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ORIGINAL

Presence of Ecuador in the Web of Science from open access in post-pandemic period 2019- 2021: A multivariate analysis

Presencia de Ecuador en la Web of Science desde el acceso abierto en el período pospandémico 2019-2021: un análisis multivariante

Patricio Álvarez Muñoz[1,2], Fernando Erasmo Pacheco Olea[2], Dennis Alfredo Peralta-Gamboa[3]

[1]Universidad Agraria del Ecuador. Milagro, Ecuador.
[2]Universidad Estatal de Milagro. Milagro, Ecuador.
[3]Facultad de Posgrados, Universidad Estatal de Milagro. Milagro, Ecuador.

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Corresponding author: Dennis Alfredo Peralta-Gamboa

ABSTRACT

Introduction: the COVID-19 pandemic has profoundly transformed scholarly communication, accelerating the global adoption of open access (OA). In this context, it is relevant to analyze how Ecuador positioned itself in these dynamics in the post-pandemic period.
Objective: to evaluate Ecuador's presence in the Web of Science (WoS) database from 2019 to 2021 and identify the impact of the pandemic on scientific production and the adoption of open-access models.
Method: a total of 9085 articles indexed in WoS under the affiliation "Ecuador" were retrieved. Data analysis was performed in R using multivariate statistical techniques and visualization tools (HJ-Biplot), complemented by Bonferroni tests at the 95 % confidence level to compare citation differences between OA and subscription publications.
Results: of the total publications, 52 % corresponded to open access. These articles received more citations on average than subscription-based articles, with statistically significant differences. Private universities accounted for 43 % of publications, public universities for 42 %, and collaborative works for 15 %. A progressive shift toward OA was evident, especially after 2020, with the green route predominating over the gold, bronze, and hybrid pathways.
Conclusions: Ecuador has notably transitioned toward open access, enhancing the visibility and impact of its scientific production. However, challenges remain, related to the lack of national policies and limited inter-institutional collaboration. Strengthening OA strategies is recommended to democratize knowledge and improve the international positioning of Ecuador's scientific output.

Keywords: Scientific Journals; WoS; Scientific Quality; Knowledge; Democratization; Citations.

RESUMEN

Introducción: la pandemia de COVID-19 transformó profundamente la comunicación científica, acelerando la adopción del acceso abierto (OA) a nivel mundial. En este contexto, resulta relevante analizar cómo Ecuador se ha insertado en estas dinámicas en el período post-pandemia.
Objetivo: evaluar la presencia de Ecuador en la base de datos Web of Science (WoS) durante 2019-2021, identificando el impacto de la pandemia en la producción científica y en la adopción de modelos de acceso abierto.
Método: se recopilaron 9085 artículos indexados en WoS bajo la filiación "Ecuador". El análisis se realizó en R mediante técnicas multivariantes y visualización de datos (HJ-Biplot), complementado con pruebas

estadísticas (Bonferroni al 95 %) para comparar diferencias de citación entre publicaciones OA y de suscripción. **Resultados:** del total, el 52 % de las publicaciones correspondieron a acceso abierto. Estos artículos recibieron en promedio un mayor número de citas que los de suscripción, con diferencias estadísticamente significativas. Las universidades privadas aportaron el 43 % de la producción, las públicas el 42 % y las colaboraciones el 15 %. Se evidenció un cambio progresivo hacia OA, especialmente a partir de 2020, con predominio de la ruta verde frente a la dorada, bronce e híbrida.
Conclusiones: Ecuador muestra una transición notable hacia el acceso abierto, lo que incrementa la visibilidad e impacto de su producción científica. No obstante, persisten desafíos vinculados a la falta de políticas nacionales y a la limitada colaboración interinstitucional. Se recomienda fortalecer estrategias que consoliden el OA como vía para democratizar el conocimiento y potenciar la inserción internacional de la ciencia ecuatoriana.

Palabras clave: Revistas Científicas; WoS; Calidad Científica; Conocimiento; Democratización; Citaciones.

INTRODUCTION

The COVID-19 pandemic has represented a turning point in contemporary history, profoundly impacting all sectors, including the academic sector. In this context, scholarly communication has undergone a significant transformation, particularly in the field of open access (OA). Globally, this change has been reflected in the growing adoption of OA policies by academic institutions and publishers, with a focus on the democratization of knowledge.[1]

In Ecuador, the transition to OA has been remarkable, particularly in the context of the health crisis. Universities and research centers have increasingly adopted OA practices, which has expanded the visibility of their work on accessible platforms.[2,3] The Web of Science (WoS), as a leading repository of scientific literature, has recorded a steady rise in Ecuadorian contributions during and after the pandemic, indicative of the country's growing international presence.[4]

Despite these advances, challenges persist in achieving comprehensive OA adoption, including the absence of standardized national policies and financial barriers related to article processing charges (APCs). These limitations, however, also represent opportunities to develop sustainable OA models aligned with local contexts.[5,6] Previous studies have also highlighted the structural challenges of OA publishing[7] and the rapid development of OA journals within the broader open science process.[8] Looking ahead, current trends suggest promising prospects for OA in Ecuador, with expectations of increased international collaboration and broader inclusion of Ecuadorian research in global discussions.[9]

Against this backdrop, this study analyses Ecuador's presence in the WoS during the post-pandemic period (2019–2021) from an open-access perspective. A dataset of 9085 publications was examined using multivariate statistical techniques in R. The analysis incorporated the Bonferroni test at a 95 % confidence level and data visualization through the HJ-Biplot method, allowing a comprehensive view of publication trends across universities and their relationship with OA practices.[10,11,13]

METHOD

The data were retrieved until August 17, 2023, and the search was performed using the following equation: 'CU=(ECUADOR) AND PY=(2019-2021) AND DT=(Article)'.

The analysis was conducted from to 2019-2021; multivariate statistical, bibliometric, and data visualization techniques were used to analyze Ecuador's presence in the Web of Science (WoS) database. With an exclusive focus on the context of open access.

First, the Web of Science (WoS) scientific information database was chosen because of its recognized integrity and coverage of the global scientific literature and rigorous indexing criteria in the academic and research sphere.[14] For the study, we stratified the data from 2019 to 2021. This left a total of 9085 data points to be analyzed.

Analysis

The R programming language was used for data analysis, complemented with various specialized tools:

- dplyr: Facilitates data manipulation and transformation.
- stringr: helpspackage Helps manage and manipulate text strings. openxlsx: Allows reading and writing of Excel files.
- ggplot2: A visualization tool for creating complex graphs. reshape2: Used to restructure and aggregate the data.

These tools were used to segment and categorize Ecuadorian universities according to their nature (public and private) and the type of access to their publications (open or subscription).

Through this approach, it was possible to evaluate the distribution of citations and their annual average, and to highlight publications under open access models.[15]

Advanced data visualization techniques were used for an effective graphical representation of the results. On the statistical side, a detailed analysis of qualitative and quantitative variables divided into factors or groups was conducted, implementing a Bonferroni test to identify significant differences in the number of citations between groups.

To obtain a better representation of universities and publication sources (Open Access and Subscription), this dataset was represented in a dynamic HJ-Biplot over the period 2019–2021,[16] with the objective of obtaining the quality of the data representations with the following information:

1. Acute angles indicate a strong direct correlation.
2. Obtuse angles represent an inverse correlation between the two variables.
3. The right angles represent independence.
4. The distance between observations (universities) indicates similarity.
5. The vector lengths approximate the standard deviation of the vectors.

RESULTS

The scientific production and the number of citations of the publications of Ecuadorian universities in WoS has increased steadily in the post-pandemic period, as shown in figure 1.

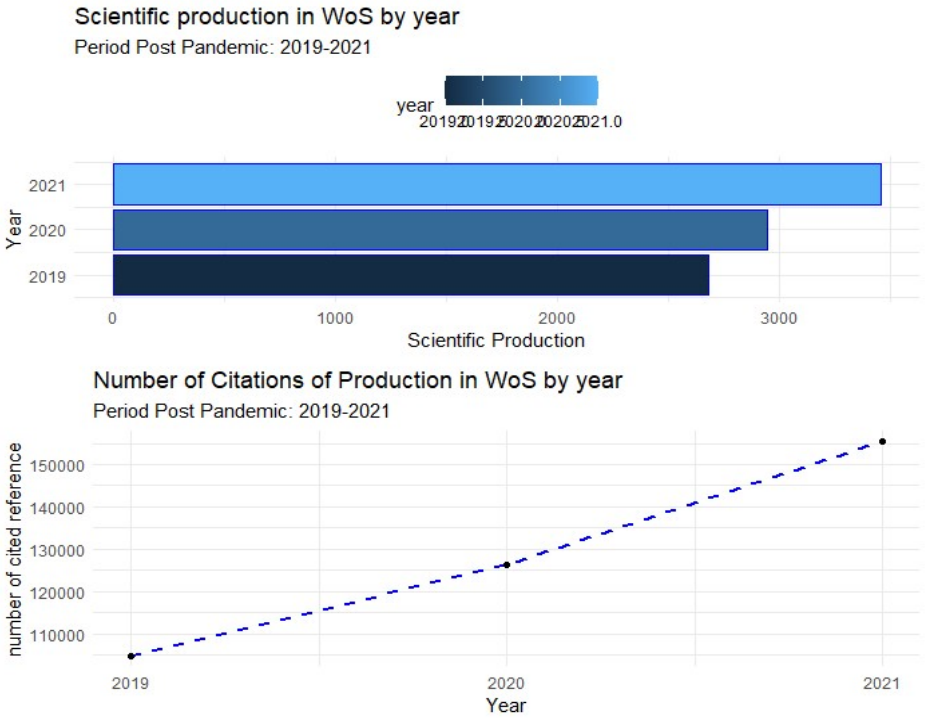


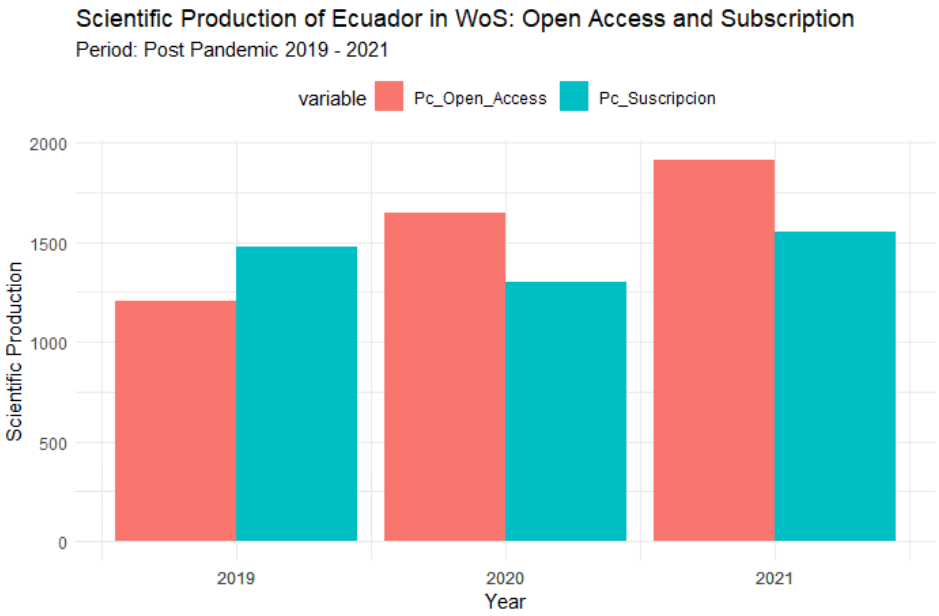
Figure 1. Scientific Production and Number of Citations of the Production in WoS by Year.

Regarding Ecuador's trend in open access, 4759 publications belong to Open Access journals out of a total of 9085 scientific articles. This implies that 52 % of Ecuadorian publications in WoS in the period studied are under this modality, as shown in figure 2.

Until 2019, publications in subscription journals outnumbered those in open access journals; this has changed as of 2020. Regarding the number of citations of scientific publications, it can be seen in figure 3 that publications in open-access journals receive more citations than those published in subscription journals.

These differences in citations were tested using a Bonferroni test at 95 % confidence level. The results were found to be significant ($p = 0$). Thus, we confirmed that an article published in open-access journals receives, on average, more citations than articles published in subscription journals.

Private institutions registered 3905 scientific publications in WoS, while public universities registered 3846 publications in the same database. 1334 scientific publications are the result of collaboration between public and private universities. As shown in table 1, these figures represent 43 %, 42 % and 15 % of the total, respectively.



	X1	X2	X3
year	2019	2020	2021
Pc_Open_Access	1202	1647	1910
Pc_Suscripcion	1477	1299	1550

Figure 2. Scientific production of Ecuador in WoS: Open Access and Subscription

Table 1. Scientific publications from Ecuador in WoS for the period 2019-2021

Year	Pc_public	Pc_private	Pc_colaboration
2019	1259	1045	375
2020	1351	1178	417
2021	1236	1682	542
Total	3846 (42 %)	3905 (43 %)	1334 (15 %)

Analyzing the trend of publications in open access, table 2 shows that, of the 3846 articles from Ecuadorian public universities, 2018 were published in open access journals and 1828 in subscription journals. Of the 3905 research papers from private universities, 1943 appeared in open access journals and 1962 in subscription journals. Finally, of the 1334 collaborative research, 798 were published in open access journals and 536 in subscription journals.

Research published in open access journals constitutes 52,4 %, 49,7 % and 59,8 % of the total number of publications in public, private and collaborative universities, respectively. This behavior demonstrates that open access is increasingly present in Ecuador's collaborative research ecosystems.

Table 2. Open access scientific output: private universities vs. public universities

Year	Open access public production	Open access private production	Open access collaborative production	Public subscription production	Private subscription production	Private subscription collaboration production
2019	568	493	141	691	552	234
2020	742	637	268	609	541	149
2021	708	813	389	528	869	153
Total	2018	1943	798	1828	1962	536

Figure 3 shows an HJ-biplot generated from a multivariate statistical analysis with a representation quality of 950 for the observations (Universities). It visualizes the relationship between different universities and the quantity of their publications in two categories, Open Access and Subscription, over several years (2019, 2020

and 2021). The orientation and length of the vectors indicate how each variable contributes to the variation in the data and the relationship between them. The proximity of the points to each vector suggests the magnitude of each variable for that observation.

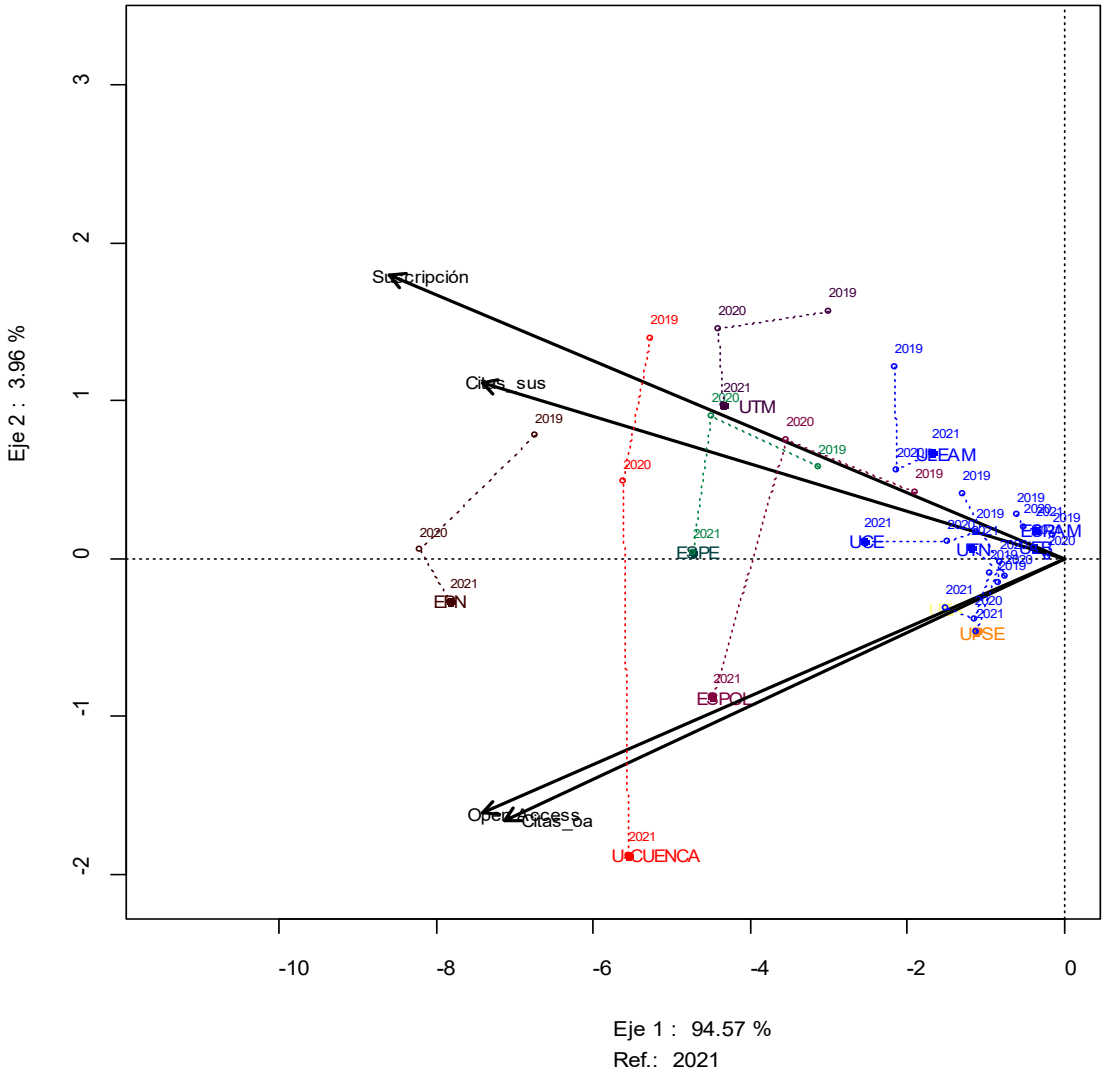


Figure 3. HJ-Biplot Multivariate Dynamics of Public Universities

HJ-Biplot Multivariate Dynamics of Public Universities

The first dimension, Axis 1, explains 94,57 % of the variance, which indicates that most of the information on the differences between universities is found along this axis, so the main variability is in the number of publications and citations, whether Open Access or Subscription.

As expected, there is a high direct correlation between the number of citations and articles in open access and subscription journals. Universities that are located at the top of axis 1 have a better representation for concentrating their scientific publications in open access journals and those that are drawn at the bottom of axis 1 have a better representation for publishing their research in subscription journals.

Publications in subscription journals have a positive correlation with most universities over the years, whereas publications in open-access journals have a less significant relationship with universities. The oldest universities in Ecuador such as Escuela Superior Politécnica del Litoral (ESPOL), Escuela Politécnica Nacional (EPN) and Universidad Estatal de Cuenca (U-CUENCA) show a remarkable change in publication sources in the post pandemic period, initially in the year 2019 these universities were best represented by concentrating their publications in subscription journals and by the end of the year 2021 a latent migratory trend to open access is observed.

Universities located near the origin of coordinates, such as Universidad Técnica del Norte (UTN) and Universidad Central del Ecuador (UCE), suggest a lower number of publications and citations in both categories compared to other public universities in Ecuador. The Polytechnic University of Santa Elena (UPSE) and the Agrarian University of Ecuador are in an atypical case, since they are the ones that have all their publications

tending to be open access.

This study highlights the preferences of Ecuadorian researchers when publishing their articles under the open-access model. Figure 4 illustrates a clear trend among academics from Ecuadorian universities, both in the public and private sectors, in choosing which open access routes they choose for the publication of their research in WoS. The evidence according to the data reflects that the green option (which allows authors to archive versions of their work in specific repositories) leads with 2425 publications. This figure exceeds the 1955 publications that chose the gold route (which involves direct publication in open-access journals), the 200 that chose the bronze route, and the 179 that chose the Hybrid route (where certain articles in traditional journals are made accessible to the public), demonstrating that these routes are not desired by Ecuadorian researchers to disseminate their findings.

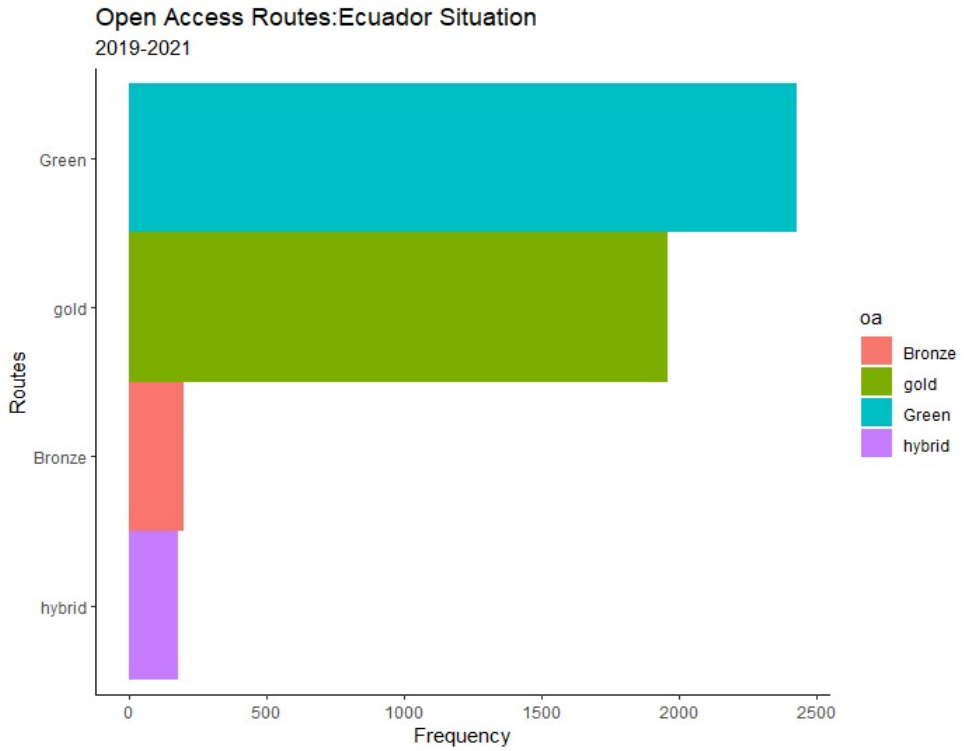


Figure 4. Paths of Scientific Production in Open Access from Ecuador in the Web of Science

DISCUSSION

This study reveals a significant change in Ecuador's scientific publication strategy in the context of open access, especially during and after the COVID-19 pandemic. The adoption of open access in Ecuador, with 52 % of publications in this format during the period studied, reflects a global trend toward greater transparency and accessibility in scientific communication.[17] However, in contrast to countries with more consolidated OS policies, as observed in the study by Moradi et al.[18], Ecuador shows an emerging and developing approach, which underscores the importance of establishing more robust national OA policies.

When comparing the scientific production and citations of Ecuadorian universities in WoS in the period studied 2019-2021, it is observed that open access publications receive, on average, more citations than subscription publications, which is consistent with the findings of Akterian.[19] This pattern suggests that OA not only improves the visibility of research but also its impact, an aspect highlighted in the literature on science communication.[20]

Collaboration between public and private universities in Ecuador, representing 15 % of total publications, is remarkable but still lower than that observed in more collaborative contexts, such as Europe, according to a report by Piazzini.[21] This indicates a potential for growth in inter-institutional collaboration in the country, with much more strength in the post-covid period.

In terms of the distribution of publications by type of access, there is evidence of a growing preference for open access journals in Ecuador, which is in line with the post-pandemic global trends observed by Nane et al.[22] However, Ecuador still faces challenges in terms of comprehensive adoption of these practices, compared to more advanced countries in this regard, as described in the research of Chakravorty et al.[23]

Finally, while Ecuador shows progress in the adoption of open access and an increasing presence in WoS, there is still room for improvement, especially in terms of national policies and inter-institutional collaboration,

as institutions lack clear regulations that stimulate open-access production.

The study is consistent with the current literature and highlights the need for a more proactive and systematic approach to OA in the field of scientific research in Ecuador.

Limitations

Despite the valuable insights provided, this study has some limitations. First, the analysis was restricted to documents indexed in the Web of Science (WoS), which, although highly prestigious, does not capture the entirety of Ecuadorian scientific production included in other databases such as Scopus, PubMed, or regional repositories. Second, the time frame analyzed (2019–2021) offers a snapshot of the immediate post-pandemic period but may not fully reflect long-term trends in open-access practices. Third, this study focused primarily on quantitative indicators (number of publications, citations, type of access) without a detailed qualitative assessment of disciplinary differences, collaboration networks, or funding mechanisms. Finally, the results should be interpreted with caution, as the multivariate statistical techniques applied (HJ Biplot and Bonferroni test) provide robust evidence of associations but do not establish causal relationships. Future research should address these limitations by expanding the dataset, incorporating additional databases, extending the analysis to a longer period, and integrating qualitative approaches that enrich the understanding of open access adoption in Ecuador.

CONCLUSIONS

The analysis has shown a significant transformation in scientific communication in Ecuador, especially marked by the adoption of open access (OA). This trend, which advocates the free availability of scientific literature, has profoundly altered the paradigm of the publication and distribution of knowledge.

These data reflect a strategic adaptation to the post-pandemic global environment and a response to the growing demand for accessible and transparent information. Despite financial challenges, reduced government spending on higher education, and changing perceptions of the quality of publications, educational institutions in Ecuador have demonstrated the ability to maintain a robust and consistent scientific output, adapting to changes in the scientific publishing landscape.

Ecuador's incorporation into the global OA landscape is a significant step towards democratizing knowledge. However, to fully leverage the benefits of OA, a more integrated strategy and sustained legal support at the national level are required. This implies encouraging OA publishing and adopting research and education policies that support the creation and dissemination of knowledge in an open and accessible manner, which is currently incipient.

In conclusion, Ecuadorian researchers have proactively embraced open access, driven by pragmatic adaptation to global trends and limited resources. The challenge now lies with national policymakers and university leaders to build upon this organic momentum. By developing a coordinated national OA strategy that addresses funding, infrastructure, and incentives, Ecuador can ensure that this promising shift translates into a sustained, equitable, and maximized scientific impact on the world stage.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORSHIP CONTRIBUTION

Conceptualization: Patricio Álvarez Muñoz and Fernando Erasmo Pacheco Olea.
Data curation: Dennis Alfredo Peralta-Gamboa.
Formal analysis: Dennis Alfredo Peralta-Gamboa.

Research: Patricio Álvarez Muñoz.
Methodology: Dennis Alfredo Peralta-Gamboa.
Project management: Dennis Alfredo Peralta-Gamboa.
Resources: Fernando Erasmo Pacheco Olea.
Software: Dennis Alfredo Peralta-Gamboa.
Supervision: Patricio Álvarez Muñoz.
Validation: Dennis Alfredo Peralta-Gamboa.
Display: Dennis Alfredo Peralta-Gamboa.
Drafting - original draft: Fernando Erasmo Pacheco Olea.
Writing - proofreading and editing: Patricio Álvarez Muñoz and Dennis Alfredo Peralta-Gamboa.