



# The geographical diversity of the citation elite in STEMM is decreasing, even as the overall scientific workforce has diversified

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## Abstract

The expansion of research systems in low- and middle-income countries has shifted science to a more diverse geographical structure. Using a global dataset of 40 million authors in Science, Technology, Engineering, Mathematics and Medical fields (STEMM), we investigate whether this shift has made it easier or more difficult for newcomers residing in the Global South to rise to prominence in their disciplines. We tracked yearly cohorts of authors who began their publication careers between 2000 and 2014, finding that the South-North gap in the likelihood of joining the ‘citation elite’ (the top 5% of most cited authors per cohort) has increased by approximately 23%. Southern Asia and South-Eastern Asia outperform Eastern Asia and Latin America and the Caribbean in terms of changing regional shares in the citation elite. South-North gaps in citation elite membership also appear to be larger and increasing in the life sciences, and smaller and shrinking in some engineering-related subfields. Using decomposition approaches, we attribute most of the widening South-North gap in citation elite membership to diverging trends in attrition rates, publication outputs and journal selection, with changes in team sizes and regional migration playing only a minor role. These findings highlight the enduring dominance of wealthier nations in the production and distribution of scientific knowledge. While the scientific workforce has diversified globally and opportunities for Global South individuals to pursue successful science careers in the Global North have expanded, regional disparities persist with scientists based in the Global South now less likely to achieve scientific prominence relative to their Global North counterparts than previously.

**Keywords** Scientific elites · Citations · Inequality · Global science · Science of science

## Introduction

The global science system is increasingly open and dynamic with a growing share of science originating from low- and middle-income countries (Gui et al., 2019; Kwiek, 2023; Wagner et al., 2015). In 2000, China accounted for 5% of global scientific publications (Zhou &

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Leydesdorff, 2006); today, it leads the world in scientific output (Tollefson, 2018). India, too, has made remarkable strides, becoming the third-largest producer after the US (Marginson & Xu, 2023). Additionally, low- and middle-income countries like Indonesia, Brazil, Iran, Nigeria, Pakistan, and South Africa have seen a rapid increase in annual publication outputs (Marginson & Xu, 2023), suggesting that nowadays Global South scientists overwhelmingly contribute to international research agendas. Nonetheless, the gap in citations between research produced in the Global North and South has grown over the same period (Gomez et al., 2022; Nielsen & Andersen, 2021).

Here, we investigate these simultaneous trends of expansion and inequality from the perspective of scientists residing in the Global South. Has science's shift from a Euro-American duopoly to a more competitive and multipolar structure (Dong et al., 2017; Marginson & Xu, 2023; Perianes-Rodriguez et al., 2024) made it easier for researchers based in Global South countries to climb the ranks and become highly cited contributors of their disciplines, or do structural barriers persist? Answering this question helps clarify the extent to which Global South economies are able to capitalize on the skills and expertise of their local scientific talent.

We focus on the early stages of scientific careers, because citation advantages during this phase are especially likely to trigger self-reinforcing cumulative dynamics, amplifying opportunities and shaping long-term trajectories (Horta & Santos, 2016; Merton, 1968; Petersen et al., 2011). From a field perspective, such early recognition operates as a form of consecration, endowing the scientist with symbolic capital that can be mobilized and converted into stronger collaborations, greater visibility, and material resources in the long run (Bourdieu, 1975, 1991).

By focusing on how early-career scientists establish themselves as top-cited scientists, as compared within their cohort and across regions, we study how changing conditions in science have affected Global South-North disparities in scientific recognition. Adding to decades of evidence on social stratification and colonial legacies in science (Demeter, 2020; Mosbah-Natanson & Gingras, 2014; Schott, 1998), our study helps clarify whether, despite expanded opportunities for Global South scientists to build careers internationally, structural barriers continue to constrain the more direct pathways to scientific prominence within the Global South.

## Background

Research on world polity diffusion shows that Global South countries increasingly emulate the organizational forms, policy models, and evaluative standards established in the Global North (Drori, 2003). Baker and Powell (2025) trace how the “university–science model”, originating in Germany and institutionalized through U.S. higher education, has now become a global template for organizing research and teaching. As a result, the landscape of national research systems has broadened, with Asian countries, especially China and India, emerging as key contributors (Marginson & Xu, 2023; Tollefson, 2018; Zhou & Leydesdorff, 2006). Indeed, for the past quarter of a century the majority of the science system's growth in publishing scientists originated from the Global South (see Supplementary Fig. 1).<sup>1</sup> Driven primarily by China, the prominence of research in the Global South has also

<sup>1</sup>Note that following Connell et al. (2017), we use “Global North” to refer to countries in Europe, as well as Canada, the United States, Australia, and New Zealand, and “Global South” to encompass all other countries (see Data and Methods).

made large strides (Perianes-Rodriguez et al., 2024). China has nearly closed the gap with the US in its share of the world's Top 1% most cited papers (Wagner et al., 2022), and in terms of leadership on international collaborations (Wu et al., 2025).

These positive signs of global convergence nonetheless say very little about individual scientists' careers. While scientists from catching-up countries are now increasingly competing in a globalized science system, their competitors in established scientific economies retain their material and reputational advantages (Demeter, 2020; Mosbah-Natanson & Gingras, 2014). Despite the enormous increase in international co-authorships, collaboration networks still maintain a stable core of high-income countries (Wagner & Leydesdorff 2005; Leydesdorff & Wagner, 2009; Leydesdorff et al., 2014; Bornmann et al., 2015). These stable disparities have prompted researchers to describe the global scientific enterprise as a core-periphery structure (Schott, 1991; Wagner & Leydesdorff, 2005; Delvenne & Kreimer, 2017; Hwang, 2008). In this structure, scientists from peripheral countries seek recognition and career advancement through connections with center institutions, thereby concentrating ties in the center (Hwang, 2008; Mosbah-Natanson & Gingras, 2014; Schott, 1993). This form of regional cumulative advantage reinforces what Schott (1998) identified as tie-deference: peripheral scientists align their research agendas and co-authorships with dominant research centers to gain credibility and resource access, thereby sustaining global disparities in local research capacity. The consequence for catching-up economies is local fragmentation, since researchers' pursuit of international collaborations with leading centers may erode the domestic institutional synergies that are central to local innovation (Kwon et al., 2012). This line of reasoning mirrors a long tradition of research on the colonial legacies of science highlighting the direct and indirect control that affluent countries hold over the production and dissemination of scientific knowledge (Delvenne & Kreimer, 2017; Demeter, 2020; Ndlovu-Gatsheni 2021; Oldac et al., 2024).

Taken together, increasing local capacity, standardization and openness, may open new opportunities for individual scientists from peripheral locations to pursue international careers. Yet they do not in themselves resolve the historical asymmetries in the accumulation of recognition and rewards that constrain the more direct pathways to scientific prominence within the Global South (Hwang, 2008; Kwon et al., 2012). This motivates our guiding research question: how have career chances, which we operationalize in terms of the likelihood that a scientist becomes a top-cited author in their discipline and age-cohort, evolved over time as the global science system has shifted toward a multipolar structure, marked by a continuous diffusion of universities and research centers in low- and middle-income countries (Marginson & Xu, 2023; Perianes-Rodriguez et al., 2024).

### **Inequalities, talent pools, and careers**

Ben-David (1960) argued forcefully early on that national science systems develop as countries find ways to embrace and support their research talent. This carried the implication that countries could develop their scientific capacity by employing more scientists and giving them the proper material support (Cole & Phelan, 1999). The relationship may of course be non-linear (de Solla Price, 1963), requiring a dramatic expansion of the scientific workforce to increase the national scientific capacity by some incremental amount. Regardless, this early line of inquiry makes clear predictions about what must have happened for science in the Global South to have expanded so dramatically: scientific careers must have received

substantial support. So one might expect career chances of gaining citation recognition to have improved in the Global South over the same period that the volume and quality of its research increased.

The problem with this account is that it overlooks basic realities of modern science. Most importantly, it did not anticipate the rise of a precarious workforce of Ph.D. students, post-docs, and other non-tenured researchers, who do much of the labor that goes into highly cited research (Stephan & Ma, 2005; Zhang et al., 2022). It may well be possible today to increase national scientific capacities without increasing the number of permanently employed scientists. Churn and attrition among the precarious workforce would make it possible for career chances to deteriorate even in a moment when the volume and quality of research is increasing.

The early work from Ben-David and his contemporaries also neglects the international mobility of scientists. While the growth of universities in low- and middle-income countries has increased the supply of global research talent, institutions in the Global North may now also be more inclusive of individuals with origins in the Global South, reflecting a shift toward greater integration (and opportunities) of diverse talent within these systems (Chen, 2025). Talented scientists may well leave their country of origin and pursue a successful career overseas, allowing them to maximize their contributions to science as a whole while still not contributing directly to the national science system in their home country. While many scientists return home later on, the volume of international migration has nevertheless increased rapidly among scientists over the past two decades (Akbaritabar et al., 2024), threatening to deplete national talent pools (Herman et al., 2024).

Our approach works to account for these factors as we examine career chances. To see if science's global expansion has widened or decreased South-North disparities in citation-elite membership, we use a linked, global dataset of 40.3 million disambiguated scientists, with roughly 28.7 million papers. Specifically, we follow author cohorts who started their publishing careers within a 15-year period between 2000 and 2014, and use field-normalized citation indices to rank authors by cohort (here defined as the year of their first paper). From that we gauge changes over time in the probability that Global North and South scientists become part of their age group's citation elite. Additionally, we use decomposition techniques to partition out the sources of observed changes in the gap between the groups, taking into account group differences in terms of attrition rates, migration, productivity and journal selection.

## Data and methods

We use data from the augmented version of Clarivate's Web of Science: *Science Citation Index-Expanded*, *Social Science Citation Index* and *Arts & Humanities Citation Index*, hosted at the Center for Science and Technology Studies (CWTS) at Leiden University. This version offers a systematic cleaning of reference data, and access to field-normalized bibliometric indices. Moreover, it includes a high-precision author-disambiguation algorithm (D'Angelo & van Eck, 2020) allowing us to track authors' performance over time and facilitating a comparison of career paths across geographical areas. However, because disambiguation quality is low before 2000, we focus our analysis on authors whose first publications came in or after the year 2000, and whose modal field of publication falls within our set of

focal fields. In the Supplementary Methods, we detail the extensive re-sampling exercise used in our study to account for systematic error in author disambiguation.

Our analysis is limited to full research papers and reviews published in journals, (see Flowchart in Supplementary Fig. 2). We exclude all of the social sciences and humanities, as their scholarly activities tend to be less commensurable across geographical regions, and only consider fields in the medical and health sciences, natural sciences, agricultural sciences and technology that have at least 66.6% coverage in WoS. That is, fields where at least 66.6% of the references listed in the bibliographies of its published papers actually appear in the database. Using the OECD schema for scientific fields, this results in 21 Minor Scientific Fields, spread across 4 Major Scientific Fields. This leaves us with a dataset of 40.3 million disambiguated scientists, and 28.7 million papers written by them. To assign authors to fields, we first identify the most common subject category from their publications in the Web of Science (WoS) and use these categories to determine primary OECD field.

### Performance metrics

We acknowledge that citations are noisy social measures whose underlying motives cannot be precisely distinguished at the individual level (Brooks, 1986; MacRoberts & MacRoberts, 1988). However, empirical studies suggest that at aggregate levels, citations represent a reliable proxy for visibility and impact, though not merit or quality (Bornmann & Daniel, 2008; Van Raan, 2005). Regardless of where one stands in this methodological debate, citations are widely employed as proxies for impact in evaluative judgments. Hence, following Bourdieu (1975), we treat citations, and their derivatives, such as journal impact metrics, as indices of symbolic capital, acknowledging their widespread use as evaluative tools for allocating opportunities and rewards.

Because we make comparisons across all of science, we use field-normalized citation scores (ncs), which are calculated by dividing raw per-paper citation scores with the mean citation counts of publications of the same document type, published in the same year and subfield (excluding self-citations). Field-normalization is based on an algorithmically constructed classification system of ~4000 fields (Ruiz-Castillo & Waltman, 2015). This enables our comparison of who becomes a citation elite across fields. To ensure that older papers are not weighed more heavily than newer ones, we use a fixed four-year citation window, inclusive of the year of publication. Further, we fractionalize citations according to the number of authors per paper to facilitate a better comparison across areas with different co-authorship norms and rates, which help our comparisons across fields even more. Yet, we obtain similar results even without fractionalization (Fig. 3). To account for database effects, where a growth in the number of journals covered by WoS may cause the gaps that we observe, we ran a supplementary analysis that only considered publications in and citations from a fixed set of journals across years. The findings from this approach are consistent with our initial results (Fig. 3). Notably, the construction of the citation metric used in the main text provides the most conservative results among the measurement alternatives.

### Cohort-based comparisons

We compare scientists to peers in the same cohort, defined as the year of their first publication. Thus, all plots that show longitudinal trends report developments across cohorts, rather

than within cohorts. We measure each author's cumulative impact in their fifth publication year and use this measure to determine whether someone is an elite or non-elite. This is a pragmatic middle ground allowing us to maximize the number of cohorts that we can compare without compromising scientists' ability to accumulate enough publications to signal their performance. With our chosen citation- and performance windows, the maximum cohort year that we can include in the analysis is 2014. As Fig. 3 shows, there are only slight differences if we determine elite membership in the 6th, 7th, 8th, or 9th year. We define elite scientists as authors in the top 5% in cumulative citations, by cohort, normalized and fractionalized as described above. Yet, the patterns that we find in the data are also visible if elites are defined as the top 10% or 1% of scientists.

## Regional categorization

We group scientists and their career performance into 16 global subregions, as defined by the United Nations' M49 subregion codes. The Global North is taken to encompass the 'Northern America' region which includes both the United States and Canada (UN M49 code 021), all European regions (codes 151, 154, 155, and 039), as well as the 'Australia and New Zealand' region (code 053). All other subregions are considered part of the Global South. Note that plots at the subregion level do not include authors from Central Asia or three Polynesian subregions due to small sample sizes, though we still include these scientists in all comparisons of North vs. South. In the Supplementary Methods, we outline the various strategies employed to impute missing affiliation data, a known limitation in some portion of papers published prior to 2008.

## Decomposition

To parse out the sources of the widening South-North disparity in elite membership, we use non-linear threefold Kitagawa-Oaxaca-Blinder decomposition, which is particularly useful for this analysis as it decomposes differences in outcomes (in our case, elite membership) into portions attributable to observed variables (here defined as endowments). This approach effectively helps in identifying and quantifying the sources of the widening gap. The decomposition analysis comprises three models: The basic model predicts a scientist's likelihood of ranking in the top 5% in the 5th year of their career based on whether the scientist suffered attrition (i.e. stopped publishing) before year 5. The second model additionally includes covariates for a researcher's median team size across all the papers they published in the first 5 years of their career, as well as whether they migrated between the Global North and the Global South in the first 5 years of their career. These types of early-career events come closest to the way "endowments" are used in traditional decomposition analyses, namely, characteristics that precede the measured performance of individuals in the system. To compute researchers' team size, so as to include it in the decomposition, for each researcher, we calculated the median number authors across all of their papers that were published during the evaluation window. To include a person's migration between the Global North and South in the decomposition, we deploy the "tenure events method" described by Herman (2024), using 1 year of backfilling for affiliations with missing data, and a maximum overlap in tenures of 3 years as parameter settings (See Supplementary Methods).

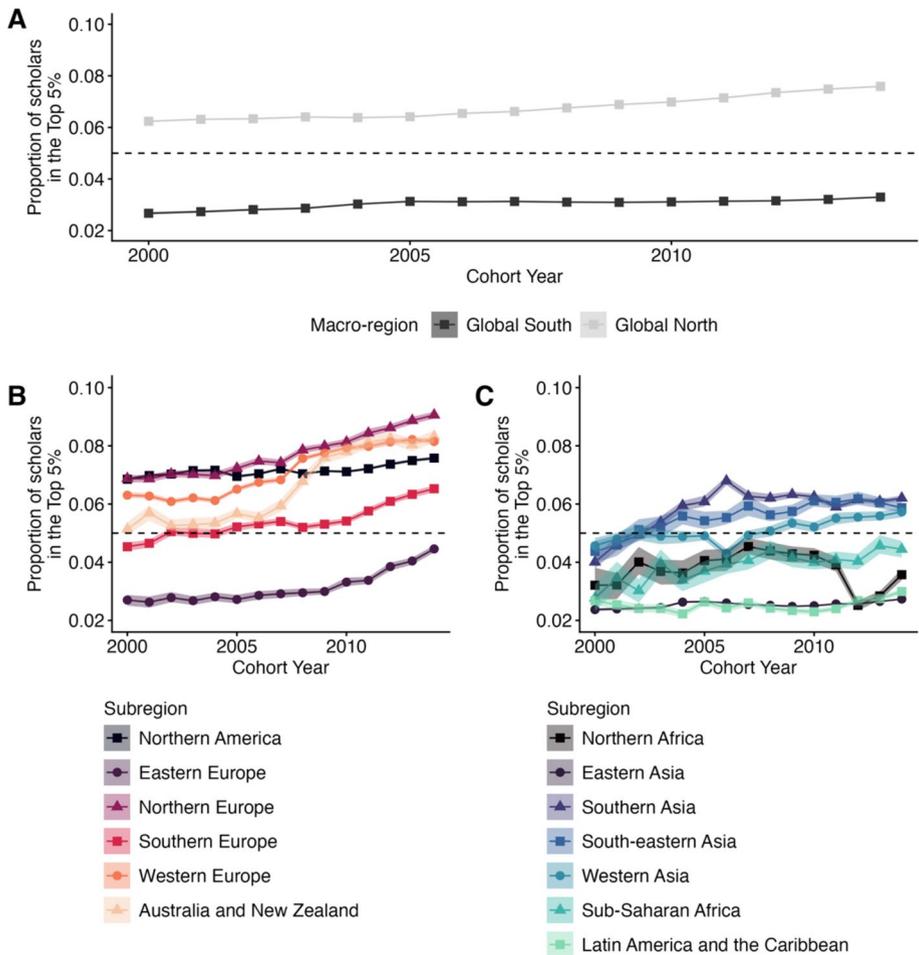
Journal impact and productivity are two more endowment-like characteristics that affects citations, though both journal and paper citation impact are driven by the same underlying factors, such as paper quality. Acknowledging this limitation, we estimated a third model that included the three aforementioned factors, plus each scientist's 'cumulative journal impact score' (cjs), a composite measure of their productivity and the average journal impact score across their papers.

We decompose the resulting models in two different ways. First, we use threefold Kitagawa-Oaxaca-Blinder decomposition to estimate the amount of the South-North gap that is explainable by the group-level differences in (i) the average values for each endowment (i.e., the portion of the gap due to Global South scientists having different attrition rates and cjs than Global North scientists), (ii) the estimated coefficients for each endowment (i.e., the difference in Global South and North scientists' outcomes if they had similar attrition rates and cjs), and the interaction between endowments and coefficients (i.e., proportion unaccounted for by endowments and coefficients) (Fairlie, 2005; Jann, 2008). Because these decompositions are cross-sectional, we estimate separate models for each cohort of scientists. Second, we additionally use a simple subtraction method (Kröger & Hartmann, 2021) to estimate the amount of change in the gap over time that is attributable to each decomposition component. For expanded details on the decomposition, see Supplementary Methods.

## Results

Our analyses show that South-North disparities in scientists' likelihood of entering the citation elite have widened, although with notable regional and disciplinary variations. Figure 1A displays the proportion of scientists by cohort that were part of their age group's most highly cited scientists by their fifth publication year. Despite the Global South's numerical expansion over the past decades (Supplementary Fig. 1), the gap between the participation of North and South scientists in the top 5% has widened from 3.5 percentage points in 2000 (Global South: 2.7%; Global North: 6.2%) to 4.3 percentage points in 2014 (Global South: 3.3%; Global North: 7.6), representing a relative gap increase of roughly 23%. Note that the trends for the Global North and Global South do not simply mirror each other because the size of each cohort and the South-North composition of each cohort change substantially over time. While both the Global North and the Global South have seen increases in their shares of scientists achieving citation elite status, the much faster growth of the Global South's publishing workforce has contributed to a widening gap in elite membership. This is because, the higher baseline proportion of elite scientists in the Global North, combined with the slower growth of its publishing workforce, results in the Global North acquiring an increasingly larger share of the citation elite relative to the South. As a result, disparities in representation continue to grow, even as both regions increase their presence within the elite.

As Figs. 1B and 1C show, this story belies substantial variation across subregions. We rely on subregions rather than countries to minimize the inherent measurement error that comes with using affiliations to infer locations (see Supplementary Methods). The reduced probability of citation elite membership in the Global South is largely attrib-

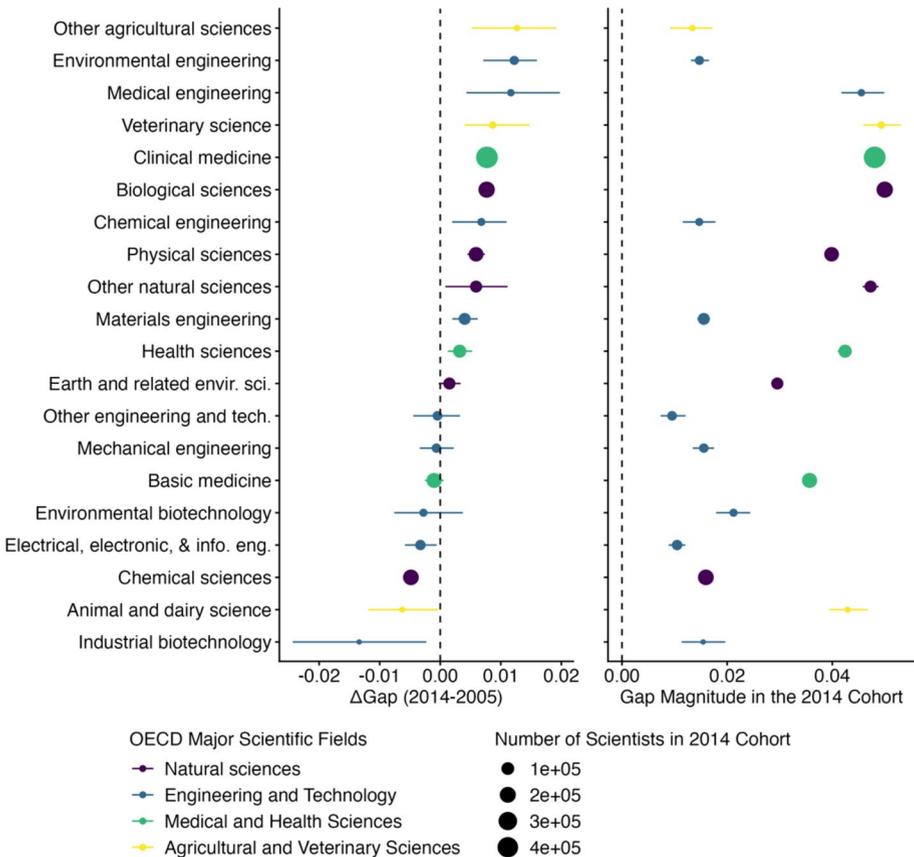


**Fig. 1** The Global North has become increasingly successful over time in producing or attracting elite scientists, while the Global South has stagnated over the same period. Panel A displays the proportion of scientists in the top 5% by cohort, aggregated for the Global North and South. Panel B details these trends for Global North subregions, and Panel C for Global South subregions. Each panel includes a dotted line marking the 0.05 threshold that definitionally represents the global mean. Elite status is assessed five years after a scientist's first publication, based on field-normalized and team-size fractionalized citation counts. Confidence intervals are based on the 2.5th and 97.5th percentiles from 1500 bootstrap simulations per cohort. The simulation procedures are detailed in the Supplementary Methods

utable to the Eastern Asia subregion. Despite representing the largest contingent of entrants, its scientists, together with scientists from Latin America and the Caribbean, face the lowest odds of reaching the top 5% compared to other subregions. Meanwhile, scientists in Southern Asia, Southeastern Asia, and Western Asia consistently show a higher probability of achieving top 5% status than their Eastern European peers throughout the observation period. Note that there does not need to be an equal number of subregions under- and over-performing the population average because of variation in the number of scientists working in each subregion.

In 2014, despite clear variations within the Global South, every subregion of the Global North, except for Eastern Europe, outperformed all subregions of the Global South in terms of presence in the top 5%. This contrasts with the mid-2000s, when scientists from Southern Asia had a higher chance of being in the top 5% compared to those in three Global North subregions (Eastern Europe, Southern European and Australia/New Zealand), and when scientists from South-Eastern Asia also matched or exceeded the performance of these three subregions in terms of citation-elite membership. Northern Africa exhibits a sudden decline between 2011 and 2012, which might stem from disruptions caused by the Arab Spring events during 2010–2011.

While the South-North disparity in citation elite membership is generally on the rise, developments vary by field. Figure 2 shows that the gap is growing fastest in the life sciences (Agricultural Sciences, Veterinary science, Clinical Medicine, Biological Sciences)



**Fig. 2** Changes in the South-North gap by subfield. Panel A displays the percentage point change in the South-North gap in terms of presence in the top 5% ( $\Delta$ Gap), by subfield, over a 10-year period (2005 to 2014). Panel B details the magnitude of the same South-North gap (in percentage points) in 2014, by subfield. Error-bars indicate confidence intervals based on the 2.5th and 97.5th percentiles from 1500 bootstrap simulations. The simulation procedures are detailed in Data and Methods. Each panel includes a dotted line marking the 0.00 threshold of no group difference in elite-membership. Full temporal trends per field are reported in Supplementary Figs. 3–6

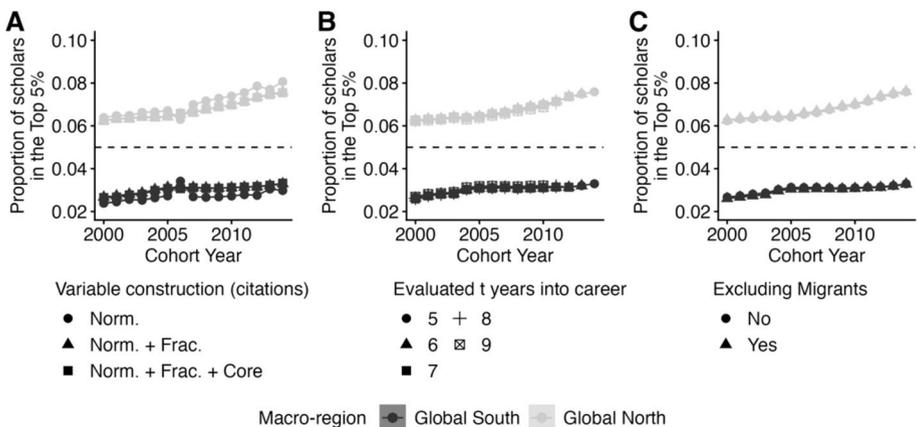
except for Basic Medicine, where it has remained stable since 2005. Across all 20 fields, the gap widened in 11 and remained relatively stable in 5, with modest gains for Global South scientists in only 4 fields. Although the 4 latter fields made modest gains in the Global South between 2005 and 2014, the gaps in favor of the Global North remained in 2014.

These findings are robust across a wide range of alternative specifications. Figure 3 shows consistent results when using full-count as opposed to fractionalized citation metrics (Fig. 3A), when fixing the journal set over time to account for changes in WoS journal coverage (Fig. 3A), when evaluating scientists' performance in years 6–9 as opposed to year 5 (Fig. 3B), and when excluding all migration between the Global North and South (Fig. 3C). The findings also hold when focusing on the top 1% or top 10% most cited scientists per cohort instead of the top 5% (Supplementary Fig. 7). The supplementary materials further show that our results at the subnational level are also robust across all of these same factors (Supplementary Figs. 8–9, 11–14).

We also checked if the growing disparity could be due to increasingly relaxed criteria for elite status, reflecting the Global South's rising share of publishing scientists. Based on simulations that maintained a constant ratio of Global North and Global South scientists over time (See Supplementary Methods), we find that, although the regional trends change (the North now remains fairly stable, while the South shows a declining trend over time) the gap between them continues to grow at an almost identical rate (Supplementary Fig. 11).

## Decomposition

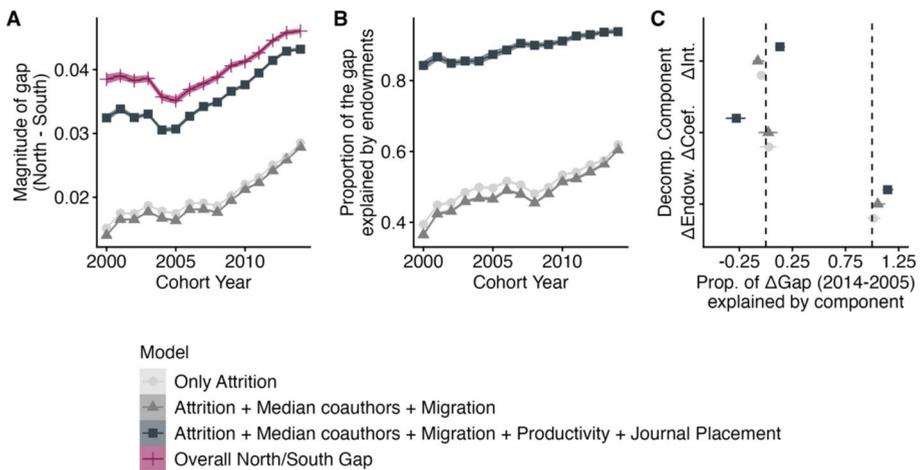
Next, we decompose the widening North–South disparity in elite membership to isolate its contributing factors. As mentioned earlier, our decomposition focuses on five different



**Fig. 3** Sensitivity checks with full-count citation metrics, a fixed journal set, and later publication career-ages. Panel A displays the proportion of scientists in the top 5%, by cohort, aggregated for the Global North and South, using three different metrics: fractionalized cumulative citations, fractionalized cumulative citations that only consider publications in and references from a fixed set of journals across years, and full-count cumulative citations. Panel B details the same outcomes on the x- and y-axes, but with elite status assessed 5 to 9 years after each cohort's earliest publication year. Panel C again uses the same outcomes on the x- and y-axes, but further comparing the results to what one obtains if every migrant is excluded from the data. Note that time series are shorter for larger window sizes because of the hard temporal limit on the data. Confidence intervals are based on the 2.5th and 97.5th percentiles from 1500 bootstrap simulations per cohort

endowments: the rate of scientists who suffered attrition (i.e., stopped publishing before year five), the rate of scientists who migrated between the Global North and the Global South and vice versa (within the first five years of their career), as well as the median team size, average publication output, and average journal placement of scholars in the two regions. Attrition directly affects productivity, so we firstly evaluate that on its own. We add migration and median team size, and then productivity and journal placement into subsequent models. As Fig. 4A shows, the magnitude of the North/South gap in citation-elite membership that one might expect simply by virtue of group-level differences in endowments has grown over time in step with the overall North/South gap. Figure 4B illustrates that the proportion of the overall gap that might be explained by endowments has also grown over time, reaching 93.8% across all five endowments for the 2014 cohort. Hence, the combination of our five endowments explains almost the entire South-North gap in citation-elite membership. Differences in attrition rates, especially, account for an increasingly large portion of the overall gap between Global North and Global South scientists.

In Fig. 4C, we use Kröger and Hartmann's (2021) subtraction method to estimate the amount of change in the South-North gap that is attributable to each decomposition com-



**Fig. 4** The gap between the Global North and the Global South is largely anticipated by scientist endowments in attrition rates, journal placement and productivity. Panel A shows the magnitude of the South-North gap for membership in the Top 5% of scientists that is anticipated by differences in endowments between the two regions, according to yearly threefold Oaxaca-Blinder decompositions, performed across two models. The first model predicts elite membership using only whether a scientist suffered attrition (i.e. stopped publishing) before the 5th year of their career, while the second model additionally includes researchers' median team size and whether they migrated between the Global North and Global South during the period in question. The third model additionally uses productivity and journal placement as predictors. We have also included a colored reference line that represents the overall South-North gap over time. Panel B is based on the same two models but represents the results in terms of the proportion of the overall South-North gap that could be explained by endowments. Panel C shows the results of a threefold decomposition of the change in the South-North gap from 2005 to 2014 ( $\Delta$ Gap) according to the contributions made by changes in endowments over time ( $\Delta$ Endowments), changes in the estimated coefficients for attrition, productivity, and journal placement over time ( $\Delta$ Coefficients), and changes in the interaction between these two factors, which is normally interpreted as the amount that remains unexplained ( $\Delta$ Interactions). Confidence intervals across all three panels represent the 2.5th and the 97.5th percentiles across 1500 bootstrap simulations

ponent. The subtraction method decomposes group differences in the change in an outcome between two specified time points (in our case between 2005 and 2014). The contribution from each of the three components sums to 1, though individually when the estimate for an individual component is larger than 1 it indicates that the component in question would, on its own, anticipate a larger gap than what is observed. When the estimate for an individual component is smaller than 0 it indicates that the component in question would, on its own, anticipate a gap in the opposite direction from what is observed.

As shown in Fig. 4C, the increasing gap between 2005 and 2014 is fully anticipated by changes in endowments over time ( $\Delta$ Endowments). Not only that, but in the model that includes productivity and journal placement, the endowments component anticipates a substantially larger gap than what we see in our estimate in Fig. 1. The coefficients component ( $\Delta$ Coefficients) represents the difference in Global South and North scientists' outcomes if they had similar attrition rates, cross-regional migration rates, team sizes, publication rates, and journal placements. Considering attrition on its own, the model anticipates a slightly larger gap than what we estimate in Fig. 1, although with confidence bounds that span zero. This is also true when we add team size and migration to the model. However, the result reverses when productivity and journal placement are added to the model, suggesting that Global South scientists, on average, benefit more (in terms of citation elite membership) than Global North scientists, provided they publish the same (average) number of papers in outlets of the same (average) journal impact. The interaction component ( $\Delta$ Interactions) estimates the amount of change in the South-North gap not accounted for by the decomposition, showing that a substantial portion of the gap, 13.2%, with confidence bounds spanning from 8.8% to 18.0%, is left unexplained.

## Discussion

Our study presents the first, large-scale evidence of an expanding South-North gap in early-career scientists' likelihood of becoming part of their age group's most cited authors. While the proportion of Global South-based researchers joining the top-cited group has plateaued across cohorts and time (Fig. 1A), the surge in their overall numbers has led to a growing share of Global North scientists entering this elite category. As a result, the South-North gap in the likelihood of joining the citation elite has widened from, 3.5 to 4.3 percentage points, representing a relative increase of roughly 23%. Broadly, these findings align with core-periphery accounts of global science, suggesting that increasing standardization and openness may open new opportunities for individual scientists from disadvantaged locations to pursue international careers, while simultaneously sustaining historical asymmetries in the accumulation of recognition and rewards (Hwang, 2008; Kwon et al., 2012; Mosbah-Natanson & Gingras, 2014; Schott, 1993).

While the South-North gap in citation elite membership is widening, our analysis shows notable variations across regions. The reduced performance of the Global South is mainly due to a standstill in Eastern Asia, while other regions, such as South Asia, Western Asia, and Sub-Saharan Africa have seen slight proportional increases in elite membership during the observation period (Fig. 1C). Eastern Asia's apparent stagnation likely stems from China's massive expansion of its research system during the past decades, alongside the simultaneous decline in Japan's scientific contributions (Phillips, 2017; Xie et al., 2014). Numerous

reports have highlighted China's rapid rise to the top of global science, often focusing on the changing "numerator"—the country's swift increase in scientific output and growing share of papers among the globe's most cited. However, these accounts typically overlook the simultaneously changing "denominator", i.e., the growing scientific workforce needed to generate this output. Therefore, while China's success is indeed noticeable in a numerical sense, the system's expansion has not boosted the production of prominent, home-based researchers beyond what would be expected, given a linear relationship between population size and advancement.

Our findings also indicate that scientists based in the Global North, particularly those in Western Europe, Northern Europe, and Australia/New Zealand, have seen large proportional increases in elite membership, surpassing their counterparts in the United States, who have shown a more modest upward trend (Fig. 1B). This aligns with previous research suggesting shifting power dynamics within the Global North (Nielsen & Andersen, 2021). Despite these changes, all subregions of the Global North, except for Eastern Europe, outperformed each subregion in the Global South in terms of presence in the top 5% in 2014. This represents a notable shift from ten years earlier, when scientists based in Southern Asia and South-Eastern Asia matched or exceeded those residing in Eastern Europe, Southern Europe, and Australia/New Zealand.

Field-level analyses also reveal notable variations in the South-North gap. Although the gap has widened in most fields, and most saliently in subfields like clinical medicine and the biological sciences where North America and North- and Western Europe are doing well (Miao et al., 2022), some areas have also seen a narrowing gap (i.e., industrial biotechnology, the chemical sciences and electrical, electronics, & information engineering), likely mirroring East Asia's competitive advantage and investment in Chemistry and Engineering related areas (Harzing & Giroud, 2014). These patterns open promising avenues for future research on country-specific specializations and trends in citation-elite membership.

The widening South-North gap in elite status should be understood in the context of diverging regional trends in attrition, publication outputs and journal placement. Our decomposition analysis suggests that the proportion of the overall gap that might be explained by these three factors grew over time, from 84.2% for the 2000 cohort to 93.8% for the 2014 cohort. Importantly, we also show that the changing gap is not due to Global North scientists receiving greater benefits (in terms of elite status) from their publication efforts, compared to scientists in the Global South. Contrarily, when publishing an equivalent number of papers in journals of similar impact, scientists from the Global South actually gain more in terms of elite status than their Global North counterparts. Nevertheless, even after accounting for diverging trends in attrition, cross-regional migration, team size, productivity, and journal selectivity, a substantial portion of the increasing gap (13.4%) is left unexplained. While this remaining difference does not necessarily imply bias, it does suggest that the North/South citation elite gap deserves more scrutiny than it has received so far.

Although changes in observed regional migration appear to play a minor role in widening the South-North gap in elite-membership, this finding should be interpreted as a lower bound. Some portion of research-related migration, including South-to-North mobility (Choudhury et al., 2023; Li et al., 2019), consists of those moving abroad for advanced training often prior to publishing (Shen et al., 2022; Teichler, 2015). Some of these students end up publishing the bulk of their early-career work abroad and are therefore classified as Global North scientists in our data. This implies that some of the widening South-North

gap in citation-elite membership may reflect increasing opportunities, not disadvantages, for individual Global South scientists, who end up contributing to the output and impact of Global North institutions. This possible mechanism, while highlighting increased opportunities and a greater inclusivity of Global North research systems, only reinforces our study's central argument: structural barriers continue to constrain the more direct pathways to scientific prominence and elite membership within the Global South – i.e., even if researchers self-identify as Global South scholars, their elite membership in terms of their intellectual oeuvre and associated research will most likely be attributed to the Global North.

Overall, our findings suggest that diverging trends in career-lengths and in author-level outputs and journal placement are the primary factors driving the increasing South-North gap in citation-elite membership. Broadly, these findings speak to the enduring dominance of wealthier nations in the production and distribution of scientific knowledge. As science has expanded globally, journal space in the most selective and influential international journals (covered by Web of Science) has remained disproportionately occupied by scientists based in the Global North, reinforcing imbalances in citation-elite membership. Possible drivers of this trend may include persistent disparities in access to knowledge, resources and facilities, the concentration of major publishing houses and journal editors in the Global North (Larivière et al., 2015), the growing dominance of English in scientific publishing (Amano et al., 2016; Gingras & Mosbah-Natanson, 2010), and the enduring Western influence on international research agendas (Castro & Alburez-Gutierrez, 2022; Evans et al., 2014). While experimental evidence remains mixed (Nielsen et al., 2021), observational analysis suggests that country- and regional biases in editorial and peer-assessments of article submissions may also play a role (Dumlao & Teplitskiy 2025).

For higher education research and policy, these findings caution against equating the expansion of doctoral training, publication activities, and absolute measures of citation impact in low- and middle-income countries with increased regional career opportunities and improved paths to scientific prominence. The widening gap in citation-elite membership we observe indicates that the returns on such investments remain limited by diverging regional attrition rates and disparities in journal placement. While the structural features of global science that shape journal placement are largely beyond the reach of national policy, a partial response for catching-up economies could involve reallocating resources from training more scientists toward retaining and supporting those already in the system.

A number of limitations of our study merit attention. One of those concerns the overrepresentation of English language papers in our database. Given the volume of scientific literature published in languages other than English (e.g., Spanish, Mandarin, or Hindi), we may underestimate the overall impact of scientists from regions where non-English publications are prevalent. However, as WoS broadened its language coverage during our study period, this is unlikely to influence the observed changes in citation-elite disparity across cohorts. Second, author-disambiguation methods tend to be less accurate for East Asian names due to the prevalence of common surnames and limited variation in given names, which can lead to errors, such as merging distinct authors with similar names. However, in a previous study of global citation disparities using the same data source, we show that the average number of papers per author in China and Taiwan is similar to that in Western reference countries (Denmark, Germany, and the US), suggesting that this bias is unlikely to substantially affect our results (Nielsen & Andersen, 2021). Even if this bias were substantial, it would likely overestimate, not underestimate, the representation of East Asian authors among the top

5% most cited, thus providing a conservative lower-bound estimate of the widening South-North gap in citation elite membership.

In summary, our findings suggest that although the global scientific workforce is becoming more geographically diverse, scientists based in affluent countries increasingly dominate among new generations of prominent scientists. Whether this development is problematic depends on perspective. From one viewpoint, it may reflect increasing opportunities and inclusivity, as more prospective scientists from the Global South gain access to training and collaboration at leading institutions in the Global North before they start publishing. From the standpoint of Global South countries, however, it also highlights enduring structural barriers that constrain more direct pathways to scientific prominence within these countries, preventing them from fully capitalizing on the skills and expertise of their local scientific talent.

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**Data and code availability** All analyses were conducted in R. The custom code required to reproduce the results is available online at OSF: <https://osf.io/agn35/overview>. Aggregated data is available at the same address.

## Declarations

**Ethics approval and consent to participate** Not Applicable.

**Competing interest** The authors declare no competing interest.

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