Proximity and Inequality in Academia

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Introduction

Besides education and outreach, universities matter through the generation and dissemination of new knowledge. However, in the hierarchical global science system, not all universities and researchers can matter equally in the sense of being able to showcase their work and findings on a global scale. Depending on their positions in the persistent core–semi-periphery–periphery structure of science, the building of scientific capital and the dissemination of ideas will be easier for some universities and researchers than for others. In this context, collaboration between universities in core and peripheral positions of global academia is a strategy aiming to make more universities matter, yet it bears the risk of perpetuating existent inequalities. The aim of this chapter is to explore how and why universities collaborate to matter—not only with regard to their proximity in various dimensions, but in light of global inequality of scientific capital. Acknowledging that this is only one potential way of mattering which is not prioritized by every university or researcher, mattering will be understood here in the sense of the production and worldwide dissemination of knowledge.

To some extent, inequality appears to be inherent to academia. The production of scientific knowledge is a social enterprise whose organization relies on mechanisms such as peer review and markers of quality ascribed to journals, affiliations, and prices. In this system, resources and rewards are distributed based on the perception and recognition of the respective scientific communities. While these processes are in place to warrant higher degrees of quality and objectivity of scientific work, they simultaneously cement a stratified landscape and grant gatekeeping positions to the already eminent individuals and institutions. Consequently, systems of knowledge

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P. Mattsson et al. (eds.), *Making Universities Matter*, Innovation, Technology, and Knowledge Management, https://doi.org/10.1007/978-3-031-48799-6_3

production mirror the mechanisms of inequality, asymmetry, and marginalization that exist in society as a whole. At the same time, science is understood as a public resource that should be social both in its practice and in the uses it serves. Therefore, a greater number of points of view represented in the scientific community promotes not only higher degrees of objectivity but also the societal relevance of scientific work (Dupree & Boykin, 2021; Hwang, 2008; Longino, 1990; Merton, 1968, 1973).

Unequal opportunities for researchers to build scientific capital prevail within countries, for example, based on gender, ethnicity, social class, or disability. Moreover, because of the mechanisms of concentration of scientific capital, geography is a crucial factor in determining an individual's or a university's potential to matter in global academia. While core–periphery structures can be observed on all scales, including regional and national, the focus of this chapter will be on inequality in global academia, specifically in collaborations between high-, middle-, and low-income countries. In this context, it has to be acknowledged that the inequality of scientific capital between countries today is to a large extent rooted in the colonial history of science and perpetuated by neo-colonial practices, including the systematic devaluation of non-Western forms of knowledge creation (Alatas, 2008; Connell, 2014; Mignolo, 2011; Radosevic & Yoruk, 2014). Largely in line with the overall economic and political power structures, the global scientific landscape shows a persistent core–semi-periphery–periphery structure. Just like in trade, exchanges between stronger and weaker countries in this structure can, on the one hand, lead to an accumulation of resources and surpluses in the core and on the other hand provide an opportunity to enlarge the group of participants and beneficiaries of the scientific enterprise (Schott, 1998; Wallerstein, 2004). The core areas, for the most part concentrated in high-income countries in Western Europe, North America, and East Asia, hold the lion's share of financial resources, host the most renowned universities and the majority of influential publishers, and attract the most human capital in the form of students and scholars. On the other hand, due to scarcer resources and opportunities in middle- and low-income countries, universities and researchers in more peripheral regions are often reliant on ties to the core in building their scientific capital. These ties and the centrality of the core can be observed in asymmetrical mobility patterns as well as asymmetrical citation and collaboration networks (Boshoff, 2010; Chinchilla-Rodríguez et al., 2018; Confraria et al., 2017; Demeter, 2019; Jonkers & Cruz-Castro, 2013; Martinez & Sá, 2020; Mêgnigbêto, 2013; Morley et al., 2018; Pasterkamp et al., 2007; Schott, 1998; Siekierski et al., 2018; Sweileh, 2022; Verginer & Riccaboni, 2020). However, a strict core–periphery dichotomy is overly simplistic and lacks nuance. Instead, a multilayered approach accounts for semi-peripheries that may perform core functions for the periphery while still being peripheral to the core. Furthermore, the scientific landscape is evolving dynamically and becoming increasingly multipolar with newly emerging science powers, most prominently China (Czaika & Orazbayev, 2018; Hwang, 2008; Oldac, 2023; Radosevic & Yoruk, 2014).

In the context of inequality in global academia, ties between high-, middle-, and low-income countries are particularly worthwhile to examine. These may form through mobility and collaboration decisions of individual researchers; however,

they are also subject to science diplomacy, incentive structures, and policies that shape the environment in which academic mobility and collaborations take place. International research collaborations between high- and low-income countries have become the main strategy in aiming to build scientific capacity in low-income countries and a major target of funding schemes of institutions in high-income countries (Bauder, 2015; Bradley, 2017; Flink, 2022; Flink & Schreiterer, 2010; Mattsson et al., 2010; Moyi Okwaro & Geissler, 2015; Wagner & Leydesdorff, 2005; Wagner et al., 2001, 2015). Scarcity of funding, lack of infrastructure, fewer employment opportunities, and fewer opportunities to publish are major factors prompting researchers in peripheral regions to relocate or enter collaborations with researchers in the core (Arocena & Sutz, 2001; Grieve & Mitchell, 2020; Muriithi et al., 2018; Wight et al., 2014). Despite the ubiquity of inequality in global academia and many empirical studies illustrating examples of inequitable collaborations between high-, middle-, and low-income countries, there is little consideration of inequality in science on a theoretical level (Hwang, 2008). Instead, one of the most prominent concepts aiming to explain why and how researchers collaborate is that of proximity.

There is abundant evidence showing that proximity is simultaneously an important precondition for and an outcome of scientific collaboration. This includes geographical proximity as well as cognitive, social, organizational, and institutional proximity in addition to other dimensions that will not be at the focus of this chapter (Boschma, 2005; Katz, 1994). Frenken et al. (2009) defined the dimensions of proximity for academic research collaborations as follows. Cognitive proximity is understood as the extent to which knowledge bases between two researchers overlap. Social proximity involves trusting relationships maintained with colleagues. Organizational proximity refers to a common hierarchical control two actors might be under. Ultimately, institutional proximity refers to similarity in the incentive structures under which researchers operate. Importantly, the concept of proximity, which originated in the fields of geography and business studies, is largely based on experiences in Europe (Hansen, 2015; Hoekman et al., 2010), North America (Saxenian, 1996), and more recently China (Scherngell & Hu, 2011). Only a few studies (Cassi et al., 2015; Gui et al., 2018) have considered the role of proximity in scientific collaborations beyond high-income countries. Hence, there have been calls for future research to investigate proximity in research collaborations across more continents and over larger geographical distances (Bergé, 2017; Werker & Ooms, 2020). While it has been acknowledged that proximity is not static and is potentially asymmetrical, implying that one party can be more proximate to a counterpart than vice versa (Balland et al., 2015; Boschma et al., 2016; Fiorini et al., 2021; Korbi & Chouki, 2017), inequality of scientific capital between collaborating researchers is barely touched upon in the proximity literature. However, considering the inequality of opportunities to build scientific capital along with spatial and non-spatial dimensions of proximity provides a more comprehensive picture of how and why researchers collaborate between core and more peripheral regions. Accordingly, the research question to be advanced in this critical narrative review is: how can the concept of proximity be expanded with notions of inequality of scientific capital between high-, middle-, and low-income

countries in order to gain a more thorough understanding of international research collaborations?

This chapter will be structured as follows. In the next section, inequality in global academia will be defined and exemplified using the concept of scientific and technical human capital. In the method section, the choice of critical narrative review and procedure will be described. The results section presents the findings of the narrative review as structured by five dimensions of proximity. The discussion section comprises a critical discussion of the findings. The final section summarizes the chapter.

Defining Inequality in Academia

The global scientific landscape constitutes an uneven playing field for researchers, depending among other things on their location in high-, middle-, or low-income countries. Scientific and technical human capital and opportunities to acquire it are distributed unequally within countries, for instance, based on gender, ethnicity, social class, or disability. Simultaneously, opportunities to acquire such capital are very unequally distributed between countries, depending on historically inherited advantages and disadvantages shaped by colonialism. Respective advantages and disadvantages tend to accumulate over time in the academic careers of individuals (Alatas, 2008; Dupree & Boykin, 2021; Martinez & Sá, 2020; Morley et al., 2018; Radosevic & Yoruk, 2014). In the following, different aspects of inequality in academia will be illustrated on the basis of the concept of scientific and technical human capital. The framework of scientific and technical human capital puts a focus on developing capacity at the individual, team, organization, or field level. Scientific and technical human capital has been defined as the sum of scientific, technical, and social knowledge, skills, and resources embodied in an individual. It further comprises a researcher's professional network ties, including links to institutions that produce, consume, and disseminate knowledge (Bozeman & Boardman, 2014; Bozeman & Corley, 2004). In the following, three levels of inequality of scientific and technical human capital in global academia will be outlined. These will be structured according to Bozeman and Boardman's (2014) distinction of material resources, capital embodied in people, and social structures and norms.

Firstly, inequality at the level of material inputs, both tangible and intangible, will be illustrated. These include financial resources, which arguably translate to time availability, and access to data or infrastructure. One of the most obvious issues of inequality between core, semi-periphery, and periphery is the access to financial resources. The bulk of scientific funding continues to be concentrated in a few countries in North America, Western Europe, and East Asia. Funding from high-income countries also makes up a significant share of the budgets of universities in middle- and low-income countries. While this enables more researchers to be employed locally, it always bears the risk of creating asymmetrical partnerships with success and desirable outcomes defined by the interests of those in the core. Closely linked to

the availability of financial resources is also the question of time availability in light of teaching responsibilities and other forms of employment researchers take on that are not related to their own projects and research priorities (Bradley, 2008; Collyer, 2018; Dean et al., 2015; Petersen, 2021). Besides financial resources, including funding and employment, there are other material forms of scientific and technical human capital that are distributed unequally. These include the access to costly databases such as Web of Science and Scopus, as well as to libraries, software, and communication technology. At the same time, the work of scholarship from more peripheral regions tends to be less accessible and not prioritized in university libraries and academic databases. Furthermore, laboratories and high-technology infrastructure have long been concentrated in high-income countries exclusively (Demeter, 2019; Moosavi, 2020; Muriithi et al., 2018; Rüland et al., 2023; Schmidt, 2020; Tetteh et al., 2020; Ynalvez & Shrum, 2008).

Secondly, inequality of human capital embodied in researchers and research support is distributed unequally. Most commonly, human capital is operationalized through formal training. In the academic system, education is symbolized by certificates, degrees, diplomas, and fellowships. The status of these markers largely depends on the location from which they are issued, underlining the significance of student mobility (Demeter, 2019; Morley et al., 2018; Tetteh et al., 2020; Wu & Zha, 2018). Moreover, researchers' human capital is frequently equated with their record of scholarly publishing. Worldwide, scientific evaluation is to a large extent measured by the number of articles published in recognized journals according to the international standards of each field. At the same time, 70% of the top publishers have their headquarters in North America and Europe, granting these private companies great influence on knowledge production worldwide and a potential gatekeeping function. As a consequence, these publishers have a major influence on defining the norms and standards of what is considered good science. This includes methodology, stylistic models, and the structuring of arguments as well as English as the main language of scientific publishing. Moreover, there is a general underrepresentation of peripheral, non-native English-speaking scientists in the editorial advisory boards of international journals, which has been shown to be coupled with the composition of authorship in terms of nationality of these journals. While there are also countries in core regions where English is not the native language, these are usually better equipped with training in scientific writing or have larger budgets available for specialized editorial staff (Arocena & Sutz, 2001; Collyer, 2018; Hanafi, 2011; Salager-Meyer, 2008).

Thirdly, social structures and norms define scientific and technical human capital, especially with regard to recognition, credibility, and research priorities. Although alternative metrics are being introduced incrementally, the most common form of recognition in the academic system continues to be citations. Scholars from both core and peripheral regions all tend to cite research produced in the core more frequently. This can be explained by the wide-ranging mechanisms of accumulation and concentration of recognition in science, also called the Matthew effect, which describes the systematic allocation of rewards and resources to the already eminent researchers. It has been shown that this effect also applies at the level of countries so that authors

from a few core countries are disproportionately cited compared to authors from other regions, even when published in the same journal. It is also worth noting that research conducted in middle- and low-income countries tends to be underrepresented in the most commonly used scientific databases and libraries (Bonitz et al., 1997; Collyer, 2018; Desrochers et al., 2018; Merton, 1968; Schmidt, 2020). These asymmetrical citation patterns are also rooted in notions of credibility, which are ascribed to individuals and institutions. As credibility assessment is typically based on the standards of good science as defined by dominant scholars and publishers in the core, other groups suffer a systematic credibility deficit in academia. As a consequence, credibility is often acquired through scientific mobility or collaboration. Collaborations with researchers in the core have been shown to serve as a kind of admission ticket for international visibility. Researchers in more peripheral regions of the science system frequently face a credibility deficit, making it difficult to even speak on issues of peripheral regions without an elite Western education (Bhakuni & Abimbola, 2021; Demeter, 2019; Martinez & Sá, 2020; Mohanty, 2003; Morley et al., 2018). Besides credibility deficits, actors in peripheral positions of the science system may also suffer from interpretative marginalization, meaning that they are not prioritized as recipients of processes of knowledge creation and they are excluded from the circulation of the knowledge produced. Clearly, social structures and norms also shape research priorities and agendas. To participate in international science, academic elites in more peripheral regions frequently adopt the research priorities defined in the core. For researchers in middle- or low-income countries, this can potentially cause conflict as they have to weigh locally relevant research problems against prospects of international publishing. Moreover, there appears to be a general understanding that theory generated in the core of the science system is universally relevant and placeless, while research from more peripheral regions is understood as case studies or merely context-specific. Research and theories developed in high-income countries are considered credible and receive more citations, whereas the role of low-income countries is often reduced to providers of raw data, case studies, and examples for application of the dominant theories (Ergin & Alkan, 2019; Hanafi, 2011; Mbaye et al., 2019; Nagendra et al., 2018; Pasterkamp et al., 2007). Furthermore, there is criticism regarding practices and terminology of fieldwork, extractive approaches to data collection, disregard of Southern Theory, and power imbalances in research partnerships (Boshoff, 2009; Connell, 2014; Gunasekara, 2020; Mawere & van Stam, 2019; Munung et al., 2017; Nhemachena et al., 2016).

In conclusion, scientific and technical human capital—in material forms, embodied in people, and in social structures and norms—is very unequally distributed across the world. Throughout scientific careers, these comparative advantages and disadvantages add up and usually solidify the status quo. Consequently, inequality prompts researchers in different regions of the global science system to pursue distinct strategies in aiming to build their scientific capital. Being internationally mobile and forming research collaborations can be a means to strategically build and deploy scientific and technical human capital (Bozeman & Corley, 2004; Jonkers & Cruz-Castro, 2013). In the context of geographical disparity in global academia, proximity is a highly relevant notion. However, the theoretical concept of proximity

barely touches on inequality in the context of scientific collaboration. Hence, in the following, these two streams of literature and their interconnection will be explored and synthesized.

Method

To approach the research question of how the concept of proximity can be expanded to account for inequality of scientific capital, a critical narrative review has been conducted. As opposed to a systematic literature review, this approach allows for more flexibility in the inclusion criteria of articles and the subjective focus on specific aspects—in this case the relation of proximity and inequality in research collaborations—while summarizing a stream of literature and conducting an interpretative analysis (Thomas et al., 2020). As the purpose of the narrative literature review is to highlight specific aspects of the literature, one cannot assert claims on completeness as one could with a systematic literature review. The literature search procedure will be outlined in the following.

Literature searches were conducted in the databases of Web of Science, Scopus, and Google Scholar between March 2021 and June 2023. As a first step, this was done separately for the literature on proximity in the context of research collaboration, on the one hand, and between-country inequality in academia, on the other hand, to become familiar with both concepts. Next, the articles were read and screened with a special focus on the notion of proximity in the inequality literature and vice versa. From there, further articles were included using snowball sampling as well as recommendations resulting from conversations with colleagues, research talks, or discussions. The first searches and consecutive screening of the literature revealed no apparent overlap between the two streams of literature.

Next, in order not to overlook research papers covering proximity and inequality in academia, the keywords were searched jointly, employing all combinations of terms displayed in Table 1. The search terms included "proximity" in relation to "inequality," "inequity," or "asymmetry." Because all of these terms are highly ambiguous and utilized in a plethora of fields and disciplines, the terms "research collaboration," "academia," and "scientific collaboration" were combined with the search terms. Nonetheless, the search yielded many articles not related to proximity in the context of scientific collaboration, and only the ones that did were included in the further analysis. Additionally, to specify the geographical scope of the search, terms such as "Global South," "emerging countries," "developing countries," and "periphery" as well as continents and selected individual country names were combined with the search terms. In the last step, searches for the terms "asymmetry" and "inequality" were conducted among some of the most widely cited papers on proximity, namely, Boschma (2005) and Knoben and Oerlemans (2006).

Table 1 Combinations of search terms

Search term 1	Search term 2	Demarcation	Geographical markers
"Proximity"	"Inequality"	"Scientific collaboration"	"Global South"
	"Inequity"	"Research collaboration"	"High-, middle-, low-income country"
	"Asymmetry"	"Academia"	"Developing countries"
			"Emerging countries"
			"Periphery"
			"Asia"/ "Latin America"/ "Africa"
			"India"/ "Nigeria"/ "South Africa"/…

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In the following section, the literature on proximity in scientific collaborations will be summarized, placing a special focus on the coverage of the topic of inequality of scientific capital between high-, middle-, and low-income countries. As summarized in Table 2, the literature search did not show a big overlap of the streams of literature on proximity and inequality or asymmetry in academia, neither in terms of simultaneous use nor in terms of citations. Moreover, the geographical scope of the proximity literature appears to be limited to high- or upper-middle-income countries in Western Europe, North America, and East Asia. The proximity literature appears to be a comparatively structured stream with, of course, a focus on theory, as implied by the concept of proximity. Literature on inequality in academia, on the other hand, appears largely unstructured with plenty of empirical examples but typically no theoretical framing. Accordingly, the critical narrative review will aim to synthesize and show potential interlinkages of these bodies of literature in order to expand the notion of proximity as an explanation for research collaboration.

The most commonly used dimensions of proximity that characterize partnerships in scientific collaborations are geographical, cognitive, social, organizational, and institutional. These dimensions of proximity are interrelated in complex ways and

Table 2 Comparison of the literature streams on proximity and inequality in academia

Proximity in research collaboration	Between-country inequality in academia
Proximity as a theoretical framework	Typically case studies without a theoretical framework
Fairly structured stream of literature	Comparatively unstructured and unconnected stream of literature
Strong geographical focus on Western Europe, North America, and to some extent East Asia	Examples from diverse geographical regions, including Asia, Latin America, Eastern Europe, and Africa

are dynamic in nature. Proximity is typically conceptualized as a spectrum whose optimum is expected between the extremes. On the one hand, a high degree of proximity between two parties facilitates communication and reduces costs of interaction but can lead to lock-in with a low inflow of new ideas. On the other hand, a low degree of proximity offers more potential for learning while requiring more effort in communication and logistics. It has been recognized that proximity is not necessarily symmetrical in nature, implying that one partner can be more proximate to another in a certain dimension than vice versa (Balland et al., 2015; Boschma, 2005; Frenken et al., 2009; Hansen, 2015). In the following, the geographical, cognitive, social, organizational, and institutional dimensions of proximity will be discussed and related to inequality in global science.

Geographical Proximity

It is well established that the greater the geographical distance is between two researchers, the less likely they are to collaborate. Geographical proximity is assumed to increase the likelihood of serendipitous encounters and to facilitate face-to-face interactions, which ultimately contribute to the building of trust and the transfer of tacit knowledge. The importance of geographical proximity and the strong tendency to collaborate with researchers who are geographically close are two of the mechanisms that contribute to the highly concentrated structures in the global system of knowledge production (Frenken et al., 2009; Katz, 1994; Nilsson, 2019; Plotnikova & Rake, 2014; Ponds et al., 2007). Geographical proximity is to a large degree intertwined with non-spatial dimensions of proximity. Some of these are found to overlap with the effect of geography, whereas others can substitute for it and thus potentially compensate for the lack of geographical proximity. In previous studies, organizational and cognitive proximities were found to substitute for geographical proximity, while the effect of geographical proximity overlaps with institutional proximity (Hansen, 2015). The relation of geographical proximity and social proximity shows both overlap and substitution mechanisms.

Although more static than the non-spatial forms of proximity, even geographical proximity in global academia can be understood as dynamic (Balland et al., 2015). In fact, it is extremely common for scientists to relocate throughout their careers. Along with collaboration, academic mobility is a common strategy to acquire scientific capital, especially for researchers in more peripheral areas of the science system. To increase geographical proximity and opportunities for collaboration, researchers frequently relocate to different countries or cities. Globally, patterns of scientific mobility are asymmetrical, with the hubs in high-income countries being the most attractive to researchers worldwide. In turn, this potentially reinforces existing inequalities as the most scientifically advanced nations profit disproportionately from the achievements of foreign-born and foreign-educated academics (Bozeman & Corley, 2004; Jonkers & Cruz-Castro, 2013; Stephan & Levin, 2001; Verginer & Riccaboni, 2020). Arocena and Sutz (2001) describe migration as a

survival strategy for researchers in low- or middle-income countries, enabling them to access salaries and conditions for better academic productivity in the competitive science system. Resource constraints and limited employment opportunities in academia in the respective home countries are major reasons to be internationally mobile (Morley et al., 2018; Ynalvez & Shrum, 2008). According to Siekierski et al. (2018), the most important factor in making a location attractive to international academic mobility is the scientific and technological infrastructure it offers. Recognition as a center of excellence, presence of prestigious scientific journals, and opportunities to learn were rated as more important sources of motivation than a higher standard of living in the host country. Similarly, Franzoni et al. (2012) found that improving future career prospects, outstanding faculties and research teams, excellence of the foreign institution, and opportunities to extend one's personal network were the most important motivations for academic mobility regardless of the country of destination. On the other hand, personal or family reasons have been named as a major motivation to re-migrate, and for many, returning home is conditional on employment opportunities. Hence, the attractiveness of a location is largely defined by the opportunities it offers for researchers to build scientific and technical human capital (Jonkers & Cruz-Castro, 2013).

Generally, the reasons for academics to be mobile are manifold and highly individual; however, there is a structural dimension to many of them as there are unequal patterns as to who can be internationally mobile and which countries benefit from scientists' mobility. Opportunities to be internationally mobile—short-term or long-term—and thus to build scientific capital are distributed unequally within and between countries. Junior researchers tend to be more internationally mobile than senior researchers, and male academics tend to be more mobile than females. A financially stable background and few care responsibilities appear as enabling factors of international mobility, constituting an opportunity mostly for middle-to-upper class individuals, especially in middle- or low-income countries, and reinforcing gender inequality in academia (Bauder, 2015; Demeter, 2019; Morley et al., 2018; Tomassini, 2021). Opportunities for scientific mobility are distributed unequally between countries not only because of a lack of financial means but also because of visa and travel restrictions, which tend to affect researchers in middle- and low-income countries more than researchers with citizenship in many high-income countries (Chinchilla-Rodríguez et al., 2018; Orazbayev, 2017). In that sense, one could argue that even geographical proximity is asymmetrical.

The duration of labor mobility in academia is highly variable, ranging from permanent relocation, to short-term stays, to a transnational orientation with affiliations in multiple countries (Bauder, 2015). In aiming to reduce geographical proximity to build scientific capital, not only long-term relocation but also short-term stays should be considered. As the cost of travel decreases and remote communication is facilitated, the importance of permanent geographical proximity for the co-creation of knowledge is being reassessed. While some have speculated that the relevance of geographical proximity could diminish to a large extent, Torre (2008) emphasizes that face-to-face interaction is still necessary for the exchange of ideas. He presents the concept of temporary geographical proximity in potentially replacing the need for

permanent colocation. Specifically, certain phases in the collaboration might require more proximity than others, for instance, the exchange of tacit knowledge in early stages (Knoben & Oerlemans, 2006). In later stages of collaboration, communication across larger geographical distances is facilitated by other non-spatial forms of proximity between actors. Werker and Ooms (2020) find that the combination of temporary geographical proximity and modern communication tools allows for collaborations at larger geographical distances than were previously possible.

Generally, short-term colocation can offer a chance for serendipitous encounters between scholars from core and more peripheral regions, which large geographical distances often prevent. At the same time, opportunities to partake in short-term mobility are very unequally distributed among researchers from high-, middle-, and low-income countries, reinforcing inequality with regard to building scientific capital. For example, there are many potential barriers to attendance at conferences. Typically, potential attendees' abstracts must be accepted by the organizing committee in a peer review process, and the conference fees are often high (Chai & Freeman, 2019). Additionally, participants need to finance the travel costs, which are typically higher the farther away they live from the conference location. Moreover, their work schedules and personal circumstances need to allow them to be away for the given amount of time. However, researchers who have the chance to participate in such events potentially benefit from the access to new networks, enabling a greater integration of the global scientific community. Chai and Freeman (2019) have shown that attending the same conference can increase the likelihood of collaboration between two researchers who have not co-published before. Moreover, the distant ties that can form through temporary colocation are particularly important as they tend to be more diverse than local ties and thus counteract cognitive lock-in. According to Nilsson (2019), social ties between geographically distant researchers can be maintained through temporary geographical proximity or virtual proximity in technology-mediated interaction.

International mobility for the purpose of reducing geographical proximity can offer benefits to the individuals, organizations, and countries participating in it; however, it comes with a risk of reproducing social and national hierarchies and an unequal distribution of benefits across continents (Morley et al., 2018; Stephan & Levin, 2001; Wagner et al., 2001). Highly educated labor mobility generates unequal outcomes for different countries and contributes to the concentration of scientific capital in the core. Verginer and Riccaboni (2020) have found that certain countries, including emerging economies such as India, are negatively affected by international exchange. In turn, the United States has been shown to disproportionally benefit from the scientific achievements of foreign-born and foreign-educated researchers. China has benefited from international mobility of scientists by encouraging their mobility and successfully attracting them back. On an individual level, researchers who maintain professional ties to their country of origin while located in a scientifically more advanced country can contribute to the building of scientific capital by channeling resources or training young scientists in their home country. In conclusion, the outcomes of relocation from peripheral regions to the core are complex. There is evidence supporting brain drain and brain gain effects, on the one hand,

and evidence supporting the brain circulation hypothesis (Saxenian, 2005), which emphasizes simultaneous benefits for sending and receiving countries, on the other hand.

For researchers located in middle- or low-income countries, the lack of geographical proximity to the core and comparatively fewer opportunities to be mobile can constitute a disadvantage in building scientific capital. Consequently and along with other factors, geography can be a source of inequality for researchers that upholds barriers. These include access to the world's most eminent institutions and influential collaborators as defined by the social norms of the science system, as well as access to the material resources and infrastructure, which are most advanced in the core areas. This underlines the interconnectedness of proximity and inequality in aiming to understand scientific collaboration. Long-term relocation to core areas is a common strategy for reducing physical distance. As geographical distance between countries and continents can never diminish entirely, being geographically proximate on temporary occasions is an alternative strategy for researchers to create proximity.

Cognitive Proximity

In the context of building scientific capital and learning, cognitive proximity between researchers is a crucial dimension. Cognitive proximity has been defined as the extent to which two or more actors share the same knowledge base. It has been operationalized based on an academic's research field and subfields, educational background including university degrees, work experience, or nationality (Boschma, 2005; Hautala, 2011). Coining the term "absorptive capacity," Cohen and Levinthal (1990) have argued that prior related knowledge is a necessary precondition enabling the intake of new ideas at both the individual and organizational levels. To work toward a common goal, for example, in scientific collaboration, it is important that actors share a minimum of understandings to enable meaningful interaction. This includes interpretations, language, and codes, which researchers either share from the start or develop as they collaborate. Hence, cognitive proximity is closely intertwined with the social, institutional, and organizational dimensions of proximity (Frenken et al., 2009; Gonzalez-Brambila, 2014; Knoben & Oerlemans, 2006; Nooteboom et al., 2007).

There are arguments in favor of seeking partners with a certain cognitive distance. Especially the opportunity of creating knowledge through the combination of dissimilar knowledge bases provides much potential to build scientific capital. While a certain degree of cognitive proximity is necessary to ensure effective communication and coordination, too much cognitive proximity does not provide enough knowledge diversity, which, however, is needed to be innovative. Previous studies have shown an optimum degree of proximity observed at medium cognitive distance. Collaborating with partners who are more cognitively distant could potentially lead to bigger leaps in knowledge production (Boschma, 2005; Cohen & Levinthal, 1990; Frenken et al., 2009; Nooteboom et al., 2007). Cognitive proximity may be the most

dynamic dimension of proximity, as Balland et al. (2015) have exemplified with the process of learning. When novel knowledge is created, the knowledge base of individuals or groups transforms and mental models are rearranged or widened. As two or more actors start to interact and share ideas, their knowledge bases naturally become more similar even though this process is not necessarily reciprocal or symmetrical. Learning, as a part of acquiring scientific capital, is a common goal of global research collaboration. Thus, in striving for optimal cognitive distance in research groups, variety of backgrounds should be considered in collaboration decisions. This does not relate only to scientific disciplines but also to aspects of cultural diversity. Studies have found a positive impact on creativity and research productivity when introducing foreign scientists in research teams. Moreover, international research collaborations tend to receive higher citation rates. Furthermore, the inclusion of more points of view can ensure higher degrees of objectivity in science (Bauder, 2015; Georghiou, 1998; Hautala, 2011; Longino, 1990; Zhou et al., 2020). This provides strong arguments in favor of exchanges and collaborations between high-, middle-, and low-income countries.

Cognitive proximity can be created and maintained through mobility and collaboration. Relocation to more central regions in the science system and collaborations with researchers in core locations are strategies to acquire scientific capital for researchers in more peripheral regions. However, patterns of scientific mobility tend to be asymmetrical, and research partnerships between high- and low-income countries also bear many risks of asymmetry. Consequently, learning and the acquisition of scientific capital will often be unidirectional rather than mutual in these cases. This potentially reinforces power imbalances in collaborations between researchers in the core and periphery and manifests the dominance of norms of good science and research priorities defined in high-income countries (Bozeman & Corley, 2004; Collyer, 2018; Gunasekara, 2020; Jonkers & Cruz-Castro, 2013; Lehuedé, 2023; Martinez & Sá, 2020; Matenga et al., 2021; Nhemachena et al., 2016; Verginer & Riccaboni, 2020).

Cognitive proximity should also be discussed with regard to the critical discourse on decolonization of scientific practice. Because theory developed in the core tends to be the most widely used and cited, disciplinary fields and knowledge bases are often surprisingly uniform across different parts of the world. This is underlined by the finding that, in many cases, common disciplinary backgrounds are more important for effective collaboration than geographical proximity. However, it is increasingly criticized that these scientific domains are artificially homogeneous because of the systematic hegemony of Western-centric knowledge. Accordingly, cognitive proximity between researchers from different parts of the world who work in the same field can facilitate their collaboration because of a large overlap of knowledge bases. In the context of decolonization of academic discourses, however, allowing for more heterogeneity in the creation and diffusion of knowledge can be beneficial for many scientific disciplines. In this regard, it is important to highlight the self-interest and potential for building scientific capital for researchers from high-income countries in collaborations with researchers in middle- or low-income countries. While the mutuality of benefits is not always recognized, researchers from the core profit

from accessing new types of knowledge, under-researched cases, and alternative funding sources when collaborating with researchers in more peripheral countries (Connell, 2014; Ergin & Alkan, 2019; Frenken et al., 2009; Mawere & van Stam, 2019; Moosavi, 2020; Munung et al., 2017).

To sum up, the right amount of cognitive proximity is a crucial factor in collaborations between researchers from high-, middle-, and low-income countries. On the one hand, cognitive distance between researchers due to different experiences and backgrounds could hinder their propensity to collaborate in the first place. On the other hand, diversity in knowledge bases offers greater opportunities for creating new knowledge and ensuring scientific objectivity by incorporating more perspectives. Yet, collaborations between universities and researchers in core and more peripheral regions of the science system also bear many risks. Learning and the building of scientific capital should be mutual activities; however, when they are not acknowledged as such, it is likely that the dominance of norms and agendas of high-income countries will be continuously perpetuated.

Social Proximity

Social proximity is commonly defined as the trust and bonds between two or more actors and encompasses all of their relations as well as embeddedness in networks. Social proximity is understood to be built on past shared experiences, which are part of a gradual trust formation process. Closely related to social proximity is what Bergé (2017) defines as network proximity. Triads of researchers who share the same contacts are important for building and maintaining trust in social networks and preventing opportunistic behavior. At the same time, very dense networks with too much cognitive proximity can also slow down the creation of new knowledge, which emphasizes the benefits of openness in networks. The importance of network and social ties in the academic system is also reflected in that it is explicitly incorporated in the notion of scientific and technical human capital. However, in the global system of science, links with eminent institutions and individuals are unequally distributed across space, potentially constituting a disadvantage for researchers working in peripheral countries. In more resource-constrained settings especially, the building of networks through mobility and collaboration is a common strategy to acquire scientific capital (Boschma, 2005; Bozeman & Boardman, 2014; Gonzalez-Brambila, 2014; Hoekman et al., 2010; Knoben & Oerlemans, 2006; MacHáček et al., 2022; Ynalvez & Shrum, 2011).

The relationship between social and geographical proximity appears to be twofold, showing overlap as well as substitution. Firstly, being geographically proximate is beneficial or even necessary for building network ties and social proximity through increased likelihood of encounters and face-to-face interactions. Secondly, once social proximity and trust are established, it facilitates collaboration even at large distances. In a dynamic process, growing social proximity between two actors can

lead to a decoupling of this tie from its original context so that it persists regardless of a change of location or organization. Once trust is established between two actors, it proves to be relatively robust, not requiring permanent spatial proximity (Balland et al., 2015; Hansen, 2015; Jonkers & Cruz-Castro, 2013; Nilsson, 2019). Both long- and short-term academic mobilities ultimately contribute to the expansion of networks—or social ties—across larger geographical spaces. As such, mobility offers an opportunity for researchers to acquire scientific capital in the form of contacts, networks, and institutional ties, which tend to be stable over time. International mobility has been reported as an important factor in expanding and diversifying the professional networks of researchers (Bauder, 2015; Morley et al., 2018; Nilsson, 2019). For instance, Jonkers and Cruz-Castro (2013) showed that Argentinian researchers drew on professional ties they formed working abroad even after their return to their home country. The study of Brazil's highly cited researchers by Martinez and Sá's (2020) illustrates that mobility is most often the initiation of connectedness to global scientific networks. These examples illustrate that once social proximity is established, geographical proximity becomes less important.

As international co-authorship networks continue to grow, Wagner et al. (2015) state that a lot of the progress of more peripheral countries is the result of links to the core. The growth of research networks can largely be explained by factors endogenous to scientific work and by the self-organization of individual researchers who are driven by their own interests. However, the cementing of core–periphery structures through asymmetrical ties always bears the risk of expanding the dominance of interests of actors in the core at the expense of marginalizing interests of researchers in more peripheral locations (Collyer, 2018; Leydesdorff & Wagner, 2008; Mohanty, 2003; Wagner & Leydesdorff, 2005). Beyond the descriptive analysis of research networks, Verginer and Riccaboni (2020) call for future research to explore the causality behind their formation. In this context, it is crucial to consider an unequal distribution of scientific and technical human capital along with the distinct dimensions of proximity.

The importance of social proximity and network embeddedness for scientific mobility and collaboration constitutes a potential disadvantage for researchers in more peripheral regions of global academia. Because of geographical remoteness, it becomes more difficult to establish social proximity through joint experiences and mutual acquaintances. Because such experiences are important for the building of trust, one can expect networks to be relatively inert and to exclude new entrants. This potentially slows down the integration of more isolated areas in the global science system. However, once trust between actors is built and ties have formed, these prove to be relatively stable over time and capable of bridging large geographical distances. Accordingly, scientific collaboration as well as long- and short-term mobilities can contribute to the strengthening of social ties and be an essential part of building scientific capital.

Organizational Proximity

Opportunities to build scientific capital through mobility or collaboration can also depend on the organizational proximity between researchers in the core and peripheral regions of global academia. Different authors have quite different conceptualizations of organizational proximity. In an academic context, Frenken et al. (2009) define organizational proximity as "the extent to which two researchers are under common hierarchical control" (p. 228), which can imply working either for the same or different organizations. In a broader sense, structural definitions of organizational proximity relate to the distance between two actors in a network as networks themselves can be seen as a form of organizational arrangement (Boschma, 2005; Knoben & Oerlemans, 2006).

Essentially, the form of organization will define the autonomy and control of its members over the flow of knowledge. The hierarchical governance structure in organizational arrangements will also have an impact on intra- and interorganizational learning. Optimal organizational proximity combines necessary control to avoid opportunistic behavior with flexibility for new knowledge creation. However, Boschma (2005) points out the risk of asymmetrical exchange relations between partners with a power imbalance. Besides other factors that potentially cause power imbalances between researchers such as career stage or gender, resource inequality between researchers in high-, middle-, and low-income countries could also be an example of this. For instance, unbalanced authorship practices, role divisions, or data appropriation have been criticized in numerous case studies. More generally, organizational differences between universities in high-, middle-, or low-income countries can be found in the prioritization of teaching as opposed to research, academic calendars, or data sharing agreements (Boshoff, 2009; Gunasekara, 2020; Kontinen & Nguyahambi, 2020; Matthews et al., 2020; Munung et al., 2017; Nhemachena et al., 2016).

With regard to organizational proximity, there can be barriers to core–semi-periphery–periphery collaboration on both levels of examination. At the dyadic level, two universities in different locations can be organizationally distant as the result of distinct institutional environments and policies. At the structural level, they can be organizationally distant because of a lack of network ties between them. In both cases, being distant from organizations in the core can constitute a disadvantage for researchers in more peripheral regions. The likelihood of being internationally mobile or of collaborating is reduced when there are no pre-existing ties and no organizational proximity between universities, making it more difficult to jointly build scientific capital.

Institutional Proximity

Lastly, inequality in academia can be reinforced by the lack of institutional proximity between countries. Institutions are defined as the set of norms and incentives under which actors operate and include formal institutions such as laws and rules as well as informal institutions such as cultural norms and habits. The more these are alike for two partners in a collaboration, the more they can be considered institutionally proximate. Institutional proximity allows initial trust between partners who have never met because of their common understanding of the rules of the game (Balland et al., 2015; Boschma, 2005; Nilsson, 2019). Definitions of institutional proximity can vary between authors depending on the level of analysis. While some authors operationalize the institutional proximity of two partners by considering their respective countries of location, others focus on the organizational type. For instance, Ponds et al. (2007) defined institutionally proximate actors in research projects as those that belong to the same type of organization, for example, governmental, academic, or private. This definition of institutional proximity, however, might overlap with how others have conceptualized organizational proximity (Knoben & Oerlemans, 2006). Applying the concept at the level of countries or regions, institutional proximity appears to be closely related to geographical proximity as national borders frequently define the institutional environment for research projects (Bergé, 2017). Hoekman et al. (2010) categorize institutional differences based on three spatial levels: regional science systems, national borders, and linguistic areas. For scientific collaborations in Europe, they find that proximity at each of these levels increases the propensity to co-publish.

According to Frenken et al. (2009), the incentive structures under which researchers operate are important elements of the institutional environment and thus define the institutional proximity between researchers. In terms of their institutional environments at universities, there is considerable heterogeneity between countries, even at similar levels of income. The attractiveness of a national research system can be one of the factors that determines whether a country or a university tends to show so-called academic inbreeding as opposed to internationalization. Countries are frequently compared through the theoretical framework of systems of innovation, which makes it possible to analyze the cultural traditions and national research policies that determine the structure of science systems in different countries (Lundvall et al., 2002; MacHáček et al., 2022; Mattsson et al., 2010).

Boschma (2005) as well as Knoben and Oerlemans (2006) include cultural proximity, so the sharing of cultural values, beliefs, and language, in the notion of institutional proximity. Cultural proximity is used to refer to the similarity of patterns of thought, behavior, or interpretation between members of a group defined by a geographical region or an organizational unit. As pointed out by Fiorini et al. (2021), cultural proximity and trust relations can be asymmetrical when the cultural attractiveness of one country is not reciprocated by the other. According to Verginer and Riccaboni (2020), low cultural and linguistic barriers to international mobility have favored the formation of the major science hubs in the United States. Having or

building cultural proximity in the sense of being able to decode and utilize situational etiquette can be crucial to collaborate with academics in or from an unfamiliar institutional context (Morley et al., 2018). Accordingly, cultural proximity between two researchers can influence their propensity to collaborate, and cultural attractiveness might be an additional factor reinforcing the dominant position of countries in the core. The institutional proximity between two actors can change dynamically as their institutional environments change over time, on both the macro- and micro-levels. Balland et al. (2015) describe the process of institutionalization as such that occurs when two actors collaborate, build social proximity, and gradually align their values, practices, and goals. On a larger scale, institutionalization between countries occurs when they formalize the conditions of collaboration in order to facilitate collaborative projects. For instance, Hoekman et al. (2010) observed that the relevance of territorial borders has been gradually diminishing as the integration of the European science landscape proceeds. As similar processes can be expected to occur on a global scale, this once again raises questions regarding dominance of the core in defining social structures and norms in science (Collyer, 2018; Connell, 2014).

The institutional environment shapes not only scientific collaboration but also scientific mobility. For scientists, collaboration and mobility are characterized, on the one hand, by a high degree of self-organization and, on the other hand, by science diplomacy and policies through which governments and institutions aim to accelerate knowledge production across borders. The growth in international research collaboration has been largely attributed to bottom-up initiatives by individual researchers; however, there is also a growing number of formalized institutional arrangements promoting it (Bauder, 2015; Georghiou, 1998; Jonkers & Cruz-Castro, 2013; Mattsson et al., 2010; Wagner & Leydesdorff, 2005). Both the sending of researchers to the core and their return to their home countries might be subject to policies and incentives. Thus, institutions and incentive structures in both sending and receiving countries provide the framework in which academics' mobility takes place. For instance, private and philanthropic foundations, national governments, and supranational institutions such as the European Union aim to stimulate academic mobility. In this context, one can observe competition between countries at different income levels in trying to attract, retain, or re-attract talents. With regard to collaboration, Mattsson et al. (2010) found that projects funded by top-down initiatives in Europe show only limited involvement of non-Europeans in such research collaborations. Accordingly, it is important to note that, depending on how they are designed, policies can potentially encourage or discourage participation by researchers from more peripheral regions. Moreover, asymmetries and inequality in institutions can be observed in questions of immigration and visa regulations as researchers with, for instance, European passports will be permitted to travel comparatively easily, while others might even be banned from entering certain countries. This has recently affected collaboration and mobility of researchers between the United States and Iran, Iraq, Libya, Somalia, Sudan, Syria, and Yemen. Aside from drastic bans, regular administrative barriers can also limit the mobility of scientists and have been shown to impact mobility and knowledge flows asymmetrically (Chinchilla-Rodríguez et al.,

2018; Morley et al., 2018; Orazbayev, 2017). Furthermore, differences in the institutional contexts of countries can constitute a barrier to cross-border mobility as employment structures and typical academic career trajectories vary considerably, even between high-income countries (Bauder, 2015).

For collaborations between high-, middle-, and low-income countries, differences in the institutional environments can be a complicating factor. At the same time, there can also be institutions in the form of policy incentives that promote collaboration and mobility across borders and continents. Because opportunities to build scientific capital are unequally distributed between countries, collaboration and mobility are important strategies for researchers and universities aiming to matter in the sense of disseminating novel knowledge. The propensity of researchers from the core and more peripheral regions to collaborate will depend on their proximity in multiple dimensions. Generally, each dimension can embody enabling or impeding potential. It is theoretically possible to circumvent distance in one dimension with proximity in another. Asymmetrical proximities can be expected to exist on all levels in scientific collaborations, especially between high-, middle-, and low-income countries.

Discussion

Like any theoretical model, the concept of proximity is an abstraction and a simplification of the complex reality of scientific collaboration. It can provide the language and ideas to describe the favorable preconditions for or barriers to collaboration among researchers. This can be helpful in describing challenges faced by researchers who aim to collaborate between high-, middle-, and low-income countries, for instance, a lack of geographical, social, or organizational proximity. Furthermore, it can illustrate the opportunities of international collaboration, for instance, the potential for the generation of new knowledge that incorporates more diverse perspectives and new opportunities for remote collaboration thanks to short-term colocation and information technology. At the same time, increasing the proximity of actors in the global science system always also bears the risk of perpetuating the dominance of already eminent actors. In Table 3, aspects of how the concept of proximity can be expanded to include aspects of inequality between countries with different income levels are shown. Frequently, these come with both risks and opportunities, highlighting the importance of awareness of inequality in designing policies and incentive structures for research collaboration.

When trying to understand why researchers collaborate between high-, middle-, and low-income countries, it becomes obvious that proximity in various dimensions is not sufficient as an explanation. Instead, mobility and collaboration decisions are made by individual researchers in a science system that exhibits an incentive structure characterized by a persistent core–semi-periphery–periphery stratification. Inequality of scientific and technical human capital within and between countries can be seen on different levels—on a material level in the form of tangible and intangible resources, in human capital embodied in people, and in social structures

Table 3 Expansion of five dimensions of proximity for research collaboration, considering between-country inequality

	Risks	Opportunities
Geographical proximity	Unequal opportunities for researchers to be internationally mobile	New information technology can help to bridge distances
Cognitive proximity	Unidirectional knowledge dissemination, continuous perpetuation of research priorities defined in high-income countries	Opportunities for mutual learning and more diverse perspectives in collaborations
Social proximity	Social networks require initial interaction to form and can exclude new entrants	Social ties appear to be robust over time and stable in bridging geographical distances
Organizational proximity	Organizational differences and power imbalances between universities impede collaboration	Once established, organizational arrangements between universities facilitate mobility and collaboration
Institutional proximity	International policy incentives for mobility and collaboration frequently exclude peripheral regions	Collaboration and mobility are facilitated as universities and researchers align practices and goals

and norms. At the European level, heterogeneity between countries in terms of size, scientific quality, and accessibility has been considered by Hoekman et al. (2010). They found that researchers in peripheral regions tend to collaborate over larger distances more than researchers in the core, as the former may lack suitable partners in close proximity or may lack access to participation in funded projects. It can be expected that these dynamics between the core and peripheral regions are even more pronounced on the global scale, which exhibits even more disparity; however, there has so far been little research on this beyond Europe and North America (Bergé, 2017). The concentration of opportunities to build scientific capital in core areas creates uneven attractiveness and will influence mobility and collaboration decisions along with the dimensions of proximity (Bresnahan & Gambardella, 2004; Sorenson, 2005). These factors highlight another complexity around scientific collaboration, which is typically not at the focus of the proximity literature. Proximity in all of its dimensions will rarely be the only factor in making collaboration and mobility decisions. In a global science system that is highly unequal in terms of opportunities to build scientific capital, proximity can explain how rather than why researchers collaborate. Since power imbalances and the uneven distribution of scientific capital can be found in global collaborations and mobility patterns, these should be taken into account in future analyses of proximity.

Conclusion

As scientific capital and opportunities to acquire it are distributed unequally in the world, not all universities and researchers have equal chances to matter in the sense of being able to disseminate their ideas and findings on a global scale. In this context, scientific collaborations and mobility between high-, middle-, and low-income countries are strategies that individuals employ in striving to make their research matter more in global academia. The theoretical concept of proximity is helpful in describing benefits, challenges, and barriers associated with scientific collaboration even across larger geographical distances than the concept's original contexts in high-income countries. However, as has been shown with this critical narrative review, the concept of proximity can be expanded in a meaningful way by incorporating a stronger emphasis on inequality and asymmetry when examining how and why researchers collaborate internationally. While proximity and the lack thereof can be understood as facilitators or barriers to collaboration, the unequal distribution of academic capital will frequently be a crucial factor in the motivation to collaborate. Moreover, a theoretical framework will be useful to provide structure to the largely scattered literature on aspects of between-country inequality in global science. For instance, future research can shed light on the conditions under which research collaborations form between researchers in different countries, how they are shaped by policies and incentives, and the circumstances under which they may be mutually beneficial.

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