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Differences by country in academic production indexed in Scopus on intellectual property and innovation systems (2001-2021)

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Abstract

This paper aims to establish what are the differences by country in scientific production on intellectual property and innovation systems between 2001 and 2021? We use text mining, non-parametric statistics, and two specialized software (Bibliometrix and VosViewer) to indicate the differences in scientific production by country on innovation systems and intellectual property. We found that scientific production in the Asia Pacific and North American countries is, on average, higher than in Eastern Europe, the Middle East and North Africa, and Sub-Saharan Africa. These last three regions do not exhibit statistically significant differences among themselves. On the other hand, the countries of Western Europe exceed the production levels of the countries of Eastern Europe and Sub-Saharan Africa. We identified that the topics in the scientific production of the most productive countries were related to case studies, technology transfer, triple helix, regional innovation systems, governance, open innovation, competitiveness, and innovation policies.

Keywords: intellectual property; innovation systems; bibliometrics; scientific production; scientometrics; data mining; knowledge representation.

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1. Introduction

The use of intellectual property (IP) has been positively related to innovation. According to [1], [2] it is a legal mechanism that allows the holder to obtain absolute and exclusive rights over what is protected. It has a framework previously established by government institutions that sets up policies to access these innovations. These are guided by innovation systems that function as connectors in the relationship of the different actors in the economic, social, and institutional environment.

Additionally, [3] indicates that: "Intellectual property (IP) refers to intellectual creations: from works of art to inventions, computer programs, trademarks, and other commercial signs". In this sense, IP is a contract between the State and the inventor. The State undertakes to protect the interests of creators. The second one leaves at the disposal of third parties and in the public domain the information necessary for the construction of innovations based on their work.

Intellectual property is divided into two branches: copyright and related rights, and industrial property [4]. The IP is fundamental in identifying the creator with his product, the contribution to knowledge, and its uses. For this, the collective construction of knowledge is immersed in IP protection and dissemination mechanisms.

Likewise, the concept of innovation systems must be clarified. In accordance with [5], National Innovation Systems correspond to "elements and relationships that interact in the production, dissemination and use of new and economically useful knowledge" and whose theoretical basis is found in the Shumpeterian proposal. [6] took up the concept of [7], stated that National Innovation Systems are made up of the public sector (whose function is to support R&D performance), universities (whose function is to conduct research and also support the development of the human capital of experts), public companies (which invest in R&D and the development of new innovations), public programs (which focus on supporting technology absorption) and a collection of laws and regulations that guide the exchange of ideas within the network. More recent works address both regional and national innovation systems ([8], [9], and [10]). Other meanings associated with innovation systems include research, innovation, and development ecosystems, a biological metaphor.

It is worth mentioning that the preliminary review did not identify any analysis that studied the differences in scientific production by country with respect to these issues. In addition, IP and innovation systems are topics that have been increasing in research worldwide, for this reason, we seek to identify how countries have been involved in this area. In this context, the guiding question of this research is: what are the differences by country in scientific production on intellectual property and innovation systems between 2001 and 2021?

The rest of the paper is organized as follows. First, we introduce the methodology. Then, the results are presented divided into (i) intellectual structure mapping, and (ii) non-parametric analysis, both including figures and tables created in Bibliometrix and VosViewer. Lastly, the conclusion is provided.

2. Method

The unit of analysis for this project is scientific articles indexed in the Scopus database. The following search equation was applied, which relates both intellectual property and innovation systems.

(TITLE-ABS-KEY ("Innovation system*") AND TITLE-ABS-KEY ("intellectual property")) AND (EXCLUDE (DOCTYPE, "ed") OR EXCLUDE (DOCTYPE, "no") OR EXCLUDE (DOCTYPE, "cr")) AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010) OR LIMIT-TO (PUBYEAR, 2009) OR LIMIT-TO (PUBYEAR, 2008) OR LIMIT-TO (PUBYEAR, 2007) OR LIMIT-TO (PUBYEAR, 2006) OR LIMIT-TO (PUBYEAR, 2005) OR LIMIT-TO (PUBYEAR, 2004) OR LIMIT-TO (PUBYEAR, 2003) OR LIMIT-TO (PUBYEAR, 2002) OR LIMIT-TO (PUBYEAR, 2001)) AND (EXCLUDE (DOCTYPE, "sh"))

Text mining techniques using VosViewer ([11], [12]) and Bibliometrix ([13], [14]) were used to perform co-citation analysis, identify geographic patterns of collaboration, and bibliographic coupling ([15]). Likewise, non-parametric statistics (specifically the Kruskal Wallis test) ([16]) were used to find differences between countries grouped under three criteria: geographic location, category according to the Human Development Index ([17]), category according to the Legatum Prosperity Index ([18]).

3. Results

3.1. Mapping the intellectual structure

Based on the search criteria, 201 documents published between 2000 and 2021 were identified. The countries with the highest number of papers during the period were (Fig. 1a); China (56), USA (39), UK (20), Canada (17), Germany (16), Brazil, India, Netherlands, and Sweden (13), Spain (12), Australia, and Iran (10). This contrasts with the most cited, which in order are China (442), Australia (344), USA (250), UK (168), Netherlands (138), and Canada (108) (Fig. 1b).

Regarding collaboration between countries (Fig. 2), we identified co-authorship scenarios especially between countries in North America, Europe, and Asia. The main production relationships reflected in Fig. 2 correspond to: (a) China with Australia, Germany, France, and United Kingdom; (b) Spain with Japan, Belgium, Netherlands, and Canada, (c) Sweden and Switzerland.

Likewise, we found that the countries with the highest number of corresponding authors were China (21), USA (11), United Kingdom (10), Canada (8), Australia, and Germany (7). However, the countries with the highest number of lead authors were Australia and USA (4), followed by Canada (3). In the case of China, most of its corresponding authors are secondary authors. According to the data, some countries did not have a primary corresponding author, such as Germany, India, South Africa, Brazil, Iran, Mexico, Slovenia, Czech Republic, Denmark, Ethiopia, France, Indonesia, Japan, Norway, Poland, Switzerland, Thailand, and Tunisia (Fig. 3a).

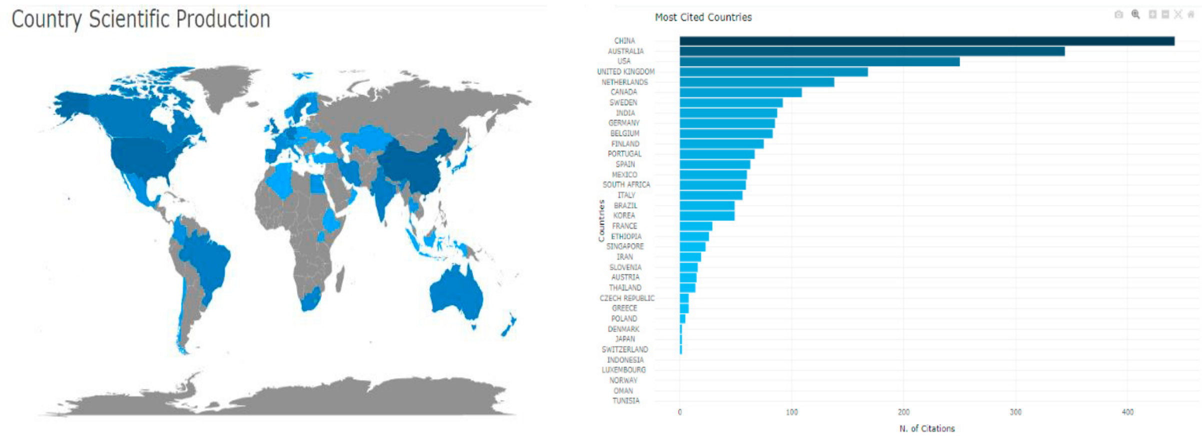

Fig. 1. (a) Country Scientific Production; (b) Most cited documents. Note. Own elaboration using bibliometrix.

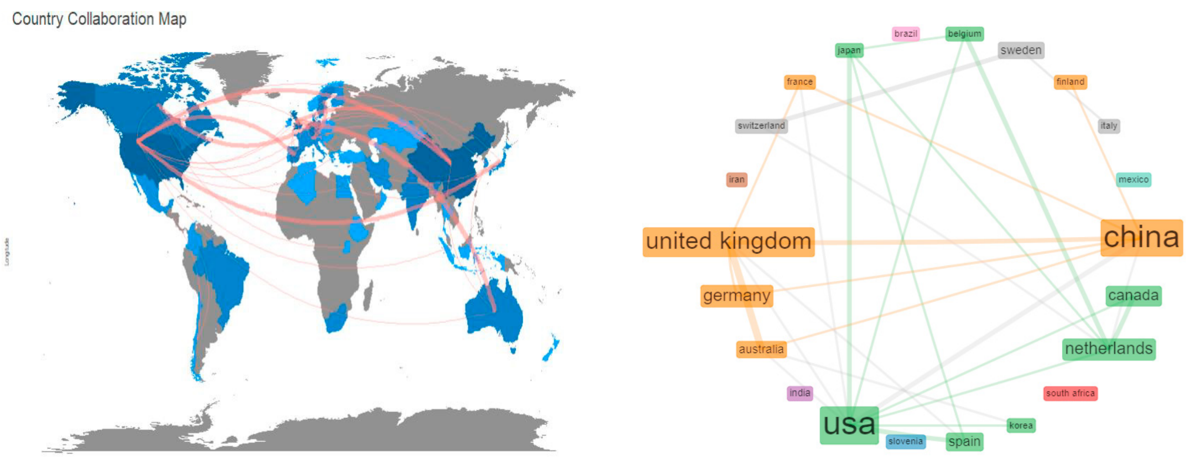

Fig 2. Country Collaboration Map. Note. Own elaboration using Bibliometrix.

In turn, in the analysis of the bibliographic coupling, we identified the knowledge network of the countries associated with the overlap in the reference lists of the publications (Fig. 3b). In other words, it corresponds to the countries of origin of the most relevant publications cited by at least a couple of papers within the selected sample. We found 8 clusters, organized as follows: (1) Algeria, Czech Republic, Hungary, Iran, Kazakhstan, Russian Federation, Taiwan, Turkey, Ukraine; (2) Brazil, Ireland, Italy, Portugal, Singapore, Spain, Thailand, United States; (3) Chile, Colombia, France, Greece, Mexico; (4) Denmark, India, Poland, Sweden, Switzerland; (5) Belgium, Japan, Luxembourg, Netherlands, United Kingdom; (6) Austria, Germany, Indonesia, Slovenia; (7) China, Finland, Tunisia; (8) Canada, Egypt, Uganda.

We also conducted an analysis of keywords and their co-occurrence. We identified that the topics in the scientific production of the most productive countries were related to case studies, technology transfer, triple helix, regional innovation systems, governance, open innovation, competitiveness, and innovation policies.

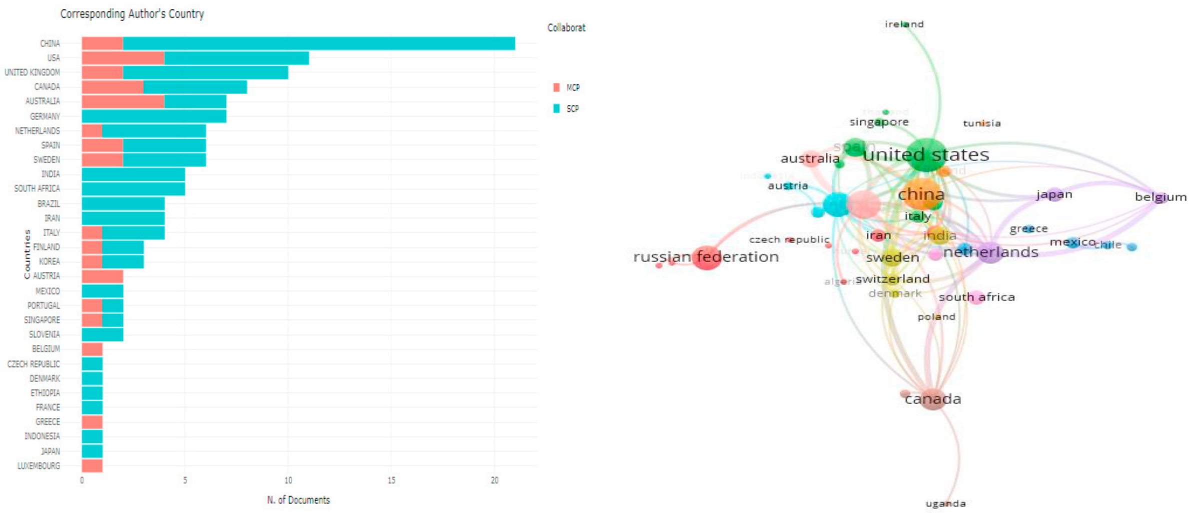

Fig 3. (a) Corresponding Author´s Country; (b) Bibliographic coupling. Note. Own elaboration using Bibliometrix and VosViewer.

3.2. Non-parametric analysis

Another analysis consisted of applying non-parametric statistical tests. The aim was to define differences in scientific production on intellectual property and associated innovation systems based on geographic criteria or level of development. First, we applied The Kolmogorov-Smirnov Test of Normality, which showed that the data did not follow a normal distribution. Second, we applied the Kruskal-Wallis Test (a non-parametric alternative to ANOVA). We grouped the countries according to: Asia-Pacific; Eastern Europe; North America, Latin America, and the Caribbean; Middle East and North Africa (MENA); Sub-Saharan Africa; and Western Europe. The test showed a statistically significant difference if the countries are grouped geographically (Fig 4).

Geographic groups	Groups according to development level	Groups according to The Legatum Index
The H statistic is 15.863 (4, N = 46).	The H statistic is 3.9249 (2, N = 51).	The H statistic is 8.1658 (2, N = 50).
The p-value is .00321. The result is significant at $p < .05$.	The p-value is .14051. The result is *not* significant at $p < .05$.	The p-value is .01686. The result is significant at $p < .05$.

Fig 4. Kruskal-Wallis Test for geographic groups [19].

We made a new grouping, this time considering the levels of the human development index (low, medium, high, very high) ([17]). In this case, the Kruskal Wallis test did not show statistically significant differences (Fig 4). Likewise, the Legatum Prosperity index (low, medium, and high) ([18]) was used as a third form of grouping. Figure 4 shows that in this case there are statistically significant differences between the three groups. Table 1 presents the multiple comparisons between geographical areas and Legatum prosperity index levels. For this purpose, the Kruskal Wallis test was also used.

Table 1. Multiple comparisons between geographical areas and Legatum prosperity index levels.

Group 1	Group 2	P-Value	H statistic	Significant difference
Asia-Pacific	America	.4808. The result is *not* significant at $p < .05$.	0.4971 (1, $N = 16$).	No
Asia-Pacific	Western Europe	.93996. The result is *not* significant at $p < .05$.	0.0057 (1, $N = 27$).	No
Eastern Europe	MENA	.66824. The result is *not* significant at $p < .05$	0.1837 (1, $N = 13$).	No
Eastern Europe	Sub-Saharan Africa	.46521. The result is *not* significant at $p < .05$.	0.5333 (1, $N = 11$).	No
MENA	Sub-Saharan Africa	.29115. The result is *not* significant at $p < .05$.	1.1143 (1, $N = 12$).	No
MENA	Western Europe	.32699. The result is *not* significant at $p < .05$.	0.9608 (1, $N = 23$).	No
America	Western Europe	.32699. The result is *not* significant at $p < .05$.	0.9608 (1, $N = 23$).	No
Low (LPI)	Medium (LPI)	.40387. The result is *not* significant at $p < .05$.	0.6968 (1, $N = 30$).	No
Asia-Pacific	Eastern Europe	.00924. The result is significant at p < .05.	6.7765 (1, $N = 16$).	Yes
Asia-Pacific	MENA	.03589. The result is significant at $p < .05$.	4.4024 (1, $N = 17$).	Yes
Asia-Pacific	Sub-Saharan Africa	.03734. The result is significant at $p < .05$.	4.335 (1, $N = 15$).	Yes
Eastern Europe	America	.00649. The result is significant at $p < .05$	7.4103 (1, $N = 12$).	Yes
Eastern Europe	Western Europe	.0041. The result is significant at $p < .05$.	8.2402 (1, $N = 23$).	Yes
Sub-Saharan Africa	Western Europe	.02556. The result is significant at $p < .05$.	4.9857 (1, $N = 22$).	Yes
America	MENA	.01516. The result is significant at $p < .05$.	5.898 (1, $N = 13$).	Yes
America	Sub-Saharan Africa	.02846. The result is significant at $p < .05$.	4.8 (1, $N = 11$).	Yes
Low (LPI)	High (LPI)	.04154. The result is significant at $p < .05$.	4.1538 (1, $N = 25$).	Yes
Medium (LPI)	High (LPI)	.01238. The result is significant at $p < .05$.	6.2558 (1, $N = 45$).	Yes

4. Conclusions

In this work we use text mining, non-parametric statistics and two specialized software (Bibliometrix and VosViewer) to establish the differences in scientific production by country on innovation systems and intellectual property. The most relevant findings include that there are no statistically significant differences if countries are grouped according to the level of development obtained in the Human Development Index. This contrasts with the differences found according to geographic area and the level achieved in the Legatum prosperity index. This can be explained by the fact that the pillars used in the Legatum index include a greater number of dimensions than the Human Development index. Thus, the first index reflects the economic, social, and environmental context in a better way.

Specifically, we found that scientific production in Asia Pacific and North American countries is higher, on average, than in Eastern Europe, the Middle East and North Africa, and Sub-Saharan Africa. These last three regions do not exhibit statistically significant differences among themselves. On the other hand, the countries of Western Europe exceed the production levels of the countries of Eastern Europe and Sub-Saharan Africa.

Future versions of this work could include a contrast of the results with the WoS database and the use of predictive models to establish whether there is a relationship between scientific production in this area and the use of intellectual property protection systems.

References

[1] Zapirain, E. A., & Massa, S. M. (2018) "Intellectual Property Management in Serious Games". In 2018 IEEE Biennial Congress of Argentina (ARGENCON) (pp. 1-5). IEEE.

[2] Ali, S., & Tang, H. (2022) "Is intellectual property beneficial to knowledge management? Literature review on organizational knowledge protection". Journal of the Knowledge Economy, **2022**: 1-19.

[3] World intellectual property organization (2020) What is Intellectual Property? https://www.wipo.int/publications/en/details.jsp?id=4528

[4] Lis-Gutiérrez, J. P., Lis-Gutiérrez, M., Gaitán-Angulo, M., Balaguera, M. I., Viloria, A., & Santander-Abril, J. E. (2018) "Use of the industrial property system for new creations in colombia: a departmental analysis (2000–2016)". In International Conference on Data Mining and Big Data (pp. 786-796). Springer, Cham.

[5] Lee, K., Lee, J., & Lee, J. (2021) "Variety of national innovation systems (NIS) and alternative pathways to growth beyond the middle-income stage: Balanced, imbalanced, catching-up, and trapped NIS". World Development **144**, 105472.

[6] Shenkoya, T., & E. Kim. (2020) "The Impact of Technology Transfer/Policies on the Economic Catch-up of the Korean National Innovation System and its Implications for Nigeria." African Journal of Science, Technology, Innovation and Development **13** (6): 685–699.

[7] Mowery, D. & Oxley, J. (1995) "Inward technology transfer and competitiveness: the role of national innovation systems". Cambridge Journal of Economics **19**: 67 - 93.

[8] Chung, S. (2002) "Building a national innovation system through regional innovation systems". Technovation **22**(8), 485-491.

[9] Rohe, S., & Mattes, J. (2022) “What about the regional level? Regional configurations of Technological Innovation Systems”. Geoforum **129**, 60-73.

[10]Balland, P. A., Boschma, R., & Frenken, K. (2022) “Proximity, innovation and networks: A concise review and some next steps”. In: Torre, A., and Gallaud, D. Handbook of Proximity Relations (70-80), Edward Elgar https://doi.org/10.4337/9781786434784

[11]Van Eck, N.J., & Waltman, L. (2011) “Text mining and visualization using VOSviewer”. ISSI Newsletter **7**(3), 50-54.

[12]Oyewola, D. O., & Dada, E. G. (2022) “Exploring machine learning: a scientometrics approach using bibliometrix and VOSviewer”. SN Applied Sciences **4**(5), 1-18.

[13]Aria, M. & Cuccurullo, C. (2017) “bibliometrix: An R-tool for comprehensive science mapping analysis”. Journal of Informetrics **11**(4), 959-975. DOI: 10.1016/j.joi.2017.08.007 (https://doi.org/10.1016/j.joi.2017.08.007)

[14]Aria, M., Misuraca, M., & Spano, M. (2020) “Mapping the evolution of social research and data science on 30 years of Social Indicators Research”. Social indicators research **149**(3), 803-831. https://doi.org/10.1007/s11205-020-02281-3)

[15]Zhang, R., & Yuan, J. (2022) “Enhanced author bibliographic coupling analysis using semantic and syntactic citation information”. Scientometrics, 1-26.

[16]Sherwani, R. A. K., Shakeel, H., Awan, W. B., Faheem, M., and Aslam, M. (2021) “Analysis of COVID-19 data using neutrosophic Kruskal Wallis H test,” BMC Medical Research Methodology **21**(1): 1–7.

[17]United Nations Development Programme (2021) “Latest Human Development Index Ranking”. UN.

[18]Legatum Institute (2022). “The Legatum Prosperity Index 2021” https://www.prosperity.com/about/resources

[19]Social Science Statistics (2022) “The Friedman Test for Repeated-Measures”. https://www.socscistatistics.com/tests/friedman/default.aspx