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Access to science and innovation in the developing world

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Abstract

We examine the implications of lowering barriers to online access to scientific publications for science and innovation in developing countries. We investigate whether and how free or low-cost access to scientific publications through the UN-led Research For Life (R4L) initiative leads to more scientific publications and clinical trials of authors affiliated with research institutions in developing countries. We find that free or reduced-fee access to the health science literature (WHO-led Hinari subprogramme) increases the scientific publication output and clinical trials output of institutions in developing countries. In contrast, once we control for selection bias, we do not find empirical support for a positive Hinari effect on knowledge spillovers and local institutions' research input into global patenting, as measured by paper citations in patent documents. Main findings can be generalized to other R4L subprogrammes and are likely to also apply to the WIPO-led Access to Research for Development and Innovation (ARDI) programme.

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1 Introduction

Scholars and policymakers have come to recognize scientific creativity, local science and innovation as important drivers of countries' industrial development [Griliches, 1979, Annan, 2004, Agarwal et al., 2007, Heinze et al., 2009, Azoulay et al., 2011, Fu et al., 2011, Hoffecker, 2018, Mugabe et al., 2020, Nayyar, 2021]. One means that policymakers have sought to boost scientific creativity, local science and innovation is by removing barriers to accessing scientific publications.

However, while the costs of access to content and information more broadly have decreased following the proliferation of online access in many sectors such as music or book publishing, the costs of accessing scientific journals and information in scholarly research have increased much faster than inflation in the digital age [Suber and Arunachalam, 2005, Waldfogel, 2017]. This has important ramifications for scientific creativity and advancement, particularly in developing countries where the costs of access to scientific journals can be prohibitively high. Recent research provides evidence that removing or significantly lowering the cost barrier to scientific journals can lead to more follow-on scientific production [Biasi and Moser, 2021], particularly in developing countries [Mueller-Langer et al., 2020]. These results suggest that restricted access to scientific publications may diminish scientific output from these institutions.

Despite recent global policy efforts that mandate open access publishing and programmes that give free or low-cost access to pay-walled articles to researchers in developing countries, it is not clear if the codified knowledge that scientific publications transmit is sufficient to improve and trickle down on local science-to-innovation pipelines, particularly in those countries with the weakest innovation ecosystems and severe lack of resources [Davis and Walters, 2011, Lee et al., 2018]. Still, similar technical information becoming more widely made available in patent documents has been shown to promote technology development and follow-on innovation in developed economies [Furman et al., 2021]. So, in theory, while restricted access to scientific publications and technical information may diminish scientific output, it can also limit innovation activity and absorptive capacity building in developing countries.

Note that similar concerns have been raised in public policy debates on access to medicine, neglected diseases, and patent-protected technology at later stages of development [Kremer, 2002, Lanjouw, 2003, Kremer and Glennerster, 2004, Mueller-Langer, 2013]. Ultimately, this is an open empirical question we seek to address in this paper, also in light of the United Nations' Sustainable Development Goals (SDGs) for developing economies.

Our global analyses of the science-to-innovation pipeline in this paper are based on data from the Research4Life initiative (henceforth, R4L), which also includes the WIPO-led Access to Research for Development and Innovation (ARDI) programme. Launched in 2002, Hinari is the inaugural, WHO-led programme of R4L targeting health sciences, which strives to facilitate open access to a wide range of journals (in various languages), e-books, and other informational resources for researchers and students in non-profit institutions like universities and public research institutes.[1]

We combine WHO data on institutional participation with large bibliometric data from Microsoft Academic Graph (MAG), clinical trial information from the international clinical trials registries, patent information collected from Patstat (Patstat Global - 2022 Spring Edition) as well as information on patent-paper linkages [Marx and Fuegi, 2020]. These data sources record close to 30 years of scientific and inventive advances in developing economies and allow us to investigate whether and how online access to scientific publications impacts the local institutions' output of (a) scientific publications and (b) clinical trials, as well as their input into the (c) global patent activity, as measured by citations in global patents.

We find that free or reduced-fee access to scientific publications in health science substantially increases follow-on scientific publications and clinical trials output of institutions in developing countries. Access granted by Hinari through the R4L initiative helps budget-constrained institutions overcome cost hurdles, and related informational gains increase the productivity of local researchers in programme-related fields. Observed effects are self-enforcing and not equally distributed, i.e., higher-performing institutions benefit more than lower performers

[1]Registration for the Hinari programme by institutions is available in 124 developing countries where it is provided for free (Group A) or at low cost (Group B). A country is designated as either Group A or B based on a series of factors. In general, the poorest developing countries (such as the UN-classified Least Developed Countries) are assigned to Group A and qualify for free-access to the repository, while relatively richer developing countries are assigned to Group B such that institutions in these countries are required to pay an access fee of USD 1,500 per institution per calendar year.

from Hinari participation. In contrast, we do not find empirical support for a positive Hinari effect on knowledge spillovers and local institutions' research input into global patenting, as measured by paper citations in patent documents. In this respect, our analysis extends the approach pioneered in [Mueller-Langer et al., 2020] in several important aspects: (1) we look at the distinct research field of health science (Hinari), while [Mueller-Langer et al., 2020] consider environmental science (OARE), another subprogramme of the R4L initiative, (2) we increase geographical coverage and significantly broaden the treatment group as we investigate all 99 countries eligible under the programme that see publications in the MAG data during the observation period, and, most importantly, (3) we broaden the scope of the analysis to not only include the impact of free or reduced fee access on scientific output, but also are first to explore its effect on clinical-trial output and local science as an input to global patent activity. Main findings from the analysis of the Hinari programme are likely to extend and generalize to other programmes operated under the R4L initiative including the ARDI programme.

A major concern in our empirical strategy relates to the self-selection bias of the more productive or informed institutions into Hinari and similar R4L programmes. To mitigate this source of bias, we adopt a difference-in-difference-in-differences model (DDD). We compare the output in Hinari fields in a given Hinari member institution with the output in other fields at the same institution and with the output of non-member institutions – before and after joining the Hinari initiative.

The remainder of the paper is organized as follows. In Section 2, we provide an overview of the related literature and our hypotheses. Section 3 presents the data and variables. In Section 4, we discuss our empirical strategy. Section 5 presents our results and Section 6 concludes.

2 Related Literature

Subsection 2.1 provides an overview of the literature on access to science and scientific output. Then, we relate our paper to the literature on access to science and follow-on local innovation

(Subsection 2.2).

2.1 Access to science and scientific output

Access to scientific literature is directly dependent on the characteristics of the academic publication market. With the takeover of academic journals by few commercial publishers in the mid-20th century - dominated in particular by five publishers [Eger and Scheufen, 2018, 2021] - as well as new price discrimination opportunities due to digitization [McCabe, 2002, Edlin and Rubinfeld, 2004, 2005, Rochet and Tirole, 2006], there has been a massive increase in academic subscription prices since the 1980s [Edlin and Rubinfeld, 2004, Ramello, 2010, Bergstrom et al., 2014]. The resulting serial crises led to a broad academic discussion and increased support for the open access (OA) publication model from academia [Shavell, 2010, Suber, 2012] and politics [European Comission, 2012, 2019].

The academic debate is characterized by three main strands of literature: (1) studies on the impact of OA on the incentives and motivation of researchers, analyzing changes in readership [Shavell, 2010, Furman and Stern, 2011, Mueller-Langer and Watt, 2021] or citation patterns[2] as researchers are motivated by scholarly esteem rather than financial gains [Partha and David, 1994, Shavell, 2010], (2) studies on the social welfare effects of different publishing regimes, with results ranging from purely positive [Shavell, 2010] to ambiguous effects [McCabe and Snyder, 2005, Jeon and Rochet, 2010, Mueller-Langer and Watt, 2021, Feess and Scheufen, 2016]) on social welfare,[3] and (3) studies on the attitude of researchers and the usage of both green and gold OA publishing modes, highlighting concerns regarding OA publishing such as low quality [Harley et al., 2010] or reputation disadvantages [Eger and Scheufen, 2018].[4]

[2] A series of papers examines the citation benefit of OA, with a very differentiated picture and results ranging from a positive effect (e.g., [Eysenbach, 2006, Davis, 2011, McCabe and Snyder, 2014, Eger et al., 2021], a very modest or no effect at all [Frandsen, 2009, Davis, 2011, Gaulé and Maystre, 2011, McCabe and Snyder, 2021] to a negative effect [Davis et al., 2008] of OA on citations. Interestingly, the effect significantly differs by discipline [Gargouri et al., 2010] or publishing culture [Eger et al., 2021].

[3] Moreover, hybrid OA journals – which combine OA and closed access (CA) publishing as they offer OA to single papers upon payment [Davis et al., 2008, Björk, 2012] – are critically viewed as they do not necessarily offer a citation advantage [Mueller-Langer and Watt, 2018] and may further spur concentration in the academic publishing market [Haucap et al., 2021].

[4] Most importantly, studies have been emphasizing the importance of the relationship between age, tenure and OA publishing [Harley et al., 2007, Eger et al., 2015, 2016].

The regulation of access to scientific articles is of particular importance for developing countries [Annan, 2004], especially as they have hardly been able to subscribe to academic journals in the past [Evans and Reimer, 2009]. A variety of studies show that free access to academic content is important for both input [Evans and Reimer, 2009, Gaulé, 2009, Frandsen, 2009, Biasi and Moser, 2021] and output [Davis, 2011, McCabe and Snyder, 2015, Mueller-Langer et al., 2020]. From the input perspective, some studies reveal higher usage of free academic content [Gaulé, 2009, Biasi and Moser, 2021], whereas other studies deny such an effect [Frandsen, 2009], meanwhile Davis [2011] finds no effect of free access on research output. Mueller-Langer et al. [2020] combine both input and output analyses revealing an increase in the usage of freely available content (+8.4 percent) and scientific output (+29.6 percent) in environmental sciences (OARE). Interestingly, looking at the OARE initiative – offering free or reduced fee access to more than 11,500 journals in environmental science – Mueller-Langer et al. [2020] can compare both member versus non-member institutions as well as variation within institutions by comparing treated versus non-treated disciplines. Similarly to these more recent studies [Mueller-Langer et al., 2020, Biasi and Moser, 2021], we hypothesize that:

Hypothesis 1 (Publication Effect): *Free and low-cost access to scientific publications leads to an increase in follow-on scientific publications.*

Our approach mimics that of Mueller-Langer et al. [2020], but differs in three important aspects: (1) We look at the research field of health science (Hinari), (2) we significantly broaden the treatment group as we investigate all eligible countries and not only five countries, and (3) we broaden the scope to not only look at the impact of free or reduced fee access on scientific output, but also its effect on (local) innovation through clinical trials.

2.2 Access to science and follow-on local innovation

Going beyond scientific publications, scientific research in universities and research institutes is seen as a precursor to innovation and associated growth in local industrial innovative activity [Brooks, 1994, Freitas et al., 2011].

However, at this point we distinguish access to science, broadly speaking, and access to

scientific publications. In addition to scientific publications, science may also be accessed through academic spin-offs [Soetanto and Jack, 2016] where researchers go on to directly translate scientific developments into innovations; through public conferences and meetings, informal information exchange, and consulting [Cohen et al., 2002]; or simply by spillovers of knowledge from universities to firms such as through the movement of students from university to workplace, research collaborations, etc. [Freitas et al., 2011, Díez-Vial and Ángeles Montoro-Sánchez, 2016, Brandão Fischer et al., 2018].

It has been argued based on a survey of U.S. based R&D managers that scientific publication is the most important route through which science is translated into innovation [Cohen et al., 2002]. Based on an analysis of patent data, Fleming and Sorenson [2004] proposed that scientific publications act as a map that makes the knowledge search process more efficient for inventors by (1) guiding inventors towards more fruitful solutions; (2) guiding inventors away from futile solutions and; (3) increasing the innovativeness of inventions. In addition, Bryan and Ozcan [2021] recently provided evidence that OA medical science publications are significantly more likely to be cited in patents than other non-open access publications. This suggests that barriers to accessing scientific publications may reduce the amount of scientific knowledge that is available to inventors, their ability to invent, and the innovativeness of their inventions.

Yet there continues to be limited explicit evidence on the relationship between access to scientific publications and the *quantity* of local innovation. Furthermore, there is evidence that the relationship between access to science and follow-on innovation is positively moderated by local stocks of knowledge [Lee et al., 2018]. Since science is by its nature complex and often involves tacit knowledge national systems of science and technology tend to be closely coupled, making it difficult for inventors from non-science producing countries to produce innovation that is based on scientific advances from elsewhere [Pavitt, 1991]. Therefore, even if one could assume away the effect of access to scientific publications on innovation in developed countries, it is eminently unclear that scientific publications alone and the codified forms of knowledge they transmit are sufficient for innovation development in developing countries. As [Davis and Walters, 2011, p208] have noted "further research is needed to investigate

whether free access [to scientific publications] is making a difference in non-research contexts" (parenthesis not included).

Based on the previously discussed arguments presented by Cohen et al. [2002], Fleming and Sorenson [2004], Bryan and Ozcan [2021], we hypothesize that:

Hypothesis 2 (Innovation Effect): *Free and low-cost access to scientific publications leads to an increase in follow-on innovation.*

In our empirical analysis we focus on health science for three main reasons. First, the translation problem in health is perhaps the most important one for welfare reasons as it is often directly related to (quality of) life and death. Certain illnesses in developing countries may receive little research attention beyond their shores because the populations affected are too poor to be of commercial interest elsewhere [Kremer, 2002, Lanjouw, 2003, Kremer and Glennerster, 2004, Boutayeb, 2007, Mueller-Langer, 2013, Confraria and Wang, 2020]. As such, supporting local science-to-innovation pipelines is of critical importance for academics and policymakers concerned with this field [Mugabe et al., 2020]. Second, the translation gap is an urgent and commercially significant one in this field. The ratio of innovative drugs output to (increasing) investment in research continues to decline and researchers and policymakers launch several initiatives to address this issue [Haeussler and Assmus, 2021]. Understanding the science-to-innovation pipeline in this field may provide some commercially relevant insights for academics and policymakers into what kinds of policy interventions work best. Third, health innovation is highly regulated. This unique scrutiny makes innovation in this industry more transparent and therefore makes the science-to-innovation pipeline in this field more readily observable. Innovation in health science typically takes the forms of new therapeutic practices, new medicines or new instruments and devices. However before a new invention can be brought to the market as an innovation in this industry, it often has to undergo clinical trials which are often also documented in scientific publications [Hoekman and Rake, 2024]. Clinical trails are processes that investigate and develop medical innovations and ultimately determine their suitability and readiness for commercialization. During this process, medical inventions are subject to immense scientific and regulatory scrutiny in a process that is highly complex in medical and organizational senses [Haeussler and Assmus,

2021]. Clinical trails therefore provide us with deep and detailed insight into innovation attempts in this industry.

3 Data and Variables

3.1 The Hinari programme

In 2002, the Hinari programme was established through a collaborative partnership between the World Health Organization (WHO) and scholarly publishing entities. It serves as a catalyst for enhancing the capabilities of low- and middle-income economies by affording local researchers access to a comprehensive and otherwise costly repository of biomedical and health literature. This repository comprises a compendium of 21,000 peer-reviewed scientific journals, complemented by an extensive collection of 69,000 e-books and an additional 115 informational resources. These scholarly assets are presently accessible to researchers in health research institutions such as universities and teaching hospitals, spanning more than 124 countries, regions, and territories. Hinari was the first programme launched by WHO under the R4L umbrella initiative which is an inter-agency collaboration of several UN agencies. From a methodological perspective, studying Hinari therefore avoids cross-treatment effects from other programmes.[5] In the initial dataset, we observe 2,265 institutions that joined the Hinari programme. Figure 1 displays the quarterly rate of cumulative Hinari programme adoption in all 124 countries for each group.[6] Furthermore, Figure 2 shows the geographical spread of our sample.[7]

Eligibility criteria distinguish between group A and group B countries. Institutions in group A countries receive free online access to the repository, while institutions in group

[5]R4L includes five subprogrammes linked to different research fields. Hinari initiative relates to research for health; AGORA (launched by FAO and partners in 2003) concerns the research for agriculture; OARE (launched by UNEP and partners in 2006) provides resources pertaining to research in the environment science; ARDI (launched by WIPO in 2009) refers to the research for innovation; and GOALI (launched by ILO in 2018) is associated with the research for global justice.

[6]We define the rate of adoption as the cumulative number of institutions that adopted the Hinari programme in a given quarter (inclusive of previous quarters) divided by the total number of institutions that had adopted Hinari at the time of data collection (2022). At the time of data collection, 124 countries were involved the Hinari initiative.

[7]The map relates to a restricted sample, where we observe Hinari subscriber institutions with publication activity during the years of study.

B countries are granted access at low cost. Assignment into group A or B is done at the country-level and is contingent upon meeting specific criteria of economic development.[8] For example, institutions situated in countries with a GNI per capita equal to or below USD 1,500 are granted unrestricted access to the entire corpus of journal articles, while institutions in countries with a GNI per capita below USD 6,300 are subject to an annual fee of USD 1,500. For access to be granted, research institutions must undergo a registration process with Hinari. We exploit the variation in country-group membership, i.e., during our observation period, 24 of the 99 countries under study switched from group A to group B or vice versa, to investigate heterogeneity of the Hinari effect on publication and clinical trial output (see Subsection 5.4).

3.2 Data

3.2.1 Scientific information and clinical trials referral

First, we obtain bibliometric article-level data from Microsoft Academic Graph. MAG consists of a diverse graph with more than 120 million publication entities [Herrmannova and Knoth, 2016]. As confirmed in the literature, it is the most extensive dataset available in terms of bibliometric scientific articles coverage [Visser et al., 2021]. These data concern all publications for the countries under the R4L programme from 1990 up to 2018.[9] From MAG, we gather information on author names, affiliation, paper title, publication year, as well as information on the level of the journal. Note that local researchers that do not publish in the observation period are unobservable to us via the MAG data, and so is the potential Hinari

[8]Specifically, the eligibility between the two groups depends on the fulfilling of at least one criterion from a list of criteria. For Group A: United Nations Least Developed Countries List; Total Gross National Income (GNI) less or equal than USD 500 million; Total GNI less or equal than USD 5 billion where Gross National Income per capita (GNIpc) less or equal than USD 10,000; Total GNI less or equal than USD 15 billion where GNIpc less or equal than USD 3,000; Total GNI less or equal than USD 200 billion (where Human Development Indicator (HDI) less or equal than 0.60 and/or, GNIpc is at or less than USD 1,500. For Group B: GNIpc less or equal than USD 6,300 where Healthy Life Expectancy (HALE) less or equal than 55; Total GNI less or equal than USD 1.5 billion; Total GNI less or equal than USD 25 billion where GNIpc less or equal than USD 10,000; Total GNI less or equal than USD 300 billion (where HDI less or equal than 0.67 and/or, GNIpc less or equal than USD 6,300.

[9]We extracted all scientific publications where at least one author belongs to a R4L country. We narrow our sample to scientific publications only. Our analysis includes 99 countries of the 124 countries included in the Hinari programme, i.e., we focus our sample on countries that have produced scientific publications observable in MAG during our study period.

effect on them. The article-level data permits us to account for research contributions in various research fields, multiple affiliations of authors, and multi-author publications.

Second, we source novel data on scientific paper-clinical trial linkages from recent work by [Smalheiser and Holt, 2022] and as done in previous research [Hoekman and Rake, 2024]. Their data made available to us originates from screening all 36 million scientific papers that entered PubMed from the 1950s to the present day (February 2023), and identifying a total of more than 167,000 papers that mention one or more clinical trial numbers in the abstract or article metadata. The data provides unique identifiers for PubMed articles, English article titles and DOI, as well as the native registry ID, country, and start date for clinical trials. Note however, that paper-trial linkages will only represent a subset of overall clinical trials conducted as there is no formal requirement to report clinical trials in scientific publications, or the linkage to the clinical trial may be mentioned only in the full-text of papers [Smalheiser and Holt, 2022]. Still, [Smalheiser and Holt, 2022] estimate that 15 to 20 percent of clinical trials conducted globally are also reported in scientific publications published on PubMed.[10] Clinical trials reported in papers mostly come from the various large national and international trial registries such as the U.S., the EU or China (by order of magnitude), but also include several smaller and regional registries relevant to this study, for example, the Pan African or Tanzania Clinical Trials Registries.[11] Compared to the frequent scientific publication activity recorded in MAG, note that clinical trials are rare events throughout the observation period. Publication-clinical trial linkages are merged to the original MAG data using the unique article DOI provided in the data.

In principle, there are two types of scientific publications attached to trials. Most

[10]Further note that about half of all trials conducted result in at least one publication, but not necessarily a PubMed publication, and relationships are not always indicated by a registry number in PubMed publications. However, the World Health Organization and its International Clinical Trials Registry (ICTRP) recorded more than 750,000 clinical trials globally since its inception in 2004, which roughly corresponds to the number of observed (linked) trials in our sample i.e. 167,000 (22% of 750,000).

[11]The following trial registries were identified in the original PubMed data [Smalheiser and Holt, 2022]: World Health Organization – International Clinical Trials Registry, ClinicalTrials.gov (US), EU Clinical Trials Register, Swiss National Clinical Trials Portal, ISRCTN (Springer Nature), Australian New Zealand Clinical Trials Registry, Chinese Clinical Trial Registry, Clinical Trials Registry – India, Iranian Registry of Clinical Trials, Clinical Research Information Service (KR), Philippine Health Research Registry, Sri Lanka Clinical Trials Registry, Thai Clinical Trials Registry, Public Cuban Registry of Clinical Trials, Pan African Clinical Trials Registry, and Tanzania Clinical Trial Registry.

publications are generated by the trial and report research outcomes. However, some publications are published by investigators as supporting evidence or motivation for conducting the trial. These latter publications may be review articles of previous trials whose publication dates may precede the trial start by years. However, once we merge the data to the publication sample from institutions in R4L countries, the median clinical trial in the sample starts 2.75 years before the associated papers are published, similar to the timing and sequence reported elsewhere in the literature.[12] In total, 96 percent of matched clinical trials pre-date the date of the official publication as recorded in MAG and when compared to start date recorded in the various clinical trial registers. We hence are confident that most publications directly report clinical trial outcomes, while the share of publications serving as a mere knowledge input to designing new trials seems negligible. In sum, paper-clinical trial linkages allow us to investigate if improved access to scientific publications impacts the international clinical trial referral and participation of research institutions in developing countries. By international clinical trials, we mean trials run globally (any location and country of recruitment, any trial phase, and as industry-sponsored and any other trial sponsors) and international trials disclosed and listed in PubMed publications.[13]

3.2.2 Patent information and patent referrals to science

Lastly, we collect patent information for developing countries and beyond from Patstat. The dataset contains information on general application details (such as the application receiving authority, filling date, etc.), the technical and industrial classification of the patent, and

[12]Publications typically appear around 1.5-2 years after the completion of a trial [Smalheiser and Holt, 2022].

[13]We also attempted a more direct approach where we aimed to link researcher and institution data directly with clinical trial information obtained from the International Clinical Trials Registry Platform. However, this approach failed for two main reasons. First, information on researchers participating in clinical trials is limited to principal investigators. This gives an incomplete picture of research teams involved in these clinical trials. Second, given that there is limited institution information and imperfect spelling matches, we attempted to match trials to institutions data from MAG using geo-coding of the reported address in the clinical trials. We declared a match if the trial occurred within 2km of an institution. However, given that trial location choices may have little to do with the location of the institution, and given that multiple institutions may be located in very close proximity (i.e. within the 2km radius), this sort of geo-matching would not have permitted us to confidently assign trials to institutions nor to scientific fields within a given institution. Hence, using the DOI linking method provides the most accurate matching and enables us to define Hinari vs non-Hinari related clinical trials and permits us to confidently apply the DDD technique.

information on the applicants (such as names, addresses, etc.). In order to distinguish the patents' field, we supplement this dataset using the International Patent Classification (IPC) dataset.[14]

To establish a systematic link between scientific publications and patents, we use data on paper-patent linkages by Marx and Fuegi [2020] (henceforth RoS data) to trace the "scientific lineage of R&D" and document spillovers from academia to industry. As RoS data links scientific references found in the front pages of worldwide patents to articles in the MAG data from 1800-2018, it may represent actual knowledge flows from science to inventors. This gives us a subset of scientific articles and patent documents that are closely tied to research conducted in institutions in R4L countries. Timing-wise, given that a paper is cited in a patent, the average paper in our sample is cited 4.5 years after initial paper publication. In addition to the link between Patstat and MAG, the authors provide supplementary information on scientific publications. Specifically, they map each unique MAG paper identifier to scientific field categories.[15] Those categories allow us to distinguish between health related papers and non-health related papers (see Table 15 for further details on health paper classification).[16]

[14]The IPC classification is added by a patent examiner who assigns the classification to a patent application at the most detailed level possible in accordance with their technical content and subject matter.

[15]MAG automatically extracts over 200,000 scientific fields based on both the abstracts and the titles of scholarly papers. Marx and Fuegi [2020] first mapped the MAG papers into 6 OECD field and 39 sub-fields; hence they provide a crosswalk between the OECD classification and the 251 Web of Science fields.

[16]In an alternative approach, we matched exact inventor names as listed on patent documents with researcher names listed on scientific publications of the focal institutions. To ensure proper name disambiguation, we further imposed a 2km distance rule between the inventors' address and the institutions' address and the similarity string names matching method (via Stata's *matchit* package). The 2km rule was added to minimize the risk that we were matching completely different persons with similar names. Such an analysis could more explicitly study programme impact on local patenting output, similar to the below analysis conducted for scientific publications and clinical trials. However, only about 250 patents could be traced back to individual researchers from institutions in our sample. Given the small sample and poor patent coverage for developing economies in general, we had to abandon this alternative approach. Finally we also attempted a similar strictly geo-coding approach as we did for the clinical trials (see footnote 13). However, this approach was ultimately discarded due to similar concerns about accurate assignment to treatment and control groups.

3.3 Definition of variables

3.3.1 Scientific publications

Table 1 presents an overview of the variables of interest and summary statistics (at the institution-field-quarter level). Our dependent variable is the number of publications by institution i, in quarter t and in research field r. As shown in Table 1, the dependent variable ranges, per institution-quarter-field, from 0 to 561.1. We constructed this variable as a fractional count of an institution's contribution to the scientific publication.[17] We collapsed the data at quarter-institution-field level. Our sample covers 318,072 observations. As for the main variable of interest, 5.5% of the observations in our sample are subject to the Hinari treatment. From MAG and RoS data, we also construct a set of control variables at the article and journal levels. This includes the average number of US co-authors and a variable that takes into account the journal impact factor of the scientific publications respectively.

3.3.2 Clinical trials

In Table 6 we present the summary statistics for the clinical trials analysis at the institution-field-quarter level. Our dependent variable is the number of clinical trials by institution i, in quarter t and in research field r. It ranges from 0 to 12 clinical trials per institution-quarter-field. We construct this variables as a fractional count of (a) the institution's contribution to the scientific publications reporting the trial (i.e., we account for scientific papers with multiple authors and affiliations), and (b) the institution's weight in all papers relating to the single trial (i.e., we account for the fact that a given trial may relate to one or multiple reporting papers).[18] We collapsed the data at the quarter-institution-field level. Our final estimation sample covers 82,348 observations including all institutions with at least one clinical trial in the observation period. As for the main variable of interest, 21.2% of the observations in our sample are subject to the Hinari treatment (see Table 6). Note that

[17] For instance, if a scientific publication has three authors from three different institutions (in a specific field), each institution has an increase in publication output of 0.33.

[18] For instance, if a scientific publication has three authors from three different institutions and the clinical trial relates to a single publication, each institution sees an increase in clinical trial output of 0.33.

clinical trials are not limited to biomedical and health research only, but they are also common in other research fields such as agriculture. We classify clinical trials in our sample on the basis of the initial categorization of the related scientific publications into Hinari and non-Hinari related fields of research. If multiple papers relate to a single trial, we implement the following decision rule: if more than 80 percent of the referral papers are classified as belonging to a Hinari field, the clinical trial is considered a Hinari trial.

4 Empirical Strategy

To investigate the impact of the Hinari programme, we employ a difference-in-difference-in-differences (DDD) estimation that is similar to Mueller-Langer et al. [2020].

First, concerning the impact of the Hinari programme on the scientific productivity of the institutions, this methodology compares the changes in scientific productivity between the treatment group (i.e., health sciences in registered institutions post-Hinari registration) and the control group (i.e., health sciences in registered institutions pre-Hinari registration, non-health sciences in registered institutions, and all research fields in unregistered institutions). The rationale behind the DDD approach is as follows: within a Hinari institution, only researchers working on health issues can be affected by the access to health (Hinari) journals post-registration with Hinari. In contrast, other scientific fields within the same institution (and Hinari fields before programme subscription) do not benefit from the programme. Examining the effects of online access across scientific fields within a given institution helps to address concerns related to programme self-selection at the institutional level.

Second, the estimator allows to evaluate the impact of the Hinari programme on the number of clinical trials from a given institution. In this case, rather than assessing scientific productivity based on publication output, the number of clinical trials is an indicator of local involvement in global clinical trial activity. In general, by running costly clinical trials on one or multiple sites and countries, evidence is collected to establish a treatment and determine safety and effectiveness (efficacy) of medications, devices, diagnostic products and treatment regimens intended for human use at home or abroad. Hence, the number of clinical trials

approximates how much clinical research with commercial intention and practical relevance on markets is conducted by researchers within a given institution.

Third, a similar approach is adopted for the impact of the Hinari programme on the paper-to-patent citations. Following Marx and Fuegi [2020], the number of citations of scientific publications in patent documents is used as a proxy for the spillovers from academia to industry. It is in this respect that local science serves as a potential knowledge input to global patenting and innovation activity. As indicated by the citation to the paper in the patent, the research has practical relevance for inventors and commercial application by firms and other institutions at home and abroad.

Hence, we estimate the following model:

$$\begin{aligned} y_{i,t,r} = \beta_0 + \beta_1 Hinari\ Field_{i,t,r} + \beta_2 Hinari\ Institution_{i,t,r} + \beta_3 Post\ Hinari_{i,t,r} + \\ \beta_4 Hinari\ Field_{i,t,r} \times Hinari\ Institution_{i,t,r} + \\ \beta_5 Hinari\ Field_{i,t,r} \times Post\ Hinari_{i,t,r} + \\ \beta_6 Hinari\ Institution_{i,t,r} \times Post\ Hinari_{i,t,r} + \\ \beta_7 Hinari\ Field_{i,t,r} \times Hinari\ Institution_{i,t,r} \times Post\ Hinari_{i,t,r} + \\ \beta_8 X_{i,t,r} + \beta_9 fe_{t,r} + \beta_{10} fe_{i,r} + \epsilon_{i,t,r} \end{aligned} \tag{1}$$

where the outcome variables refer to institution i, in quarter t and research field r (see Section 3.3). The main coefficient of interest is β_7. It relates to the triple interaction term which is equal to 1 if institution i subscribed to the Hinari programme in quarter t and if the institution's affiliated publications or clinical trials relate to the Hinari research field, and 0 otherwise. Hence in all analyses, we distinguish between two research fields: Hinari vs. non-Hinari. Accordingly, our main explanatory variable of interest is defined as a triple interaction between three binary variables. $X_{i,t,r}$ is a matrix of time-varying controls. By comparing the outputs of research fields within a given institution, this methodology accounts for the possibility that more productive and prominent institutions may be more likely to register with Hinari.

In model (1), we also control for quarter fixed effects ($fe_{t,r}$) and institution fixed effects

($fe_{i,r}$). While the former takes out time trends, the latter allows us to control for unobserved heterogeneity at the institutional level, e.g., differences in ICT and research infrastructure. In addition, in the different model specifications we adopt several fixed effects (not shown in model 1), such as: country fixed effects; city fixed effects; # quarters with publication fixed effects; the more demanding specification also accounts for country-specific time trends.

5 Empirical Analysis

5.1 Hinari impact on publication output

Table 2 reports the coefficients from our OLS regressions on the Hinari effect on publication output. Going from column (1) to column (6), we subsequently add more variables and fixed effects. There is a notable increase in the R-squared from +0.59 to +0.76 once we include institution fixed effects going from column (3) to (4). It further increases to +0.79 once we include the # quarters with publication fixed effects and the country-specific time trend (column (6)). Column (6) is our preferred specification. We find a positive and robust Hinari effect on publication output that is statistically significant at the 1% level across all specifications of Table 2. It ranges between +1.208 in column (1) and +0.754 in column (6). Overall, these results provide empirical support for a robust effect of Hinari on publication output, supporting Hypothesis 1.

We also ran the regressions reported in Table 2 separately for institutions at three different levels of productivity, i.e., institutions that published in at least x quarters in at least one of the two disciplines with $x < 20$, $20 \leq x \leq 67$, and $x > 67$, respectively. Results are reported in Table 3. All specifications in the table are based on the preferred specification (6) of Table 2. Specification (1) reports results for institutions with publications in less than 20 quarters (25th percentile). Specification (2) reports results for institutions with publications in between 20 and 67 quarters. Finally, specification (3) reports results for the most productive institutions that publish in more than 67 quarters (75th percentile). As shown in the Table 3, the Hinari coefficient is statistically significant at the 1% level across all columns. It ranges from +0.397 for institutions with a low level of productivity as

reported in column (1) to +0.681 and +0.621 for institutions with intermediate and high levels of productivity as reported in columns (2) and (3), respectively. The results reported in Table 3 suggest that higher productivity institutions benefit more from Hinari adoption than low-productivity institutions in terms of their publication output.

5.2 Hinari impact on clinical trials

Table 7 reports the coefficients from our OLS regressions on the Hinari effect on clinical trial output. Going from column (1) to column (6), we subsequently add more variables and fixed effects. There is a slight increase in the R-squared from +0.45 to +0.47 once we include city and institution fixed effects going from column (2) to (4). It further increases to +0.48 once we include the # quarters with publication fixed effects and the country-specific time trend (column (6)). Column (6) is our preferred specification.[19] We find a positive and robust Hinari effect on clinical trial output that is statistically significant at the 1% level across all specifications of Table 7. The effect ranges between +0.243 in column (1) and +0.222 in column (6). Overall, these results provide empirical support for a robust effect of Hinari adoption on clinical trial output, supporting Hypothesis 2.

We run additional regressions reported in Table 7 separately for institutions at three different levels of productivity, i.e., institutions that were involved in clinical trials in at least x quarters in at least one of the two research fields with $x < 2$, $2 \leq x \leq 6$, and $x > 6$, respectively. Results are reported in Table 8. All further analyses are based on the preferred specification (6) from Table 7. Column (1) reports results for institutions with clinical trials in less than 2 quarters (25th percentile). Column (2) reports results for institutions with clinical trials in between 2 and 6 quarters. Finally, specification (3) reports results for the most productive institutions that are involved in clinical trials in more than 6 quarters (75th percentile). The Hinari coefficient is statistically significant at the 1% level in all specifications. It ranges from +0.063 for institutions with a low level of productivity as reported in column

[19]Note that the explanatory powers of these models are relatively lower than those of scientific publication outcomes. This may be because many other determining factors surrounding clinical trial counts are unobservable to us (e.g., trial phase, trial sponsor, target markets, involvement of research institutions outside R4L country sample etc.).

(1) to +0.138 and +0.322 for institutions with intermediate and high levels of productivity as reported in columns (2) and (3), respectively. The results reported in Table 8 indicate that higher productivity institutions benefit more from Hinari adoption than lower-productivity institutions in terms of their involvement in clinical trials.

5.3 Robustness

A relevant concern with respect to our empirical strategy relates to the presence of pre-Hinari trends concerning the institutions adopting the programme. For instance, despite the adoption of the DDD model, it is possible that participating institutions follow different time trends concerning the variables of interest and as compared to institutions staying outside the Hinari programme. In theory, this may bring up biased estimates and challenge the robustness of results. To investigate the presence of pre-Hinari trends, we adopt an event study analysis approach. Figure 3 plots the event study and coefficient estimates for publication output in pre-treatment and post-treatment periods. Outside lines bound the 95% confidence interval based on robust standard errors clustered at the institution level. Figure 3 does not indicate an upward or downward trend in publication output in the 30 quarters before the Hinari treatment. This suggests that the parallel trend assumption is likely to hold and confirms the overall robustness of findings in terms of publication outcome.

Similarly, Figure 4 shows the event study estimates for clinical trials output. If anything, coefficient estimates indicate a very weak positive trend in pre-periods, with trends growing less pronounced shortly before the actual programme adoption. Still, this suggests that the post-period coefficients could also be upward biased when there is a potential underlying upward trend. So, while there is some indication from the event study that estimates might be slightly upward biased, we can reject the null that all lead terms are jointly significant via the formal test at the 10% level. In general, results for clinical trial outcomes continue to hold and are robust. However, the magnitude of effects will require cautious interpretation.

5.4 Effect heterogeneity

In this section, we analyse the possible heterogeneous impact of the Hinari programme. Specifically, treatment under the programme could have different implications for middle-income and low-income economies at different stages of development. Table 4 presents the results of specification (6) of Table 2 for four different types of institutions: (1) institutions situated in a low-income economy and belonging to country group A in the observation period; (2) institutions situated in a middle-income economy and belonging to country group B in the observation period; (3) institutions initially situated in a low-income economy but transitioning to a middle-income economy due to reclassification of the country in the observation period (from group A to group B); and (4) vice versa (from group B to group A). The results show that more developed countries benefit most from the Hinari programme in terms of publications (+0.595 for institutions in group A countries and +0.849 for institutions in group B countries). Similarly, we find a significant and most pronounced impact of programme subscriptions for institutions seeing their country transition from less developed to more developed stages, i.e., from group A to group B (+0.897), as compared to institutions and countries transitioning in the reverse direction, i.e., switching from group B to group A (+0.703).

We also perform a similar analysis discriminating institutions and countries by their location in a given world region. Table 5 presents the main results, adopting the model specification (6) of Table 2. Regardless of the regions of the world, we observe a significant and positive impact of the Hinari programme, ranging from + 0.505 to +1.018. In this regard, the research institutions that have benefited most from programme participation are located in Europe and Central Asia as well as in Latin America and the Caribbean.

Similarly, we investigate the heterogeneous impact of the Hinari programme on clinical trial activity. Table 9 presents the results for the analysis by the various country groups (see above). Results show that Hinari programme benefits are almost equally distributed between more and less developed economies in terms of their clinical trial output changes after adoption (+0.232 for institutions in group A countries, and +0.236 for institutions in

group B countries). Seemingly, in the case of clinical trials, programme impact might be less reliant on development stages. Again, we find that institutions in group A countries transitioning to higher development stages (reclassified as middle-income in group B) see a higher average programme impact (+0.171), as compared to research institutions in group B countries (+0.108) transitioning to lower development stages (low-income in group A). Note that effects for group switchers are lower than those observed in stayer groups A and B. Albeit interesting, this result may be due to small-sample effects (as fewer countries change group affiliation in the observation period), or a lack of precision in terms of the exact timing of transitioning institutions and countries (as we are using a binary dummy for switching countries). In a more elaborate set-up, effects could be disentangled and the impact of the (arguably exogenous) variation of access cost at the institutional level due to countries' transition from one group to the other could be explored in greater detail.

In Table 10, we also study the mixed impact on world regions and clinical trial outcomes. Different to publications, programme participation for research institutions located in East Asia and the Pacific as well as the Middle East and North Africa seems most impactful in terms of their clinical trial involvement. Nevertheless, Hinari adoption yields positive effects across all world regions, i.e., the estimated coefficients range from +0.174 to +0.345.

5.5 Additional results

We now turn from an output analysis to an input perspective. Here, science from focal institutions can provide an important knowledge resource in global patenting activity (spillover). Knowledge flows manifest in forward citation to patents. More precisely, we investigate the implication of the Hinari programme on global patent citations received by focal institutions and their locally produced scientific publications after Hinari adoption. Table 11 provides summary statistics on Hinari and patent citation impact at the institution-discipline-quarter level. Our sample covers 174,928 observations. The dependent variable measures the patent citation input of an institution in a given scientific field and quarter. As for the main variable of interest, 6.9% of the observations in our sample are subject to the Hinari treatment.

Table 12 reports the coefficients from our OLS regressions on the Hinari effect on paper-to-

patent citations in a more basic DiD setup, as compared to the previous analysis. Specifically, we narrow the sample to solely health field of study paper-to-patent citations (i.e., to the institution-health discipline-quarter level). Regardless of the model specification, we find a weak positive impact of the Hinari programme on the citation of papers in patents, ranging from +0.0028 to +0.109. This may be indicative of the higher chances of adopting institutions to be cited in a patent following the post-adoption growth in publication outcome. However, the result warrants cautious interpretation as it could still be subject to selection bias, i.e., institutions that have a higher propensity to receive patent citations being more likely to join the program in the first place.

To address this issue, we rerun the model using the full sample and the more demanding triple interaction approach further accounting for differences between research fields within the same institution. Table 13 reports the Hinari effect coefficients. Regardless of the model specification, we find a negative impact of the Hinari programme on the citation of papers in patents, ranging from -0.019 to -0.101. Similar to previous sections, we investigate the impact of the programme separately for institutions at three different levels of productivity, i.e., institutions that see patent referrals (citations) in at least x quarters in at least one of the two disciplines with $x < 2$, $2 \leq x \leq 13$, and $x > 13$, respectively. We find a significant negative impact of the Hinari programme only for the middle and high levels of productivity (column (2) and (3) of Table 14).

Again, a possible concern about the coefficient estimates relates to potential pre-trends in paper-to-patent citations and the validity of the parallel trend assumption required by the DDD model. Figure 5 plots the coefficient estimates of the event study model. A negative pre-trend with respect to the variable of interest is evident upon visual inspection. We address these concerns using the more elaborate test approach proposed by Freyaldenhoven et al. [2019]. Panel A in Figure 6 plots the point estimates at 95% coefficient estimates. In Panel B, we also include a linear time trend period from quarter 20 before adoption and onwards[Dobkin et al., 2018].[20] Taken together, the evidence presented here supports the idea that Hinari institutions are subject to time trends that can explain the negative

[20]The event study estimates also include institution-field fixed effects.

impact of the Hinari programme on the main estimates shown in Table 13. Beyond time trends, a possible explanation may be that, at large, research conducted at focal institutions is changing its overall direction towards more basic science and publication in academic journals. Hence, there may be a substitution or specialization effect between basic and more applied research once Hinari is adopted. Another possible explanation may be that research from focal institutions published in academic, and arguably, higher-impact journals after joining Hinari, is more likely to be 'gated' and less accessible for worldwide inventors and patenting communities as compared to pre-Hinari outlets including many regional, open access journals. Both aspects effectively would lower the probability of scientific publications from focal institutions, even though growing in numbers, to be cited in patent documents. This is yet another interesting area for exploration in this or future research.

6 Conclusion

We have analyzed the effect of free and reduced-fee online access to the health science literature via the R4L initiative on science and innovation in developing countries. We provide robust empirical evidence for a positive Hinari program effect on scientific publication output and clinical trials output of institutions in developing countries. In contrast, we find no evidence for a positive Hinari effect on knowledge spillovers and local institutions' research input into global patenting, as measured by paper citations in patent documents and once we control for selection bias. To the best of our knowledge, this study is the first to move beyond aggregate outcomes to directly link access to scientific publications in developing countries to welfare implications along the science-to-innovation pipeline. Thereby, we extend the prior research that has linked access to scientific publications with follow-on science [Biasi and Moser, 2021, Mueller-Langer et al., 2020]. Main findings can be generalized to other R4L subprogrammes and are likely to also extend to the WIPO-led Access to Research for Development and Innovation (ARDI) programme.

R4L consortium members have committed to supporting the initiative until at least 2025. The findings of this paper contribute to informing the decisions of these stakeholders as to

whether to renew or modify their commitment beyond 2025. From a managerial perspective, our results suggest that there is potential for programme improvement on two grounds. First, in terms of scientific publication and clinical trials output, we provide evidence that more productive institutions benefit more from Hinari. This result suggests that Hinari increases the productivity difference between the most and least productive institutions for both scientific publications and clinical trials. Under these conditions, the least productive institutions are *ceteris paribus* less likely to catch up. Still, at large, it must be noted that the Hinari programme and other R4L programmes such as the WIPO-led ARDI make an important contribution to achieving SDG goals as they substantially help strengthen research and innovation capacity in developing economies.

In terms of broader policy implications, our study indicates that open access mandates or policies may promote scientific creativity and publication output, and strengthen local involvement in international clinical trials. Arguably, these economic effects likely will extend beyond research institutions in developing countries. Spillovers from new knowledge created under the programme thus also can benefit clinical research and innovation conducted in developed economies. While the overall welfare effects of Hinari and other R4L programmes are beyond the scope of the present paper, these spillover effects may possibly be compensating for some of the foregone profits of publishers in developed economies when joining the R4L initiative and making content available on a no or low cost basis. Second, innovation is often developed with consideration for the unique social and economic issues concerning the innovating place or country. This is in contrast to importing innovations developed primarily for contexts with different challenges and factor configurations [Lester, 2005]. Therefore, while scientific research in developing countries may lag the cutting edge [Fu et al., 2011], they may result in outcomes that are no less relevant for their unique contexts.

Lastly, the paper opens up several interesting directions for future research. Extending on the link between academic research and economic growth (see the literature discussed in Section 1) our findings may point to direct economic effects as a higher publication and clinical trials output level stemming from Hinari membership may result in new biomedical innovations. A natural follow up is to explore the question of whether Hinari has increased

the number of local patent applications using free or reduced-fee access throughout the Hinari programme. Second, it would be interesting to investigate in more detail how lower barriers to online access to scientific publications have changed the way scientists do research and collaborate internationally. Third, in a more elaborate set-up and with richer data becoming available, studying actual usage of scientific information made available via the R4L initiatives rather than the effects of (binary) access would be desirable. This could also serve as a meaningful robustness check for our general findings.

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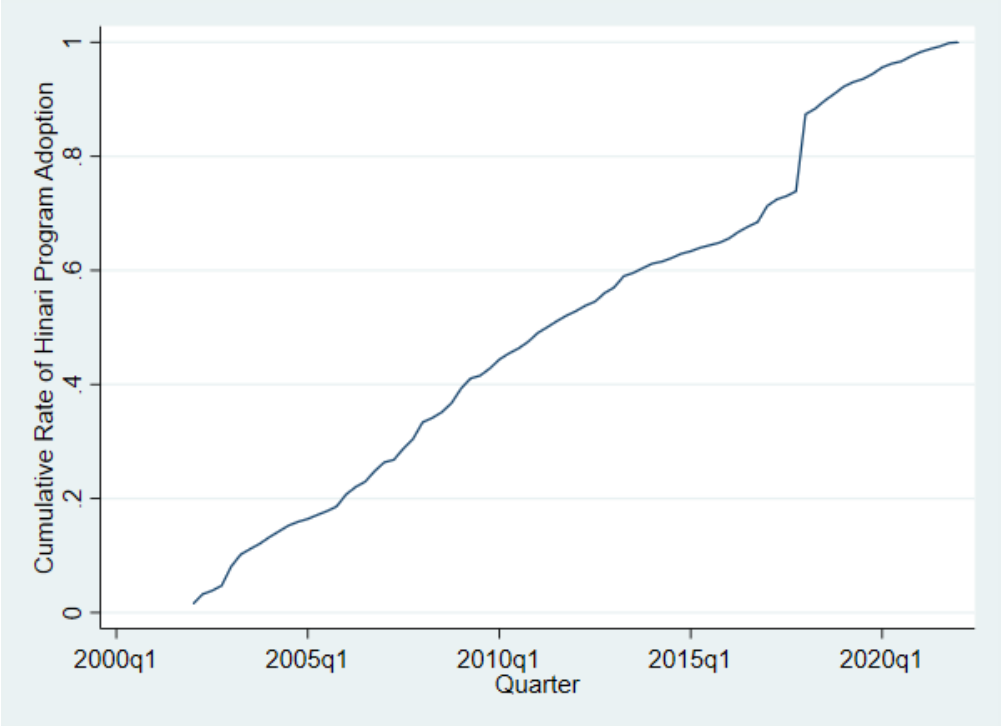
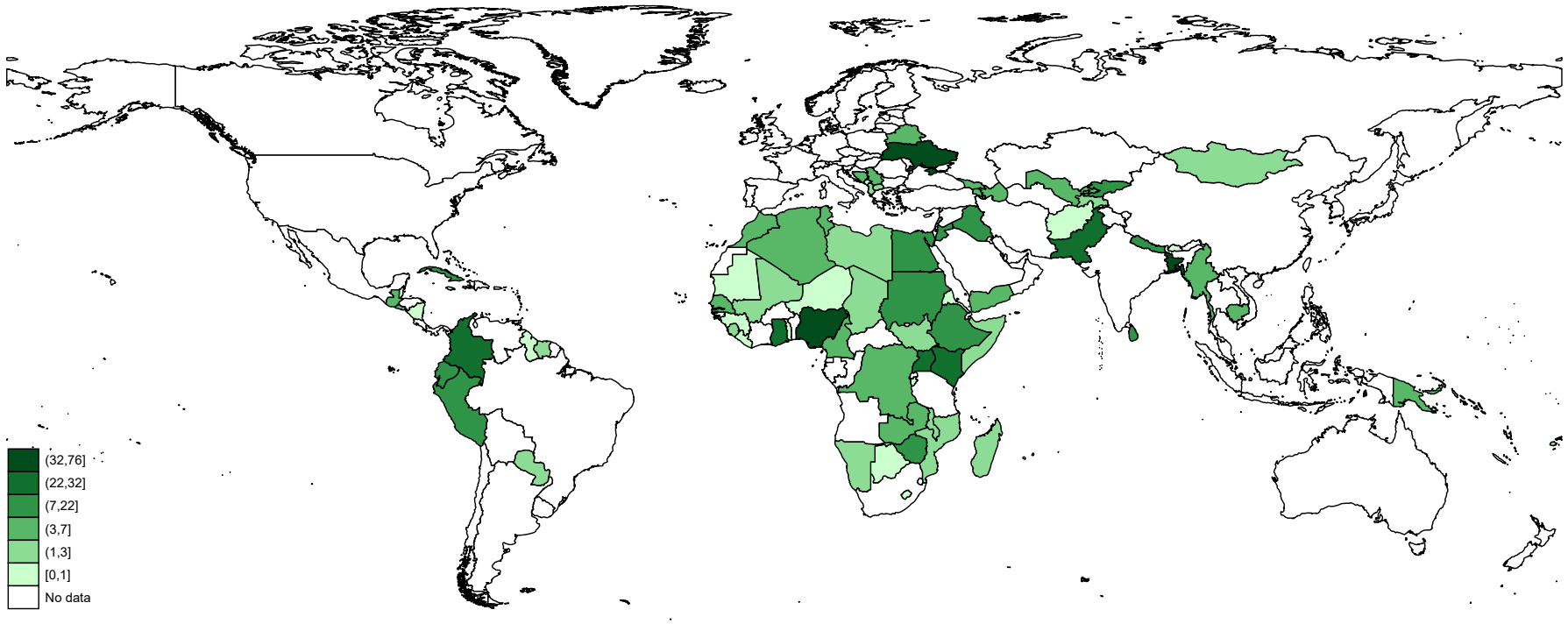
Tables and Figures

Fig. 1: Cumulative rate of the Hinari programme adoption



Notes : Hinari adoption rate for all countries defined as the cumulative number of institutions that registered with the Hinari programme in a given quarter divided by the total number of institutions. The Hinari initiative started in the first quarter of 2002. Different institutions registered with the Hinari programme at different points in time.

Fig. 2: Hinari institutions by country



Notes : Hinari-field publishing institutions. Eswatini country not included in the map (missing boundaries in the shapefile). Geo distribution by percentiles (0%-25%, 25%-50%, 50%-75%, 75%-90%, 90%-95%, 95%-99%).

Hinari Impact on Publication Output

Table 1: Summary Statistics

	mean	sd	min	max	N
Dependent variable:					
Publication output[21]	1.951	9.538	0	561.1	318,072
Main variable of interest:					
HINARI treated (DDD)	0.0554	0.229	0	1	318,072
Article characteristics:					
Mean #US co-authors	1.342	13.58	0	675	318,072
Mean journal impact factor	1.344	1.179	0	30.14	318,072
Other variables:					
# quarters with publication, by institution	37.42	33.18	0	116	318,072
GOALI programme	0.019	0.136	0	1	318,072
ARDI programme	0.048	0.213	0	1	318,072
OARE programme	0.087	0.282	0	1	318,072
AGORA programme	0.103	0.304	0	1	318,072

Notes : Unit of observation: Institution-discipline-quarter level. We consider institutions with, at least, one publication during the observation period.

[21] Non-log transformed variable reported.

Table 2: Effect of HINARI on Publication Output

	Baseline (1)	+ Controls (2)	+ City FE (3)	+ Institution FE (4)	+ # Quarters with public. FE (5)	+ Country-specific time trend (6)
HINARI treated (DDD)	1.2081***	1.1859***	1.1300***	0.7786***	0.7693***	0.7538***
	(0.0474)	(0.0489)	(0.0491)	(0.0288)	(0.0271)	(0.0248)
Mean # US co-authors		0.0014**	0.0015**	0.0011**	0.0004	0.0003
		(0.0007)	(0.0007)	(0.0005)	(0.0004)	(0.0004)
Mean journal impact factor		-0.0132***	-0.0087*	-0.0092***	-0.0002	-0.0037
		(0.0043)	(0.0047)	(0.0032)	(0.0031)	(0.0028)
GOALI programme		0.0327	-0.0139	-0.0231	-0.0282	0.0498
		(0.0549)	(0.0559)	(0.0392)	(0.0390)	(0.0307)
ARDI programme		0.0329	0.0767	0.0550	0.0541	-0.0261
		(0.0619)	(0.0626)	(0.0440)	(0.0438)	(0.0358)
OARE programme		0.0313	0.0397	-0.0007	-0.0023	0.0103
		(0.0587)	(0.0570)	(0.0371)	(0.0371)	(0.0338)
AGORA programme		0.0016	-0.0116	-0.0206	-0.0199	0.0307
		(0.0445)	(0.0409)	(0.0306)	(0.0307)	(0.0283)
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE			Yes	Yes	Yes	Yes
Institution FE				Yes	Yes	Yes
# Quarters with publication FE					Yes	Yes
Country-specific time trend						Yes
N	318,072	318,072	318,072	318,072	318,072	318,072
R-squared	0.56	0.56	0.59	0.76	0.78	0.79

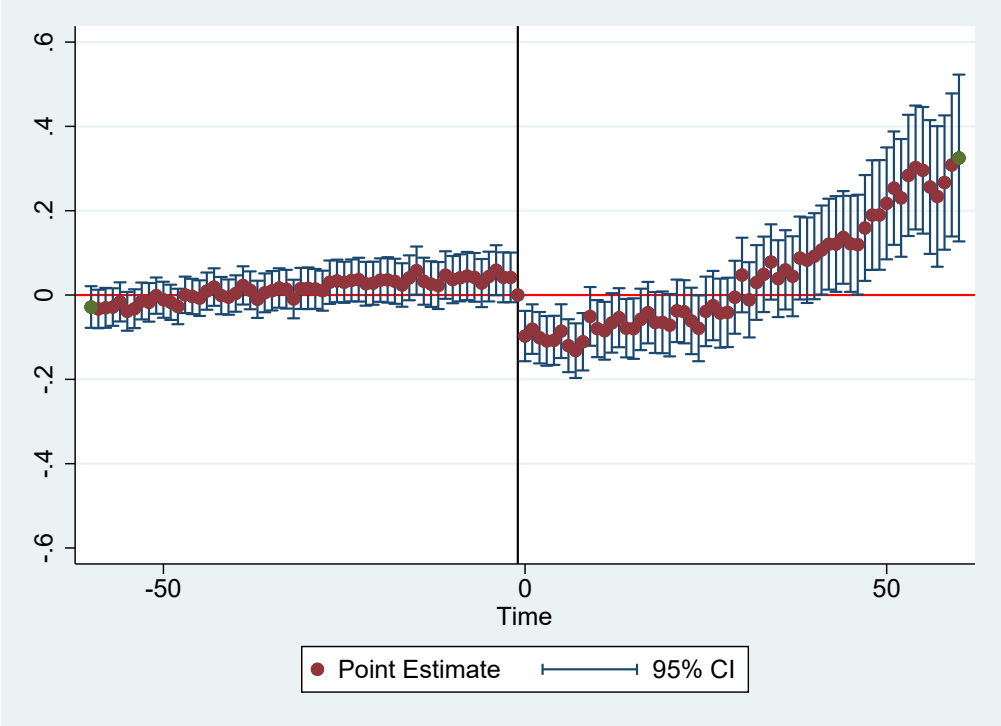
Notes : Dependent variable: *log*(publications +1). OLS estimation using a balanced panel. Results on the impact of Hinari membership (treated) on publication output of research institutions in 99 countries from OLS DDD. Other DDD interaction terms included but not reported. The institution-discipline-quarter triplets constitute the unit of observation. Period under study: 1st quarter 1990 to 4th quarter 2018. Robust standard errors clustered at the institutional level. Note that serial correlation is not an issue in our balanced panel because the large number of periods with zero publications breaks any time correlation for any given institution. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 3: Effect of HINARI on Publication Output, by the Number of Quarters with Publications

	<20 quarters (1)	20 ≤ quarters ≤ 67 (2)	>67 quarters (3)
HINARI treated (DDD)	0.3966***	0.6809***	0.6205***
	(0.0215)	(0.0265)	(0.0526)
Mean # US co-authors	-0.0003	0.0003	-0.0003
	(0.0002)	(0.0005)	(0.0004)
Mean journal impact factor	-0.0063***	-0.0270***	-0.0685***
	(0.0022)	(0.0026)	(0.0070)
GOALI programme	0.0062	0.0053	0.1041
	(0.0101)	(0.0349)	(0.0636)
ARDI programme	-0.0032	-0.0302	0.0333
	(0.0091)	(0.0326)	(0.0749)
OARE programme	-0.0035	0.0201	0.0526
	(0.0056)	(0.0261)	(0.0633)
AGORA programme	-0.0019	-0.0029	0.0303
	(0.0033)	(0.0208)	(0.0538)
Quarter FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Institution FE	Yes	Yes	Yes
# Quarters with publication FE	Yes	Yes	Yes
Country-specific time trend	Yes	Yes	Yes
N	83,288	157,064	77,720
R-squared	0.67	0.67	0.81

Notes : Dependent variable: *log*(publications+1). OLS estimation using a balanced panel. Results on the impact of Hinari membership (treated) on publication output of research institutions in 99 countries from OLS DDD. Other DDD interaction terms included but not reported. We consider institutions with three different levels of productivity, i.e., institutions that published in at least x quarters in at least one of the two disciplines whereas x<20 (25th percentile), 20 ≤ x ≤ 67, and x>67 (75th percentile), respectively. The institution-discipline-quarter triplets constitute the unit of observation. Period under study: 1st quarter 1990 to 4th quarter 2018. Robust standard errors clustered at the institutional level. Note that serial correlation is not an issue in our balanced panel because the large number of periods with zero publications breaks any time correlation for any given institution. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Fig. 3: Event Study on Publication Output



Notes : Event study using a balanced panel with 60 lead and lag quarters. Dependent variable: *log*(publications +1). Results on the impact of Hinari membership (treated) on publication output of research institutions in 99 countries from OLS DDD at $p<0.05$. The institution-discipline-quarter triplets constitute the unit of observation. The estimations include the following control variables: mean # US co-authors; mean journal impact factor; dummies for other R4L programmes adoption (GOALI, ARDI, OARE, AGORA). We also control for city FE, country FE, quarter FE, and country-specific time trend. Robust standard errors are clustered at the institutional level. Note that serial correlation is not an issue in our balanced panel because the large number of periods with 0 publications breaks any time correlation for any given institution.

Table 4: Effect of HINARI on Publication Output by Group

	Group A	Group B	A to B	B to A
	(1)	(2)	(3)	(4)
HINARI treated (DDD)	0.5950***	0.8494***	0.8975***	0.7030***
	(0.0360)	(0.0472)	(0.0440)	(0.0928)
Controls	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Institution FE	Yes	Yes	Yes	Yes
# Quarters with publication FE	Yes	Yes	Yes	Yes
Country-specific time trend	Yes	Yes	Yes	Yes
N	100,688	114,608	68,848	18,040
R-squared	0.77	0.81	0.78	0.72

Notes : Groups indicate cost-free access (A) to Hinari repositories for institutions in the affiliated country, or institutional access by fee-based subscription (B). Countries in Group A (1) and Group B (2) stay in the same group throughout the observation period. Switching countries transition from A to B (3), or from B to A (4). Dependent variable: *log*(publications +1). OLS estimation using a balanced panel. Results on the impact of Hinari membership (treated) on publication output of research institutions in 43 countries for group A and 24 countries for group B from OLS DDD (we exclude countries without publication output and countries that switched from group A to B, and vice-versa more than once). Other DDD interaction terms included but not reported. The estimations include the following control variables: mean # US co-authors; mean journal impact factor; dummies for other R4L programmes adoption (GOALI, ARDI, OARE, AGORA). The institution-discipline-quarter triplets constitute the unit of observation. Period under study: 1st quarter 1990 to 4th quarter 2018. Robust standard errors clustered at the institutional level. Note that serial correlation is not an issue in our balanced panel because the large number of periods with zero publications breaks any time correlation for any given institution. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5: Effect of HINARI on Publication Output by World Regions

	East Asia and Pacific (1)	Europe and Central Asia (2)	Latin America and the Carabbean (3)	Middle East and North Africa (4)	South Asia (5)	Sub-Saharan Africa (6)
HINARI treated (DDD)	0.5054***	1.0179***	0.8010***	0.7483***	0.7377***	0.6604***
	(0.0640)	(0.0536)	(0.0549)	(0.0755)	(0.0675)	(0.0367)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Institution FE	Yes	Yes	Yes	Yes	Yes	Yes
# Quarters with publication FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-specific time trend	Yes	Yes	Yes	Yes	Yes	Yes
N	18,898	50,171	34,748	49,939	68,818	95,495
R-squared	0.64	0.81	0.82	0.83	0.74	0.80

Notes : Dependent variable: *log*(publications +1). OLS estimation using a balanced panel. Results on the impact of Hinari membership (treated) on publication output of research institutions relative to world regions. The institution-discipline-quarter triplets constitute the unit of observation. Period under study: 1st quarter 1990 to 4th quarter 2018. Other DDD interaction terms included but not reported. The estimations include the following control variables: mean # US co-authors; mean journal impact factor; dummies for other R4L programmes adoption (GOALI, ARDI, OARE, AGORA). Robust standard errors clustered at the institutional level. Note that serial correlation is not an issue in our balanced panel because the large number of periods with zero publications breaks any time correlation for any given institution. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 6: Summary Statistics

	mean	sd	min	max	N
Dependent variable:					
# trials[22]	0.0358	0.248	0	12	82,348
Main variable of interest:					
HINARI treated (DDD)	0.212	0.409	0	1	82,348
Article characteristics:					
Mean #US co-authors	1.836	5.977	0	168.7	82,348
Mean journal impact factor	2.199	2.065	0	23.74	82,348
Other variables:					
# Quarters with trials, by institution	6.601	10.84	1	77	82,348
GOALI programme	0.0387	0.193	0	1	82,348
ARDI programme	0.0821	0.275	0	1	82,348
OARE programme	0.129	0.335	0	1	82,348
AGORA programme	0.140	0.347	0	1	82,348

[22]Non-log transformed variable reported.

Table 7: Effect of HINARI on Clinical Trial Output

	Baseline	+ Controls	+ City FE	+ Institution FE	+ Quarters with trials FE	+ Country-specific time trend
	(1)	(2)	(3)	(4)	(5)	(6)
HINARI treated (DDD)	0.2426***	0.2437***	0.2429***	0.2361***	0.2217***	0.2215***
	(0.0241)	(0.0243)	(0.0239)	(0.0218)	(0.0190)	(0.0188)
Mean #US co-authors		-0.0002***	-0.0003***	-0.0003***	-0.0003**	-0.0003**
		(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Mean journal impact factor		-0.0003*	-0.0005*	-0.0021***	-0.0021***	-0.0021***
		(0.0002)	(0.0003)	(0.0005)	(0.0006)	(0.0006)
GOALI programme		0.0052*	0.0046*	0.0043	0.0043	0.0039
		(0.0029)	(0.0027)	(0.0027)	(0.0027)	(0.0028)
ARDI programme		0.0022	0.0026	0.0021	0.0021	0.0024
		(0.0018)	(0.0019)	(0.0019)	(0.0019)	(0.0022)
OARE programme		-0.0005	-0.0007	-0.0006	-0.0006	-0.0004
		(0.0016)	(0.0017)	(0.0015)	(0.0015)	(0.0015)
AGORA programme		-0.0031**	-0.0032**	-0.0033***	-0.0033***	-0.0028**
		(0.0012)	(0.0012)	(0.0012)	(0.0013)	(0.0014)
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE			Yes	Yes	Yes	Yes
Institution FE				Yes	Yes	Yes
# Quarters with publication FE					Yes	Yes
Country-specific time trend						Yes
N	82,348	82,348	82,348	82,348	82,348	82,348
R-squared	0.45	0.45	0.46	0.47	0.48	0.48

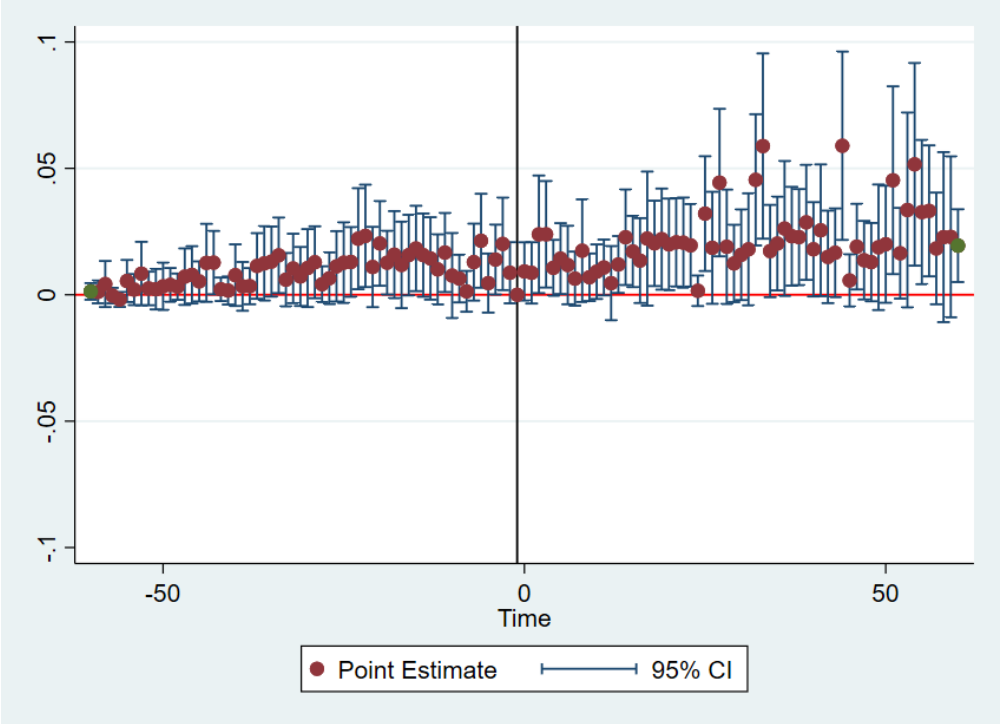
Notes : Dependent variable: *log*(Clinical Trials +1). OLS estimation using a balanced panel. Results on the impact of Hinari membership (treated) on clinical trial output of research institutions in 67 countries from OLS DDD. The institution-discipline-quarter triplets constitute the unit of observation. Other DDD interaction terms included but not reported. Period under study: 1st quarter 1990 to 4th quarter 2018. Robust standard errors clustered at the institutional level. Note that serial correlation is not an issue in our balanced panel because the large number of periods with 0 clinical trials breaks any time correlation for any given institution *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 8: Effect of HINARI on Clinical Trial Output, by the Number of Quarters with Trials

	<2 quarters	2 ≤ quarters ≤ 6	>6 quarters
	(1)	(2)	(3)
HINARI treated (DDD)	0.0627***	0.1383***	0.3217***
	(0.0098)	(0.0128)	(0.0308)
Mean #US co-authors	-0.0000**	-0.0003***	-0.0044***
	(0.0000)	(0.0001)	(0.0011)
Mean journal impact factor	0.0002**	-0.0000	-0.0055***
	(0.0001)	(0.0003)	(0.0015)
GOALI programme	-0.0012	-0.0005	0.0120
	(0.0010)	(0.0022)	(0.0091)
ARDI programme	-0.0008	-0.0019	0.0093
	(0.0009)	(0.0019)	(0.0079)
OARE programme	0.0020	0.0016	-0.0110**
	(0.0015)	(0.0011)	(0.0055)
AGORA programme	-0.0007	0.0001	-0.0035
	(0.0012)	(0.0009)	(0.0057)
Quarter FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Institution FE	Yes	Yes	Yes
# Quarters with publication FE	Yes	Yes	Yes
Country-specific time trend	Yes	Yes	Yes
N	32,130	29,274	20,944
R-squared	0.31	0.40	0.54

Notes : Dependent variable: *log*(Clinical Trials+1). OLS estimation using a balanced panel. Results on the impact of Hinari membership (treated) on clinical trial output of research institutions in 67 countries from OLS DDD. We consider institutions with three different levels of productivity, i.e., institutions that published in at least x quarters in at least one of the two disciplines whereas $x < 2$ (50th percentile), $2 \leq x \leq 6$, and $x > 6$ (75th percentile), respectively. The institution-discipline-quarter triplets constitute the unit of observation. Other DDD interaction terms included but not reported. Period under study: 1st quarter 1990 to 4th quarter 2018. Robust standard errors clustered at the institutional level. Note that serial correlation is not an issue in our balanced panel because the large number of periods with 0 clinical trial breaks any time correlation for any given institution. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Fig. 4: Event Study on Clinical Trial Output



Notes : Event study using a balanced panel with 60 lead and lag quarters. Dependent variable: *log*(Clinical Trials +1). Results on the impact of Hinari membership (treated) on clinical trial output of research institutions in 67 countries from OLS DDD at $p<0.05$. The institution-discipline-quarter triplets constitute the unit of observation. The estimations include the following control variables: mean # US co-authors; mean journal impact factor; dummies for other R4L programmes adoption (GOALI, ARDI, OARE, AGORA). We also control for city FE, country FE, quarter FE, and country-specific time trend. Period under study: 1st quarter 1990 to 4th quarter 2018. Robust standard errors clustered at the institutional level. Note that serial correlation is not an issue in our balanced panel because the large number of periods with 0 clinical trials breaks any time correlation for any given institution.

Table 9: Effect of HINARI on Clinical Trial Output by Group

	Group A	Group B	A to B	B to A
	(1)	(2)	(3)	(4)
HINARI treated (DDD)	0.2319***	0.2362***	0.1711***	0.1082**
	(0.0304)	(0.0351)	(0.0305)	(0.0427)
Controls	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Institution FE	Yes	Yes	Yes	Yes
# Quarters with publication FE	Yes	Yes	Yes	Yes
Country-specific time trend	Yes	Yes	Yes	Yes
N	29,274	32,844	12,614	3,822
R-squared	0.50	0.50	0.39	0.47

Notes : Groups indicate cost-free access (A) to Hinari repositories for institutions in the affiliated country, or institutional access by fee-based subscription (B). Countries in Group A (1) and Group B (2) stay in the same group throughout the observation period. Switching countries transition from A to B (3), or from B to A (4). Dependent variable: *log*(Clinical Trials +1). OLS estimation using a balanced panel. Results on the impact of Hinari membership (treated) on clinical trials output of research institutions in 65 countries from OLS DDD, excluding Syria and Belize. The institution-discipline-quarter triplets constitute the unit of observation. Other DDD interaction terms included but not reported. The estimations include the following control variables: mean US co-authors; mean journal impact factor; dummies for other R4L programmes adoption (GOALI, ARDI, OARE, AGORA). Period under study: 1st quarter 1990 to 4th quarter 2018. Robust standard errors clustered at the institutional level. Note that serial correlation is not an issue in our balanced panel because the large number of periods with zero clinical trials breaks any time correlation for any given institution. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 10: Effect of HINARI on Clinical Trial Output by World Regions

	East Asia and Pacific (1)	Europe and Central Asia (2)	Latin America and the Carabbean (3)	Middle East and North Africa (4)	South Asia (5)	Sub-Saharan Africa (6)
HINARI treated (DDD)	0.3451***	0.1739***	0.2113***	0.3396***	0.1762***	0.2266***
	(0.0931)	(0.0304)	(0.0285)	(0.1103)	(0.0274)	(0.0277)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Institution FE	Yes	Yes	Yes	Yes	Yes	Yes
# Quarters with publication FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-specific time trend	Yes	Yes	Yes	Yes	Yes	Yes
N	4,049	5,950	10,501	14,994	15,039	31,815
R-squared	0.48	0.43	0.48	0.53	0.51	0.49

Notes : Dependent variable: *log*(Clinical Trials +1). OLS estimation using a balanced panel. Results on the impact of Hinari membership (treated) on clinical trials output of research institutions relative to world regions. The institution-discipline-quarter triplets constitute the unit of observation. Other DDD interaction terms included but not reported. The estimations include the following control variables: mean # US co-authors; mean journal impact factor; dummies for other R4L programmes adoption (GOALI, ARDI, OARE, AGORA). Period under study: 1st quarter 1990 to 4th quarter 2018. Robust standard errors clustered at the institutional level. Note that serial correlation is not an issue in our balanced panel because the large number of periods with zero clinical trials breaks any time correlation for any given institution. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Hinari Impact on Patent Citations

Table 11: Summary Statistics

	mean	sd	min	max	N
Dependent variable:					
#patent citations[23]	0.142	1.565	0	256	174,928
Main variable of interest:					
HINARI treated (DDD)	0.0693	0.254	0	1	174,928
Patent characteristics:					
Mean # inventors	0.0733	0.429	0	17	174,928
Article characteristics:					
Mean #US co-authors	1.906	18.07	0	675	174,928
Mean journal impact factor	1.439	1.047	0	30.14	174,928
Other variables:					
#quarters with patent citations, by institution	11.81	17.56	1	117	174,928
GOALI programme	0.020	0.142	0	1	174,928
ARDI programme	0.056	0.230	0	1	174,928
OARE programme	0.102	0.302	0	1	174,928
AGORA programme	0.121	0.326	0	1	174,928

Notes : Unit of observation: Institution-discipline-quarter level.

[23]Non-log transformed variable reported.

Table 12: Effect of HINARI on Patents Citation - DiD

	Baseline	+ Controls	+ City FE	+ Institution FE	+ # Quarters with public. FE	+ Country-specific time trend
	(1)	(2)	(3)	(4)	(5)	(6)
HINARI treated (DiD)	0.0104***	0.0109***	0.0108***	0.0028*	0.0028*	0.0042***
	(0.0020)	(0.0023)	(0.0026)	(0.0017)	(0.0017)	(0.0013)
Mean # inventors		0.2157***	0.2153***	0.2142***	0.2142***	0.2140***
		(0.0449)	(0.0448)	(0.0447)	(0.0447)	(0.0447)
Mean # US co-authors		-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Mean journal impact factor		0.0036***	0.0036***	0.0042***	0.0042***	0.0040***
		(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
GOALI program		0.0002	-0.0009	-0.0016	-0.0016	-0.0000
		(0.0031)	(0.0031)	(0.0027)	(0.0027)	(0.0027)
ARDI program		0.0017	0.0026	0.0018	0.0018	-0.0003
		(0.0020)	(0.0022)	(0.0018)	(0.0018)	(0.0016)
OARE program		-0.0011	-0.0012	-0.0022	-0.0022	-0.0003
		(0.0017)	(0.0018)	(0.0015)	(0.0015)	(0.0014)
AGORA program		-0.0034***	-0.0042***	-0.0040***	-0.0040***	-0.0010
		(0.0011)	(0.0012)	(0.0011)	(0.0011)	(0.0009)
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE			Yes	Yes	Yes	Yes
Institution FE				Yes	Yes	Yes
# Quarters with patents FE					Yes	Yes
Country-specific time trend						Yes
N	87,464	87,464	87,464	87,464	87,464	87,464
R-squared	0.02	0.13	0.14	0.17	0.17	0.18

Notes : Dependent variable: log(# patent citations+1). OLS estimation using a balanced panel and restricted to only health (Hinari) field. Results on the impact of Hinari membership (treated) on patent citations of research institutions in 84 countries from OLS difference-in-differences. The institution-quarter constitute the unit of observation. Period under study: 1st quarter 1990 to 4th quarter 2018. We exclude institutions that have not attracted any patent citation over the observation period. Robust standard errors clustered at the institutional level. Note that serial correlation is not an issue in our balanced panel because the large number of periods with zero publications breaks any time correlation for any given institution. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 13: Effect of HINARI on Patent Citations

	Baseline	+ Controls	+ City FE	+ Institution FE	+ # Quarters with public. FE	+ Country-specific time trend
	(1)	(2)	(3)	(4)	(5)	(6)
HINARI treated (DDD)	-0.0240***	-0.0193***	-0.0304***	-0.1006***	-0.1006***	-0.0908***
	(0.0054)	(0.0074)	(0.0096)	(0.0106)	(0.0106)	(0.0111)
Mean # inventors		0.1038***	0.1022***	0.0961***	0.0961***	0.0967***
		(0.0128)	(0.0125)	(0.0100)	(0.0100)	(0.0098)
Mean # US co-authors		0.0004*	0.0005**	0.0005**	0.0005**	0.0005**
		(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Mean journal impact factor		0.0099***	0.0104***	0.0141***	0.0141***	0.0131***
		(0.0026)	(0.0029)	(0.0025)	(0.0025)	(0.0024)
GOALI programme		0.0211	0.0120	-0.0006	-0.0006	0.0110
		(0.0172)	(0.0169)	(0.0138)	(0.0138)	(0.0110)
ARDI programme		-0.0148	-0.0067	-0.0007	-0.0007	-0.0185*
		(0.0169)	(0.0174)	(0.0139)	(0.0139)	(0.0106)
OARE programme		0.0225	0.0221	0.0043	0.0043	0.0209
		(0.0251)	(0.0255)	(0.0152)	(0.0152)	(0.0156)
AGORA programme		-0.0221	-0.0254*	-0.0261**	-0.0261**	-0.0038
		(0.0145)	(0.0144)	(0.0108)	(0.0108)	(0.0101)
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE			Yes	Yes	Yes	Yes
Institution FE				Yes	Yes	Yes
# Quarters with patent citations FE					Yes	Yes
Country-specific time trend						Yes
N	174,928	174,928	174,928	174,928	174,928	174,928
R-squared	0.14	0.17	0.18	0.29	0.29	0.30

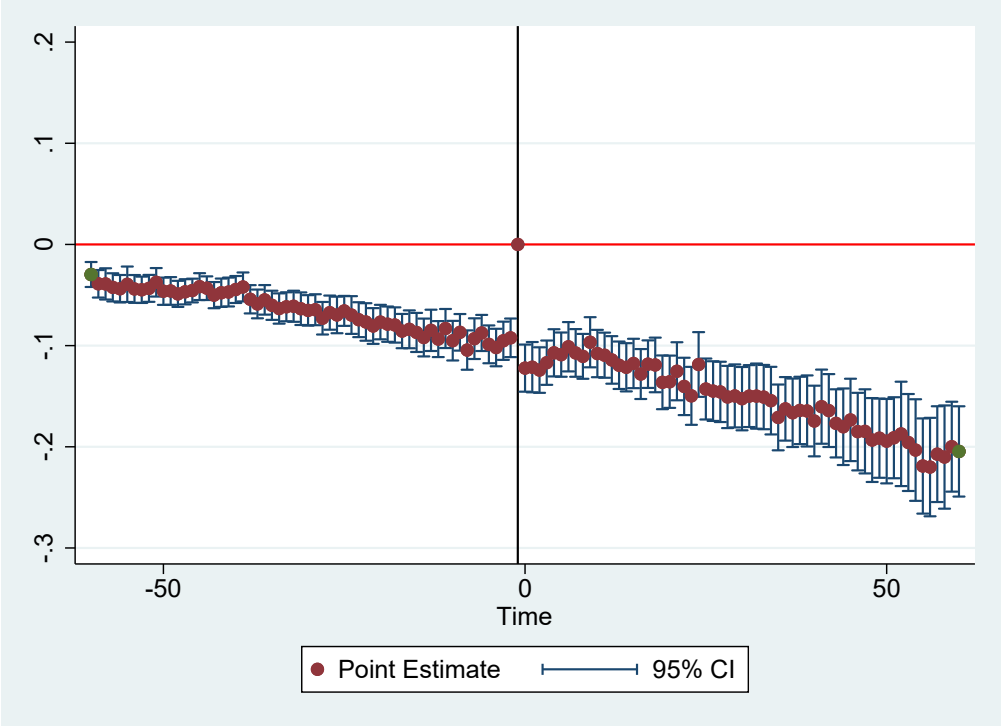
Notes : Dependent variable: log(# patent citations+1). OLS estimation using a balanced panel. Results on the impact of Hinari membership (treated) on patent citations of research institutions in 84 countries from OLS DDD. The institution-discipline-quarter triplets constitute the unit of observation. Period under study: 1st quarter 1990 to 4th quarter 2018. We exclude institutions that have not attracted any patent citation over the observation period. Robust standard errors clustered at the institutional level. Note that serial correlation is not an issue in our balanced panel because the large number of periods with zero publications breaks any time correlation for any given institution. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 14: Effect of HINARI on Patent Citations by the Number of Quarters with Citations

	<2 quarters (1)	2 ≤ quarters ≤ 13 (2)	>13 quarters (3)
HINARI treated (DDD)	0.0003	-0.0219***	-0.2737***
	(0.0013)	(0.0037)	(0.0352)
Mean # inventors	0.0483***	0.0818***	0.1454***
	(0.0059)	(0.0077)	(0.0391)
Mean # US co-authors	-0.0001***	0.0001	0.0006
	(0.0000)	(0.0001)	(0.0005)
Mean journal impact factor	-0.0002	0.0035**	0.0174*
	(0.0008)	(0.0015)	(0.0089)
GOALI programme	-0.0053	0.0071	-0.0230
	(0.0054)	(0.0097)	(0.0353)
ARDI programme	-0.0007	-0.0115	0.0167
	(0.0037)	(0.0095)	(0.0344)
OARE programme	0.0001	0.0040	0.0825*
	(0.0027)	(0.0055)	(0.0477)
AGORA programme	-0.0003	0.0088	-0.0486
	(0.0019)	(0.0056)	(0.0342)
Quarter FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Institution FE	Yes	Yes	Yes
# Quarters with patent citations FE	Yes	Yes	Yes
Country-specific time trend	Yes	Yes	Yes
N	60,088	71,688	43,152
R-squared	0.10	0.15	0.39

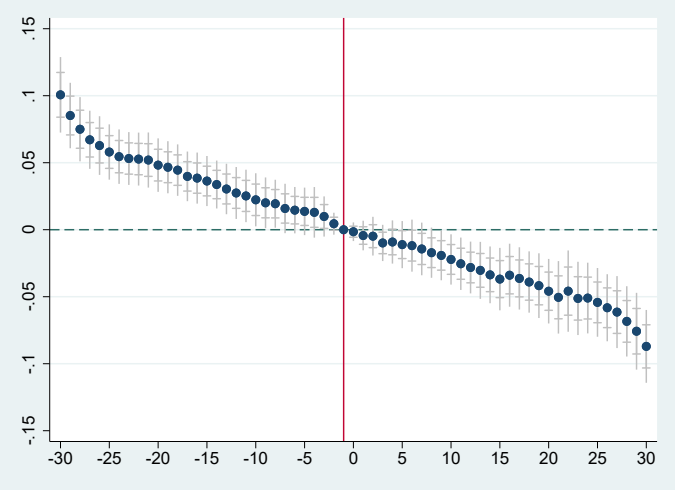
Notes : Dependent variable: log(# patent citations+1). OLS estimation using a balanced panel. Results on the impact of Hinari membership (treated) on patent citations of research institutions in 84 countries from OLS DDD. We consider institutions with three different levels of patent citations, i.e., institutions that received a patent citation in at least x quarters in at least one of the two disciplines whereas x<2 (25th percentile), 2 ≤ x ≤ 13, and x>13 (75th percentile). The institution-discipline-quarter triplets constitute the unit of observation. We exclude institutions that have not attracted any patent citation over the observation period. Period under study: 1st quarter 1990 to 4th quarter 2018. Robust standard errors clustered at the institutional level. Serial correlation is not an issue in our balanced panel because the large number of periods with zero publications breaks any time correlation for any given institution. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Fig. 5: Event Study on Patent Citations - Baseline

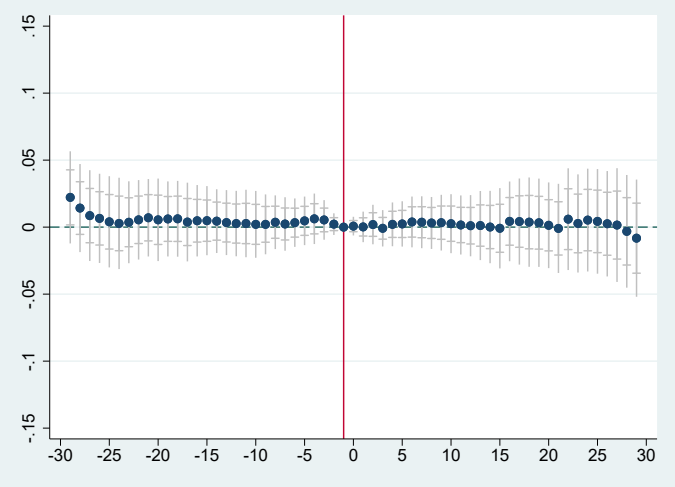


Notes : Event study using a balanced panel with 60 lead and lag quarters. Dependent variable: *log*(patent citations +1). Results on the impact of Hinari membership (treated) on patent citations of research institutions in 99 countries from OLS DDD at $p<0.05$. The institution-discipline-quarter triplets constitute the unit of observation. We exclude institutions that have not attracted any patent citation over the observation period. The estimations include the following control variables: mean # US co-authors; mean journal impact factor; dummies for other R4L programmes adoption (GOALI, ARDI, OARE, AGORA). We also control for city FE, country FE, quarter FE, and country-specific time trend. Robust standard errors are clustered at the institutional level. Note that serial correlation is not an issue in our balanced panel because the large number of periods with 0 publications breaks any time correlation for any given institution.

Fig. 6: Event Study on Patent Citations



Panel A



Panel B

Notes : Event study using a balanced panel with 30 lead and lag quarters. Dependent variable: *log*(patent citations +1). Results on the impact of Hinari membership (treated) on patent citations of research institutions in 99 countries from OLS DDD at $p<0.05$. The institution-discipline-quarter triplets constitute the unit of observation. We exclude institutions that have not attracted any patent citation over the observation period. The estimations include the following control variables: mean # US co-authors; mean journal impact factor; dummies for other R4L programmes adoption (GOALI, ARDI, OARE, AGORA). We also control for quarter FE, institution-field FE, city FE, and country FE. In Panel B we extrapolate a linear trend between time periods from quarter 20 before the Hinari subscription, as in Dobkin et al. [2018]. The Hinari impact is measured by the deviation from the extrapolated linear trend. Robust standard errors are clustered at the institution and quarter level.

Online Appendix

Table 15: MAG Health scientific publication classification by Web Of Science field

Allergy	Medicine, Legal
Anatomy & Morphology	Medicine, Research & Experimental
Andrology	Microbiology
Anesthesiology	Mycology
Audiology & Speech-Language Pathology	Neuroimaging
Biochemical Research Methods	Neurosciences
Biochemistry & Molecular Biology	Nursing
Biodiversity Conservation	Nutrition & Dietetics
Biology	Obstetrics & Gynecology
Biophysics	Oncology
Cardiac & Cardiovascular Systems	Ophthalmology
Cell & Tissue Engineering	Ornithology
Cell Biology	Orthopedics
Chemistry, Medicinal	Otorhinolaryngology
Clinical Neurology	Parasitology
Critical Care Medicine	Pathology
Dentistry, Oral Surgery & Medicine	Pediatrics
Dermatology	Peripheral Vascular Disease
Developmental Biology	Pharmacology & Pharmacy
Emergency Medicine	Physiology
Endocrinology & Metabolism	Plant Sciences
Engineering, Biomedical	Primary Health Care
Entomology	Psychiatry
Evolutionary Biology	Psychology, Clinical
Gastroenterology & Hepatology	Psychology, Psychoanalysis
Genetics & Heredity	Public, Environmental & Occupational Health
Geriatrics & Gerontology	Radiology, Nuclear Medicine & Medical Imaging
Gerontology	Rehabilitation
Health Care Sciences & Services	Reproductive Biology
Health Policy & Services	Respiratory System
Hematology	Rheumatology
Immunology	Social Sciences, Biomedical
Infectious Diseases	Sport Sciences
Integrative & Complementary Medicine	Substance Abuse
Limnology	Surgery
Marine & Freshwater Biology	Toxicology
Mathematical & Computational Biology	Transplantation
Medical Ethics	Tropical Medicine
Medical Informatics	Urology & Nephrology
Medical Laboratory Technology	Virology
Medicine, General & Internal	Zoology

World Intellectual Property Organization
34, chemin des Colombettes, P.O. Box 18
CH-1211 Geneva 20, Switzerland

Suggested citation: Cuntz, A., Mueller-Langer, F., Muscarnera, A., Oguguo, P.C., and Scheufen, M. (2024), “Access to science and innovation in the developing world”, WIPO Economic Research Working Paper No. 78, Geneva: World Intellectual Property Organization.

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