexico between the years 1980 and 2018, considering the number of publications during this period.

The results of this study reveal that the National Autonomous University of Mexico and the Tecnológico de Monterrey are the most productive institutions in innovation research in Mexico. In particular, the non-Mexican universities that are included among those with the greatest influence are those that are located in other Spanish- or English-speaking countries. Similarly, the study provides an analysis of the journals with the highest publication on innovation in Mexico. While most of the universities that stand out are Mexican, in the case of journals, a greater diversity of countries is observed; however, the fact that they belong to regions of the aforementioned languages remains constant.

The results show an important joint work with foreign researchers within Mexican institutions. There is also a strong tendency to work with authors who also speak Spanish or English, which suggests an important communication barrier for scientific production on this topic. Among the most productive institutions, not only universities are registered, but government institutions that have generated publications on innovation are also listed, and most of them are directed to the areas of health and nutrition. In the same way, four areas of research with the highest levels of production are presented on the subjects of innovation, business economics, engineering, education and environmental sciences. Moreover, in
the WoS, through quantitative research on the articles with the highest numbers of citations, those with the greatest influence within the topic of innovation can be observed, through the use of additional indices such as total citations (TC) and citations per year (C/Y). Finally, the journals with the highest publication of articles show a trend towards the conception of innovation in a broader way; however, it is necessary to carry out a study analyzing the journals impacted by the subject of innovation in Mexico over time to observe their coverage of the research areas.

The above analysis identifies an article from the medical area as the most influential on the subject; that is, although the health area is not the area with the highest production, it has the greatest influence on the subject of innovation. It is also observed throughout this work that the impact of the research on this topic is not guaranteed by publishing in indexed journals such as JCR or that register a high h-index. It is necessary to carry out more in-depth studies on the behavior of the articles published in the different types of journals because, according to the results found, the target journals for the publications depend not only on the visibility of the journal or its status within the academic environment but also on the access that researchers may have to these journals. A thorough study of this phenomenon will help direct resources appropriately to achieve greater impact with less investment.

Regarding the countries with the greatest collaborations in research on innovation in Mexico, it is very noticeable that there is a preference for association with Spanish- and English-speaking authors. However, this work reveals the need to carry out exploratory research to determine the regions with the greatest scientific production on the subject and thus suggest that researchers in the area study a third language to be able to access the best articles on innovation, to have the opportunity to link with these authors, and to create links to form work networks with stronger collaborators.

The results of this article are particularly different from other studies, such as that of Cancino et al., (2017), which carried out the study on the most influential universities with respect to production on the subject of innovation worldwide. However, this study was carried out on the research produced on the subject of innovation directly related to Mexico to determine the evolution of the subject and its current presence in the country’s research.

Future in-depth studies into the investigation are required to complement the analysis with the journals with the greatest publication, the impact of the authors as researchers, and the position of the institutions in the world, among other factors.

Finally, in the table of authors, it is observed that those who obtain the highest score carry out their research on their own. However, a small cluster of authors also stands out, i.e., those in the first half of the ranking of authors with the highest production. It is observed that this small group of authors has managed to consolidate a high h-index compared to most of the other authors that make up this list, publishing each article with the names of the other authors. In this case, it will be interesting to study the benefits and areas of opportunity that this publication strategy gives them and the way in which these authors are associated, that is, to determine if they belong
to the same university or if there is a project that motivates them to publish together.

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