KOME – An International Journal of Pure Communication Inquiry
DOI: 10.17646/KOME.of.32

ARTICLE

Parallel Empires of Knowledge

AI and the Fracturing of Global Science

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This study examines shifting patterns in global academic knowledge production through the lens of world-systems theory, focusing on the role of generative artificial intelligence (AI) in reshaping epistemic hierarchies. Drawing on longitudinal bibliometric data (1996–2023), it analyses publication volumes, international collaborations and open access trends across core (U.S., U.K.), semi-peripheral and peripheral regions, with special attention to China's emergence as a leading scientific producer. The paper highlights a growing divergence in AI infrastructure and access: Western scholars increasingly rely on open tools like ChatGPT, while China's closed ecosystem is governed by distinct political and epistemic norms. These developments may entrench parallel scientific systems, exacerbating inequalities in visibility, legitimacy and collaboration. As AI becomes a central driver of research practices, this paper argues for inclusive, interoperable knowledge infrastructures to avoid deepening global academic fragmentation. The findings offer a critical perspective on the geopolitics of knowledge in the digital age.

Keywords: world-systems theory, generative artificial intelligence, global knowledge production, academic bifurcation

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Article received on 24 June 2025. Article accepted on 1 August 2025.
Conflict of interest: The authors declare no conflicts of interest.
Funding: The authors received no financial support for the research, authorship, or publication of this article.

Introduction

Generative Artificial Intelligence (AI) technology has rapidly become a transformative force in scholarly publishing, causing excitement and concern among academics (Lund et al., 2024; Yin et al., 2025). The development of AI technologies has led to a significant increase in scientific publications, with China leading in the number of its publications followed by the United States of America (the U.S.) and India (Al-Marzouqi & Arabi, 2024). AI tools are widely used for literature searches, organization of scientific publications, and visualization of research results (Filetti et al., 2024). Specifically, the public release of OpenAI's ChatGPT in late 2022 sparked fierce debates among researchers and publishers about the appropriate role of AI in scientific writing, with issues raised ranging from factual accuracy and hallucinated references to questions of authorship and transparency (Fehér & Demeter, 2025; Lund & Naheem, 2024; Oladokun et al., 2025). Proponents argue that large language models (LLM) can streamline the writing process and even help non-native English-speaking authors to overcome language barriers in academic communication (Hwang et al., 2023). Indeed, early evidence suggests that some academics have begun to use chatbots when preparing manuscripts "to save time or to bolster their command of English". In an era of publish or perish (Stokel-Walker, 2024) this is an unsurprising trend. At the same time, critics highlight the pitfalls of relying on generative AI – from biased outputs reflecting predominantly Western training data to the risk of further eroding trust in scientific integrity through automated, opaque content generation (Mollema, 2024; Qu & Wang, 2024).

These technological developments are unfolding against a backdrop of persistent global inequality in knowledge production (Demeter, 2020). Scholarly publishing has long been dominated by a few high-income countries, institutions and languages, leading to what some have called a *geopolitics of knowledge* that privileges the Global North while marginalising researchers in the Global South (Demeter, 2020; Demeter & Goyanes, 2021). The advent of generative AI thus raises critical questions: Will AI tools democratise academic writing and help bridge the gap between peripheral and core knowledge producers? Or will they exacerbate existing disparities by giving well-resourced scholars yet another advantage?

Similarly, the evolving landscape of Open Access (OA) publishing – with its promise of free knowledge for readers but through several business models; and with high article processing charges (APCs) for authors – presents a double-edged sword for global equity in scholarship (Demeter & Istratii, 2020). On the one hand, OA could decolonise knowledge by making research universally accessible; on the other hand, costly pay-to-publish models may reinforce the two-tier system of haves and have-nots in publishing (Pooley, 2020). In this article, we examine how generative AI is impacting scientific publishing practices, including open access models, and how these impacts intersect with global inequalities in academic knowledge production.

Theoretical framework: A world-system perspective on academic publishing

Inequalities in scientific publishing can be understood through the lens of world-system analysis, which views global academia as a stratified system of core and peripheral regions (Demeter, 2019; Wallerstein, 2004). Demeter (2019) argues that academic knowledge production operates within a centre–periphery structure that is analogous to the economic hierarchy of the world-system. In this model, a small number of hegemonic "core" countries concentrate the bulk of academic prestige, resources and transnational academic capital, while a multitude of other countries occupy semi-peripheral or peripheral positions with significantly less influence. Crucially, the core's knowledge is almost automatically treated as having global relevance, whereas research from peripheral regions is often deemed of local or regional interest only. This hierarchy is reinforced by academic institutions and journals: elite universities and well-indexed journals (mostly based in North America and Western Europe) set the standards and gate-keep what counts as international knowledge, often privileging English-language output and Western theoretical frameworks (Demeter, 2020).

Demeter's (2019) world-systemic model, building on both Wallerstein's world-systems analysis (Wallerstein, 1990, 2004) and Pierre Bourdieu's field theory (Bourdieu, 2009, 1998), introduces a three-dimensional perspective to capture both geographic and social stratification in science. He distinguishes between horizontal inequalities (core vs. periphery differences between countries or regions) and vertical inequalities (hierarchies within each country's academic field, such as elite versus non-elite institutions or researchers). This provides a detailed view in which even peripheral countries have internal elites, and core countries have internal stratifications – yet the global flows of academic capital are skewed toward the centre. A few English-speaking countries occupy the very top tier (the United States of America [U.S.] and the United Kingdom [U.K.] in particular); their national academic systems are in essence the international system's centre of gravity. Demeter (2019) and others identify several ideal-typical tiers in the hierarchy of global science. Core countries such as the U.S. and the U.K. hold a privileged position in which national research outputs automatically attain international significance. Scholars based in these countries dominate editorial boards and citation networks, and affiliation with the Anglo-American academic sphere effectively grants access to the global scientific elite. Academic capital accumulated in these contexts – such as publications in top journals or prestigious degrees – is widely recognised and legitimised without question.

Semi-peripheral major powers, including France, Germany, Japan and, to a lesser extent, Spain, maintain strong national scholarly traditions that exist alongside the international, Anglophone-dominated academic field. In these countries, researchers often build careers by either producing nationally recognised work in their own language or by engaging with the international research community through English-language publications. However, these two tracks generally remain separate, and achievements within national academic systems do not automatically confer international status. As a result, scholars frequently face an early strategic decision: whether to pursue visibility within the global academic hierarchy or to remain embedded in their national scholarly networks.

In semi-peripheral but small advanced countries such as Switzerland and the Netherlands, international science is the dominant mode of academic practice, and local scholarly circuits play a comparatively minor role. Researchers in these countries typically focus on publishing in English-language international journals to advance their careers. While their national education systems are of high quality, academic capital generated domestically does not easily translate into global recognition. Consequently, many ambitious scholars pursue doctoral training or establish collaborative ties in core countries, especially the U.S., to boost their visibility and credibility on the global stage.

Peripheral countries – comprising the majority of nations, often in economically developing or politically marginalised regions – face profound structural barriers in achieving global academic integration. Research in these contexts is often constrained to local concerns, and attempts to enter high-impact international venues are frequently met with systemic exclusion. While many scholars in these regions aspire to contribute meaningfully to global science, their work is often undervalued or overlooked by dominant academic centres (Wu & Zha, 2018). Talented individuals from peripheral countries often migrate to institutions in the core in search of better infrastructure and professional opportunities, a phenomenon widely known as "brain drain" (Gerhards et al., 2017). This pathway, however, tends to be accessible primarily to those with privileged socioeconomic backgrounds, thereby reinforcing existing inequalities along both geographic and class lines.

This world-systemic theoretical framework makes it clear that global academic publishing is not a level playing field, but rather a stratified hierarchy in which structural power imbalances are continually reproduced. As Immanuel Wallerstein (2004) observed, knowledge production is an integral part of the world-system itself, intertwined with geopolitical and economic dominance. Academic ideas, much like capital, flow disproportionately from the centre to the periphery, and the core retains hegemony in setting research agendas and standards (Galtung, 1971, 1980). Demeter (2020) further argues that this inequitable distribution of what he terms "transnational academic capital" (prestige, citations, funding, etc.) not only disadvantages Global South scholars but impoverishes global science as a whole by impeding the circulation of diverse and innovative scholarship. Biases such as the dominance of English-language journals, Western-centric theories, and the underrepresentation of Global South researchers on editorial boards serve to peripheralise non-Western knowledge (Demeter, 2020). In summary, the world-system approach highlights that any new development in academic publishing – including technological innovations like AI or policy shifts like open access – must be analysed in light of these entrenched centre–periphery dynamics. The question is whether such developments will challenge the stratification of global knowledge, or inadvertently reinforce it?

Generative AI in scientific writing

The recent explosion of interest in generative AI for scientific writing has led to a burgeoning literature on its potential benefits and pitfalls. On the positive side, AI writing assistants (such as GPT-3.5/4, Bard and other large language models) offer novel support tools for researchers during manuscript preparation. Early adopter reports and user studies indicate

that these tools can make scientific writing more efficient and accessible. For instance, AI-driven text generation and editing can help authors overcome writer's block, refine their grammar and style, and even format text according to academic conventions (Liao & Zhang, 2024; Thomas, 2023; van Dis et al., 2023). Perhaps most significantly, generative AI has been hailed as a "fire of Prometheus" for non-native English-speaking researchers, providing on-demand assistance with translation, phrasing and polishing of academic prose (Hwang et al., 2023). By serving as "round-the-clock English tutors" (Hwang et al., 2023, p. 952), large language models can lower language barriers in scholarly communication, allowing researchers to focus more on their domain-specific contributions rather than worrying about idiomatic writing. In a world where publishing in English-language journals is often essential for career advancement, such AI tools have the potential to democratise authorship by empowering scholars whose first language is not English. Indeed, anecdotal evidence suggests that many academics are already using ChatGPT or similar models to edit and refine portions of their manuscripts, finding that it improves clarity and readability when used responsibly (Stokel-Walker, 2024).

However, alongside these benefits come serious concerns. A recurring warning in the literature is that generative AI systems are prone to generating fabricated or inaccurate content if used naively (Oladokun et al., 2025). LLMs do not possess genuine understanding: they can produce text that sounds plausible but may include erroneous facts or entirely hallucinated references (Bik, in Stokel-Walker, 2023). Studies have documented instances of chatbots inventing bibliographic citations for papers that do not exist, which poses obvious risks if such output is incorporated into a submission unnoticed (Thorp, 2023). Even when not outright fabricating, AI-generated text might subtly misrepresent scientific nuance or gloss over uncertainties, potentially misleading readers about the state of evidence (Silverman et al., 2023).

Ethical and transparency issues are another major theme. Because LLMs draw on vast training data (much of it from previously published literature), there are concerns about plagiarism or lack of originality in AI-composed passages (Gupta & Pruthi, 2025; Lee et al., 2023). Researchers must grapple with the questions of how to give proper credit (Should AI tools be acknowledged in authors' notes?) and of what constitutes acceptable use. A consensus is emerging that AI cannot be an author – it lacks accountability and cannot consent – and that human authors must take responsibility for any text generated by AI (Stokel-Walker, 2024; Thorp, 2023). A bibliometric analysis of policies at top journals found virtually unanimous agreement that AI tools must not be listed as authors and that any use of generative AI in the writing process should be fully disclosed in the manuscript (Fehér & Demeter, 2025). In response to these issues, major publishers and editorial bodies have released guidelines: for example, the journal *Science* implemented an explicit ban on text or images produced by AI unless explicitly approved by editors, and requires authors to affirm that no portion of the manuscript was generated by AI. Other publishers (e.g. Elsevier and PLoS) allow AI-assisted writing but mandate detailed disclosure of what tools were used and how, often in a dedicated section of the paper.

Beyond accuracy and ethics, scholars have also voiced concerns about bias and inequality in the use of AI for scientific writing. Generative models like ChatGPT have been shown to reflect the biases of their training data, which is heavily skewed toward English-language and

Western sources. For instance, Qu & Wang (2024) revealed that when ChatGPT simulates public opinion using World Values Survey data, its outputs consistently align with Western (particularly U.S.) norms, even in scenarios centred on non-Western countries, underscoring a persistent bias toward English-speaking, developed societies. This suggests that an LLM may implicitly favour Western perspectives or mainstream scientific paradigms, potentially marginalising diverse viewpoints. If researchers rely on such tools for literature reviews or to frame their arguments, there is a risk of reinforcing the epistemic dominance of the Global North.

Additionally, access to cutting-edge AI may itself become a new differentiator between well-resourced and resource-poor researchers. While models like ChatGPT are widely available now, effective use often requires robust internet access, computational resources for any custom model and digital literacy to know the limits of the tools. There is speculation of an emerging AI divide in which institutions with more funding and training will leverage AI to accelerate research and publications, whereas others may fall still further behind (Ahmed & Wahed, 2020; OECD, 2024).

The evolving role of open access publishing

Parallel to the rise of AI, scholarly communications have been transformed over the past two decades by the growth of OA publishing (Demeter et al., 2021). OA is intended to make research findings freely available to readers everywhere, removing paywall barriers that traditionally limited access to science for those without institutional subscriptions. Recent studies document an ongoing acceleration in OA publishing: by 2023, approximately 38% of global journal articles, reviews and conference papers were published under Gold OA, up from just 11% in 2013; while subscription-only content dropped from 70% to 52% (STM, 2024). The proportion of articles that could be published via Gold OA also swelled from 45% to 79% over the same period (STM, 2024). This expansion has been catalysed by funder mandates – such as Plan S, whose implementers report OA rates of around 80% for funded research alongside a surge in transformative agreements encouraging hybrid journals to transition toward OA (Jahn, 2025). Additionally, many large publishers now offer extensive OA options: for instance, Springer Nature reported that 50% of its primary research articles were OA in 2024 (Lauer et al., 2025) and Cambridge University Press had reached a 63% OA output by 2023, largely due to institutional agreements (Moran, 2024).

From the perspective of global equity, OA is often championed as a force for democratisation of knowledge. When anyone with an internet connection can read scientific articles for free, scholars and students in low-income or peripheral regions – whose universities cannot afford expensive journal subscriptions – ostensibly gain the ability to access the latest research on an equal footing with their peers in wealthier countries. This reader-side benefit of OA has been documented in increased usage and citation of OA articles in developing regions, and it aligns with calls to "decolonise" scholarly knowledge by breaking the monopoly of Western publishers over information dissemination (Mwambari et al., 2022).

However, the literature also provides sobering evidence that the current dominant models of Open Access can exacerbate other inequalities, particularly on the producer side of

research. The most common model for OA in high-profile journals is the author-pays model in which journals charge authors an Article Processing Charge (APC) to cover publication costs instead of charging readers. These APCs can be substantial – often ranging from $1,500 to over $5,000 (USD) for a single article in a top journal. Researchers with generous grant funding or those at affluent institutions can usually pay these fees (or their libraries arrange transformative read-and-publish deals to cover them). In contrast, authors from the Global South or less-funded universities may find APCs to be an insurmountable barrier, effectively pricing them out of publishing in the same venues (Smith et al., 2021). A large-scale study by Demeter and Istratii (2020) confirmed a positive correlation between journal prestige (impact factor) and APC levels, noting that many high-impact OA journals charge high fees that researchers from lower-income settings struggle to afford. This raises the concern that OA, while removing paywalls for readers, "lowers barriers to readers only to raise them for authors" (Pooley, 2020). The result can be a two-tier system of publication: well-resourced scholars enjoy seamless OA publication through institutional deals or personal funds, whereas those lacking funding are either forced to publish in lower-tier journals with no/low APCs or not at all (Brainard, 2024). In this way, the APC model can inadvertently mirror and entrench the core–periphery structure: authors from North America and Western Europe make up a disproportionate share of OA articles in prestigious journals, while authors from Africa, Latin America, or South Asia remain underrepresented (Smith et al., 2021).

The literature also discusses mitigating strategies and alternative models to make Open Access more equitable. Many journals offer waiver programs for authors from certain low-income countries, but researchers note that these waivers are not always well-publicised, may exclude upper-middle income countries (where funding gaps still exist), and can also carry a stigma or additional administrative burden. Another model is "Diamond" Open Access, in which neither readers nor authors pay fees – the publication costs are covered by institutions, consortia or governmental subsidies. Diamond OA journals and platforms (such as SciELO in Latin America or journals funded by universities) are highlighted as important outlets that empower researchers in the Global South to publish without charge, although they often operate with limited resources and face sustainability challenges (Demeter et al., 2022). Additionally, preprint servers and repositories provide a route for papers to be freely shared regardless of journal status, which can at least ensure access if not formal recognition. Still, as of 2025, the mainstream of scientific publishing – including most elite journals – has embraced an APC-based Open Access model, which means the resources of the author continue to play a role in who gets to publish openly (Brainard, 2024). The inequities arising from this have prompted calls for a rethinking of the academic reward system: for instance, less emphasis on venue prestige (which is tied to expensive journals) and more on the quality and openness of the work itself, or greater global investment in publication funds and infrastructure in the South (Heuritsch, 2024).

Implications of global epistemic inequality

Bringing together the discussions on generative AI and OA, a central question emerges: are these developments reducing or reinforcing the entrenched inequalities in global knowledge

production? Recent scholarship is mixed in its response. On the one hand, both AI tools and OA publishing are often portrayed as democratising forces. Generative AI has the potential to level the playing field in academic writing by giving every researcher a capable assistant for editing and composition – something that formerly might have required hiring a skilled (and expensive) English editor or having a well-networked mentor. In principle, a researcher in a peripheral context could use a tool like ChatGPT to produce a manuscript that meets international style norms and thereby improve their chances in peer review (Agarwal et al., 2025). Similarly, OA has the potential to amplify voices from the periphery by making their work visible and accessible to all, rather than hidden behind paywalls and accessible only to rich universities. Optimistically, one could imagine a scenario in which a scholar in sub-Saharan Africa uses AI assistance to write a high-quality paper and publishes it in an open-access journal, allowing peers worldwide to read and build on it – a virtuous cycle enhancing the visibility and impact of research from traditionally underrepresented regions.

On the other hand, without deliberate attention to equity, these same trends could perpetuate or even worsen gaps. Generative AI might create new dependencies: if cutting-edge AI tools (or the skills to use them effectively) concentrate in the hands of the core, researchers on the periphery could lag behind in productivity or quality of writing. There is also the risk that AI-generated text homogenises academic writing, pushing it towards a particular normative style (likely Western-centric, given the AI training data), and thereby undermining diversity in scholarly voices. As mentioned above, biases in AI outputs could sideline indigenous perspectives or context-specific knowledge, especially if researchers lean on AI for literature reviews or to frame arguments – the algorithmic filtering might inadvertently preferentially surface mainstream, core publications. Meanwhile, OA in its current form may be skewing the geography of knowledge production. Wealthy institutions in Europe and North America are striking big read-and-publish deals that allow their researchers to publish OA in major journals at no personal cost, while institutions in poorer countries often cannot afford such deals (or APCs directly), leaving their researchers on the outside (Brainard, 2024; Smith et al., 2021). In effect, the global North's dominance might actually increase, with them not only producing the lion's share of publications but also with a higher proportion of those publications being OA (hence garnering more citations and influence); whereas many Global South researchers could remain confined to either less visible national journals or struggling to finance international publication.

Some scholars have begun to use the term *epistemic inequality* or *epistemic injustice* to describe these compounded disadvantages in who can produce and disseminate knowledge (De Sousa Santos, 2016). The integration of AI and the economics of publishing are new layers atop the old patterns of inequity. To ensure that these innovations mitigate rather than amplify inequalities, several proposals surface in the literature: for AI, calls for capacity-building are common – training programs to ensure that researchers globally can use AI tools effectively and ethically; also, development of language models in diverse languages to reduce the Anglophone bias. For publishing, there are calls to subsidise APCs or expand diamond OA models in the Global South, and to reform evaluation metrics so that researchers are not penalised for publishing at local or lower-cost venues. Ultimately, as Demeter (2020) argues, a more inclusive global knowledge ecosystem will require conscious efforts to redistribute academic capital and challenge the notion that excellence is the monopoly of

the centre. Generative AI and Open Access each offer a promise to open up science – but with the realisation that the promise equitability will depend on policy choices, community norms, and possibly new forms of international collaboration to support researchers in underrepresented regions. The coming years will be critical in observing whether these trends lead to a more polycentric world of knowledge production, or whether the "hegemonic countries" will simply use these tools to further consolidate their advantage in the global academic system (Demeter, 2019).

Set against the backdrop of the corresponding literature, this study focuses on the interplay between publication trends, OA trends and GenAI usage with a specific focus on its possible impact on global patterns in academic research production. With this in mind, we address the following research question:

> **RQ:** To what extent do structural geopolitical factors shape the interplay between generative AI usage, academic knowledge production, internationalisation and open access publication models in the global academic system?

Methods

Data collection

LLM usage

Generative AI adoption is accelerating worldwide, but the pace remains highly uneven across regions, sectors and demographic groups. Peer-reviewed surveys show that national uptake already spans a range of two-to-one: in a seven-country study (Australia, Denmark, Germany, Israel, South Korea, Taiwan and the U.S.) the share of adults who had used ChatGPT for science information searches in 2024 varied from 28% in Denmark to 57% in the U.S. (Greussing et al., 2025). Outside the Organization for Economic Co-operation and Development (OECD), adoption is often even faster. India tops global consumer tables, with 73% of respondents reporting GenAI use, while corresponding figures are 45% for the U.S., 49% for Australia and 29% for the U.K. according to the 2024 Salesforce State of the Connected Consumer survey (Salesforce, 2025). China's Ministry of Industry and Information Technology counted 230 million registered users of home-grown GenAI services by June 2024 – roughly 16% of the national population (Kaiwei & Wenxing, 2024). A similar split is visible at organisational level. The 2024 McKinsey Global AI Survey shows that 65% of firms world-wide now run at least one GenAI use-case in production, up from 33% in 2023 (Singla & Sukharevsky, 2024), while a May 2025 U.S. corporate poll found that 95% of U.S. companies have deployed GenAI somewhere in their workflows (Webb, 2025). Sector-specific studies echo that pattern: German university communication departments reported a sharp jump in use of text-generation tools between 2023 and 2024, especially in private institutions (Henke, 2025).

However, these statistics should be interpreted with caution due to major methodological inconsistencies. Current global data on GenAI use are fragmented and sporadic, gathered

through disparate commercial surveys, industry reports and media investigations, often relying on self-reported behaviour or undefined user bases. There is no centralised, academically vetted platform that systematically collects, compares and updates cross-national GenAI usage statistics. This lack of standardisation across sources, definitions and measurement periods limits the comparability and generalisability of available data. Moreover, many surveys focus on specific platforms – most notably ChatGPT – whose accessibility is not global. In China, for instance, ChatGPT is not officially available, and users instead rely on domestic alternatives such as Ernie Bot or Kimi Chat. As a result, Chinese figures on ChatGPT-centric usage reports are misleading because they fail to capture the scope and nature of GenAI engagement within China's closed AI ecosystem.

The China case

Between 2022 and 2025, China's approach to generative artificial intelligence (GenAI) has been shaped by a comprehensive regulatory framework, a deliberate restriction on foreign AI platforms, and the accelerated development of domestic alternatives. The implementation of the Interim *Administrative Measures for Generative Artificial Intelligence Services* in August 2023 by the Cyberspace Administration of China (CAC) marked a critical regulatory milestone that requires GenAI providers to align outputs with socialist core values, ensure lawful data sourcing and undergo algorithmic security reviews (He, 2023). The 2025 Labeling Measures introduced by multiple government agencies further mandated explicit and implicit labelling of AI-generated content to bolster transparency and traceability (Wang & Yu, 2025).

Access to foreign platforms such as OpenAI's ChatGPT has been systematically blocked in mainland China, Hong Kong and Macau since July 2023, on grounds of data security, technological sovereignty and ideological control (He, 2023). These restrictions have led to a burgeoning domestic GenAI ecosystem, with major technology firms like Baidu, Alibaba, Tencent, and academic institutions such as Tsinghua University introducing models like Ernie Bot, Qwen, Hunyuan and ChatGLM. These models are designed not only to compete technologically with Western counterparts but also to comply with state censorship and regulatory standards (McMorrow & Hu, 2024).

In the academic sector, China has actively promoted the integration of GenAI in scientific research, especially in prioritised domains such as biomedicine and climate modelling. Government-led initiatives such as those at the Chinese Academy of Sciences and Tsinghua University have employed GenAI to accelerate tasks like protein structure prediction (Yang et al., 2025) and weather forecasting (Gao et al., 2025). However, stringent ethical and operational guidelines govern this usage. GenAI tools are prohibited from being credited as co-authors, and their use must be disclosed in research publications. AI-generated content cannot be cited as original literature unless accompanied by an explanatory note (Chinese Academy of Sciences & Cyberspace Administration of China, 2025).

China's regulatory approach has also introduced challenges for international academic collaboration. Data localisation laws, strict content controls and ideological mandates complicate cross-border research workflows and constrain the scope of AI-assisted inquiry, particularly in politically sensitive fields such as public policy or human rights (Liu, 2020;

Silver, 2025). Studies have found that Chinese AI-generated publications often avoid topics that could conflict with state narratives, contributing to self-censorship and ideological filtering (Chen, 2025). Moreover, despite widespread informal use of tools like ChatGPT via VPNs, formal academic outputs typically rely on domestically approved models due to institutional compliance pressures (Li et al., 2025).

Statistical data highlight the scale and strategic depth of China's GenAI ecosystem. By June 2024, the number of users of generative AI services in China had reached approximately 230 million – roughly one in six internet users – according to the China Internet Network Information Center (Kaiwei & Wenxing, 2024). In addition, industry reports indicate that China hosts over 130 distinct large language models, accounting for nearly 40% of the global total (Global Times, 2023). While domestic models continue to improve, they still lag behind leading Western systems in areas like cross-disciplinary reasoning and factual accuracy, posing challenges to global interoperability and academic parity (White & Case LLP, 2025). Nevertheless, China's investment in GenAI infrastructure and talent has positioned it as a formidable parallel AI power, shaping the international norms and ethical standards of AI governance.

Publication trends

We used the Scopus database to check the publication trends because it is considered to be the most inclusive international database for peer reviewed publications (Burnham, 2006; Visser et al., 2020). We worked with Scimago, which reports world statistics on publication trends across various world regions on both country and continent levels. The analysed time period covers the years from 1996 to 2024, starting with the earliest to the most recent years that Scimago reports. To provide a global comparison, we conducted both country-level and region-level analysis with the following categories.

- "Big three": the single countries with the highest publication record: The U.S., the U.K. and China
- Europe: The European countries with the highest publication record (Germany, France, Spain, Italy and the Netherlands)
- Asia: The Asian countries (other than China) with the highest publication record (India, Japan, Korea, Indonesia and Taiwan)
- LATAM: The Latin American countries with the highest publication record (Brazil, Mexico, Argentina, Chile and Colombia)
- Global: Key regions with the highest publication records (Ibero-America, Western Europe, North America and Asia)

For each category, we analysed the following trends:

- publication records across the analysed time period (number of Scopus-indexed publications)
- international collaboration: the number of papers published in international collaboration
- open access: the number of open access publications

Analysis strategy

To analyse publication trends, we provided longitudinal descriptive statistics that shows trends in the analysed categories mentioned above. To estimate future trends in scientific publication output, we conducted a time series analysis using ARIMA (AutoRegressive Integrated Moving Average) models. ARIMA is a widely used statistical method for forecasting time-dependent data that is capable of capturing autoregressive patterns, differencing to ensure stationarity, and accounting for moving average components (Box & Jenkins, 1976).

Results

"Big three"

Publication

Figure 1 illustrates the longitudinal growth in the number of scientific documents published by the U.S., the U.K. and China between 1996 and 2024. A striking trend emerges: while the U.S. (green line) maintained a consistently high volume of publications, its growth has plateaued since approximately 2016. The U.K. (blue line) shows modest but steady growth throughout the period, with a relatively stable output compared to the other two countries. Most notably, China (orange line) exhibits exponential growth, surpassing both the U.K. by around 2005 and the U.S. by 2020. By 2024, China's publication output exceeded 1.2 million documents annually – more than double that of the U.S. This rapid expansion reflects China's strategic prioritisation of scientific output as a national objective and underscores its emerging dominance in the global academic landscape. However, as previous sections have noted, this surge in volume does not necessarily correspond to proportional gains in international collaboration or open access adoption, suggesting a complex decoupling of productivity and epistemic integration.

Figure 2 presents the total number of citations received annually by scientific documents. The trajectory reveals a peak-and-decline pattern across all three countries, with notable temporal and structural distinctions. The U.S. (green line) maintained global dominance in citation impact from the late 1990s through the 2010s, peaking around 2011–2013 with over 25 million citations per year. However, since then, a marked decline is visible, accelerating sharply after 2020. The U.K. (blue line) follows a similar but less pronounced pattern, peaking around 2012 and showing a gradual decline thereafter. China's citation trajectory (orange line), by contrast, shows steady growth beginning in the early 2000s, peaking just after 2020. However, by 2024, all three countries exhibit a steep drop in total citations.

This recent convergence and collective decline likely reflect both structural and technical shifts: the lag effect of citation accumulation, delayed indexing for recent publications and possible changes in database aggregation methods post-2020. Additionally, China's ascent in citation volume underscores its growing integration into global citation networks, although the subsequent drop raises questions about long-term visibility and citation lag in newer

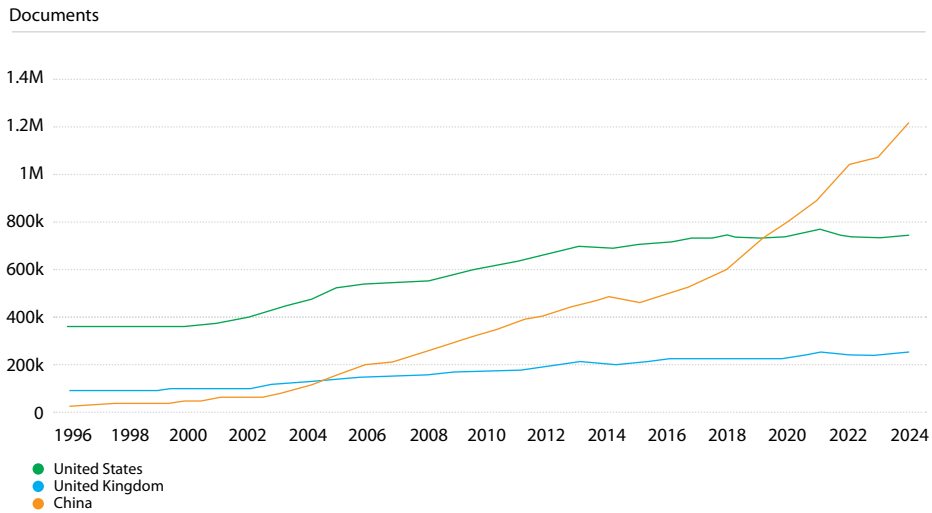
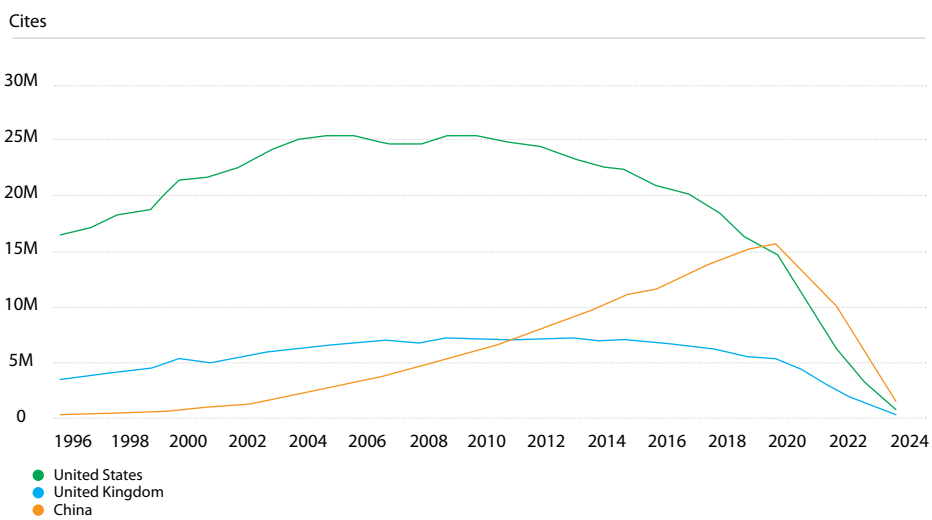


Figure 1:
Publication measures in Scopus for the U.S., the U.K. and China (1996–2024)
Source: Compiled by the authors



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Citation measures in Scopus for the U.S., the U.K. and China (1996–2024)
Source: Compiled by the authors

publications. The decline across all countries suggests that citation metrics alone may be insufficient to capture contemporary scientific influence, especially in an era of rapidly changing digital and AI-driven publication practices.

International collaboration

Figure 3 displays trends in international scientific collaboration measured as a percentage of publications co-authored with at least one international partner. The U.K. (blue line) leads consistently and markedly in international collaboration, rising from approximately 27% in the mid-1990s to over 63% by 2024. This trajectory reflects the U.K.'s strong institutional integration into global academic networks and its historical openness to cross-border research initiatives. The U.S. (green line) exhibits a more moderate but steady increase in collaboration, from around 18% in the late 1990s to about 37% by 2024. This trend aligns with the country's growing emphasis on global partnerships, particularly in large-scale scientific infrastructures and consortia, despite its dominant domestic research capacity.

China (orange line), by contrast, shows relatively stagnant collaboration rates, remaining near 20% throughout the period, with minor fluctuations. This suggests that despite China's surge in publication volume and increasing global scientific visibility, its integration into international co-authorship networks remains limited. The divergence highlights a structural asymmetry: while China is ascending in output, its research is still disproportionately domestically oriented, potentially reflecting linguistic, institutional, or geopolitical barriers to broader collaboration.

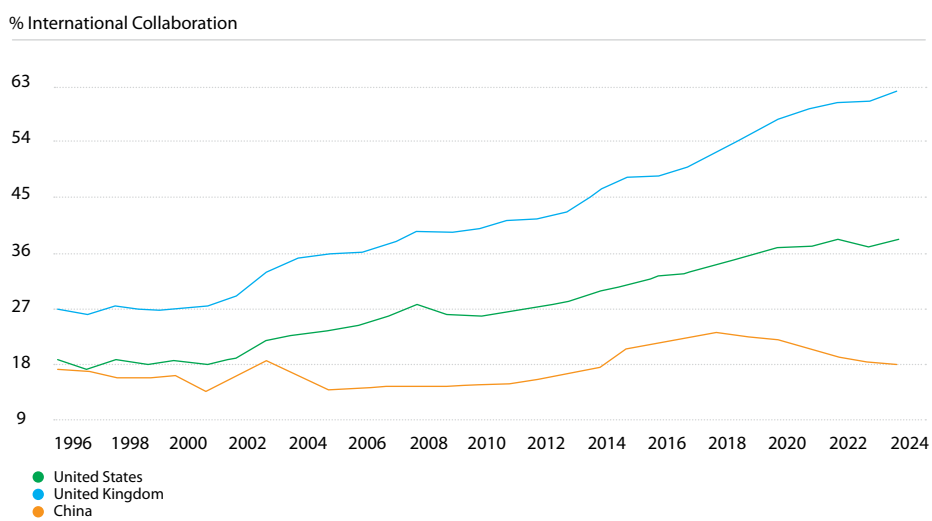

Figure 3:
International collaboration measures in Scopus
for the U.S., the U.K. and China (1996–2024) in percentages
Source: Compiled by the authors

Open access

Figure 4 illustrates the percentage of open access (OA) publications. The U.K. (blue line) demonstrates a remarkable upward trajectory, particularly after 2014, peaking at around 70% in 2022 before a slight decline in 2023–2024. This sharp rise aligns with the introduction of strong national mandates and funding requirements – such as those from U.K. Research and Innovation (UKRI) and the implementation of Plan S – which have made OA publishing a normative standard in the U.K. research ecosystem. The U.S. (green line) shows steady growth in OA adoption, rising from just over 20% in the late 1990s to approximately 55% by 2022, followed by a similar recent decline. Despite lacking a single national OA policy, the U.S.'s increase likely reflects a combination of institutional mandates, public funding conditions and growing participation in hybrid and green OA models across disciplines.

China (orange line) reveals a slower but consistent upward trend, increasing from below 20% in the early 2000s to over 45% by 2022. However, its OA share remains lower than that of the U.K. and the U.S., indicating institutional or systemic constraints. The more modest rise may stem from differing incentives in China's academic promotion systems, limited alignment with Western OA policy frameworks, and reliance on domestic publication venues less integrated with global OA standards. The post-2022 dip in all three countries may reflect systemic lags in indexing, changes in OA categorisation, or broader disruptions in the publishing ecosystem – possibly influenced by shifting APC models, economic pressures, or the saturation of low-barrier OA outlets.

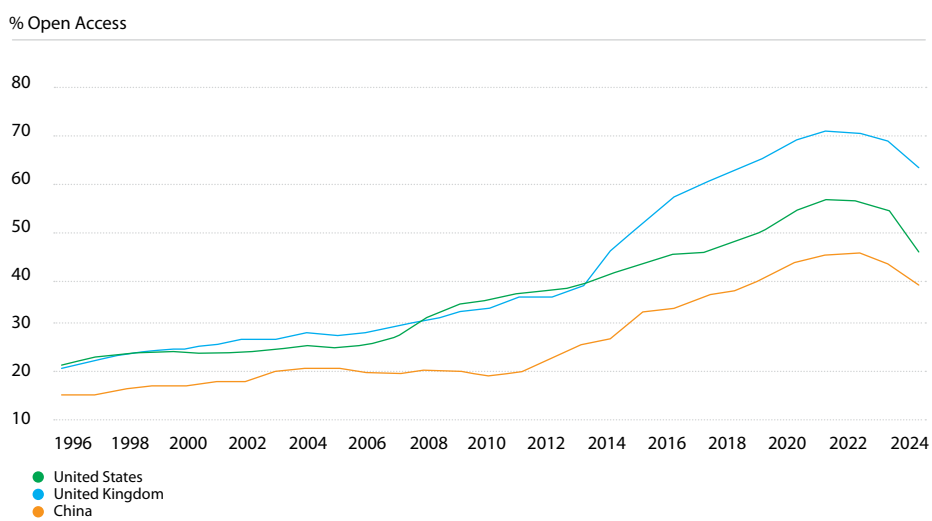

Figure 4:
Open access measures in Scopus
for the U.S., the U.K. and China (1996–2024) in percentages
Source: Compiled by the authors

European Union

Publication

Figure 5 charts the annual number of scientific documents produced by Germany, France, Spain, Italy and the Netherlands between 1996 and 2024. Germany (green line) consistently leads the group, with steady growth in publication output from around 80,000 documents in 1996 to a peak above 220,000 around 2021, followed by a slight decline in more recent years. This plateau may reflect structural saturation or a shift toward quality over quantity in research evaluation policies. France (blue line) and Italy (purple line) follow with relatively similar trajectories until the mid-2010s. Italy then shows a notable surge, overtaking France by 2018 and reaching over 160,000 publications by 2023. This upward shift suggests intensified investment in research or improved indexing practices for Italian outputs. Spain (orange line) demonstrates steady and consistent growth throughout the period, closely converging with France and Italy in recent years. The Netherlands (red line), while exhibiting the lowest total output among the five, maintains a steady growth curve with fewer fluctuations, likely reflecting its smaller research system but sustained productivity relative to population size.

Overall, the figure indicates a general upward trend in scientific output across continental Western Europe, albeit with national variations in scale and growth dynamics. The recent stabilisation or slight decline in some countries' output may signal shifting institutional priorities, funding cycles, or publication model transformations – such as the pivot toward open access or a reorientation around quality metrics.

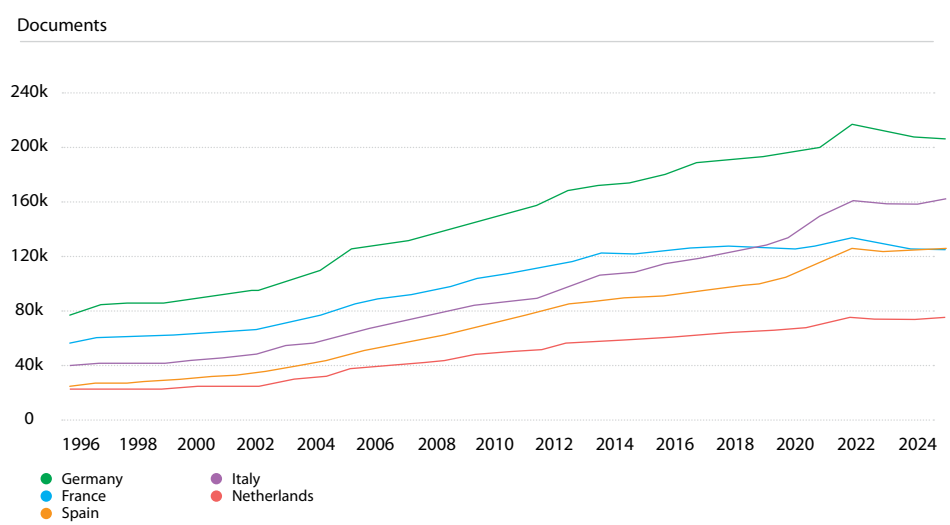

Figure 5:
Publication measures in Scopus
for Germany, France, Spain, Italy and the Netherlands (1996–2024)
Source: Compiled by the authors

International collaboration

Figure 6 displays the percentage of scientific publications involving international co-authorship. All five countries show a clear upward trend, reflecting increased integration into global research networks over the past three decades. The Netherlands (red line) stands out as the consistent leader in international collaboration, beginning the period at around 33% and rising steadily to exceed 68% by 2024. This exceptional growth underscores the Netherlands' strong international orientation and its strategic emphasis on open, collaborative science – despite its comparatively smaller research system. France (blue line) and Germany (green line) both follow upward trends, with France reaching around 60% and Germany approximately 53% by 2024. These patterns highlight the central role both countries play in European and global science, benefiting from their position as hubs within large-scale EU research frameworks. Spain (orange line) and Italy (purple line) started with lower collaboration rates, but show robust convergence with the other countries over time. Both reach over 45% by 2024, suggesting increased participation in EU-funded programs and greater cross-border integration.

Collectively, the data reflects a strong European trajectory toward internationalisation, likely driven by structural support through EU initiatives such as Horizon 2020 and Horizon Europe, as well as the expansion of multilingual and cross-national research consortia. The upward trend across all five countries signals a clear policy shift prioritising global research cooperation as a pathway to academic visibility and scientific impact.

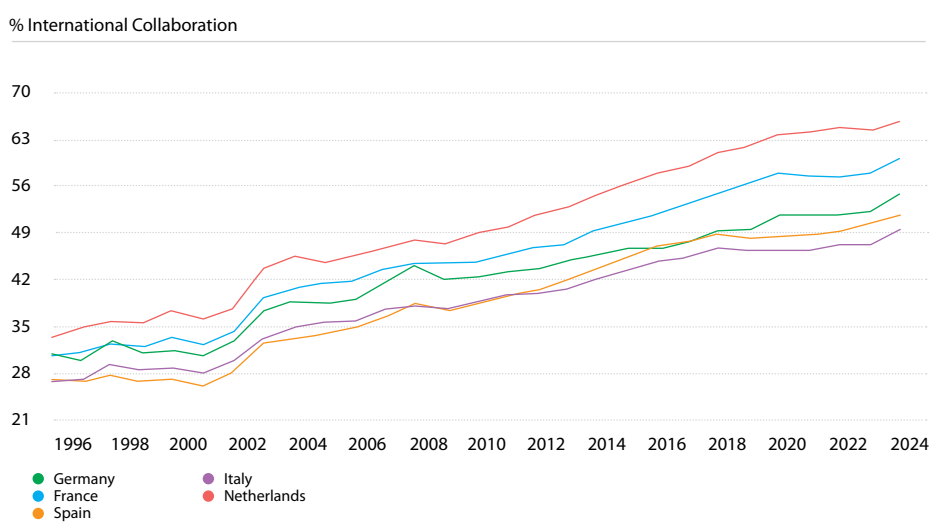

Figure 6:
International collaboration measures in Scopus
for Germany, France, Spain, Italy and the Netherlands (1996–2024) in percentages
Source: Compiled by the authors

Open access

Figure 7 tracks the percentage of scientific publications made available through OA. A clear collective trajectory emerges: all five countries demonstrate a long-term rise in OA adoption, with particularly sharp increases after 2014 that were probably catalysed by the implementation of national and EU-level OA mandates. The Netherlands (red line) leads consistently, beginning the period at an already elevated level (~30%) and rising steeply after 2015 to a peak above 80% around 2022. This leadership reflects early national investment in OA infrastructure, a culture of policy-driven openness and compliance with initiatives such as Plan S. Spain, France and Italy (orange, blue and purple lines, respectively) show closely aligned trajectories, with all three surpassing the 60% threshold by 2022. These countries benefited from strong national policies and increasing alignment with European Commission OA frameworks. Germany (green line), while also trending upward, appears to have lagged slightly behind the others until recent years, though by 2022 it had reached comparable OA levels (~65%). The uniform drop in OA percentages across all countries in 2023–2024 suggests either a lag in indexing, temporary classification inconsistencies, or a recalibration of what constitutes OA in bibliometric databases.

Overall, the data points to successful regional coordination in advancing OA practices, while also highlighting how national contexts (such as funding mechanisms, institutional mandates and digital infrastructures) affect the pace and sustainability of OA implementation.

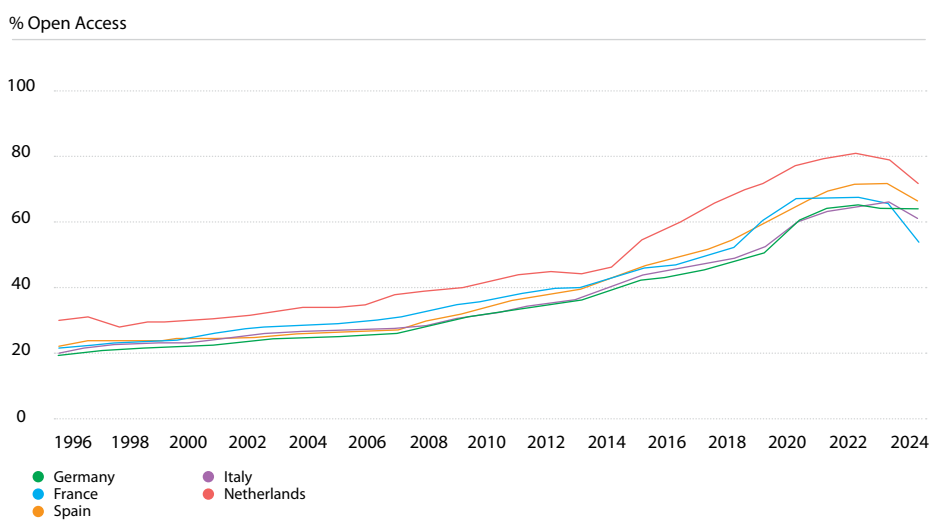

Figure 7:
Open access measures in Scopus
for Germany, France, Spain, Italy and the Netherlands (1996–2024) in percentages
Source: Compiled by the authors

Asia

Publications

Figure 8 illustrates the evolution of scientific publication output for five Asian countries – India, Japan, South Korea, Taiwan and Indonesia – between 1996 and 2024. One key trend is the dramatic rise of India (green line), which moves from approximately 25,000 publications in 1996 to nearly 350,000 by 2024, overtaking all others in the region by a substantial margin. This sharp increase likely reflects India's expanding research infrastructure, increased investment in STEM education and national incentives for scientific publishing. Japan (blue line), once the clear regional leader, shows a stagnating trend. Its publication output remained relatively flat from 1996 through the mid-2010s, with a slight decline in recent years. This plateau may indicate a mature scientific system shifting focus from quantity to quality, or broader demographic and funding constraints. South Korea (orange line) shows steady growth, climbing from around 20,000 in 1996 to approximately 140,000 in 2024. Taiwan (purple line) and Indonesia (red line) also exhibit upward trajectories, with Taiwan's growth tapering in the late 2010s and Indonesia demonstrating a steep rise after 2015, reflecting the latter's increasing participation in global research networks and domestic science policy reforms.

The diverging curves suggest a rebalancing within Asia's academic publishing landscape, with India emerging as a dominant regional force and Indonesia showing potential for future acceleration. Meanwhile, Japan's relative decline signals a possible repositioning of leadership within the Asian scientific ecosystem.

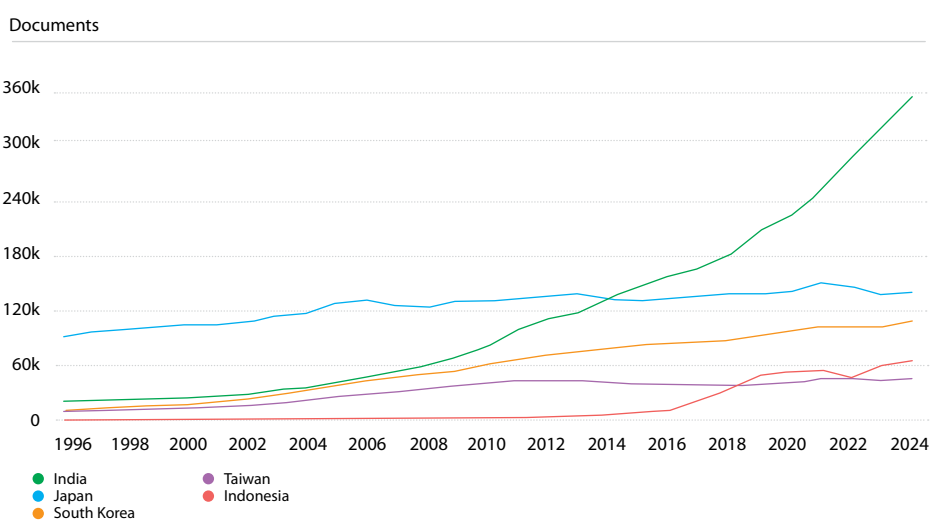

Figure 8:
Publication measures in Scopus
for India, Japan, South Korea, Taiwan and Indonesia (1996–2024)
Source: Compiled by the authors

International collaboration

Figure 9 tracks the percentage of scientific publications involving international co-authorship. The patterns reveal distinct trajectories in regional integration into global research networks. Indonesia (red line) begins as the clear outlier, maintaining extremely high international collaboration rates (above 65%) until 2010. However, a sharp and sustained decline follows, dropping to below 20% by 2018 before stabilising and slightly rebounding in recent years. This dramatic shift likely reflects the expansion of domestic research capacity and a growing share of nationally driven publications.

Taiwan (purple line) exhibits the most dramatic growth in collaboration, rising from under 20% in the early 2000s to over 45% by 2024. This trend suggests deliberate policy efforts to internationalise its science system, possibly through bilateral agreements, joint research programs and regional partnerships. South Korea (orange line), Japan (blue line) and India (green line) all show relatively modest but steady increases over time. South Korea climbs from 25% to about 36%, while Japan increases from 18% to 31%. India remains the lowest throughout most of the period, although its collaboration rate has improved in recent years, rising from around 15% to over 25% by 2024.

Figure 9 reflects broader asymmetries in how Asian countries are positioning themselves in global science: while some (e.g. Taiwan) are becoming more outward-looking, others (e.g. India and South Korea) are strengthening domestic production capacity first, with international integration proceeding more cautiously. Indonesia's inverted trajectory further demonstrates how growing national capacity can reduce reliance on international partnerships, but also raise concerns about epistemic insularity if not balanced with global engagement.

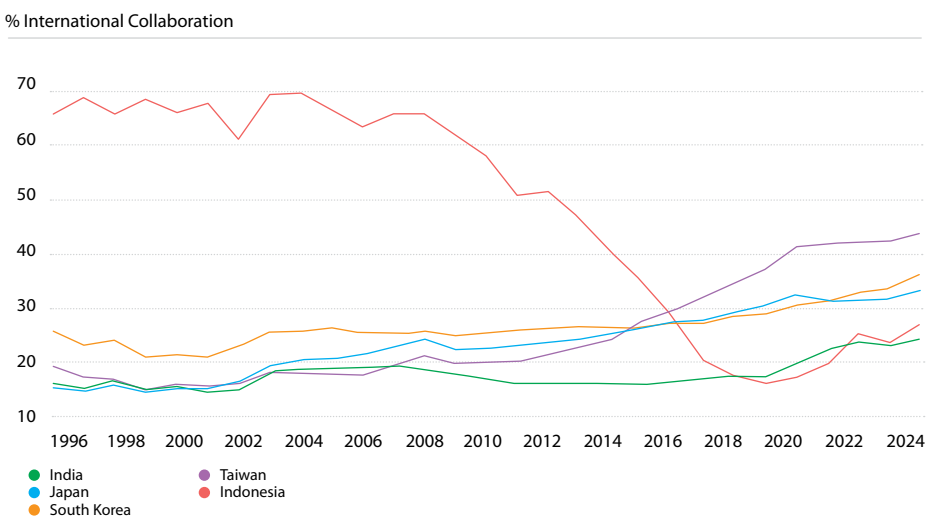

Figure 9:
International collaboration measures in Scopus
for India, Japan, South Korea, Taiwan and Indonesia (1996–2024) in percentages
Source: Compiled by the authors

Open access

Figure 10 presents the share of scientific publications made available via open access in the countries analysed. Overall, the data reveals a regional trend toward increased OA adoption, although the pace and stability of growth differ markedly across countries. Indonesia (red line) stands out with a sharp rise in OA adoption beginning around 2016, peaking at nearly 80% by 2021. This rapid growth may reflect government-driven OA mandates, national repository expansion and integration with regional indexing platforms. Although the rate dips slightly after 2021, it remains the highest among the five countries. South Korea (orange line), Japan (blue line) and Taiwan (purple line) all exhibit relatively similar trajectories. These countries began with OA shares of around 20%–30% and steadily increased to roughly 55%–60% by 2021–2022, with minor declines in 2023–2024. These patterns suggest a regional convergence in OA policy alignment and journal participation in international OA infrastructures such as the Directory of Open Access Journals (DOAJ) and Scopus-indexed repositories. India (green line), in contrast, lags behind the regional trend. Although its OA share increased gradually until around 2020, it then plateaued and began to decline after 2021, falling to below 30% by 2024. This suggests systemic challenges in implementing large-scale OA practices, possibly related to APC affordability, institutional readiness, or the dominance of national journals not fully integrated into global OA platforms.

In summary, while open access has gained momentum across the Asian region, national contexts – including policy support, infrastructure and funding models – continue to shape the extent and sustainability of OA adoption. Indonesia's rapid rise and India's relative stagnation exemplify how divergent trajectories can emerge even within similar economic or regional contexts.

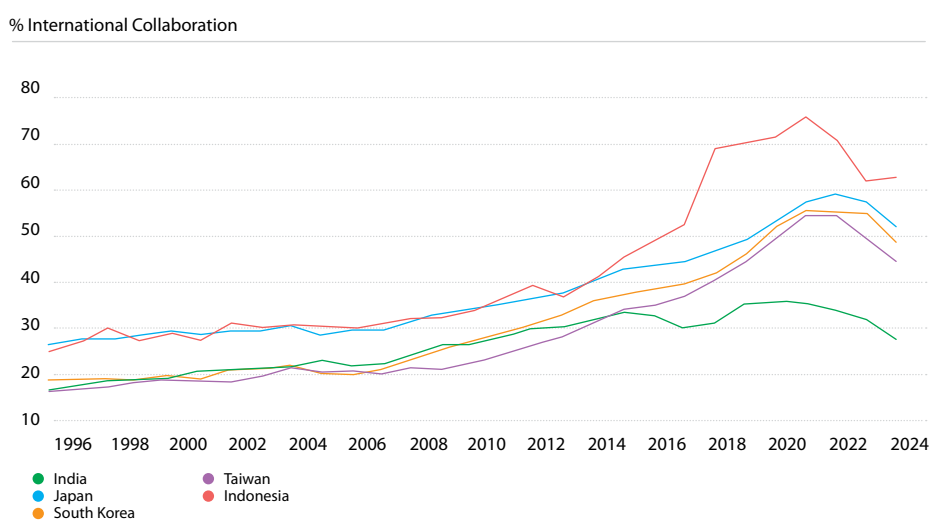

Figure 10:
Open access measures in Scopus
for India, Japan, South Korea, Taiwan and Indonesia (1996–2024) in percentages
Source: Compiled by the authors

LATAM

Publication

Figure 11 presents the evolution of scientific publication output for Colombia, Brazil, Mexico, Argentina and Chile between 1996 and 2024. Brazil (blue line) emerges as the clear regional leader, with output rising steeply from fewer than 10,000 publications in the late 1990s to a peak of over 110,000 around 2021, followed by a notable decline in more recent years. This trajectory reflects Brazil's strong public investment in higher education and research during the 2000s and 2010s, but also reveals recent stagnation or contraction likely tied to economic and political shifts. Mexico (orange line) shows steady growth over the same period, reaching nearly 40,000 publications by 2024, although the pace has levelled off since around 2020. Argentina (purple line) and Chile (red line) have followed similar patterns, with gradual increases and moderate recent plateaus. Colombia (green line), while still the lowest in total output, has demonstrated strong relative growth, particularly after 2015, signalling expanding national research capacity.

Collectively, Figure 11 illustrates the continued development of scientific systems in Latin America, although at varying rates. Brazil's leadership is clear, but its recent decline raises concerns about the sustainability of its research model. Meanwhile, the upward momentum in countries such as Colombia points to the diversification of regional contributions to global science. These trends underscore the interplay between national science policies, regional funding structures and political stability in shaping long-term publication trajectories.

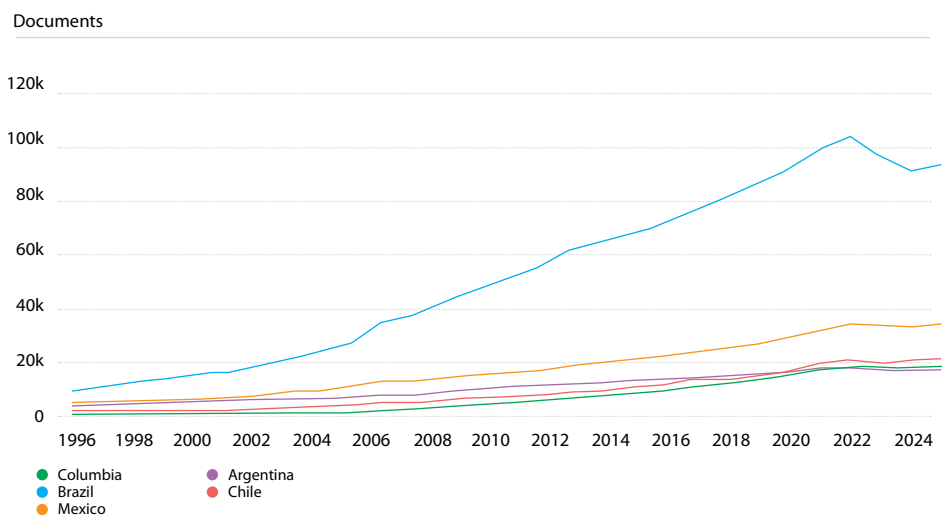

Figure 11:
Publication measures in Scopus
for Colombia, Brazil, Mexico, Argentina and Chile (1996–2024)
Source: Compiled by the authors

International collaboration

Figure 12 presents the percentage of scientific publications involving international co-authorship. The data reveals both longstanding patterns and emerging shifts in regional research connectivity. Chile (purple line) consistently leads the region in international collaboration, increasing from approximately 43% in 1996 to nearly 65% by 2024. This sustained growth reflects Chile's strategic emphasis on internationalisation, likely driven by its relatively small research system and the role of international partnerships in enhancing visibility and impact. Colombia (green line) also shows high and generally stable levels of collaboration, fluctuating around 50%–55% for most of the period and rising more clearly after 2016. Argentina (orange line) and Mexico (blue line) exhibit moderate but stable collaboration rates, both hovering between 40%–45% by the end of the period. Their flatter trajectories suggest long-standing institutional connections to global networks but without major recent expansions. Brazil (red line), despite being the region's publication leader, consistently has the lowest international collaboration rate, starting below 30% in 1996 and gradually increasing to around 38% by 2024. This pattern likely reflects Brazil's substantial domestic research capacity, which enables high-volume output without proportional reliance on international partners, and the fact that Brazil does not share a common language – Spanish – with the other countries analysed means intra-regional collaboration can be more challenging for Brazilian researchers. However, this also points to a relative insularity that may limit integration into global knowledge flows.

In sum, Figure 12 reveals a mixed landscape: while countries like Chile and Colombia are increasingly outward-facing, others – especially Brazil – still operate with a stronger

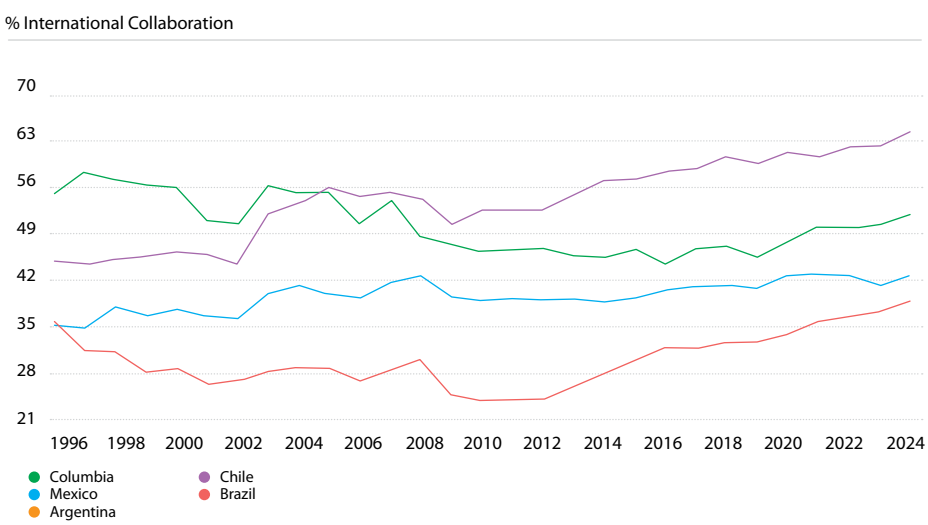

Figure 12:
International collaboration measures in Scopus
for Colombia, Brazil, Mexico, Argentina and Chile (1996–2024) in percentages
Source: Compiled by the authors

domestic orientation. These disparities illustrate how national science systems, size, language and policy environments shape the nature and depth of international scientific engagement in Latin America.

Open access

Figure 13 presents data that reveals Latin America's strong and early commitment to OA publishing, with all five countries showing significant upward trends. Mexico (orange line) shows the most striking trajectory, rapidly increasing its OA share after 2010 and peaking above 70% around 2017–2019 before experiencing a slight decline in recent years. This surge likely reflects national mandates, the influence of institutional repositories and integration with regional platforms such as RedALyC and SciELO. Chile (purple line) and Argentina (red line) also display consistent growth, both surpassing 60% by 2020. Argentina's early and steady increase reflects long-standing public policies in support of OA, while Chile's trajectory aligns with its broader commitment to internationalisation and digital science infrastructure. Colombia (green line) and Brazil (blue line) both show marked improvement in OA adoption, reaching around 65% and 60% respectively by 2022. Brazil's growth is especially significant given its high volume of publications, underscoring its dual status as both a regional research powerhouse and a major proponent of OA publishing through SciELO.

The slight dip across most countries in 2023–2024 may reflect database reclassifications, temporary reporting lags, or changes in how OA is defined or indexed. Despite this, the overall pattern confirms Latin America's global leadership in open access, driven by regional platforms, public infrastructure and a strong normative commitment to equitable access to knowledge.

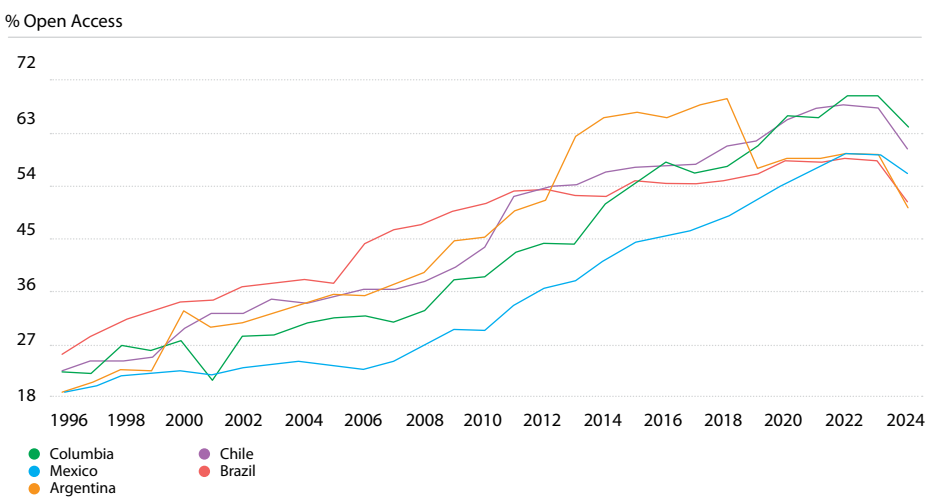

Figure 13:
Open access measures in Scopus
for Colombia, Brazil, Mexico, Argentina and Chile (1996 –2024) in percentages
Source: Compiled by the authors

Global trends

Publications

Figure 14 presents the total number of scientific publications produced annually across four major world regions with the highest research production: Ibero-America, Western Europe, Northern America and the Asiatic Region, between 1996 and 2024. The data reveals both long-standing hierarchies and significant shifts in global knowledge production. The Asiatic Region (purple line) shows the most dramatic transformation, with exponential growth beginning around 2005. Surpassing all other regions by 2014, it continues its steep ascent, reaching over 2 million documents by 2024. This trajectory is largely driven by the rise of China, alongside significant contributions from India, South Korea and other emerging Asian research powers. Western Europe (blue line) and Northern America (orange line) maintain relatively stable trajectories, with Western Europe overtaking Northern America around 2017. These trends reflect mature, high-capacity research systems with incremental growth, likely constrained by demographic and funding ceilings, as well as a growing emphasis on research quality over quantity. Ibero-America (green line), while still producing fewer publications overall, exhibits steady and consistent growth across the entire period. Its progress highlights the expansion of regional scientific capacity, supported by open access infrastructures and national science policies that emphasise global visibility.

The widening gap between the Asiatic Region and other regions of the world suggests a reconfiguration of the global research order. While the Global North continues to lead in infrastructure, influence and institutional prestige, the Global East is asserting dominance in terms of output volume, signalling a potential shift in the balance of global epistemic power.

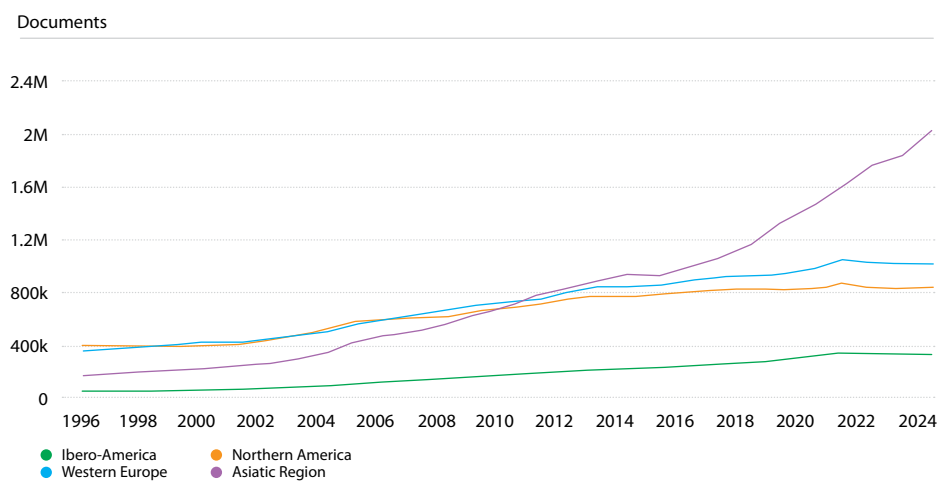

Figure 14:
Publication measures in Scopus
for the four most productive world regions (1996–2024)
Source: Compiled by the authors

Citations

As discussed above, the recent decline in citation counts across regions from 2021 to 2024 is most likely due to structural factors rather than a genuine drop in scientific influence. Citations naturally accumulate over time, so recent publications have had less opportunity to be cited. Additionally, delays in indexing by bibliometric databases and shifts in how citations are tracked can temporarily suppress citation counts. Post-pandemic disruptions, the rise of preprints and non-traditional publishing formats, and the growing use of alternative metrics may also contribute to lower recorded citation activity in the short term.

Figure 15 reflects these dynamics clearly. Northern America and Western Europe, long-standing leaders in citation volume, show steady rises through the early 2000s before peaking around 2014–2016 and then declining sharply after 2020. The Asiatic Region, despite its continuing growth in publication output, also experienced a rapid fall in citation counts post-2020, suggesting a decoupling of volume and impact, at least in the short term. Ibero-America follows a similar pattern to a lesser degree. Together, these trends highlight a systemic temporal lag and underscore the need to interpret recent citation data cautiously, particularly when comparing across regions with different publishing and indexing dynamics.

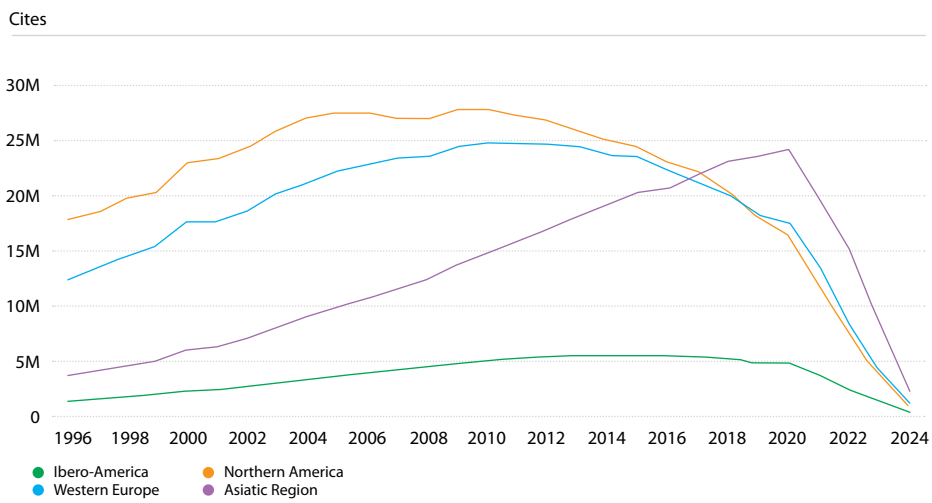

Figure 15:
Citation measures in Scopus
for the four most productive world regions (1996–2024)
Source: Compiled by the authors

International collaboration

Figure 16 depicts trends in international scientific collaboration measured as a percentage of co-authored publications involving foreign institutions, from 1996 to 2024. Western Europe shows a steady rise from around 25% to nearly 50%, reflecting deep integration within transnational research frameworks such as the European Union's funding programs. Northern America also increases over time, though more modestly, reaching just over 40% by 2024. Ibero-America follows a similar upward path, approaching 40%, indicating successful regional efforts to globalise research through OA platforms and networked institutions. The Asiatic Region, in contrast, remains significantly lower throughout the period, increasing only from about 15% to 25%. Despite its dramatic rise in publication volume, it continues to operate with limited international engagement, suggesting a more domestically driven research model. The regional gap in collaboration highlights structural asymmetries in global science, where high-output regions may still lag in epistemic integration.

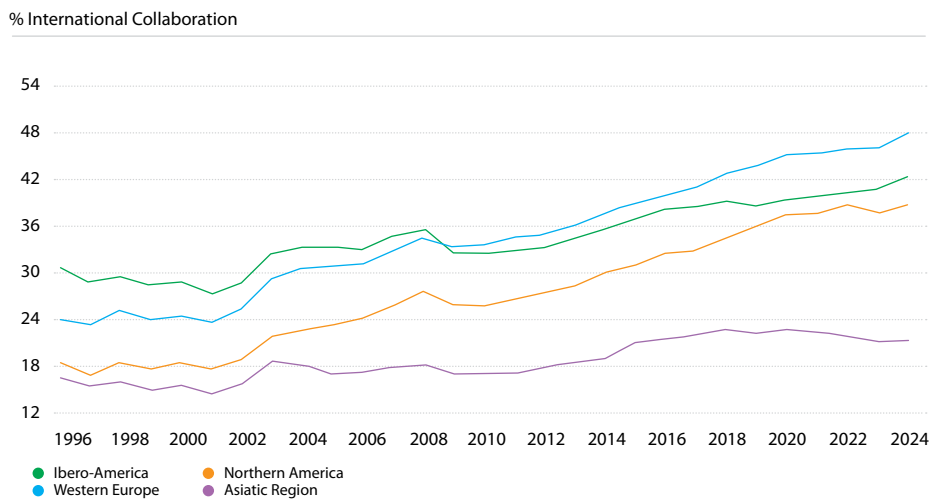

Figure 16:
International collaboration measures in Scopus
for the four most productive world regions (1996–2024) in percentages
Source: Compiled by the authors

Open access

Figure 17 displays the evolution of open access publishing as a percentage of total scientific output. Over the nearly three-decade period, all regions exhibit a consistent upward trajectory, underscoring a global shift toward more accessible models of scholarly communication. Ibero-America (green line) emerges as an early and persistent leader in OA adoption. Its steady rise, culminating in over 65% OA by 2022, reflects the success of regional platforms such as SciELO and RedALyC, which have institutionalised OA without author-facing fees in line with public and governmental support for democratising knowledge. Western Europe (blue line) shows the most rapid acceleration after 2014, eventually surpassing other regions and peaking near 70% by 2022. This surge aligns with the implementation of Plan S and other policy mandates by European funders that require publicly funded research to be published in OA formats. The trend also reflects the influence of strong institutional OA mandates and comprehensive national repositories. Northern America (orange line), while slower to adopt in the early 2000s, steadily increases its OA share and follows closely behind Western Europe. By 2022, it reached over 60%, driven largely by a combination of institutional repositories, hybrid journal models and increased awareness of the limitations of pay-walled research – especially during the Covid-19 pandemic, which heightened the perceived need for open access to scientific knowledge. The Asiatic Region (purple line) demonstrates a clear upward trend but maintains the lowest OA percentages throughout the period, peaking around 50% in 2022. While countries such as China and India have expanded their OA presence, structural barriers – such as reliance on high-impact pay-walled journals for academic evaluation – continue to constrain full transition to open models.

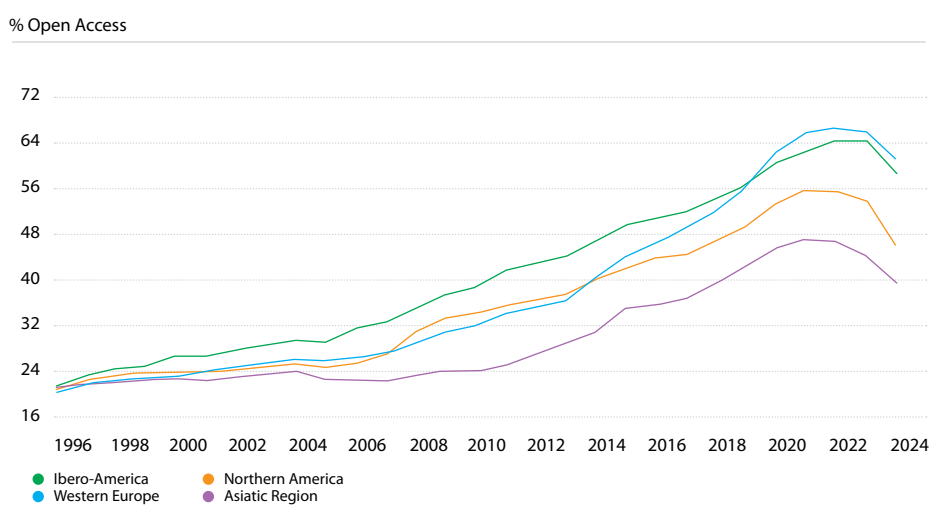

Figure 17:
Open access measures in Scopus
for the four most productive world regions (1996–2024) in percentages
Source: Compiled by the authors

The slight downturn across all regions after 2022 may be attributed to data indexing delays, shifting OA classification criteria, or changes in the inclusion of repository content in bibliometric databases. Nevertheless, the overall trajectory illustrates a global realignment in the politics of academic publishing in which open access is no longer a fringe movement but an institutionalised norm, albeit unevenly distributed across geopolitical and infrastructural lines.

Trend setting (ARIMA)

"Big three"

To estimate future trends in scientific publication output for China, the U.S. and the U.K., we conducted a time series analysis using ARIMA (AutoRegressive Integrated Moving Average) models. ARIMA is a widely used statistical method for forecasting time-dependent data, capable of capturing autoregressive patterns, differencing to ensure stationarity and accounting for moving average components (Box & Jenkins, 1976; Cicero, 2025). The analysis used longitudinal publication data from 1996 to 2024 (N = 29 years per country) obtained from the Scimago database. Because the underlying data exhibited upward trends with potential non-stationarity, first-order differencing (d = 1) was applied to each series. After visually inspecting the autocorrelation and partial autocorrelation functions and considering model parsimony, an ARIMA(2,1,0) model was fitted for each country. This configuration implies a second-order autoregressive process on the first-differenced data, without a moving average term. Model fitting and forecasting were implemented in Python 3.11 using the statsmodels library. The models were estimated using maximum likelihood. Forecasts were generated for six future years (2025–2030), and results were visualised alongside historical data to assess growth trajectories.

Model diagnostics indicated a good fit across all three countries. The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values were low, suggesting model adequacy: China (AIC = 663.51, BIC = 667.50), the U.S. (AIC = 646.63, BIC = 650.63) and the U.K. (AIC = 590.55, BIC = 594.54). Residual autocorrelation was tested using the Ljung–Box Q-test at lag 10. All models returned non-significant p-values (China: p = .18; the U.S.: p = .999; the U.K.: p = .996), indicating no significant autocorrelation and well-specified models.

The forecasts revealed diverging trajectories among the three countries (Figure 18). Publication output in China is projected to increase steeply, reaching over 1.75 million publications by 2030. In contrast, output in the U.S. is expected to remain stable at around 744,000, while the U.K.'s output is projected to slightly increase, stabilising near 254,000 publications annually. These results confirm prior observations of China's rapid expansion in scientific output and highlight continuing structural differences in global academic productivity.

To examine future trajectories in the internationalisation of scientific collaboration, we conducted a time series analysis of international collaboration rates (Figure 19). Here we also employed AutoRegressive Integrated Moving Average (ARIMA) models. Initial exploratory data analysis revealed upward and non-linear trends, justifying the use of first-order differencing (d = 1). After assessing autocorrelation functions and balancing

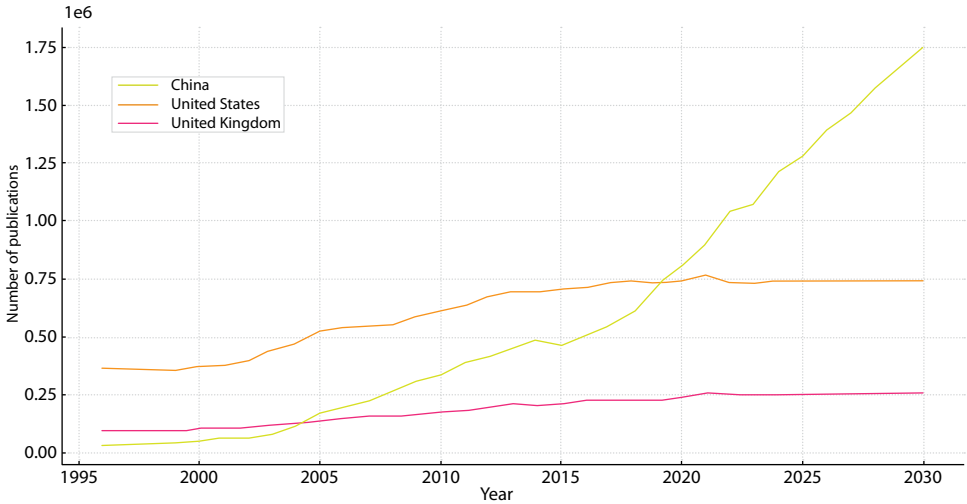

Figure 18:
Research production forecast for China, the U.S. and the U.K.
Source: Compiled by the authors

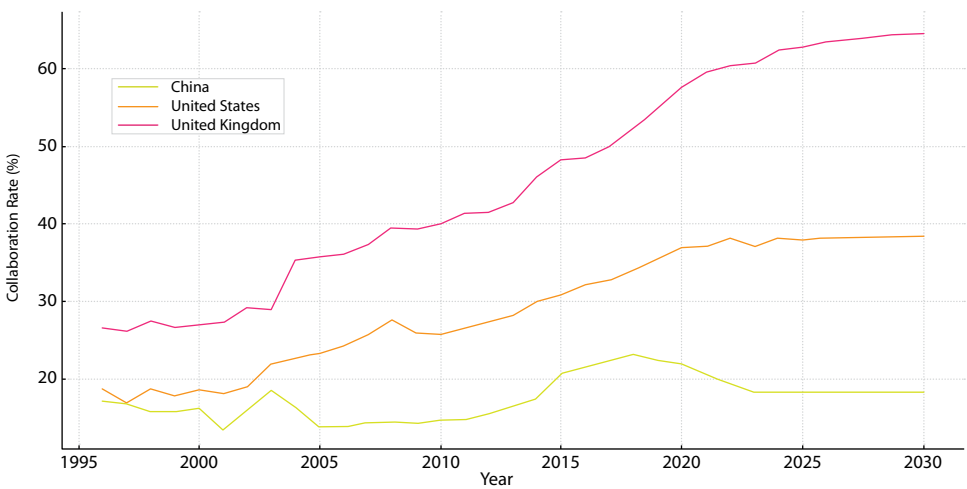

Figure 19:
International collaboration forecast for China, the U.S. and the U.K.
Source: Compiled by the authors

model parsimony with predictive power, an ARIMA(2,1,0) model was specified for each country. This model includes two autoregressive terms and one differencing step, but no moving average term. The analysis was implemented in Python 3.11 using the statsmodels library. Historical and forecasted values were plotted jointly to visualise national trajectories.

Model diagnostics indicated a good fit and specification. The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were as follows: China (AIC = 663.51, BIC = 667.50), the U.S. (AIC = 646.63, BIC = 650.63) and the U.K. (AIC = 590.55, BIC = 594.54). Residuals were tested for autocorrelation using the Ljung–Box Q-test at lag 10; all returned non-significant p-values (China: $p = .18$; the U.S. $p = .999$; the U.K.: $p = .996$), suggesting no significant autocorrelation and supporting model adequacy.

The forecasts indicate that collaboration rates will continue to grow, albeit at varying paces. For China, the proportion of internationally co-authored publications is projected to increase gradually, continuing a steady upward trajectory. The U.S. is expected to maintain a relatively stable collaboration rate, with marginal year-to-year variation. In contrast, the U.K.'s already high collaboration rate is projected to rise further, albeit modestly, suggesting consolidation rather than expansion. These results reflect broader geopolitical and institutional dynamics in global science. China's increasing collaboration rates align with its broader international science diplomacy agenda and integration into global research networks. The U.S., while still a central node, appears to have reached a plateau, possibly reflecting internal shifts in funding or policy. The U.K. continues to demonstrate high engagement, likely supported by institutional structures that incentivise international networking, even in the post-Brexit landscape.

To investigate national-level developments in OA publishing, we conducted a time series forecast of OA publication rates in three major scientific producers: China, the U.S. and the U.K. (Figure 20). OA rates were defined as the percentage of annual scholarly outputs published in openly accessible formats. The historical data covered the period 1996 to 2024 (N = 28 years), and forecasts were generated through 2030. For consistency with prior modelling strategies we applied AutoRegressive Integrated Moving Average (ARIMA) models.

The forecasted trends reveal divergent national trajectories in OA publishing. The U.K. continues to lead globally, with OA rates projected to exceed 50% by 2030. This is consistent with sustained national-level mandates, funder requirements (e.g. UKRI, Wellcome Trust), and long-term compliance with international initiatives such as Plan S. The U.S. exhibits more modest projected growth. While a substantial share of research in the U.S. is published as open access, the decentralised policy environment and reliance on hybrid journals may limit more dramatic increases in the short term. China, which has shown relatively lower OA adoption compared to its output volume, is forecast to experience continued, if moderate, growth. This aligns with the country's gradual policy alignment with open science norms, as well as increasing international engagement that encourages openness. However, the institutional and infrastructural transition required to support systemic OA may explain the slower pace.

Taken together, these forecasts suggest that while OA adoption is increasing globally, its national trajectories are shaped by distinct policy environments, publishing ecosystems and strategic priorities. ARIMA-based forecasting offers a valuable quantitative tool to

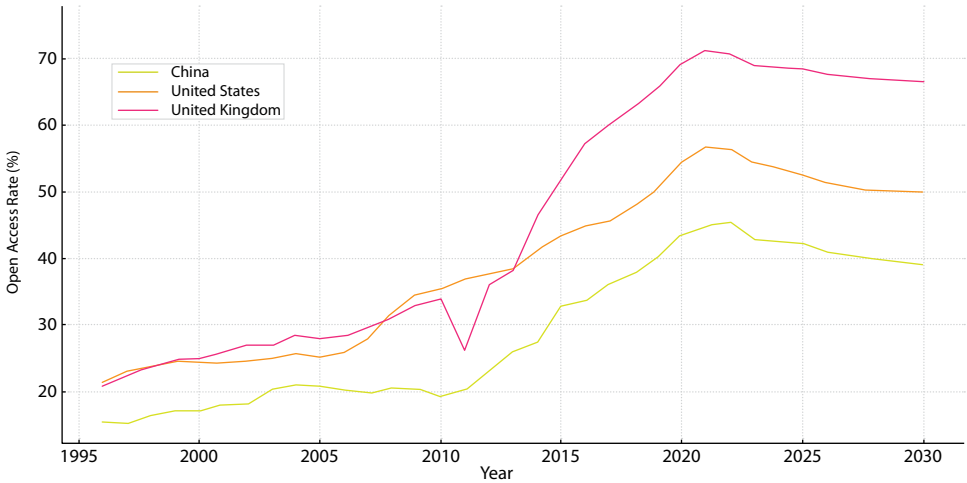

Figure 20:
Open access forecast for China, the U.S. and the U.K.
Source: Compiled by the authors

anticipate future developments, although its predictive scope is limited with respect to sudden policy shifts or structural innovations in scholarly communication.

Discussion and conclusions

The findings of this study reinforce and complicate the theoretical framework articulated in the world-systems approach to global academic publishing. As Demeter (2019) and Wallerstein (2004) have argued, scientific knowledge production operates within a structurally unequal system in which core countries dominate not merely in volume, but in the recognition, prestige and global visibility of their research. Our analysis of publication trends, open access expansion and the uneven diffusion of generative AI tools suggests that this core-periphery hierarchy is not static, but in flux – subject to both reproduction and transformation through technological, geopolitical and institutional dynamics.

The rise of generative AI in academic writing offers a potent example of this dual character. On the one hand, AI tools such as ChatGPT have begun to lower traditional barriers to participation in global science, particularly for scholars in semi-peripheral and peripheral contexts who face linguistic and stylistic gatekeeping in English-language publishing. These tools promise a degree of epistemic empowerment: an algorithmic assistant that levels the linguistic playing field, accelerates manuscript preparation and supports broader access to publication venues. However, as our theoretical framing reminds us, technological access and capability are not evenly distributed. The most advanced large language models remain concentrated in the hands of core-based corporations and researchers, with training data

that overwhelmingly reflects Global North perspectives, language and epistemologies. Our findings on China's parallel AI ecosystem underscore this bifurcation: while the country boasts massive user bases and a sophisticated state-led AI infrastructure, its models remain circumscribed by regulatory, ideological and infrastructural constraints. The blocking of Western platforms such as ChatGPT, combined with the prioritisation of state-aligned research topics, illustrates how core-periphery dynamics in AI are not simply a matter of technological diffusion but are embedded in national strategies of control and legitimacy.

These geopolitical cleavages are mirrored in our ARIMA-based forecasts of scientific output. China is projected to continue its exponential growth in publication volume, outpacing both the U.S. and the U.K. by 2030. However, this surge in quantity does not translate into equivalent gains in open access adoption or international collaboration. Our data suggests that while Chinese science is becoming more productive, it remains relatively insulated, with slower increases in cross-border co-authorship and more modest open access trajectories. This supports Demeter's (2019) concept of "semi-peripheral hegemony": an actor that dominates in scale but does not yet shape global epistemic norms.

In contrast, the U.K. – although smaller in output – is forecast to retain leadership in international collaboration and OA. This reflects the country's embeddedness in transnational academic networks and its alignment with progressive publication policies such as Plan S. The U.S. appears to occupy a plateaued position, maintaining high output but with less dynamism in collaboration or OA growth, indicative of its mature, yet somewhat inward-facing scientific system. Taken together, these trends suggest a realignment of the academic world-system: while the Global North retains its central role, the Global East – China in particular – is exerting increasing gravitational pull in terms of the sheer scale of production. The question is whether this quantitative dominance will evolve into qualitative influence over what counts as legitimate knowledge.

Our regional analyses further substantiate these observations. The Asiatic Region, led by China, India and emerging Southeast Asian powers, is on track to surpass traditional hubs in publication volume. However, internationalisation and open access adoption remain uneven, raising concerns that these regions may replicate the same inequalities they seek to escape, albeit from a position of growing economic and political strength. Western Europe and Ibero-America, meanwhile, show high and increasing levels of collaboration and OA publishing, suggesting that regional strategies – rooted in shared infrastructure, linguistic networks and policy alignment – can counteract core-periphery asymmetries. Yet even within these regions, the disparities between elite and non-elite institutions, between national and global circuits of knowledge persist.

A key insight emerging from this study is that global academic inequalities are no longer simply geographic but are becoming stratified along technological, institutional and epistemic axes. Access to generative AI tools, the ability to pay article processing charges, and the integration into citation and editorial networks now function as the new currencies of academic capital. This raises the spectre of a multi-layered hierarchy: core countries with core institutions that concentrate not only material resources but also algorithmic and epistemological authority. The result may be a more intricate, yet still unequal, academic order – what we might term *platform stratification* in science, where visibility, credibility and productivity hinge on access to both infrastructures and networks of validation.

And yet, the future need not be one of deterministic stratification. The very tools and practices that risk reinforcing inequalities also contain the seeds of transformation. If global institutions commit to expanding equitable access to AI training and infrastructure, if funders rethink the dominance of APC-based open access in favour of diamond or subsidised models, and if scholarly communities revalue diversity of voice over conformity to Anglophone norms, then a more polycentric and inclusive system of knowledge production becomes imaginable. Regional OA platforms, multilingual LLMs and international collaborations that decentre the Global North can all serve as pathways toward a reconfigured world-system in science.

Indeed, the AI revolution could herald not just a shift in how research is written, but in who writes it, who reads it and who is recognised for it. Just as earlier waves of digitisation opened the gates of scientific communication, the current convergence of AI, open access and global networking holds the potential for a "great unbundling" of prestige and productivity. In this future, recognition would be less tied to institutional affiliation or national origin, and more to contribution, transparency and accessibility. The democratisation of writing and publishing – if harnessed inclusively – could help rewire the circuits of global science, creating a space for peripheral perspectives to shape global paradigms rather than merely echoing them.

At the same time, caution is warranted. Our forecasts are based on extrapolations from historical trends and current trajectories. They cannot account for disruptive events such as geopolitical conflicts, funding crises, or paradigm shifts in evaluation metrics. Moreover, our analysis relies on aggregate indicators – publication volume, collaboration rates, OA percentages – that, while being informative, obscure intra-national disparities and epistemic nuances. We have not disaggregated by discipline, institutional tier, or language of publication – factors that critically shape academic opportunities and exclusions.

In short, the academic world-system remains deeply stratified, but is also dynamically evolving. Technological advances such as generative AI and policy shifts like open access introduce new variables into the equation. Whether these forces will entrench or unsettle the existing hierarchy depends on choices yet to be made by institutions, funders, governments and scholars themselves. The challenge ahead is not merely to predict the future of academic publishing, but to shape it toward equity, inclusiveness and epistemic justice. Our vision is of a global knowledge ecosystem where excellence is not confined to the centre, but diffused across a pluralistic, interconnected scientific community – one in which ideas rise not by geography, but by their capacity to enlighten, challenge and transform.

Limitations and future research directions

This study, while comprehensive in its scope and methodological consistency, is not without limitations. First, the reliance on aggregate national and regional indicators – such as total publication counts, international collaboration rates and open access percentages – may obscure significant intra-national disparities and disciplinary variations. Elite institutions often drive national performance, while peripheral universities within the same country may face vastly different constraints and opportunities.

Second, the forecasts are based on ARIMA models that, by design, extrapolate from historical trends without incorporating exogenous shocks, non-linear transformations, or abrupt policy changes. As such, our projections are probabilistic, not deterministic and should be interpreted as scenario-based illustrations rather than predictive certainties.

Third, while this study touches on the role of generative AI in shaping future publishing dynamics, it does not empirically examine how AI is currently used by researchers across different contexts, nor does it model the potential disruptive effects of platform-specific LLMs on global knowledge hierarchies. Further qualitative and ethnographic research is needed to understand how AI tools are being adopted, adapted, or resisted in everyday academic practices.

Finally, our analysis privileges English-language and internationally indexed data sources, which may underrepresent the contributions of non-Anglophone scholars and alternative knowledge systems. Future research should explore bibliodiversity, epistemic justice and linguistic inclusion in greater depth, especially as open access infrastructures and regional platforms continue to evolve.

Advancing this line of inquiry will require not only methodological refinement but also critical engagement with the politics of knowledge production. Cross-disciplinary collaborations, multimodal data integration and participatory approaches with underrepresented academic communities will be essential to move beyond description toward transformation.

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