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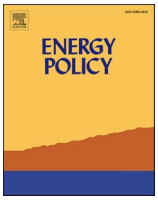

Bridging the divide in energy policy research: Empirical evidence from global collaborative networks

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ABSTRACT

Energy research seeking to influence policy in low- and middle-income countries (LMICs) is often funded by – and conceptualised by authors in – institutions from higher income countries (HICs). Research agendas and policy recommendations determined in HICs potentially yield the most influence on policymaking in LMICs. This risks leaving a multidimensional gap in how LMICs frame, evidence and enact policies. This paper is the first to provide quantitative evidence to geographical imbalances in energy policy research, and to shed light into the fact that research proposing energy policy coupled with development objectives to LMICs is dominated by HICs researchers. We find that the latter not only publish more articles proposing energy policy to LMICs, but also are more cited when doing so. We reach these findings by analysing the spatial dynamics of energy research on LMICs through a multi-method approach using bibliometric, network science and regression-based techniques. We established a framework using a sample of 6,636 papers from the Web of Science database, journal impact data from Scimago Journal Ranking and country economic data from the World Bank. Results show the existence of a cycle of imbalances across research practices. Most scientific articles recommending energy policy for LMICs have a primary author based in a HIC, funded by a HIC institution. The number of citations articles receive increases with the GDP of the country of primary author. Funders support authors based in countries of the same income band or higher. We recommend revising research practices and funding policies to place local actors and knowledge at the heart of energy policy research, enabling high-impact policymaking in LMICs.

1. Introduction

Understanding and seeking to reduce inequalities and environmental damages related to the global energy system is a central focus of academic research, enshrined in the widely used language of sustainable energy transitions. Within this, the asymmetrical power relations which exist between groups, and their implications from a policy perspective, is a long established field of energy research. Research fields such as energy poverty (Bouzarovski et al., 2012; Pachauri and Spreng, 2011) and energy justice (Debnath et al., 2020; Jenkins et al., 2016) have explored the effects of these imbalances. An emerging field of research regards the careful contextualization of research to inform "just" policy design (Debnath et al., 2021); in order to ensure that energy policy is sensitive to context and the imbalances which may frame and influence policymaking processes.

Concurrently, there is longstanding recognition in many academic disciplines that the position and perspective of the author in relation to the object of study plays a key role in shaping research (see for example Wolf (1996)). The value of local knowledge for research and the importance of critical reflection regarding the authors' positionality and "epistemic locus" (Mignolo, 2009) has long been recognised. Embeddedness of theories and researchers in a geographic context better equips researchers to frame research questions, select better samples and datasets, be critical of the application of methodologies, and interpret results of the country or region under analysis (Adame, 2021; Amarante et al., 2021; Tilley and Kalina, 2021).

Curiously, this opening up of the academic knowledge production process to critique and self-reflection, which is prevalent in disciplines

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such as geography, anthropology, and decolonial theory, remains largely absent from discussions of energy. Prevailing energy policy research tends to focus more on imbalances in the energy value chain – who benefits, who is excluded and who is negatively impacted by them - than on imbalances in the knowledge production process for energy research.

In this paper, we bring together these academic debates, which have remained largely siloed to date, in the context of energy policy. Our results confirm empirically that energy research seeking to influence policy in low- and -middle-income countries (LMICs) is often conceptualised in, and is funded by, institutions from high-income countries (HICs). Research agendas determined in HICs potentially yield the most influence on policymaking for LMICs. This leaves a multidimensional gap in how LMICs frame, contextualise, evidence and enact policy processes.

Our research demonstrates how research aligned with the broad goal of reducing inequalities in the global energy system needs to actively evaluate the identity of those doing energy research, and the extent to which they are embedded in the contexts they seek to influence. This is of central importance for energy research seeking to influence policy in lower income economies. In doing so, we contribute to the state of the art in contextualising energy policy research, and context-sensitive policy design. We also use innovative multi-method analyses to indicate the existence of imbalances in knowledge production. Furthermore, our research reflects on the nuances of possible configurations between individual researchers, institutions and funders - and how this complex interplay informs the exact risks and imbalances which may occur in any given research project.

This research is both relevant and timely given contemporary demands by policymakers for energy transitions. How energy transitions are conceived and understood in research – by whom, where and through what frameworks – can play a significant role in the transitions which take place. And, similarly, the extent to which the drivers for a country's energy transition are - or are perceived to be - endogenous. Recognising that practices and infrastructures are contingent and relational to other factors, such as policy (Shove et al., 2015; STAR, 1999), our analysis raises questions regarding how dominant energy research infrastructures, practices and understandings related to LMICs may affect these countries' policies and energy pathways. We therefore propose fundamental changes to the prevailing knowledge production process for energy research related to lower income economies, by prioritising local perspectives and knowledge creation, even when research is funded by institutions from higher income countries.

The analysis in the paper tests a broad hypothesis that a self-reinforcing cycle of geographic imbalances exist in energy research production processes, with implications for how LMICs frame, contextualise, evidence and enact policy processes. This hypothesis is unpacked into sub-hypotheses on specific aspects of this imbalance, which can be found in the methodology section. It is beyond the scope of this paper to comprehensively prove or disprove the existence of this cycle. However we believe that gathering evidence across the sub-hypotheses enables this paper to foreground and quantitatively evidence the possible existence of a cycle of interrelated imbalances. Furthermore, the concept of a cycle connects our analysis to literature which explores the possible drivers and implications of imbalanced knowledge production processes, such as influence in policy processes (Karlsson et al., 2007).

2. Literature review

In this section we review areas of literature relevant to the hypothesis under investigation. First, we operationalise how we understand imbalances in knowledge production processes. Second, we summarise literature which explicitly investigates the existence of geographic imbalances in research, citation and funding practices. Third, we review selected literature which may shed light on possible drivers and implications of these imbalances. Fourth, we review energy-specific scholarship relevant to possible imbalances in knowledge production processes.

Taken together, this review illustrates that there is a lively and engaged academic debate across a number of disciplines related to the notion of imbalances in knowledge production processes and seeks to both quantitatively evidence and qualitatively explore these imbalances. However, as shown by the final area of literature reviewed, these established debates are yet to permeate substantively into prevailing energy policy research discourse.

2.1. Understanding spatial dynamics and imbalances in knowledge production processes

Energy research is subject to spatial dynamics. These dynamics are between the locations where energy research is funded, produced and consumed, and the spatial relations between the researchers and researched. At the core of our understanding of dynamics and imbalances in knowledge production processes is a recognition of asymmetrical relations between actor groups which inform who produces prevailing knowledge. Critical scholars have focused attentions on modalities of knowledge production to shed light on how dynamics of identity and social difference, such as race and ethnicity, class, gender and sexuality, govern the knowledge production process. The work of Elabor-Idemudia (2011) work explores the dominance of eurocentric over indigenous knowledge production, and subsequently what knowledge is considered valid. They suggest that "Insider knowledge" produced by scholars from within a group with which they identify as a member is often marginalised. This is due to the asymmetrical power relations between established knowledge producers – outsiders – and subjects of knowledge.

From the perspective of spatial dynamics, imbalances occur at many different scales, within as well as between countries; as Backhouse (2021, p. 31) explains "whether they are in the centres or the peripheries, the only individuals who can successfully participate in "global" (or, more precisely, Anglo-American) science and academia are those who have gained the required professional experience abroad, the language skills they need, and whose class background provides them access to international networks".

Nonetheless, while energy scholars across the world can engage with marginalised knowledges if they choose to, structural differentiators between countries remain which inform dynamics of who produces valid knowledge. These include the physical location of funders, journals and research institutions (Backhouse, 2021) as well as modalities of funding and governance arrangements in research partnerships (Vincent et al., 2020). In this paper we focus primarily on the spatial dynamics of knowledge production processes between countries.

While the notion of a binary geographic distinction between more and less "developed" places has been critiqued (Horner, 2020), we nonetheless find drawing a distinction between the GDPs of countries useful, in order to quantitatively illustrate these imbalances at a macroeconomic scale. In this paper, our primary interest is in analysing spatial dynamics and imbalances in knowledge production between higher income and lower income countries. In our own analysis, where we quantitatively characterise these groupings, we define lower income countries to be "Low and Middle Income Countries" (LMICs) and higher income countries to be "High Income Countries" (HICs) as defined by the World Bank (Hamadeh et al., 2021). While we avoid using the ambiguous terms "developed" and "developing" countries in our discussion, we use the commonly used term "developing countries" in our WoS search purely to capture literature which can be considered part of the energy research mainstream which we intend to study. Further details of the search terms and our own quantitative distinctions can be found in the methodology.

2.2. Evidence of spatial dynamics and imbalances in knowledge production processes

Inequalities in publishing have been identified in several academic disciplines, with the type of imbalance in authorship varying across fields. Cummings and Hoebink (2017) found a geographical misrepresentation in development studies, with a disproportionately high share of HIC-based scholars as opposed to vice versa. Amarante et al. (2021) analysed development research publications and concluded that most research on development and development policies in the LMICs is conducted by researchers from HICs.

A number of studies have utilised citation practices to illustrate imbalances in the knowledge production process (Nielsen and Andersen, 2021) and more broadly underrepresentation of lower income country scholars in academia. Amarante et al. (2021) have shown that only 15% of articles published in top 20 development journals from 1990 to 2019 were by researchers from "developing" economies, yielding fewer citations per article than articles published by researchers in "developed" economies. In economics, only a quarter of papers on African countries have Africa-based authors and a very small percentage of journals that publish papers on African countries have editorial board members based in Africa (Chelwa, 2021).

Research funding trends have also been analysed in this context. Overland et al. (2021) trace funding related to climate change research and demonstrate that a disproportionately small share of funding is spent on African topics, and what funding is available goes to institutions based in HICs. This is all in spite of the widespread recognition of Africa's vulnerability to the effects of climate change. Recent analysis of the UK's Global Challenge Research Fund suggests that some African research institutions have much stronger relationships with European funders than others, which distorts the research landscape in favour of certain institutions (Grieve and Mitchell, 2020). Furthermore, there are claims that research structures funded and led by Northern institutions can lock their partners into the position of "recipient," having their "capacity built", ultimately reproducing unequal dynamics and leading to lower quality research outcomes (Vincent et al., 2020).

Several scholars have highlighted the dominating role that researchers and funders from HICs often occupy in research related to LMICs (Adame, 2021; Minasny et al., 2020; Tilley and Kalina, 2021). However, this trend should not be understood as uniform. HIC country scholars may seek to mitigate geographic relationships of dominance through alternative research configurations, and China's substantial increase in academic output means much contemporary prevailing research focused on China is domestically produced (Horta and Shen, 2020). Furthermore, LMIC countries may conceivably have thriving domestic academic production processes which go "under the radar" by not publishing in internationally recognised journals. However the available evidence suggests that knowledge flows from HICs to LMICs remain far more common than vice versa.

2.3. Drivers and implications of spatial dynamics and imbalances in knowledge production

A longstanding multidisciplinary literature of post- and decolonial thinking has shown how western worldviews have come to dominate and drive complex effects across many aspects of society, including but going beyond academia and policy (Fanon, 2002; Mbembe, 1992).

On a theoretical level, this literature has explored how knowledge production processes dominated by authors at HIC institutions lead to a variety of imbalances, such as knowledge associated with HICs assuming a preferential right of interpretation. As Dhareshwar observes, "there are many cultures. But only one culture has offered descriptions of other cultures" (Dhareshwar, 1998, p. 215). The importation and usage of rigid HIC theories and understandings in scholarship and practice is seen as a serious threat to the ability of LMICs to determine their own development pathways (Mahvunga, 2017).

On a practical level, concerns exist regarding the structure of research relationships between higher and lower income countries, with scholars alleging this as one of many areas in which neocolonialist processes of indirect control continue to be exerted by these countries (Bradley, 2008). The literature recognises the practice of "helicopter research," in which researchers from HICs fly to a LMIC to collect data, and then fly back to the HIC where they are based to conduct the analyses (Adame, 2021; Minasny et al., 2020). Such practice implies that researchers in HICs lead research projects and publish their results without substantively involving local scientists from the country of study. These dynamics are likely to have a self-reinforcing effect, as there are limited opportunities for local researchers to play a central role.

Furthermore, scholars have investigated the implications of these dynamics for the lived experience of researchers in LMICs collaborating with institutions in HICs. Researchers in LMICs are often positioned as "assistants" to the research process. The research activities they practice - often data collection - may lead to their safety being compromised, and their marginalisation in the overall research process (Baganda, 2021). This is despite the observed burden upon local scholars to act as "gatekeepers" in facilitating fieldwork by reliant researchers from HICs (Tilley and Kalina, 2021). In the context of policy research, these observed dynamics are likely to place local researchers in a subordinate position with limited agency over the final outputs. These relationships have important implications for how LMICs frame, contextualise, evidence and enact policy processes.

From a policymaking perspective, these geographic imbalances in knowledge production can lead to an ongoing "braindrain" effect in which inferior resources and opportunities lead LMIC scholars to leave their home countries. This creates a shortage of locally based researchers who are well-equipped to influence policy through research (Pasgaard et al., 2015). Similarly, Karlsson et al. (2007) explore whether the same geographic imbalances in knowledge production processes, which lead to LMIC-based scholars lacking international credibility, may contribute to governments in LMICs not trusting their own experts in policy processes.

2.4. Energy-specific scholarship on spatial dynamics and imbalances in knowledge production processes

Scientific literature linking energy and development has been growing exponentially since the early 2000s. However, despite the debates described above around decolonising research and academic curricula, literature questioning knowledge production processes is virtually non-existent in prevailing energy research. Searching the Web of Science database using terms which characterise this prevailing research (see Methodology), we did not find any paper explicitly analysing the spatial dynamics of knowledge production processes related to lower income economies in the energy field.

Nonetheless, we can identify relevant discussions and insights in energy research. Sovacool (2014) analyses geographic representation imbalances, highlighting the overwhelming dominance (87.4%) of European and North American-based authors in English language energy research. However, this study is on energy research on a broad basis, as opposed to energy research related specifically to lower income economies.

A common trend in energy research on lower income economies is to observe how empirical evidence is primarily from higher income economies. This geographic evidence gap is then used as a justification for research (see for example Dauda et al., 2021; Delina, 2020; Tigabu et al., 2015). Furthermore, energy research has observed that research agendas established in Europe, such as "Just Transitions", have so far neglected investigation of the effects of transitions elsewhere (Sovacool et al., 2020). While the Energy Justice literature (Jenkins et al., 2016) has the potential to engage with these issues, having highlighted embodied energy justice issues across national borders (Castán Broto

et al., 2018; Healy et al., 2019) and the phenomenon of "energy bullying" by higher income countries (Monyei et al., 2018), it has not yet substantively engaged in knowledge production imbalances specifically.

3. Methodology

In this paper, we explore the broad hypothesis that a self-reinforcing cycle of geographic imbalances exist in knowledge production processes, operationalised by a set of subhypotheses which are summarised below. We do so by conducting a bibliometric analysis using the Web of Science (WoS) database of journal articles studying and seeking to influence energy policy for developing countries[1] (Web of Science, 2021). We then apply a network-science based approach to explore the collaborations between countries, and a regression analysis to measure the effects of first authors being from higher income countries on citations and potential influence of papers.

By analysing data for authors' countries of affiliation, country of study of each paper, country of funder institution, number of citations of each paper and metrics of the journal where each paper was published, we test the following subhypotheses:

- HICs study and propose policies for lower income countries, while LMICs only do so for themselves.
- Funders are concentrated in HICs and tend to fund primary authors affiliated with institutions in the same country or other HICs.
- HICs-LMICs collaboration papers usually have the primary author affiliated with an institution in a HIC.
- Funded papers usually have a primary author affiliated with institutions in the country of the funding institution.
- Collaboration flows are mostly from and between HICs, even when the study is on LMICs.
- Papers whose first authors are from higher income countries usually get more citations.
- Authors from higher income countries are more likely to study multiple countries in the same paper.

We recognise that first authors are highly heterogenous in relation to their country of affiliation – this affiliation may be very shortlived. However we are limited by the lack of data availability regarding that scholar's relationship with the stated country at time of publication. Furthermore, we believe the institutions where scholars are affiliated at time of publication may still exert influence on theories and approaches used, particularly for early career scholars. See section 5.5 for further discussion of this.

The sample used for all analyses conducted was obtained through a search of the Web of Science database for the words "energy", "developing", "countries" with the operator "AND". The initial search yielded 29,241 results. The chosen terms are suitable to characterise prevailing (e.g. dominant) energy policy scholarship on higher income countries. Moreover, our usage of the terms *developed* and *developing* reflects prevailing terminology in energy policy research related to LMIC countries and therefore represents the most influential energy policy mainstream.

The next step then consisted in limiting the search to journal articles and refining it to the research areas: Energy Fuels or Engineering or Science Technology Other Topics or Business Economics; and to the following Web of Science Categories: Environmental Sciences or Energy Fuels or Green Sustainable Science Technology or Economics. Refining the search to specific research areas was relevant given that broader searches of the word "energy" include a range of areas unrelated to energy policy such as cell biology, medicine, nutrition, or studies which are heavily focused on energy technology and do not propose policies.[2] All languages of publication were included.

All journal articles from 1966 to 2019 were included, excluding the years 2020 and 2021, in order to allow time for papers to be cited. The vast majority of articles included were published in the last 15 years. The described search refinement resulted in a sample of 6,636 journal articles (Web of Science, 2021), treated as follows.

1. From the 6,636 papers, we mapped each country name for the country of study of each paper (CoS) in the Title (CoS_T) and in the Abstract (CoS_A), country of first author (CoA) and country of funder (CoF) for those with funding information.
2. We attributed the country Gross Domestic Product (GDP), GDP per capita (GDPpc) and Gross National Income per capita (GNIpc) to each country datapoint. To do so, we used the World Bank country GDP and GNI list to index match with words contained in the title, abstract, author affiliation and funding information.
3. We used the World Bank's threshold of USD 12,535 GNI per capita (GNIpc) in 2018 (World Bank, 2021b) to classify countries as lower income countries (low or middle income countries which are below the threshold) or higher income countries (countries above the threshold)
4. We selected only papers which subject is one or more lower income countries according to the criteria in point 3. The sample size for papers exclusively studying lower income countries is 4,281.
5. A network-science based approach was applied to this sample to explore the collaborations between countries. The CoA is considered as the emerging node whereas the collaborating countries are considered as the ending nodes. The number of collaborative published articles are considered as the weight of the edges. These edges connect the nodes and define our collaboration network structure. In total, 74 unique emerging nodes were identified which ended in 125 nodes that illustrated the spread of the collaboration.
6. We selected only papers whose subject is one or more lower income countries which provided funding information, resulting in a sample of 905 papers. We attributed economic data for each Country of Funding (CoF). Multilateral agencies were classified as and attributed economic data of the main donor country. We then analysed the linear relationships between such variables.

We use two main models to test our hypothesis. Using the sample of papers aggregated at the country level, we regress GDP on total citations of country of primary author. The model controls for Source Normalized Impact per Paper (SNIP), age of article and population of country of study.[3] Using the same sample of papers, but disaggregated by individual paper, we regress measures of development of the country of primary author on the number of citations a paper receives. We use three measures of development: total GDP of country of primary author, GDP per capita of country of primary author and, using the World Bank's old country income classification (Hamadeh et al., 2021), a dummy variable signifying whether the country of primary author is higher or lower income. The model controls for different scientometric indices of journal impact, age of a paper and regional dummies. We estimate the model using Ordinary Least Square (OLS) estimation and report heteroskedasticity-consistent, robust standard errors. We also test the

[1] We assume that papers which focus on energy policy are seeking to somehow affect energy policy, whether directly or indirectly. Furthermore, we refer to "developing countries" in this section in order to characterise the literature, recognising that this is a commonly used term in energy research, whilst we prefer to refer to higher and lower income countries elsewhere.

[2] The search result can be found through the following link: https://www.webofscience.com/wos/woscc/summary/646770b3-315e-4b27-86a8-290577a11b10-0061b916/relevance/1.

[3] In a study of why certain African countries are studied more than others (Porteous, 2021), finds that population explains 60% of the variation in number of articles published about a country. We control for population of country of study as a potential explanatory variable for interest in a country and, hence, an influential variable on number of citations an article receives.

hypothesis that authors from higher income countries are more likely to study multiple countries at once. We regress the same measures of development on a multiple country dummy: whether a paper studies multiple countries or a single country. We specify a logit model to test this hypothesis.

There are potential confounding variables in the relationship between total citations and GDP of the country of primary author, such as access to funding and relevance of the research topic. We acknowledge that authors in HIC have more access to funding and access to funding can affect research output. But recognising that all published work goes through the same peer review process and is, therefore, of similar quality, we argue that the way in which funding affects total citations is by allowing researchers to engage in more relevant research, which is not independent of the GDP of the country of primary author. While it is expected that authors in HIC publish more papers, it is not necessarily true that those papers should receive more citations.

4. Results

When both higher and lower income country papers are combined (n = 6,636) the trend on who does research on who reveals important inferences on research dominance. A variety of different types of results is presented. The main body of evidence relates to energy research practices, along with some more cautious observations related to research networks and themes in energy research.

The research output gap between authors in high income and low income countries has increased over time, particularly from 2005 to 2015 (Fig. 2). From 2015 to 2020, the gap remained near constant between higher countries and the group of lower income countries without China. Primary authors from HICs have consistently published more than their counterparts in LMICs. While this is expected, this difference becomes problematic when we consider the impact of the published research (for the purpose of this paper, impact is measured in number of citations). Fig. 3 shows that the difference in the total number of citations over time between papers published by authors from HICs and LMICs is more palpable than the difference in number of papers published. This might be due to the high impact journals authors from HICs publish in (we control for impact factor in the regression analysis later in the paper).

4.1. Inequalities in citation practices

A sample of the papers focusing only on lower income countries (n = 4,281) showed a strong positive correlation (R2 = 0.55) between number of citations and the GDP of the country of the primary first authors (see Fig. 4). It shows the dominance of authors from institutions in specific countries. Studies on lower income countries are cited more when authored by a researcher based in higher income countries than by their own researchers (see Fig. 1). It was observed that 51% of primary authors are based in higher income countries, 18% of which are based in the UK or US, and 49% of first authors are based in lower income countries, 17% of whom are based in China. Nonetheless, with China being the outlier, the general trend from Fig. 1 suggests that countries with larger GDP levels appear to receive more citations.

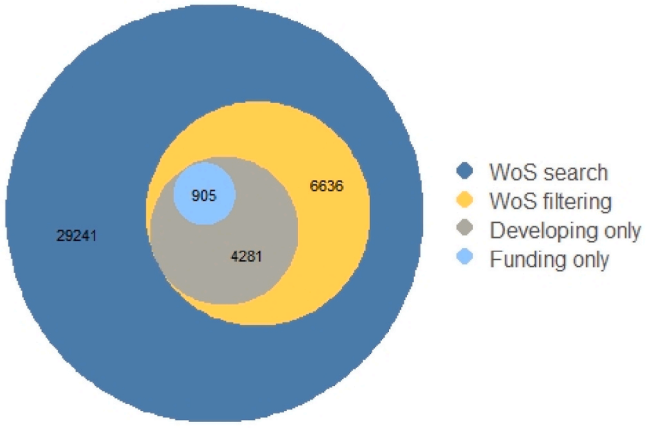

Fig. 1. Euler diagram for literature search refinement.

4.2. The income gap between study country and author country

We found that the lower the GDP of the country of study, the higher the difference between the GDP of the country where the first author is based and the GDP of the country of study, when estimated across the entire sample (n = 6,636). There is a clear trend in which only authors from higher-income countries study lower-income countries, while negative differences are observed solely when high-income countries study each other, as shown in Fig. 5.

We filtered papers focusing on lower income countries with exclusive funding information, which revealed 905 documents. In this document corpus, funding dominance was observed from higher income countries, as illustrated in Fig. 6. Excluding papers about China, 71% of papers focusing on lower income countries are funded by higher income country institutions, while only 29% by funders from lower income country institutions. The same analysis for 143 papers in the Scopus database reveals similar proportions: 72%–28%.

4.3. Inequalities related to the institutions receiving research funding

Fig. 6 shows that higher income countries fund most papers studying lower income countries, and tend to fund authors from their own countries or other high income countries (Box 1). Also, funding from lower income countries is significantly lower (smaller bubbles in Box 2), and also tends to go towards funding research conducted by authors from higher income countries (Box 2). Notably, Fig. 6 shows almost no points below the 45° line. In our sample, virtually no country funds first authors based in low-income countries.

4.4. Research networks

At the institutional level, analysis of the collaborative network shows a division of collaborations which most are either HIC-HIC or LMIC-LMIC, with fewer cases of LMIC-HIC collaborations (see Fig. 7). The edges of the network diagram show that collaborations have strong regional boundaries, even with larger node sizes.

For example, Tsinghua University is the most common first author affiliated institution in the entire sample space of 6,636 articles, corresponding to its proportionality bubble in Fig. 7. The straight lines emerging from it represent the edges and its thickness denotes the edge weights, meaning thicker lines illustrate higher number of collaborative papers. Thus, for Tsinghua University, a typical South-South collaborative network is with Beijing Normal University and North China Electrical Power University. Similarly, Beijing Normal University with Peking University; Xiamen University and Shandong University. Local collaborative network with strong edges (denoted by red thick lines) can be seen between the Chinese Academy of Sciences, Tsinghua University, Beiging Normal University and Peking University in China. In Japan, the National Institute for Environmental Studies and the University of Tokyo show a similar connection (see Fig. 7). A similar regional collaborative links were observed between Chinese Academy of Sciences, Islamic Azad University in Iran and University of Malaya, Malaysia (see Fig. 7).

Fig. 8 further reveals the weighted collaboration network, with a clear HIC dominance. The x-axis represents the affiliated institution of the first author in terms of GDP per capita. In the HIC categories, more collaborations originate from the US, the UK, Germany, Sweden, and Australia. Only China has a grand collaborative output structure with international institutions in this category. For LMICs, India and Vietnam

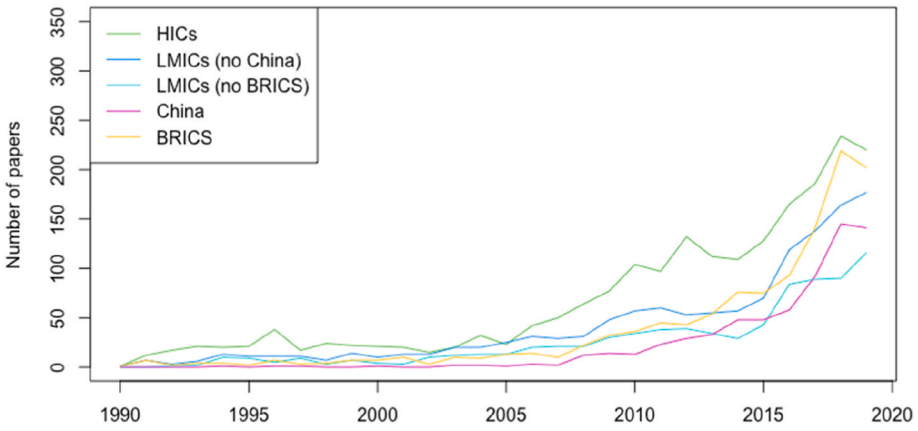

Fig. 2. Number of papers published per year by region/country of first author (1990–2019).

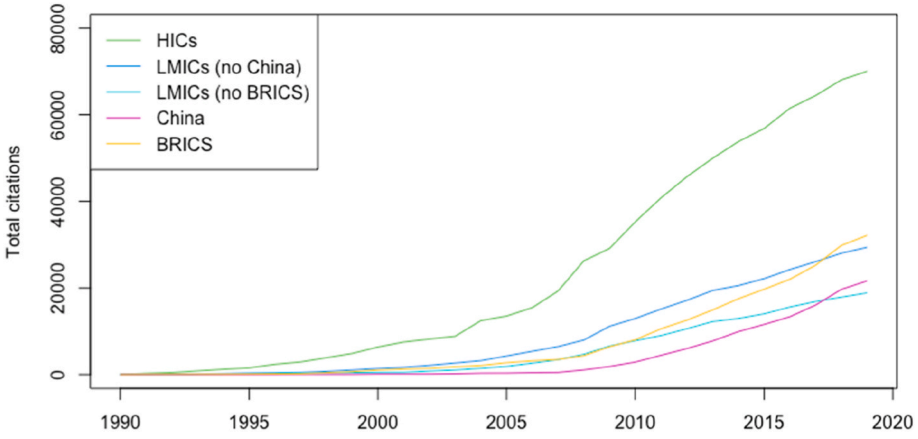

Fig. 3. Cumulative number of citations for papers published each year by region/country of first author (1990–2019).

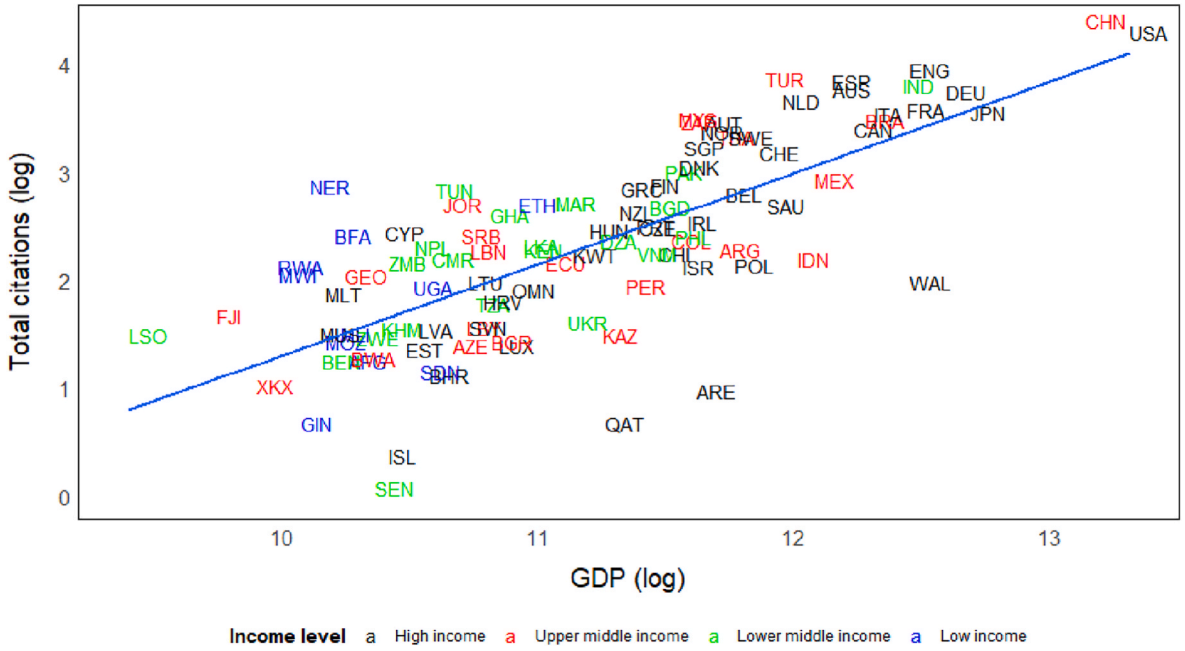

Fig. 4. Correlation between the log of total citations and log of GDP of country of primary author ($R^2 = 0.55$) (the two-tier characterisation of countries into lower income countries and higher Income countries we use is expanded to show the relationship between total citations and GDP across the World Bank's four income groupings. Our lower income category corresponds with Low Income, Lower-Middle Income, Upper-Middle Income on the figure. Our higher income category correspond with High Income on the figure).

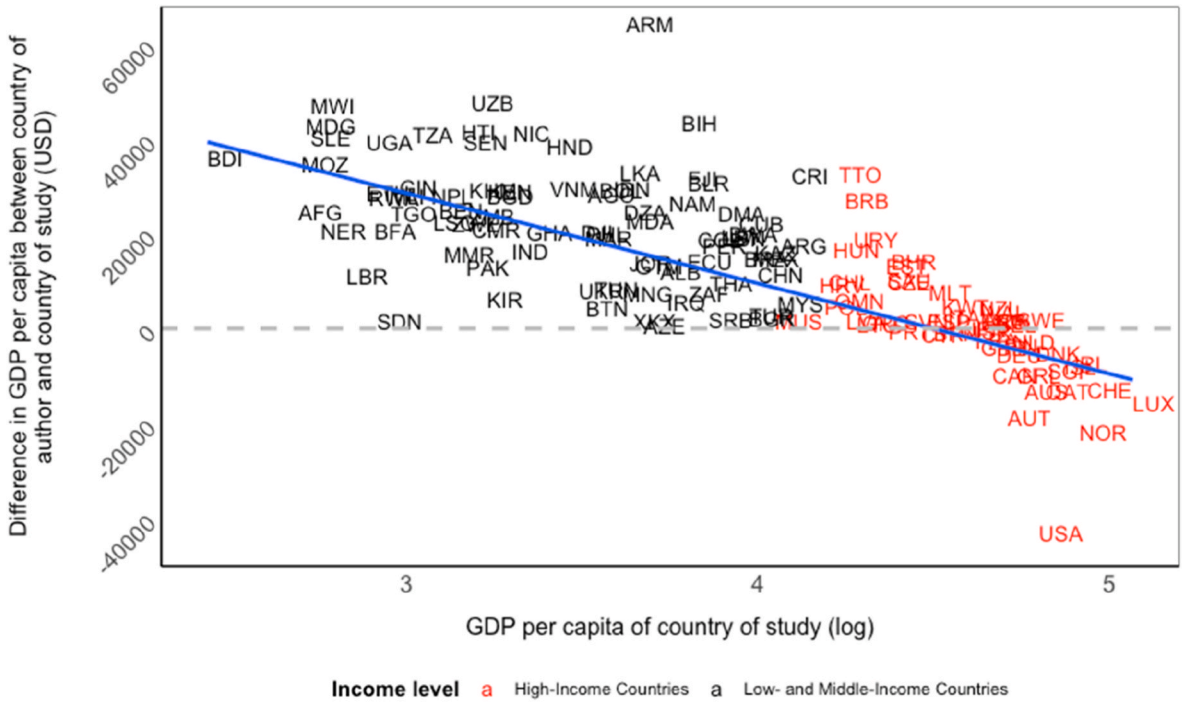

Fig. 5. Trend for the difference in GDP per capita between country of first author and the country of study verses the GDP per capita of the country of study.

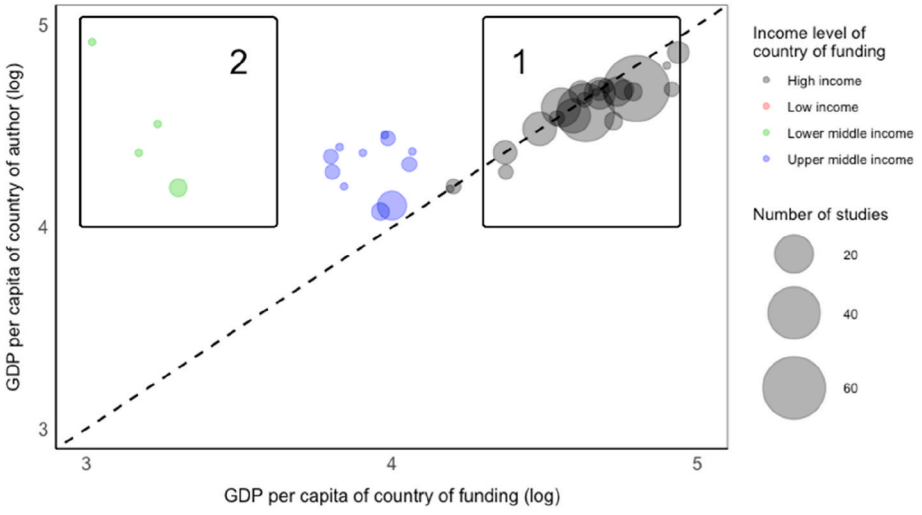

Fig. 6. GDP per capita of country of author vs country of funding (sample of 905 papers for which funding information is available) (the size of the bubbles is the number of studies; the x-axis represents the GDP per capita of the country of funding; the y-axis represents the GDP per capita of the country of primary author. The two-tier characterisation of countries into lower income countries and higher Income countries we use is expanded to show the relationship between total citations and GDP across the World Bank's four income groupings. Our lower income category corresponds with Low Income, Lower-Middle Income, Upper-Middle Income on the figure. Our higher income category correspond with High Income on the figure).

have institutions that collaborate with several international institutions, but it is incomparable with the scale of collaboration of higher income countries. Additionally, characteristic North-North and South-South patterns exist for the countries with higher collaborations, which complements the institutional collaboration network in Fig. 7.

4.5. Research themes

Fig. 9 shows the dominant themes across the 6,636 through word cloud of 'abstract', 'article title', 'keyword plus' (i.e., journal keywords) and 'author keyword'. The size of the word denotes its frequency of representation.

The word clouds show a descriptive link between energy access/consumption and economic growth (economic development, GDP, energy demand, sustainable development, energy intensity of economic growth, energy security, energy poverty, productivity, trade). Economics appears to dominate as a discipline with words/terms like economic growth, economic analysis, international trade, trade, investment and income. It further indicates significant representation of 'technoeconomic' approaches and epistemologies of study, reflecting the fact that the predominant disciplines are among the mainstream of energy research and may not be involved in debates and critiques of development paradigms. Notably, the absence of keywords representing frequently used methods in energy research such as energy-system modelling or Integrated Assessment Modelling (IAMs) or other words indicating method development may indicate that papers in the sample do not focus on new methodologies, but cases studies instead.

The author keywords category shows significant representation of papers on energy and climate change, GHG emission reduction, sustainability, energy efficiency, life cycle assessment, waste management, cleaner production, rural electrification, that is reflective of perceived challenges in both lower and higher income countries. Several specific

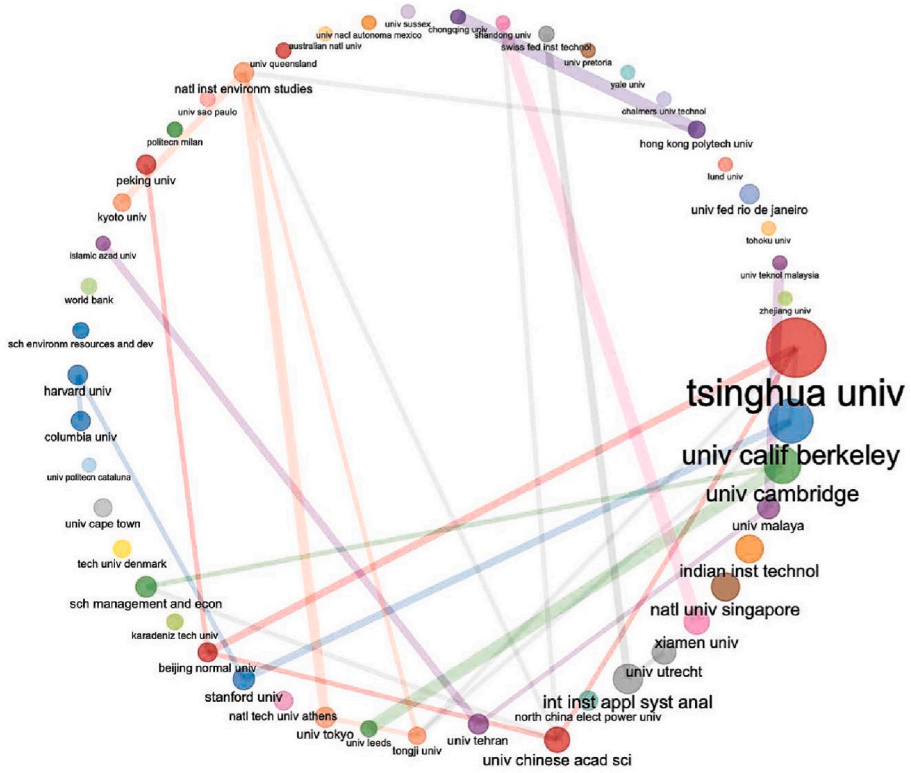

Fig. 7. - Institution level collaborative network for 6636 articles based on the country of first author (Note: the size of the bubble (node) denotes number of papers while the thickness of straight lines (edges) denote number of collaborative outputs).

technologies are mentioned, which are associated with Biomass, Biofuels, Bioenergy, Biogas, Wind, Solar PV and Natural gas (see Fig. 6).

4.6. Regression results

Table 1 shows the results from the OLS regressions of the log number of citations on the explanatory and control variables. Variation in GDP explains 55% of the variation in total citations of country of primary author (Column 1). For the whole sample of countries, a 1% increase in GDP is correlated with a 0.68% increase in total citations. For the same sample, the population of the country of study does not affect total citations (Column 2). Among low-income country authors, the effect of GDP is not statistically significant. On the other hand, for the same sample of countries, journal impact (SNIP) has a positive and statistically significant effect on total citations (column 3), and so does population of country of study. The effect of GDP is most pronounced among high-income countries, where a 1% increase in GDP is correlated with a 0.89% increase in total citations (column 5). For all four samples, age of paper has a negative effect on total citations, but is only statistically significant for the whole sample.

Table 2 shows the results of the OLS regressions of the log of citations an individual paper receives on explanatory and control variables. The GDP of the country of primary author explains just over 1% of the variation in citations a paper receives, and a 1% increase in GDP increases citations by only 0.08% (column 1). Once we control for journal impact factor, age of article and a regional dummy for Sub-Saharan Africa, the effect of GDP on total citations decreases to 0.04% (column 4). Regional dummies show that authors from Sub-Saharan African countries are less likely to be cited (column 4). The same is true for authors from India and Brazil (columns 6 and 7). Once we control for primary authors for China, GDP is no longer a statistically significant predictor of number of citations (column 5).

We identify a number of key messages in our regressions with regard to citations and the object of study. With regard to citations, our sample shows that the GDP of the country of the first author's affiliation correlates positively with citations. The first author being affiliated to an institution in any country in the African continent, as well as in India or in Brazil, correlates negatively with citations. Conversely, being affiliated to an institution in China correlates positively with citations. With regard to the object of study, HIC-based authors are much more likely to study multiple countries in the same paper. The first author being based in any African country, Brazil, India or China makes it less likely that they will study multiple countries.

For the aggregated sample (Table 1), GDP of country of primary author is the main predictor of aggregate total citations for each country. On aggregate, the journal impact factor has little impact on total citations. Neither does average age of papers or the population of the country of study. For the sample of country of primary author for low-middle income countries, journal impact factor and population of country of study explain 80% of the variation in total citations. This means that for primary authors from LMICs, journal strength and country of study matter. On the other hand, for the sample of HICs, GDP of country of primary author matters more than the strength of the journal the paper is published in. So, primary authors from low-middle income countries are likely to receive more citations if they publish in a strong journal as opposed to being from a richer low-middle income country. For authors from high-income countries, the opposite is true.

For the disaggregated sample, while journal impact factor has a stronger correlation with the number of citations a paper receives than the GDP of the primary author's country, the latter remains a statistically significant factor. Authors from Sub-Saharan African countries are cited less than authors from other countries. The same is true for primary authors from India and Brazil. This is contrary to the findings of Porteous (2021) who concludes that population is the main explanatory variable of research interest on African countries. Both Brazil and India are countries with large populations and research on them by both national and foreign authors should be equally attractive. On the other hand, the primary author being from China has a positive and statistically

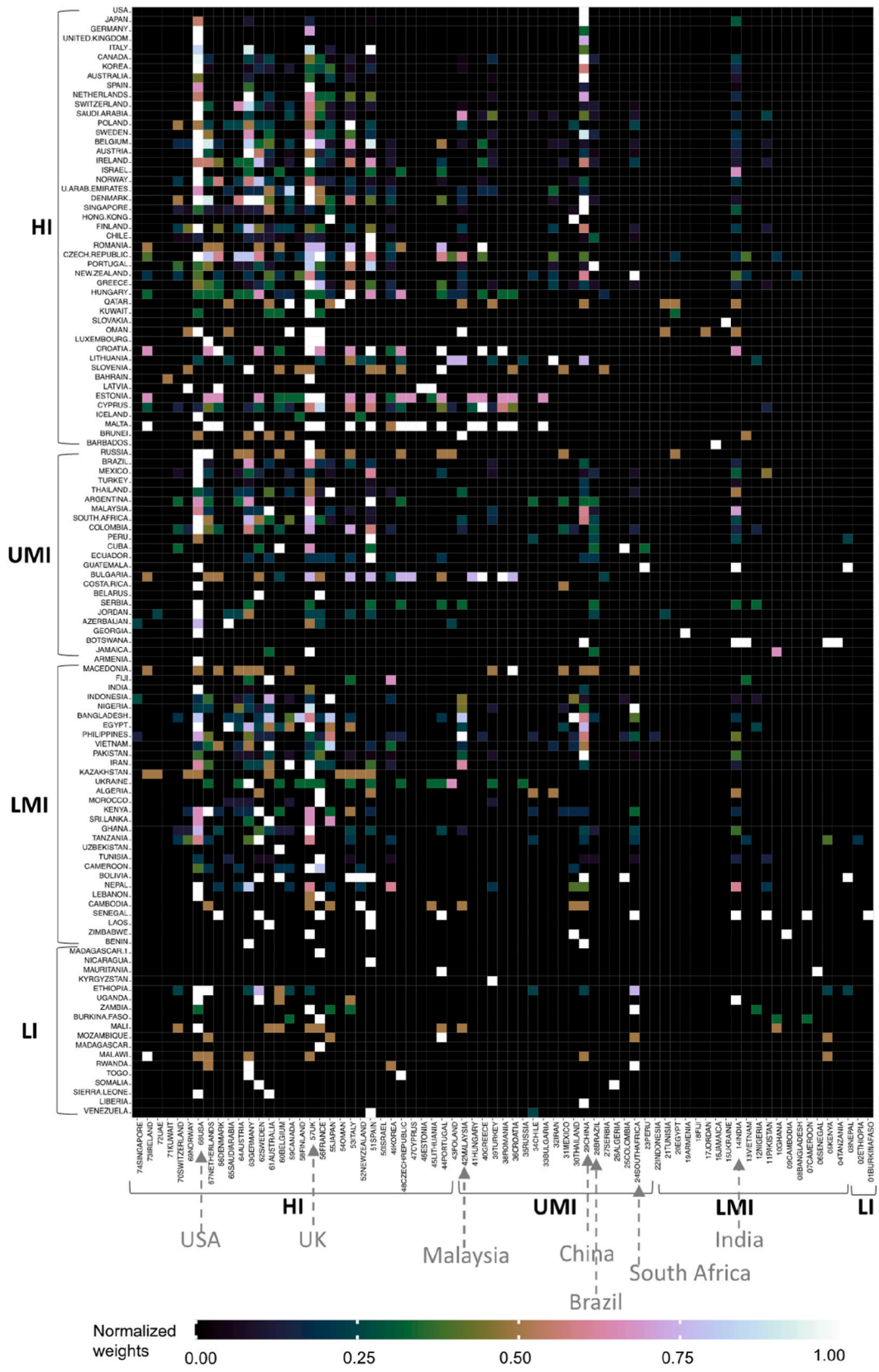

Fig. 8. A heatmap denoting country of first author (x-axis) and country of collaborating authors with respect to its publication weights (normalized values: 1 = strong collaboration and 0 = no collaboration) (Note: LI: Low-Income; LMI: Low-middle income; UMI: Upper-middle income; HI: High-income. The publication weights are the number of papers published between the CoA and their collaboration in their respective country).

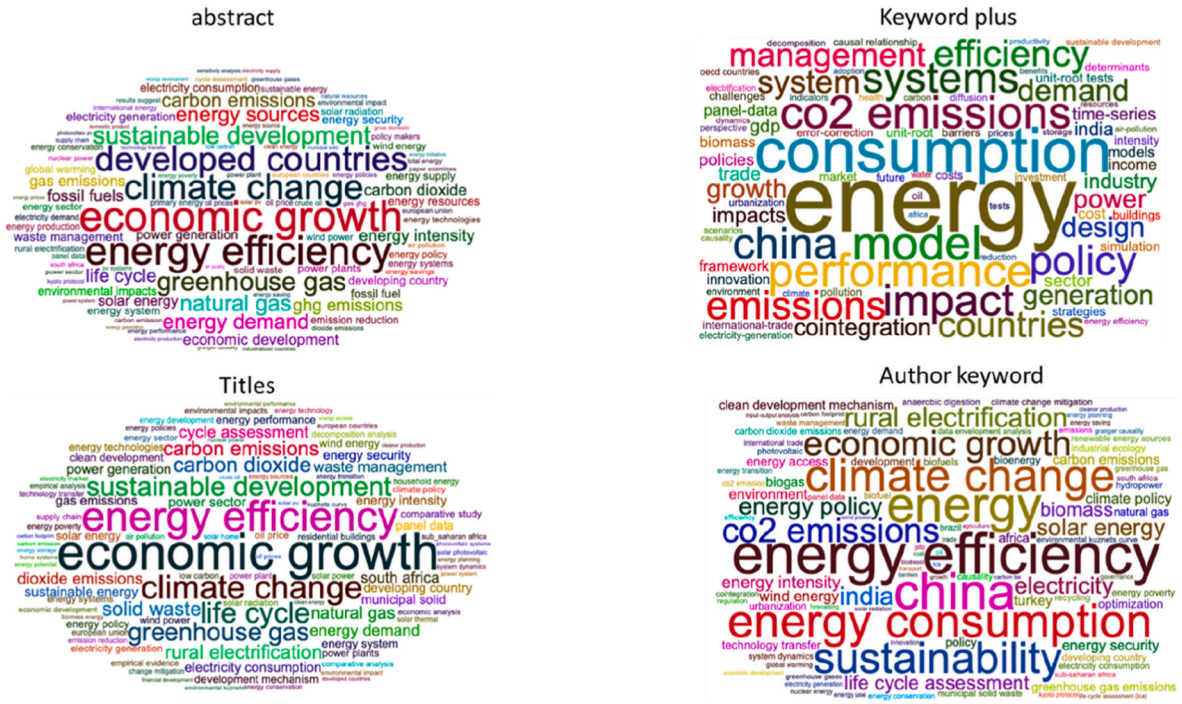

Fig. 9. Word cloud constructed for abstract, keyword plus, article title and author supplied keywords for paper between 2001 and 2020 (n = 6,636).

Table 1
Regression results of OLS regression of total citations aggregated by country on GDP of country of primary author and other control variables.

	Dependent variable:				
	Total citations (log)				
	All		LMI	UMI	HI
	(1)	(2)	(3)	(4)	(5)
GDP	0.810***	0.677***	−0.023	0.701*	0.890***
	(0.075)	(0.089)	(0.316)	(0.345)	(0.124)
SNIP		0.476***	0.965***	0.223	0.096
		(0.161)	(0.169)	(0.665)	(0.256)
Age		−0.033**	−0.032	−0.020	−0.049*
		(0.013)	(0.019)	(0.037)	(0.027)
Population		0.212	1.176**	0.230	0.248
		(0.133)	(0.417)	(0.482)	(0.238)
Constant	−6.810***	−7.540***	−7.994***	−7.585***	−9.524***
	(0.843)	(0.956)	(1.351)	(2.289)	(1.854)
Observations	95	90	21	22	38
R^2	0.555	0.617	0.839	0.584	0.687
Adjusted R^2	0.550	0.599	0.799	0.486	0.649
Residual Std. Error	0.587 (df = 93)	0.535 (df = 85)	0.336 (df = 16)	0.656 (df = 17)	0.506 (df = 33)
F Statistic	115.799*** (df = 1; 93)	34.299*** (df = 4; 85)	20.844*** (df = 4; 16)	5.968*** (df = 4; 17)	18.131*** (df = 4; 33)

Note: *p<0.1; **p<0.05; ***p<0.01.

significant effect on citations, which fits well with the findings of Porteous (2021).

5. Discussion

Taken together, our results provide evidence which supports the existence of our broad hypothesis of a cycle of imbalances across knowledge production processes in mainstream energy research. Higher income country authors find funding in their own geographies (Fig. 6) to conduct research about lower income economies (Figs. 2 and 5). Existing research practices mean they receive a higher number of citations than local authors (Figs. 3 and 4). This may lead their theorizing and evidence to become dominant. Furthermore, we also tentatively posit that the way problems and solutions are conceptualised by higher income country authors may subsequently influence policy and attract funding comparatively more than lower income equivalents. More funding means more research output and more citations (Table 1). Cumulatively, this may influence accepted knowledge, shaping which understandings are used in research (Fig. 9). Lower income country authors have to adopt established knowledge or exist outside the mainstream, risking irrelevance.

In Fig. 10, we characterise two indicative pathways that two equivalent scholars (based at higher and lower income country institutions respectively) might follow in researching and publishing energy

Table 2
Regression results of OLS regression of citations an individual paper receives on GDP of country of primary author and other control variables.

	Dependent variable:						
	Citations (log)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP	0.082***	0.053***	0.057***	0.042***	0.017	0.042***	0.040***
	(0.012)	(0.013)	(0.013)	(0.015)	(0.018)	(0.015)	(0.015)
SNIP		0.318***	0.313***	0.312***	0.310***	0.310***	0.313***
		(0.027)	(0.026)	(0.025)	(0.025)	(0.025)	(0.026)
Age			0.012***	0.012***	0.013***	0.012***	0.012***
			(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Africa				−0.102**	−0.123**	−0.107**	−0.113**
				(0.048)	(0.049)	(0.048)	(0.048)
China					0.081***		
					(0.031)		
India						−0.074*	
						(0.045)	
Brazil							−0.194***
							(0.048)
Constant	0.111	−0.056	−0.191	0.006	0.293	0.006	0.036
	(0.154)	(0.163)	(0.164)	(0.186)	(0.219)	(0.186)	(0.186)
Observations	3,388	2,267	2,267	2,267	2,267	2,267	2,267
R^2	0.012	0.127	0.146	0.148	0.150	0.149	0.153
Adjusted R^2	0.012	0.127	0.145	0.146	0.148	0.147	0.151
Residual Std. Error	0.574 (df = 3386)	0.493 (df = 2264)	0.488 (df = 2263)	0.488 (df = 2262)	0.487 (df = 2261)	0.488 (df = 2261)	0.486 (df = 2261)
F Statistic	42.072*** (df = 1; 3386)	165.110*** (df = 2; 2264)	128.915*** (df = 3; 2263)	98.075*** (df = 4; 2262)	79.978*** (df = 5; 2261)	79.160*** (df = 5; 2261)	81.583*** (df = 5; 2261)

Note: *p<0.1; **p<0.05; ***p<0.01.

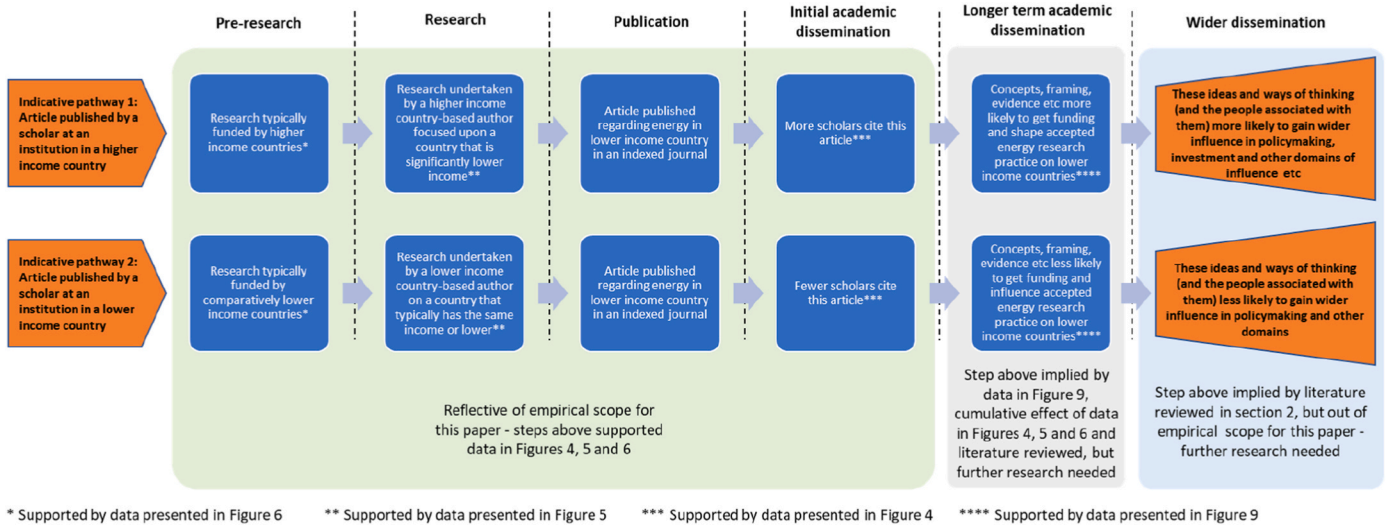

Fig. 10. Indicative pathways to compare two hypothetical articles published which related to energy in lower income countries, drawing on evidence presented in the paper and indicating where further research is needed.

research. This helps us to demonstrate the phases of the academic production process within the empirical scope of our paper - shaded in green – where we have high confidence of the existence of imbalances between geographies. We then set out two subsequent stages – longer term academic and wider dissemination. While empirically demonstrating these stages is outside this paper's empirical scope, related imbalances are implied both by the literature reviewed and by Fig. 9 which indicates the keywords in energy research on lower income countries (which follow the technoeconomic mainstream).

With regard to the latter phase of wider dissemination, if policy makers from lower income countries prioritise policy recommendations which ultimately owe their framing and theorizing to papers authored in higher income countries (as implied by Fig. 10), this risks lower income countries replicating policies which may be unsuitable for their specific contexts and adopting inappropriate technologies in their geographies. This chimes with the empirical research of Yuliani (2017) who finds that "Indonesia is an example of a country where Feed-in Tariff policy, which is considered quite successful in developed countries, is duplicated without careful considerations of the existing sociopolitical conditions". Policymakers would, therefore, risk neglecting their countries' potential advantages and disadvantages, and ability to guarantee energy access and justice (Garces et al., 2021). From an energy innovation perspective, it risks positioning activities perceived to be innovative as exogenous to LMICs, given that lower income countries track behind higher income

countries when viewed through dominant innovation indicators such as patenting and R&D spend (Cornell University et al., 2020). This further locks in imbalances in knowledge and resource flows.

5.1. Energy research practices

One potential argument against our claim regarding the dominance of papers whose first authors are based in higher income countries could be that papers published by authors from higher income countries are more cited simply because their total scientific output is greater. However, there are several reasons behind this phenomenon. One could argue that authors based in higher income countries publish more due to the greater availability of funding, editorial biases, common language (given that the majority of indexed journals are in English), or even their work conditions allowing time for them to write research articles. The literature shows that papers submitted by authors from "developed" economies may be several orders of magnitude more likely to be accepted than those from "developing" economies (Amarante et al., 2021), hence the editorial bias is inherent to the total number of papers published.

With regards to the regressions conducted in this study, we therefore chose not to control for the total number of publications by authors from HIC or LMIC countries. Doing so could have meant accepting the bias described above, as part of the publishing process. This is because the forces causing lower income country authors to publish less are inherently connected to our hypothesis that energy policy knowledge and practice is dominated by a HIC perspective.

5.2. Energy research understandings

It stands out from our analysis that, in the 4,281-paper sample, keywords relating different aspects of energy policy to economic growth are dominant. The presence of the keywords *economic growth*, *GDP*, *demand*, *sustainable development*, *energy intensity of economic growth, energy poverty, productivity* and *trade* (Fig. 4) strongly suggest that, in general, energy research on LMICs proposes policies aiming at promoting economic development. Also, the dominance of a technoeconomic approach to methods applied in these papers corroborate such impression, with a remarkable presence of keywords indicating the use of econometric analyses, and alluding to the existence of implicit assumptions associated with these disciplines Birch (2017).

Predictably, energy is broadly coupled with infrastructure development and ultimately economic growth. However, as interest in energy policy grows over time, driven partly by the development challenges connected to the climate crisis, policy recommendations are increasingly coupled with more far reaching and comprehensive policy objectives. This suggests that dominant energy research perspectives can have a spill-over effect on broader development strategies. Energy production and consumption patterns are unlikely to be the only areas impacted by the transfer of policy and technology approaches from higher income to lower income countries. The success of broader development policies could also be hindered by energy-related policymaking which is not adequately rooted in the local context.

5.3. Research infrastructures and funding

Taking a broad definition of infrastructure, the analysis of research networks (Fig. 5) can be understood as indicative of the research infrastructures which connect institutions together and govern energy research practices. These infrastructures may be more tangible (for example, in the form of research partnerships, facilities, telecommunication capabilities) or intangible such as the cultural norms and relationships between senior staff which connect institutions and make collaboration easier.

Our research-collaboration analysis shows a clear trend in which higher income countries are the main sources of cooperative research on lower income countries (Fig. 5). Generalising the network structure of Fig. 5 with Fig. 4 implies that more collaborations originate from higher income countries as they provide the funding. It establishes the epistemological basis of the collaboration, that enables higher income countries to modulate the research theme and potentially policy outcomes.

Regression results also show that researchers in lower income countries are less likely to study multiple countries. Lack of funding for field work can reduce capacity to conducting multi-country analyses, while the funding abundance in higher income countries could allow them not only to perform the latter, but also to lead cooperative projects and their subsequent publications. Also, since most collaborative studies do not focus on developing methodological capacity in LMICs, researchers in LMICs may not have enough methodological autonomy, e.g. their own energy system models or IAMs, to perform multi-country analyses.

Indeed, the results of the regression on who studies multiple countries shows that HICs are more than twice more likely to study multiple countries than authors from LMICs. This may also lead to higher income countries being more likely to generalise conclusions across countries, further devaluing the central importance of context and local nuance.

Our data further reveals that funding institutions tend to fund publications whose first author comes from the same country, or another high-income country, meaning authors from countries with higher GDP attract most funding (Fig. 3). It also emphasises that funder countries with lower GDP tend to fund authors in their own country or authors from richer countries. Moreover, China also has a clear dominance on funding as 46% of all papers that provided funding information study China and were funded by Chinese institutions.

5.4. China and the potential role of emerging economies

China, while not a HIC, is responsible for 16.8% of first authored papers in the 4,281-paper corpus. Some factors that make China an outlier in this case are: China has the world's second largest total GDP and research funding despite being categorised as a lower income country by the GNI per capita threshold (World Bank, 2021b). In 2018, China had the most academic publications (Normile, 2020), and with a steady growth of R&D investment, China spent a record 2.5% of GDP (USD322 billion) on R&D in 2020 (Warren, 2020). In the energy-policy field, China's number of publications per year has grown exponentially from a 2% growth rate in 2009 to 22% in 2019, when it ranked first with 208 publications (World Bank, 2021a). China here demonstrates a potential alternative knowledge production process for emerging economies. China shows it is possible to establish energy research knowledge production processes which do not rely on HIC countries to undertake the research. Recognising that much Chinese research is domestically focused, this enables greater contextual embeddedness of the researcher.

5.5. Nuances in energy research configurations

Our analysis of citations, collaboration and authorship indicate that imbalances exist in energy research on lower income countries, but nonetheless is constrained by data availability. The accessible datapoints, such as first author affiliation, second author affiliation and funding sources, are only the tip of the iceberg. On the one hand, author affiliation tells the reader about the scholar's current affiliation, but not where they consider home. On the other hand, authors from LMICs who are based in HICs countries represent their institutions and may in fact reflect the institutions' perspectives. Moreover, they have access to funding from countries where they are based, whose calls for projects are usually conditional on the Principal Investigator (PI) being based in the funder country.

In the context of alleged "colonisation of the mind" (Ndlovu, 2017), focusing analysis only on author affiliation obscures the rich nuances, opportunities and risks that exist in the configurations that govern research practices and may influence – and be influenced by -

infrastructures and understandings. In most empirical energy research related to lower income countries (as in many other fields) the following generalised actor groups can be identified:

- *Lead author*
- *Other authors*
- *Lead author's research institution*
- *Other authors' research institutions*
- *Actors providing financial support for the research*
- *Empirical research approach*

It is through a specific paper's unique configuration across these variables that some of the imbalances described in our literature review might be experienced by individual scholars. To illustrate this, we have developed Table 3 which indicates the possible risks which may arise in a number of configurations which are common across energy research. These are hypothetical, but draw on the experiences of the authors in working across configurations. This analysis seeks to highlight risks associated with particular configurations, rather than implying outcomes are inevitable.

Table 3 provides a means of qualitatively expressing the nuances and complexities which are obscured by our quantitative analysis. While this kind of research configuration can still be considered part of the broader dominance of higher income country institutions in lower income country research, this is clearly distinct from research undertaken exclusively by higher income country scholars. The table provides a framework which can structure discussion of research configurations in the conception stage of research, helping to avoid configurations and their effects being kept hidden, and in doing so enabling the proposal of risk mitigation measures and alternatives.

6. Conclusion and policy implications

Many of the claims and concerns discussed in this article are already well known, whether anecdotally or through awareness of critical theory such as post- or decolonial perspectives in other fields, such as development studies and economics. It may also resonate in some way with the lived experience of energy scholars, whether based in higher or lower-income countries. Our original contribution is to bring robust, quantitative evidence to these claims, in doing so enabling them to be taken more seriously by a wider range of actors and thus drive change. By organising our analysis around different aspects of dominance claims we seek to facilitate constructive discussion on how these effects might be confronted.

One could normatively question whether this research direction risks destabilising the foundations of broader energy research agendas seeking to facilitate provision of sustainable and inclusive energy services. This agenda often draws upon ways of knowing and knowledges stemming from higher income countries, and with this contributes towards recognised development outcomes desired by many in both higher and lower income countries.

Our response is that this line of enquiry is intended to be an uncompromising yet constructive critique of energy research practices, proposed by a group of scholars who acknowledge and value the transformative benefits which carefully-designed energy research has the potential to deliver.

Table 3
Illustrative research configurations in energy research related to lower income economies.

Illustrative research configuration	Authors	Research institutions	Financial support	Empirical research approach	Possible Risks
Research configuration 1: Higher income country lead author	Lead author is higher income country national, co-authors are lower income country nationals	Lead author research institution based in higher income countries, co-authors based in lower income countries	Higher income country Foundation that prioritises renewable energy	Fly-in, fly-out research trip by lead author to country of study	- Lead author research institution takes lead on research approach - likely to have stronger relationship with funders - despite having less contextual knowledge - Lead author may get credit for work which does not reflect the balance of effort undertaken - Possible exploitative relationship with uncredited local research partners
Research configuration 2: Lower income country lead author	Lead author is lower income country national, co-authors higher income country nationals	All research institutions based in higher income countries	Higher income country Foundation that prioritises renewable energy	Fly-in, fly-out research trip by lead author to country of study	- Lead author may be pressured to respond to research institution (e.g. supervisors, colleagues) and funder priorities and preferred methodologies - Lack of travel to the country of study may limit the quality of the results
Research configuration 3: Lower income country research team	Lead author and co-authors are Lower income country nationals	Research institutions based in lower income countries	Lower income country government	Fieldwork undertaken in the country of study	- Likely smaller scale of funding may limit research scope - May have lower capacity in accepted higher income country research approaches, alternative research approaches less recognised by the academy - Lack of high-visibility networks may make publishing in high impact journals challenging - Policymakers may privilege research from higher income countries
Research configuration 4: Higher income country research team	Lead author and co-authors are higher income country nationals	All research institutions based in higher income countries	Higher income country government	Fly-in, fly-out research trip by lead author to country of study	- Authors may lack contextual knowledge, apply frameworks and concepts from elsewhere - Challenges to meaningfully recognise 'local' perspectives in research - Due to familiarity of actors, research recognised by academy as authoritative on the country of study - Possible exploitative relationship with uncredited local research partners

Policy implications of this study leverages the evidence gathered here, especially reflecting on the need of contextualising local circumstances and needs of lower income countries in energy policy research and pedagogical development. Actors who do not consider the country of study to be home should ensure that the whole process through which research is undertaken embodies a sincere focus on local context and norms, as opposed to seeing this as a research obligation. Attention must be given to the coloniality of the funding organisation such that capacities are built using local researchers and indigenous knowledge transfer. Experiential learning between the local partner and funding agencies should prioritise local knowledge in research infrastructure and practices. This would ensure research funding flows to lower income countries where resources are severely limited, while allowing them to conduct the most relevant research, answering their specific research questions and proposing appropriate policy recommendations.

Experiential learning in this context should be encouraged through co-development of methods and experiments that can reflect the grounded realities of the energy research. This in turn, can ensure that the funding received from higher income countries exercise epistemic openness and care, giving thought to the understandings which are at work in published research calls and the ways of thinking which may be excluded by them.

LMIC policymakers should make institutional efforts to be aware of the extent to which the policies they adopt reflect Northern frameworks and perspectives and how much of that is applicable to their specific contexts. Such streamlined pedagogical and research focus could allow LMICs to close the energy justice gap by focusing on tailored policy-design and technologies.

We believe that there is both theoretical and practical value – in terms of the lived experience of researchers and the effect on a country's talent pool and policymaking capabilities - in understanding the dynamics of knowledge production processes related to the domain of energy research. Given the volume of academic output and funding related to energy research, scholarly practice and research funding decisions which are more mindful of these spatial dynamics – and actively avoid reproducing the kinds of problematic trends highlighted by our own results and by the work of other scholars summarised in Sections 2.2 and 2.3 - could help realise this value.

This paper's limitations largely relate to the data which was available, with which to conduct the analysis. In using recognised search repositories for top-tier journals, we potentially exclude many publications related to lower income countries. In excluding conference papers, we potentially missed some newer or more original contributions. However, we argue that robust, policy-relevant research typically finds form in a journal article eventually; if it doesn't, it is likely to either be of insufficient quality or the authors do not have the resources for it, which further reinforces the claims made in the article. Similarly, by using WoS results we exclude all journals not indexed in WoS, where many researchers from lower income countries may publish. Here, we again refer to power of influence.

While further research would be welcome in this area, we work under the assumption that research that is not indexed or published in international journals is significantly less likely to be seen by policymakers, let alone to inform policymaking. In this spirit, with regard to further studies, we would welcome research which engages with lower income country policymakers. This research could explore the extent to which they are influenced by the policy recommendations in academic publications, and which recommendations they are most keen to implement. These areas for further research – focused on how academic research disseminates, and how it is used – is indicated in Fig. 10.

CRediT authorship contribution statement

Muez Ali: Project administration, Conceptualization, Data curation, Formal analysis, Investigation, Software, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Lilia Caiado Couto:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Sam Unsworth:** Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Ramit Debnath:** Conceptualization, Formal analysis, Software, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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A. Appendix

Regression models

To test our hypothesis, we specify two regression models using:

$$log(C_i) = \beta_0 + \beta_1 \log(GDP_i) + \boldsymbol{X}_i^{'}\beta + \varepsilon_i$$

Where C_i is the number of citations, GDP_i is the GDP of the country of author, $\boldsymbol{X}_i^{'}$ is a K-dimensional vector of control variables and β is a (K x 1) vector of coefficients. The first, using the sample data aggregated at the country level, specifies C_i as total citations for the country of primary author as a function of the GDP of the country of primary author, the average SNIP journal rating for country of primary author, the average age of papers published by authors from that country and the average population of country of study. The second, using the sample data, disaggregated by individual paper, specifies C_i as the number of citations a paper receives as a function of the GDP of the country of primary author, the SNIP rating for the journal the paper is published in, the age of the paper and regional dummies.

To check if authors from high income countries are more likely to generalise (study multiple countries at once), we specify a logit model:

$$logit(p_i) = \alpha + \beta_0 GDP_i + \beta_1 Age_i + \boldsymbol{X}_i^{'}\beta$$

where p_i is the probability that the i^{th} paper is about multiple countries, Age_i is the age of the paper and $\boldsymbol{X}_i^{'}$ is a vector of regional dummies. The model estimates the log odds as a linear combination of the independent variables.

Table A.1
Robustness check using different journal metrics.

	Dependent variable:							
	Citations (log)							
	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
GDP	0.042***	0.017	0.042***	0.040***	0.044***	0.010	0.044***	0.042***
	(0.015)	(0.018)	(0.015)	(0.015)	(0.015)	(0.018)	(0.015)	(0.015)
SNIP	0.312***	0.310***	0.310***	0.313***				
	(0.025)	(0.025)	(0.025)	(0.026)				
SJR					0.140***	0.141***	0.139***	0.141***
					(0.034)	(0.034)	(0.034)	(0.034)
Age	0.012***	0.013***	0.012***	0.012***	0.011***	0.012***	0.011***	0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Africa	−0.102**	−0.123**	−0.107**	−0.113**	−0.111**	−0.138***	−0.116**	−0.121**
	(0.048)	(0.049)	(0.048)	(0.048)	(0.050)	(0.051)	(0.050)	(0.050)
China		0.081***				0.109***		
		(0.031)				(0.031)		
India			−0.074*				−0.077*	
			(0.045)				(0.045)	
Brazil				−0.194***				−0.178***
				(0.048)				(0.048)
Constant	0.006	0.293	0.006	0.036	0.344*	0.728***	0.343*	0.374**
	(0.186)	(0.219)	(0.186)	(0.186)	(0.189)	(0.221)	(0.189)	(0.190)
Observations	2,267	2,267	2,267	2,267	2,267	2,267	2,267	2,267
R^2	0.148	0.150	0.149	0.153	0.112	0.117	0.113	0.116
Adjusted R^2	0.146	0.148	0.147	0.151	0.111	0.115	0.112	0.115
Residual Std. Error	0.488 (df = 2262)	0.487 (df = 2261)	0.488 (df = 2261)	0.486 (df = 2261)	0.498 (df = 2262)	0.497 (df = 2261)	0.498 (df = 2261)	0.497 (df = 2261)
F Statistic	98.075*** (df = 4; 2262)	79.978*** (df = 5; 2261)	79.160*** (df = 5; 2261)	81.583*** (df = 5; 2261)	71.484*** (df = 4; 2262)	59.771*** (df = 5; 2261)	57.895*** (df = 5; 2261)	59.610*** (df = 5; 2261)

Note: *p<0.1; **p<0.05; ***p<0.01.

Table A.2
Robustness check using different measures of development (the Developed country variable is a binary variable which takes a value of 1 if the country of primary author is a developed country and 0 otherwise).

	Dependent variable:	
	Citations (log)	
	(16)	(17)
GDP per capita	0.072***	
	(0.023)	
Developed country		0.078***
		(0.025)
Citescore	0.036***	0.036***
	(0.005)	(0.005)
Age	0.013***	0.013***
	(0.002)	(0.002)
Africa	−0.080	−0.099**
	(0.050)	(0.048)
China	0.121***	0.148***
	(0.027)	(0.030)
Constant	0.433***	0.692***
	(0.110)	(0.055)
Observations	2,267	2,267
R^2	0.136	0.135

(*continued on next page*)

Table A.2 (*continued*)

	Dependent variable:	
	Citations (log)	
	(16)	(17)
Adjusted R^2	0.134	0.133
Residual Std. Error (df = 2261)	0.491	0.491
F Statistic (df = 5; 2261)	70.955***	70.711***

Note: *p<0.1; **p<0.05; ***p<0.01.

Table A.3
Regression results of regression on the likelihood of authors studying multiple countries in one paper.

	Dependent variable:		
	Multiple countries		
	(18)	(19)	(20)
GDP	0.219***		
	(0.067)		
GDP per capita		0.693***	
		(0.120)	
Developed country			0.861***
			(0.125)
Africa	−0.297	0.156	0.086
	(0.206)	(0.226)	(0.213)
China	−1.288***	−0.757***	−0.419**
	(0.156)	(0.154)	(0.174)
India	−0.521***	0.341	0.187
	(0.168)	(0.221)	(0.196)
Brazil	−1.158***	−0.787***	−0.480
	(0.298)	(0.305)	(0.314)
Age	0.027***	0.027***	0.028***
	(0.006)	(0.006)	(0.006)
Constant	−3.904***	−4.321***	−1.894***
	(0.814)	(0.542)	(0.125)
Observations	3,386	3,386	3,386
Log Likelihood	−1,726.589	−1,713.864	−1,705.458
Akaike Inf. Crit.	3,467.177	3,441.728	3,424.917

Note: *p<0.1; **p<0.05; ***p<0.01.

References

Adame, F., 2021. Meaningful collaborations can end 'helicopter research'. Nature. https://doi.org/10.1038/d41586-021-01795-1.

Amarante, V., Burger, R., Chelwa, G., Cockburn, J., Kassouf, A., McKay, A., Zurbrigg, J., 2021. Underrepresentation of developing country researchers in development research. Appl. Econ. Lett. 1–6. https://doi.org/10.1080/13504851.2021.1965528.

Backhouse, M., 2021. Global inequalities and extractive knowledge production in the bioeconomy. In: Backhouse, M., Lehmann, R., Lorenzen, K., Luhmann, M., Puder, J., Rodriguez, F., Tittor, A. (Eds.), Bioeconomy and Global Inequalities: Socio-Ecological Perspectives on Biomass Sourcing and Production. Springer International Publishing, pp. 25–44. https://doi.org/10.1007/978-3-030-68944-5_2.

Baganda, S.B., 2021. How the Global North Marginalises Local Researchers In the Global South. Africa at LSE. January 4 (Blog).

Birch, K., 2017. Techno-economic assumptions. Sci. Cult. 26 (4), 433–444. https://doi.org/10.1080/09505431.2017.1377389.

Bouzarovski, S., Petrova, S., Sarlamanov, R., 2012. Energy poverty policies in the EU: a critical perspective. Energy Pol. 49, 76–82. https://doi.org/10.1016/J.ENPOL.2012.01.033.

Bradley, M., 2008. On the agenda: North–South research partnerships and agenda-setting processes. Dev. Pract. 18 (6), 673–685. https://doi.org/10.1080/09614520802386314.

Castán Broto, V., Baptista, I., Kirshner, J., Smith, S., Neves Alves, S., 2018. Energy justice and sustainability transitions in Mozambique. Appl. Energy 228, 645–655. https://doi.org/10.1016/j.apenergy.2018.06.057.

Chelwa, G., 2021. Does economics have an 'Africa problem'? Econ. Soc. 50 (1), 78–99. https://doi.org/10.1080/03085147.2021.1841933.

Cornell University, INSEAD, WIPO, 2020. Global Innovation Index 2020: Who Will Finance Innovation?.

Cummings, S., Hoebink, P., 2017. Representation of academics from developing countries as authors and editorial board members in scientific journals: does this matter to the field of development studies? Eur. J. Dev. Res. 29, 369–383. https://doi.org/10.1057/s41287-016-0002-2.

Dauda, L., Long, X., Mensah, C.N., Salman, M., Boamah, K.B., Ampon-Wireko, S., Kofi Dogbe, C.S., 2021. Innovation, trade openness and CO2 emissions in selected countries in Africa. J. Clean. Prod. 281, 125143 https://doi.org/10.1016/j.jclepro.2020.125143.

Debnath, R., Bardhan, R., Darby, S., Mohaddes, K., Sunikka-Blank, M., Coelho, A.C.V., Isa, A., 2021. Words against injustices: a deep narrative analysis of energy cultures in poverty of Abuja, Mumbai and Rio de Janeiro. Energy Res. Social Sci. 72, 101892 https://doi.org/10.1016/j.erss.2020.101892.

Debnath, R., Simoes, G.M.F., Bardhan, R., Leder, S.M., Lamberts, R., Sunikka-Blank, M., 2020. Energy justice in slum rehabilitation housing: an empirical exploration of built environment effects on socio-cultural energy demand. Sustainability 12 (7), 3027. https://doi.org/10.3390/su12073027.

Delina, L.L., 2020. A rural energy collaboratory: co-production in Thailand's community energy experiments. Journal of Environmental Studies and Sciences 10 (1), 83–90. https://doi.org/10.1007/s13412-019-00572-x.

Dhareshwar, V., 1998. Valorizing the present: orientalism, postcoloniality and the human sciences. Cult. Dynam. 10 (2), 211–231. https://doi.org/10.1177/092137409801000208.

Elabor-Idemudia, P., 2011. Identity, representation, and knowledge production. Indigenous Philosophies and Critical Education: A READER Counterpoint 379, 142–156.

Fanon, F., 2002. *Black Skin, White Masks* (Pluto Classics). Pluto Press.

Garces, E., Tomei, J., Franco, C.J., Dyner, I., 2021. Lessons from last mile electrification in Colombia: examining the policy framework and outcomes for sustainability. Energy Res. Social Sci. 79, 102156 https://doi.org/10.1016/j.erss.2021.102156.

Grieve, T., Mitchell, R., 2020. Promoting meaningful and equitable relationships? Exploring the UK's global challenges research fund (GCRF) funding criteria from the perspectives of African partners. Eur. J. Dev. Res. 32 (3), 514–528. https://doi.org/10.1057/s41287-020-00274-z.

Hamadeh, N., van Rompaey, C., Metreau, E., 2021. New World Bank country classifications by income level: 2021-2022. July 1 World Bank Blogs (Blog). https://blogs.worldbank.org/opendata/new-world-bank-country-classifications-income-level-2021-2022.

Healy, N., Stephens, J.C., Malin, S.A., 2019. Embodied energy injustices: unveiling and politicizing the transboundary harms of fossil fuel extractivism and fossil fuel supply chains. Energy Res. Social Sci. 48, 219–234. https://doi.org/10.1016/j.erss.2018.09.016.

Horner, R., 2020. Towards a new paradigm of global development? Beyond the limits of international development. Prog. Hum. Geogr. 44 (3), 415–436. https://doi.org/10.1177/0309132519836158.

Horta, H., Shen, W., 2020. Current and future challenges of the Chinese research system. J. High Educ. Pol. Manag. 42 (2), 157–177. https://doi.org/10.1080/1360080X.2019.1632162.

Jenkins, K., McCauley, D., Heffron, R., Stephan, H., Rehner, R., 2016. Energy justice: a conceptual review. Energy Res. Social Sci. 11, 174–182. https://doi.org/10.1016/J.ERSS.2015.10.004.

Karlsson, S., Srebotnjak, T., Gonzales, P., 2007. Understanding the North–South knowledge divide and its implications for policy: a quantitative analysis of the generation of scientific knowledge in the environmental sciences. Environ. Sci. Pol. 10 (7–8), 668–684. https://doi.org/10.1016/J.ENVSCI.2007.04.001.

Mahvunga, C., 2017. Introduction: what do science, technology, and innovation mean from Africa. In: Mahvunga, C. (Ed.), What Do Science, Technology, and Innovation Mean from Africa? MIT Press.

Mbembe, A., 1992. Provisional notes on the postcolony. Africa: Journal of the International African Institute 62 (1), 3–37. https://doi.org/10.2307/1160062.

Mignolo, W.D., 2009. Epistemic disobedience, independent thought and decolonial freedom. Culture & Society 26 (8), 159–181. https://doi.org/10.1177/0263276409349275.

Minasny, B., Fiantis, D., Mulyanto, B., Sulaeman, Y., Widyatmanti, W., 2020. Global soil science research collaboration in the 21st century: time to end helicopter research. Geoderma 373, 114299. https://doi.org/10.1016/j.geoderma.2020.114299.

Monyei, C.G., Jenkins, K., Serestina, V., Adewumi, A.O., 2018. Examining energy sufficiency and energy mobility in the global south through the energy justice framework. Energy Pol. 119, 68–76. https://doi.org/10.1016/j.enpol.2018.04.026.

Ndlovu, M., 2017. Being African and innovative: a decolonial perspective. In: Muchie, M., Gumede, V., Oloruntoba, S., Achu Check, N. (Eds.), Regenerating Africa. Africa Institute of South Africa, pp. 152–166. https://doi.org/10.2307/j.ctvh8r2t1.15.

Nielsen, M.W., Andersen, J.P., 2021. Global citation inequality is on the rise. Proc. Natl. Acad. Sci. USA 118 (7), e2012208118. https://doi.org/10.1073/pnas.2012208118.

Normile, D., 2020. China again boosts R&D spending by more than 10%. August 28 Science.

Overland, I., Fossum Sagbakken, H., Isataeva, A., Kolodzinskaia, G., Simpson, N.P., Trisos, C., Vakulchuk, R., 2021. Funding flows for climate change research on Africa: where do they come from and where do they go? Clim. Dev. 1–20. https://doi.org/10.1080/17565529.2021.1976609.

Pachauri, S., Spreng, D., 2011. Measuring and monitoring energy poverty. Energy Pol. 39 (12), 7497–7504. https://doi.org/10.1016/J.ENPOL.2011.07.008.

Pasgaard, M., Dalsgaard, B., Maruyama, P.K., Sandel, B., Strange, N., 2015. Geographical imbalances and divides in the scientific production of climate change knowledge. Global Environ. Change 35, 279–288. https://doi.org/10.1016/j.gloenvcha.2015.09.018.

Porteous, O., 2021. Research Deserts and Oases: Evidence from 27 Thousand Economics Journal Articles.

Shove, E., Watson, M., Spurling, N., 2015. Conceptualizing connections: energy demand, infrastructures and social practices. Eur. J. Soc. Theor 18 (3), 274–287. https://doi.org/10.1177/1368431015579964.

Sovacool, B.K., 2014. What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda. Energy Res. Social Sci. 1, 1–29. https://doi.org/10.1016/j.erss.2014.02.003.

Sovacool, B.K., Hook, A., Martiskainen, M., Brock, A., Turnheim, B., 2020. The decarbonisation divide: contextualizing landscapes of low-carbon exploitation and toxicity in Africa. Global Environ. Change 60, 102028. https://doi.org/10.1016/j.gloenvcha.2019.102028.

Star, S.L., 1999. The ethnography of infrastructure. Am. Behav. Sci. 43 (3), 377–391. https://doi.org/10.1177/00027649921955326.

Tigabu, A.D., Berkhout, F., van Beukering, P., 2015. The diffusion of a renewable energy technology and innovation system functioning: comparing bio-digestion in Kenya and Rwanda. Technol. Forecast. Soc. Change 90, 331–345. https://doi.org/10.1016/j.techfore.2013.09.019.

Tilley, E., Kalina, M., 2021. “My flight arrives at 5 am, can you pick me up?”: the gatekeeping burden of the African academic. J. Afr. Cult. Stud. 33 (4), 538–548. https://doi.org/10.1080/13696815.2021.1884972.

Vincent, K., Carter, S., Steynor, A., Visman, E., Wågsæther, K.L., 2020. Addressing power imbalances in co-production. Nat. Clim. Change 10 (10), 877–878. https://doi.org/10.1038/s41558-020-00910-w.

Warren, P., 2020. Evidence reviews in energy and climate policy. Evid. Policy A J. Res. Debate Pract. 16 (1), 83–98. https://doi.org/10.1332/174426418X15193815413516.

Web of Science, 2021. Energy developing countries (all fields) - 6,636 - Web of science core collection. https://www.webofscience.com/wos/woscc/summary/646770b3-315e-4b27-86a8-290577a11b10-0061b916/relevance/1.

Wolf, D.L., 1996. Feminist Dilemmas in Fieldwork, first ed. Routledge.

World Bank, 2021a. GDP (current US$). In: World Development Indicators Database (GDP.MKTP.CD). https://data.worldbank.org/indicator/NY.

World Bank, 2021b. GNI per capita, Atlas method. In: World Development Indicators Database. https://data.worldbank.org/indicator/NY.GNP.PCAP.CD.

Yuliani, D., 2017. Is feed-in-tariff policy effective for increasing deployment of renewable energy in Indonesia? In: Arent, D., et al. (Eds.), The Political Economy of Clean Energy Transitions. Oxford University Press. https://doi.org/10.1093/oso/9780198802242.003.0008, 0. Available at: