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Science diplomacy from the Global South: the case of intergovernmental science organizations

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Abstract

Intergovernmental science organizations (IGSOs) address many challenges of the 21st century. Several countries of the Global South have joined established IGSOs or have created new ones. Yet we know little about their interests in IGSOs. Our study addresses this blind spot by investigating which objectives Southern actors pursue in IGSOs and under which conditions they are likely to achieve their objectives. Using insights from three strands of literature, we compare four IGSOs with Southern participation: the European Organization for Nuclear Research, the International Thermonuclear Experimental Reactor, the Square Kilometer Array, and the African Lightsource. We show that countries of the Global South pursue a multitude of political and scientific objectives in IGSOs, ranging from capacity-building to casting off political isolation. Moreover, we demonstrate that Southern countries have varying chances of attaining these objectives, depending on their scientific community, domestic politics, industrial capacities and in some cases geographic location as well as an IGSO's maturity.

Key words: intergovernmental science organizations; international research collaboration; science diplomacy; Global South; CERN; ITER; SKA; African Lightsource.

1. Introduction

Intergovernmental science organizations (IGSOs) address many challenges of the 21st century (Zapp 2018) and resemble conventional collaborative research projects. Both IGSOs and traditional research projects are essentially scientific investigations that aim to achieve previously-defined research objectives. However, as IGSOs are specialized international organizations (IOs) founded on an intergovernmental agreement among two or more nations, they differ from regular research projects in two important aspects. First, they are much more institutionalized than traditional research projects. Second, IGSOs are marked by a much stronger interlocking of science and politics than conventional research collaborations.

Similar to other IOs, many IGSOs have long been dominated by the Global North. In this study, we do not understand Global North and South as geographical concepts, but as characterizations of past and present power asymmetries of the global political economy (Dados and Connell 2012; Prashad 2014). Core principles of this economy benefit the Global North at the expense of the Global South, leaving the 'majority world' (Doyle 2005: 14–15) economically disadvantaged (Dados and Connell 2012). Some emerging powers of the Global South, however, were able to overcome some of these economic disadvantages. During the last decade, they have joined several European IGSOs and helped establish IGSOs in the Global South like the Synchrotron Light for Experimental Science and Applications in the Middle East.

Although Southern rising powers are becoming more visible in the global IGSO landscape, we know little about their interests in IGSOs. Our exploratory study addresses this blind spot by asking the following two questions:

(1) Which objectives do countries of the Global South pursue in IGSOs?
(2) Under which conditions are they likely to achieve their objectives?

In doing so, we concentrate on four IGSOs with formal and informal participation of policymakers and scientists from Southern emerging powers:

(1) The European Organization for Nuclear Research (CERN), an established European organization that over time has intensified connections to countries like India;
(2) The International Thermonuclear Experimental Reactor (ITER), an emerging IGSO with participation from India;
(3) The Square Kilometer Array (SKA), an emerging organization with a strong South African component; and

(4) The African Lightsource (AfLS), an example of a planned pan-African IGSO.

These four IGSOs are at different stages of completion. Emerging IGSOs are either in the late or early stages of construction, established IGSOs are fully operational and in planned IGSOs construction has not yet begun.

We explore each case by drawing on insights from the literature on international research collaboration, science diplomacy (SD), and institutionalism and advance two arguments. First, we contend that countries of the Global South pursue a multitude of political and scientific objectives in IGSOs, which may range from strengthening science and technology (S&T) capacities to casting off political isolation. Second, we argue that Southern countries have varying chances of attaining these objectives, depending on their scientific community, domestic politics, industrial capacities and in some cases geographic location as well as an IGSO's maturity. In doing so, our study contributes new insights to the literature on international research collaboration and institutionalism, which have prioritized the study of conventional research projects or traditional IOs over that of IGSOs. It also adds to the SD literature, which has predominantly focused on the SD practices, capacities, and experiences of the Global North (Polejack et al. 2022) and neglected to study Southern SD (for some exceptions, see Hornsby and Parshotam (2018), Ezekiel (2020), and Echeverría King et al. (2021)) as well as IGSOs (notable exceptions are Höne and Kurbalija (2018) and Robinson (2020)). Finally, our findings have important implications for science policy.

The remainder of this article is structured as follows: in Sections 2 and 3, we outline our analytical framework and methods. In Section 4, we present our case studies. We discuss the main findings of our analysis and their policy implications in Section 5 and conclude by pointing out future research directions in Section 6.

2. Analytical framework

Our case study analysis is informed by empirical and theoretical insights from three strands of literature, each of which addresses an important IGSO characteristic.

First, because conventional research projects and IGSOs share some similarities, we draw on insights from the literature on international research collaboration. This type of scholarship demonstrates that many international research projects are plagued by North–South asymmetries. This is mainly due to the unequal distribution of S&T capacities between Global North and South (Madsen and Adriansen 2021). For instance, because countries of the Global North possess the necessary economic resources, human capital, and technology, they typically initiate collaborative research projects and then look for suitable collaboration partners (Feld and Kreimer 2019). Southern researchers are often invited to join when the broad lines of the work plan have already been drawn up (Feld and Kreimer 2019). They thus lack room for maneuver during the early negotiations of a project (Perrotta and Alonso 2020). Moreover, scientists from the Global South rarely determine the research agenda and the theoretical and methodological framework of a research collaboration (Chinchilla-Rodríguez et al. 2019). Under these conditions, it is difficult for them to develop and maintain capacity for (large) research infrastructures (Moyi Okwaro and Geissler 2015).

Second, to account for the fact that IGSOs are marked by a much stronger interlocking of science and politics than conventional research projects, we consult recent SD scholarship. This type of literature lends itself to our purposes because it seeks to conceptualize the role of science, technology, and innovation in three dimensions of policy:

(1) Science in Diplomacy (SiD): informing policy through scientific advice;
(2) Diplomacy for Science (D4S): leveraging political capital to advance scientific research; and
(3) Science for Diplomacy (S4D): using science cooperation to improve international relations (The Royal Society and AAAS 2010).

In recent years, this threefold SD taxonomy has received much criticism. For example, some scholars argue that the differentiation between SiD, D4S, and S4D is artificial and rarely holds in practice (e.g. Copeland 2016; Penca 2018; Rüland 2023). In line with this, recent studies show that SD often serves both scientific *and* political ends, which can be collaborative or competitive in nature (e.g. Ruffini 2020; Rüffin and Rüland 2022). Building on these new insights, we employ a pragmatic definition of SD that includes all activities at the intersection of science and foreign policy that are meant to achieve scientific and political objectives.

Third, to honor the strong institutionalization of research collaboration in IGSOs and to systemize the comparative case analysis, we apply a broad institutionalist perspective. This institutional perspective, first, allows us to analytically distinguish two phases in the life cycle of an institution. A first phase deals with questions of institutional design during the planning and construction of a new institution (initiation) that include but are not limited to funding, site selection, scientific access, and procurement (Hallonsten 2014). A second phase addresses interactions in existing organizations that are shaped by previously-established institutional rules (development). Second, an institutional perspective shows that recurring organizational features like centralization, membership, and control mechanisms shape power relations between Member States, often in the long term (Koremenos et al. 2001).

3. Methods of investigation

Against the backdrop of this analytical framework, we compare four IGSOs, which we selected based on three criteria. First, we aimed for maximal organizational heterogeneity to learn from different contexts and to develop careful generalizations (Khan and VanWynsberghe 2008). Accordingly, we chose IGSOs that are situated in different scientific fields and characterized by different institutional configurations (Table 1). Second, we selected organizations which Southern actors joined at different institutional phases of their life cycle and during different science policy 'regimes' (Elzinga 2012). Third, to focus the case study analysis (Yin 2003), we concentrated on the activities of one specific country of the Global South and covered an IGSO's initiation and development in all cases but AfLS. Currently, AfLS is still in the phase

Table 1. An overview of IGSO case studies.

Name	Discipline	Year of establishment	Founding members/ proponents	Location	Phase in the life cycle	Initiated by
CERN	Particle Physics	1954	Belgium, Denmark, France, Germany, Greece, Italy, the Netherlands, Norway, Sweden, Switzerland, UK, and Yugoslavia	Geneva, Switzerland	Established	Global North
ITER	Nuclear Fusion	2007	USA, China, Russia, EU, South Korea, and India	Cadarache, France	Emerging	Global North
SKA	Astronomy	2019	UK, China, Portugal, Italy, South Africa, the Netherlands, and Australia	Karoo, South Africa; Murchison Region, Australia	Emerging	Global North
AfLS	Inter Alia: Medical Sciences, Cultural Heritage Sciences, Geosciences, Environmental Sciences, Energy Sciences, Nano-Sciences, Material Sciences, and Mineral Sciences	~2030	South Africa and Ghana	To be determined	Planned	Global South

Table 2. An overview of conducted interviews.

	Case study			
	CERN	ITER	SKA	AfLS
Number of interviews	2	1	4	3
Code/name	INT07	INT08	Wolfgang Reich INT02 Adrian Tiplady Justin Jonas	Tshepo Ntsoane INT06 Trevor Sewell
Affiliation	CERN	ITER IO	Max Planck Society – SARAO SARAO	South African Nuclear Energy Corporation – University of Cape Town

of initiation and is mainly driven by scientific actors, depicting an outlier in our case study analysis.

We combine a document analysis with qualitative interviews for the description and analysis of our case studies (for an overview of the interviews, see Table 2). Pursuing such a strategy comes with a considerable advantage as triangulating data from non-reactive and reactive sources is generally believed to increase the reliability of inferences (in Webb et al. 1999: 2). In the cases of CERN and ITER, we supplemented the findings from a document analysis with interview data that we had collected in previous research projects. We made limited use of these interviews, as both CERN and ITER are well documented in the secondary and gray literature. For SKA and AfLS, in contrast, there is little academic literature available. As a result, we triangulated data from gray literature, for example, project documents, parts of which have not yet been published, and exploratory expert interviews that we conducted between February and September 2022. Exploratory interviews are generally considered a suitable method to examine under-researched topics such as Southern participation in IGSOs (Kaiser 2014: 29). However, since exploratory interviews are less structured, cross-case comparability is hard to achieve (Gläser and Laudel 2009: 144). We tried to increase comparability by covering similar themes in the interviews. In addition, we transcribed all interviews and paid attention to differences and similarities between the interviewees' accounts as we analyzed them using flexible coding (Deterding and Waters 2021).

4. The Global South in IGSOs

4.1 CERN: European laboratory turned global

4.1.1 Initiation

Founded in the 1950s near Geneva, CERN is the oldest European IGSO. Over time, it has become a major example of multilateral collaboration in high-energy physics (HEP) and a role model for several other IGSOs. The earliest negotiations on the laboratory included suggestions to open membership to the USA and Commonwealth countries like Pakistan and India (Krige 1987: 251). Yet, the final compromise resulted in cementing the European nature of CERN in a convention that grants incumbent countries veto powers on new members.

The provisions of the CERN convention have important institutional effects to this day, particularly for countries that wish to join CERN. As a matter of fundamental institutional importance, CERN's Council decides on the accession of new members. Every Member State dispatches two official delegates to the Council, where votes require various types of majorities. New Member States are only admitted 'by a unanimous decision of Member States' (CERN Council 1953: Art. III, 2(a)). As a result, CERN's governance system—although it is getting increasingly diverse and global—has largely remained under European control.

4.1.2 Subsequent development

Despite this rigid institutional framework, nowadays, CERN collaborates with interested parties via a variety of membership types. India and Pakistan, for instance, have become associated members of the organization. In the past decades, CERN has, moreover, concluded a large number of agreements with additional countries around the globe (CERN 2022a). This partial expansion of membership types is tied to the intricate relationship between scientific progress and CERN's mostly-unchanged governance model, which, in turn, shapes opportunities and challenges for Southern actors to pursue their objectives in this IGSO until today.

HEP has long been characterized by a need for ever-increasing cutting-edge facilities, which come at growing costs. For example, CERN's first particle accelerator, the Synchrocyclotron, which was commissioned in 1957, measured about 16 m in circumference and cost about 24 million Swiss Franc (CHF) (Herman et al. 1987). The Large Hadron Collider (LHC), which went into operation in 2008, in comparison, has a circumference of 27 km and a price tag of 4,332 million CHF (CERN 2022b). Given these ever-increasing costs, each time CERN set out to build a new accelerator, questions of funding moved to the foreground. During large periods of the 20th century, members were able to secure sufficient resources for new projects. This was particularly the case for the Super Proton Synchrotron and the Large Electron–Positron Collider commissioned in the 1970s and 1980s (Schopper 2009). However, since then, it has become clear that the next accelerator would require resources that members were not willing to provide due to various economic and political circumstances (Smith 2007). Scientific progress dictated the inclusion of new partners in CERN projects. As a result, during the negotiations leading up to the construction of the LHC, for the first time, contributions from non-Member States became a valuable bargaining chip to trade for 'a "voice" in the [IGSO's] governance' (Smith 2007: 284). Already existing collaborations at an executive level (i.e. with individual scientists and research institutions) supported these new interactions at the political level, enabling Southern actors to get more involved in CERN even when the IGSO's institutional framework had not fundamentally changed. Institutionally, the LHC cooperation was consolidated in bilateral ad hoc agreements, which usually specified the type of contribution, procurement provisions, and delegation of personnel (CERN 2002). However, these ad hoc agreements were focused on the LHC and did neither touch CERN's basic research program nor fundamental governance mechanisms.

India was one of the countries that tried to benefit from this changing environment. During the 2000s, due to agreements struck earlier between the Indian government and CERN, the country's scientists were heavily engaged in the development of the LHC's magnets (Chohan 2007). From the Indian perspective, there were two main reasons for joining this specific collaboration within CERN. First, India's participation was driven by 'the desire to increase the pace of accelerator development … and to give a thrust to [its] experimental high energy physics programme' (Sahni 2004: 441). Second, Indian companies could showcase their technological capabilities within the collaboration, strengthening the country's image as a rising S&T power. Institutionally, however, the CERN Council only granted observer status to India in the wake of the construction of the LHC in 2002. Observer status gave India the right to attend open sessions of the Council and to receive official documents, 'a step that had mainly political significance' (CERN 2002: 6). It took another 15 years for the country to become an associated member of the organization (CERN 2017). Siddhartha (2017) argues that India was keen to obtain this status to 'catch up' with its rival Pakistan, which had become CERN associate members two years earlier. According to this reasoning, India's institutional commitment to CERN can be read as an attempt to use S&T cooperation to settle regional political rivalries. This seems plausible, given that associate membership gives a country the right to express its opinion in the Council, to appoint nationals to staff positions, and to bid for CERN contracts, all of which increase a country's political standing and prestige (CERN 2002: 12–14; Cogen 2012). Despite the privileges that come with the status of associated membership, the number of Indians on CERN staff and the number of users have remained at a low level for years; the full potential of exchanges has thus not yet been reached.

Although useful for non-Member States, the extensions of interstate collaborations have not significantly changed the composition of full members in the Council as only three European countries (Cyprus, Estonia, and Slovenia) are currently associated members in the pre-stage to full membership. States of the Global South are not yet represented at this level. This may change in the future, enabling Southern actors to pursue more ambitious objectives in CERN. For example, the LHC illustrates how Southern actors and CERN are caught in a relationship of mutual dependency. On the one hand, countries of the Global South currently have few alternatives to CERN if they want to access cutting-edge HEP instruments. In fact, CERN cemented this special status in the 1990s when the US-based Superconducting Super Collider was canceled (Riordan et al. 2015). Within a few years, CERN became the last HEP facility capable of constructing the next generation of colliders. On the other hand, it is increasingly obvious that budgetary constraints among current CERN members render contributions from additional international partners imperative for the construction of these colliders (INT07 2017; European Strategy Group 2020: 6). Southern actors could make their financial support for future projects contingent on either getting more institutional rights at CERN or developing a new consortial framework in which CERN exclusively represents European interests much like EUROfusion does in ITER. As the specific trajectories for a successor to the LHC are still unknown, these considerations are primarily rooted in experiences of the past and expert opinions. Yet, given the ever-changing structure of the global science system, it is plausible to assume that Southern countries will have a part in shaping the future of HEP at CERN.

4.2 ITER: a missed opportunity for India?

4.2.1 Initiation

ITER is an experimental nuclear fusion reactor in the billion euro class currently under construction in Cadarache, France. Its objective is to demonstrate the viability of fusion as a future source of sustainable energy (European Commission 2017). The ITER IO, the IGSO in charge of managing the reactor's construction and operation, was established in 2007 by the USA, Russia, the European Union (EU), South Korea, China, and India.

The project resulted from a 1985 high-level meeting between Ronald Reagan and Mikhail Gorbachev, during which the two leaders agreed to cooperate on a thermonuclear fusion project (McCray 2010). Shortly after the initiation of the project, the European Community and Japan joined ITER, as did China and South Korea at the beginning of the 2000s. In 2005, ITER welcomed India as a seventh and, to this day, last ITER partner during a meeting on Jeju Island, South Korea (EUROfusion 2005).

As a newly-accepted ITER partner, India was able to fully participate in the negotiations on Jeju Island and to determine some key institutional issues, such as decision-making procedures, intellectual property rights, and management within the prospective ITER IO (EUROfusion 2005). It had little influence on ITER's scientific objective, however, because this issue had been settled during the project's engineering and conceptual design activities in the 1990s. During the negotiations on Jeju Island and subsequent discussions, India pursued two main interests. First, it wanted to strengthen its national capacities in fusion research and technology (Anupama et al. 2021). The country was particularly keen to further develop its blanket, divertor, and cryogenic technologies (Mattoo 2006). Second, it sought to re-establish itself as a responsible nuclear state and to regain trust among international nuclear powers after it had been excluded from the nuclear mainstream over its nuclear weapons test and refusal to sign the Nuclear Non-proliferation Treaty in the mid-1970s (Joshi 2018). Prior to this point in time, India had enjoyed civilian nuclear engagement with other states, but as a reaction to its nuclear tests in 1974, erstwhile partners sanctioned nuclear technology exports to the country (Ritch 2006).

4.2.2 Subsequent development

Currently, ITER is not yet operational, but the construction of the reactor has progressed considerably (Harvey F 2017). In theory, the IGSO's institutional rules enable India to pursue its scientific and political objectives in ITER: strengthening its national capacities in S&T and building a reputation as a trustworthy nuclear power. In practice, however, India either fails to use ITER's institutional framework to its full advantage or disregards parts of it, thus endangering the attainment of its objectives.

As a non-host, India shares 9 per cent of ITER's estimated costs during the construction phase. The ITER agreement—the intergovernmental treaty which gave birth to ITER IO—specifies that contributions to the reactor can be made in-cash and in-kind. In a separate document, the partners determined that during the reactor's construction phase, a majority of the contributions would be provided in-kind. In the case of ITER, this means that Member States manufacture components and hardware for the project, provide services and second scientific as well as administrative personnel to ITER IO. India's Institute for Plasma Research manages the country's in-kind contributions. Ultimately, however, it is India's industry that produces components and hardware (Anupama et al. 2021). By doing so, India's industry has gained experience in key fusion technologies, which is crucial for building an Indian DEMO, a machine that is capable of exploiting fusion energy commercially (Arnoux 2014).

By seconding personnel to an IGSO, countries can further enhance their national S&T capacities as dispatched experts infuse their home institutions with novel knowledge upon their return. From an institutional perspective, dispatching staff is important because it increases a state's visibility in an organization. If a country's staff is placed in key positions, it can exert control over IGSO decision-making processes. In ITER's case, India agreed to second staff proportional to its project contribution (IAEA 2007). During the last few years, however, the country has not managed to fulfill this pledge. Instead of an agreed-upon staff size of eighty-six, between 2016 and 2020, India never had more than thirty-six staff members at ITER IO (ITER IO 2021). This equals two per cent of ITER's overall IO staff, seven per cent less than what India would be allowed under the ITER agreement. India's inability or unwillingness to fill its full roster has two important consequences. First, it allows other countries, such as China, to have excess staffing (Bagla 2020). This means that India cedes institutional control to other countries as more staff often equals more influence (Parizek and Stephen 2021), particularly if such staff fills key positions. Although Indians are comparatively well represented in management positions, among all ITER partners, India also supplies the highest share of construction workers (Personal Communication from ITER IO 2023) and ITER project associates, individuals who work in supporting roles devoid of management responsibilities (Kamble 2020). This effectively reduces India's ability to exert institutional influence through staffing. Second, India's personnel policy impedes knowledge transfer between its domestic fusion community and ITER IO as there are few experts who infuse their home institutions with novel knowledge following their secondment. What complicates matters is that the few Indian experts deputed to ITER only stay for a short period of time, which makes it hard for them to gain in-depth experience in fusion technology. Indian experts are deputed for such short periods because regulations of the country's Department of Personnel and Training determine that government staff cannot be posted overseas for more than 2 years; experts from autonomous institutes cannot be dispatched for more than 5 years (Bagla 2020).

Additionally, India provides in-cash contributions to ITER IO. Like the USA, India has not paid its full in-cash contributions during the past few years. Currently, its outstanding contributions amount to approximately 131 million US dollars (USD) (Bagla 2020). This has led to ill-will among the remaining ITER parties because they have to make up for lacking funds and accept delays (INT08 2021). A downturn in India's domestic economy cannot account for Delhi's failure to provide its in-cash contributions because while India withheld funds for ITER during the past few years, it lent a substantial amount of 36 billion USD in development assistance to sixty-five countries in almost the same period (Indian Ministry of External Affairs 2022). A former member of the ITER Council instead implied that India's lack of financial commitment to and interest in the project is related to domestic politics and, in particular, the country's change in government in 2014 (ITER IO 2021; INT08 2021). This change in government seems to have led to a focus on developing nuclear fusion technology *within* the country. In 2015, then ITER-India project director Deshpande stated that 'the knowledge that we gain will be used to set up our own demonstrator reactors at home' (quoted in Rupera 2015). Indian nuclear expert Kakodkar equally suggested that 'having done so much on ITER, we should actually prepare ourselves to set up the DEMO plant … on Indian soil' (quoted in Bagla 2020). This would also explain why India deputed a rather junior person to represent the country at a high-level ITER event in 2020 when all other ITER members dispatched their heads of state (Bagla 2020). Coupled with its inability to meet its human capital contributions for ITER, the lacking financial commitment to ITER could endanger India's image as a reliable partner in civilian nuclear cooperation and fusion research, putting its political strategy of gaining trust among other civilian nuclear powers at risk. However, given that ITER is a long-term project—with key milestones set to be reached by the middle of this decade—the country can still make up for its temporary loss of focus.

4.3 SKA: from Afro-pessimism to Afro-empowerment

4.3.1 Initiation

SKA is a multibillion euro astronomy project that aims to explore a range of fundamental cosmological questions (Pozza 2015). In 2019, the UK, Portugal, China, Italy, the Netherlands, Australia, and South Africa signed an intergovernmental treaty, the so-called SKA Observatory (SKAO) Convention, to establish SKAO, the IGSO responsible for building and operating SKA. The organization's headquarters is located in the UK, but Australia, South Africa, and eight other African countries will eventually co-host SKA's instruments.

Although SKAO was only recently established, deliberations for a large international astronomy project began already in the late 1980s (Baneke 2020). Discussions intensified after 1993, when the possibility of realizing a large international astronomy project was raised in several fora, including the International Union of Radio Science (URSI), the International Astronomical Union, and the Organization for Economic Cooperation and Development (OECD) (Ekers 2012). A so-called Large Telescope Working Group (LTWG) was first set up with the task of specifying scientific goals and technical requirements for a prospective large international telescope at URSI (Ekers 2012). South Africa did not participate in the LTWG, but followed the developments through one of its URSI representatives (Jonas 2022). Apparently, at that point, no one was expecting significant technological or scientific contributions from South Africa (Reich 2022), mainly because the country only had five radio astronomers back then (Du Toit 2021). However, early on, South Africa was aware that it held a geographic advantage for radio astronomy (Reich 2022) as it has several areas with low radio-frequency interference, a prerequisite for highly sensitive radio astronomy projects as the one discussed in the LTWG. Therefore, the country's S&T department (DST) had identified astronomy as one of its focus areas for its S&T sector shortly after the downfall of South Africa's apartheid regime in 1994 (INT02 2022).

Discussions on a large radio telescope advanced further during the early 2000s. At that point in time, DST began to support a site bid for the project—which had by then been named SKA—for two main reasons. First, it saw SKA as a means to develop national S&T skills and capacities and to diversify the country's S&T sector, which had historically been dominated by the defense industry (INT02 2022; Tiplady 2022). Second, participating in an international project like SKA promised increased interaction with international and regional scientific and political communities. Less than 10 years after the fall of apartheid and following decades of scientific isolation (Sooryamoorthy 2010), such interaction was crucial for the growth of South Africa's S&T sector. The country's motivation for getting involved in SKA thus clearly went beyond purely scientific rationales.

South Africa's 2003 site bid for SKA was met with considerable skepticism from some Northern partners, such as the USA and Australia (INT02 2022). The latter doubted that South Africa and its African partner countries would be able to 'build the world's largest scientific instrument' (INT02 2022). This Afro-pessimism began to subside when South Africa made progress in developing SKA's precursors, KAT-7 and MeerKAT (INT02 2022; Tiplady 2022). Local engineers who had previously worked in the country's electronics and defense industry proved crucial for MeerKAT's success (INT02 2022). Convinced that South Africa could host and operate SKA, project proponents agreed early on that they did not simply want to 'offer a piece of land' (INT02 2022). Rather, they were adamant about nurturing a radio astronomy community to 'strengthen their position' in the project and to give SKA's remaining partners 'confidence in [them]' (INT02 2022). Hence, South Africa established a Human Capital Development Program to develop the necessary S&T capacities for SKA. Ultimately, these efforts paid off as in 2012, rumors spread that SKA's site advisory committee would recommend South Africa's site over that of its competitor Australia (Quick 2012). Surprised and angered, Australia threatened to leave the collaboration (INT02 2022). As this would have depicted a big blow to SKA, the UK proposed to consider a dual-site solution. Although this option proved more expensive, politicians finally opted for it. As a result, South Africa will eventually host SKA's high and mid-frequency dishes, while Australia will host its low-frequency antennas (SKAO 2022). Moreover, both countries will host science and engineering operations as well as 'science processing' centers (Chrysostomou et al. 2020: 16).

4.3.2 Subsequent development

SKA is not yet fully operational. Due to the corona pandemic and subsequent economic fallouts, construction had to be delayed. Nevertheless, it is possible to assess how SKA's institutional features impact South Africa's political and scientific objectives in the project.

In line with a strategy of strengthening S&T capacities, South Africa was eager to ensure a fair return on investment from SKA for its national economy and to guarantee its scientific community access to the instrument and the huge amounts of data it would generate. In the SKAO Convention, return on investment is guaranteed by the principle of 'fair work return' (SKAO 2019: Art. 1). This principle is common practice in other IGSOs, but not uncontested (European Space Agency 2014). It determines that the cumulative values of goods, works, and services provided by an IGSO member through the procurement process should broadly reflect its financial project contributions (SKAO 2019). A manager who works for the South African Radio Astronomy Observatory (SARAO), the entity that manages the African component of SKA, puts it this way: with SKA, 'what you put in is what you get out' (Tiplady 2022). As in ITER, contributions to SKA can be made both in-cash and in-kind (SKAO 2019). In-kind contributions are manufactured locally and transported to the project site. This enables participants to maximize skills, knowledge, and technology transfer at the national level. South Africa bears a considerable share of SKA's construction and operation costs. As a result, the country will obtain substantial procurement contracts under the principle of 'fair work return' from which it is likely to benefit.[1] Scientific access to SKA is organized on a similar basis as procurement: SKA members and associate members will have access to its telescopes proportional to their project share (SKAO 2019: Art. 13). Through its financial contributions, South Africa secured valuable observing time for its domestic science community.

While the institutional principle of 'fair work return' ensures procurement and observing time proportional to a country's project share, some scholars suggest that the centralization of SKAO management in the UK could perpetuate asymmetries that have haunted conventional research projects (Walker and Chinigò 2018). They argue that this centralization might lead to Southern partners being sidelined when major project decisions are taken (Walker and Chinigò 2018). A former SARAO manager, however, underlined that SKA's Northern partners began to see South Africa as an equal partner soon after it joined the collaboration (INT02 2022). Personnel from SARAO further emphasized that South Africa had a considerable influence on the project design and the negotiation for the SKAO Convention (Jonas 2022; INT02 2022).

Tensions could also arise among African project partners, endangering South Africa's goal of fostering both regional scientific *and* political cooperation through SKA. Within the African component of SKA, South Africa takes a leading role, so much so that its African partner countries are not even mentioned in the SKAO Convention. An interviewed SKA science manager said that the African SKA's partners chose South Africa as a representative for all project partners on the continent for reasons of practicality (INT02 2022). At the same time, this interviewee implied that South Africa got additional African countries involved in the project because SKA was intended to cover 3,000 km—an area 'you couldn't fit into South Africa' (INT02 2022). This could be an indication that South Africa sees the remaining African SKA countries as means to an end rather than partners. However, given that South Africa invests considerable resources in S&T capacity-building in its partner countries, this seems unlikely.

4.4 AfLS: 'by the community for the community'

4.4.1 Initiation

AfLS is a planned South–South IGSO driven by the vision to establish the first pan-African lightsource. Such a source emits X-rays that serve as a tool for multidisciplinary scientific investigations in fields like biology or physics.

First brought up as an idea in the 1990s by the scientific community, the African Laser Centre was the first to formally call for a pan-African lightsource in its 2002 Strategy and Business Plan (Mtingwa and Winick 2018: 12). Since then, AfLS has taken several steps toward institutionalization, including the creation of the AfLS Foundation in 2018. The majority of the foundation's executive committee is composed of researchers from African institutions and members of the African diaspora, but its advisory board features directors and senior scientists from lightsources around the world (African Lightsource 2022a). At an institutional level, there is a strong connection between the European Synchrotron Radiation Facility (ESRF) and AfLS, with the former serving as a hub for training and education for African users and facilitator of conferences and workshops. This relationship probably is due to the strong historical ties between ESRF and African researchers reaching back to the 1990s (Connell et al. 2018).

Currently, the AfLS Foundation fulfills two main functions. First, it drives the initiation of partnerships with regional and international scientific networks and local capacity-building (Connell et al. 2019). In doing so, it is supported by stakeholders from the Global North, e.g. the UK Research and Innovation's Science and Technology Facilities Council, which initiated the British Synchrotron Techniques for African Research and Technology scheme. This scheme aims to improve access to lightsources for researchers from the Global South (Nicklin et al. 2022). In addition, AfLS gets considerable support for training young African researchers at lightsources in the Global North through the partnership with the Lightsources for Africa, the Americas, Asia, and Middle East and Pacific project, which is primarily financed by the International Science Council (Newton et al. 2022). Second, the AfLS Foundation lobbies governments to support the project. Such support is necessary because although the project was referred to in the 2015 African Higher Education Summit (Trust Africa 2015) and the Ghanaian government pledged support for it, as of now, there are no concrete funding and political commitments. Both, however, are crucial for key institutional decisions like site selection (INT06 2022). To convince African policymakers and funding agencies of the project's viability, the AfLS Foundation has established a 'minister forum' that creates closer links between policymakers and project proponents at the 2021 virtual AfLS conference (Ntsoane 2022). In addition, it is in the process of drafting a Conceptual Design Report (CDR) that outlines the AfLS science case, technical infrastructure, and governance (African Light Source, forthcoming).

AfLS proponents name the geographical distribution of the approximately fifty existing lightsources as a key rationale for a pan-African lightsource (Connell et al. 2019). The majority of these are concentrated in the Global North, as are technological equipment, knowledge, and skills. Yet, in theory, researchers from African countries can access all Northern-located lightsources, even if their host countries do not have membership status because experimental time is allocated according to the scientific excellence of submitted proposals. As in conventional research collaborations, however, in practice, the largest financial shareholders of these facilities—predominantly Northern states—shape research priorities and procedural matters because financial contributions usually determine voting rights in the Council, which, in turn, determines the scientific program. In addition, full membership is often linked to a certain financial threshold, which many Southern countries struggle to reach (Cramer 2020: 109, 166ff.).

The growing availability of remote data collection services provided by many lightsources gradually reduces access barriers to Northern facilities (Nji et al. 2019). Yet, proponents of an AfLS argue that a lightsource is crucial for African countries and scientific communities because it could advance African research agendas and capacity-building. For instance, the AfLS Manifesto, concluded at the end of the first AfLS conference in 2015, claims that AfLS 'is expected to contribute significantly to the African Science Renaissance, the return of the African Science Diaspora, the enhancement of University Education, the training of a new generation of young researchers, the growth of competitive African industries and the enhancement of research that addresses issues, challenges and concerns relevant to Africa' (African Light Source 2015: 3).

Proponents also hold that AfLS could provide a greater balance of institutional rights and obligations compared to Northern-located lightsources. They argue that they can maintain this balance by relying on the concept of Ubuntu throughout the institutionalization process. Ubuntu is an African humanist concept that scholars conceptualize as an ethical harmony of values and identity among a person, humanity, and nature (Madise and Isike 2020). Building on values such as inclusivity, equity, and empathy, it is seen as a relational and community-centered concept and an alternative form of political soft power that 'does not conform to the normative foundations of international relations [based] on competition and the accumulation of power over others' (Madise and Isike 2020: 2).

By prescriptively enshrining Ubuntu as the guiding principle for negotiations on AfLS, the project breaks new ground and distinguishes itself from European IGSOs. The founding phases of the latter can also be described as consultative as they involved a global community of scientists and policymakers. Yet, studies have shown that in many of these IGSOs, siting and financing issues have led to contention among stakeholders (e.g. McCray 2010; Riordan et al. 2015). In the case of AfLS, an inclusive initiation process driven by Ubuntu aims to overcome such political frictions through different means (Newton et al. 2022). For example, in the current phase of AfLS's initiation, applications of Ubuntu range from symbolic uses of ceremonial calling and speaking sticks that link closely to the spirit and traditions of the concept as well as its inclusion in the draft version of the CDR (African Light Source, forthcoming). Through a consultative drafting process, which includes town hall meetings and community workshops, the CDR is expected to become a document 'by the community for the community' (African Lightsource 2022b). Ultimately, key actors hope that AfLS emerges as a community-driven project for which African governments and researchers can claim ownership. For them, ownership is crucial because it is seen as a means to guarantee long-term funding from African governments as well as a solid and well-connected African user community (Connell et al. 2019).

Yet, at the current stage of initiation, it remains an open question whether the inclusionary principle of Ubuntu will prevail when it is faced with competing political interests that have been known to shape Northern IGSOs. Although the AfLS Foundation has put forward basic requirements for hosting the lightsource, the draft version of the CDR does not make any site or funding proposals for AfLS (African Light Source, forthcoming) and it seems unlikely that it will do so in its final version. Past siting and funding negotiations in Northern lightsources show that these issues can be difficult to resolve because they require political consensus at the highest level. This is why concrete funding schemes and site proposals are rarely included in CDRs (Cramer 2020: 194f.). In the case of AfLS, African countries that seek common ground for AfLS may thus not necessarily refrain from pushing their national political and scientific interests when it comes to siting and funding. Time will show whether AfLS's visionary approach and the rhetorical and procedural prescriptions of Ubuntu will withstand the reality of intergovernmental negotiations.

5. Discussion and policy implications

In our study, we examined which objectives countries of the Global South pursue in IGSOs and under which conditions they are likely to achieve their objectives. In doing so, we compared four different IGSOs with Southern participation. Concerning our first question, we found that Southern actors pursue various political and scientific objectives in IGSOs. These include but are not limited to strengthening S&T capacities (CERN, ITER, SKA, and AfLS), casting off international political isolation (ITER and SKA) as well as overcoming relationships of dependency and inequality (AfLS). Regarding our second question, the cross-case comparison shows that Southern actors are more likely to obtain their objectives in IGSOs if four—in some cases five—conditions are met.

The first condition is related to an IGSO's maturity. Our analysis indicates that the younger an IGSO and the less rigid its institutional framework, the more far-reaching objectives the Southern actors can pursue. One reason for this is that the Global North established many now-mature IGSOs and cemented their rights and privileges in rigid institutional frameworks, which make it difficult for newcomers, including those from the Global South, to pursue ambitious political and scientific objectives, e.g. setting an IGSO's research agenda or initiating new research infrastructures. These are challenges that Southern actors also experience in traditional research collaborations. If countries from the Global South pursue less ambitious objectives, it may still pay off for them to participate in mature IGSOs as collaborations in these organizations expose them to cutting-edge technology and enhance their S&T capacities. Our case study of SKA further shows that countries of the Global South may be able to mitigate institutional constraints and take a leadership position in IGSOs. This seems to be the case if they get involved at an early phase, ideally as founding members, because as such, they have greater chances of shaping institutional frameworks before institutional inertia sets in. The cases of ITER and AfLS partly support this finding.

The remaining four conditions are linked to a country's scientific community, domestic politics, industrial capacities, and its location if an IGSO has rigid geographic requirements. First, the cases of CERN, SKA, and AfLS underline the importance of an existing research community that champions participation and provides expertise for the active involvement of Southern actors in IGSOs. For instance, India's nuclear physicists have collaborated with CERN even before the more institutionalized cooperation of the 1990s and 2000s. Similarly, the idea of AfLS is largely driven by African researchers and scientific diaspora nested in a global community of scientists. In the case of SKA, South Africa first lacked a community of radio astronomers, but its willingness to build capacities in this field was understood as a signal of commitment to the project. Second, continuous domestic political support and long-term national commitments, in-cash and in-kind, are essential. Where such political support is lacking and contributions fail to materialize, IGSO partners may quickly fall into disgrace, as the remaining ITER partner's ill-will toward India and the USA demonstrates. With respect to long-term national commitments, many Southern actors have a considerable disadvantage compared to countries of the Global North as they have to plan and work under more acute political, economic, and human capital constraints. For example, one of our interviewees explained that South African policymakers currently consider it 'risky' to spend public money on IGSOs when the country's limited resources could also be used to address more pressing domestic challenges (Sewell 2022). Third, IGSOs often rely on large-scale infrastructures to be built by industrial contractors. Possessing suitable industrial capacities can thus strengthen the position of Southern actors in IGSOs. Indian companies, for instance, provided important hardware to the LHC. Similarly, South Africa relied on expertise from its advanced defense industry to build SKA's forerunners that showcase the country's capabilities. Fourth, while scientific, political, and industrial capacities matter for all IGSOs, geography is more crucial for some projects than for others. For example, geographic requirements are very clear-cut in fields such as astronomy, but more flexible in HEP (CERN), nuclear fusion (ITER), and synchrotron-based sciences (AfLS). For SKA, geography played an important role because the conditions necessary for the proposed research were only met in a few places around the globe. For AfLS, in turn, the question of geography is one of identity, because for project proponents, a lightsource realized on the African continent symbolizes a fairer participation of African researchers in the global science system.

The findings from our cross-case comparison have two important implications for science policy. First, countries of the Global South may benefit from adjusting their investments in and objectives for an IGSO to an organization's institutional maturity. To do so, political and scientific actors first have to explicitly map out which objectives they seek to attain through IGSO participation. For example, if Southern actors want to take a political and scientific leadership role in an IGSO, they are more likely to do so if they invest in an emerging or planned IGSO as our study shows that mature IGSOs possess rigid institutional frameworks that make it hard for newcomers to pursue ambitious objectives. Second, our case studies in sum indicate that countries of the Global South are more likely to attain their political and scientific objectives if they are able and willing to mobilize their scientific community, secure continuous domestic political support, muster their industrial capacities, and, in some cases, leverage their geographic location for an IGSO. In contrast to S&T-lagging countries, emerging Southern powers are likely to have the capacity to do so, at least in areas they deem important. Yet, compared to countries in the Global North, they face more scientific, political, and economic constraints. As a result, policymakers from the Global South may benefit from strategically investing in IGSOs instead of taking a scattergun approach. This also applies to the four factors that condition a Southern actor's ability to achieve its IGSO objectives. For example, as the case of the radio astronomy community in South Africa demonstrates, it can be useful for countries of the Global South to invest in a domestic science community that conducts specialized research instead of spending big amounts of limited funding on an entire discipline. Such strategic investments may also increase chances that long-term commitments can be honored from an economic and political perspective.

6. Conclusions and outlook

IGSOs are characterized by long-term perspectives, relatively-fixed institutional frameworks, as well as high demands on financial, technical, and scientific capacities. Our study started off with an investigation of India's role in CERN, Europe's oldest IGSO, and concluded with AfLS, a planned Southern IGSO. Throughout our analysis, we showed that the position of Southern countries in IGSOs can range from one of dependency and junior partnership in established organizations (CERN) to one of (self-)empowerment in planned IGSOs (AfLS).

Although our study provides important empirical contributions to the literature on international research collaboration, IGSOs and SD, further research is required. First, given that our study only looks at a small number of IGSOs, there is a need for additional in-depth case studies and large-scale case comparisons to refine our findings. As the Global South represents a rich diversity of socio-economic and scientific systems, such studies should ideally move beyond our focus on Southern emerging powers. Second, our line of research should be extended because it may enable us to examine if certain global governance trends also have an impact on the global science system. For example, in recent years, we have seen that some Southern states under authoritarian rule have begun to position their nationals at the head of a wide range of United Nations (UN) agencies to gain greater influence in world politics. Given the pivotal role that the UN system plays for global governance, some see this as an indication that 'the arc of global governance is beginning to bend toward a more illiberal orientation' (Lee 2020). Additional research on Southern participation in IGSOs could illuminate whether similar developments are unfolding in the global science system and if so, what consequences this may have for academic freedom, international scientific collaboration, and, ultimately, scientific progress.

Data availability

The datasets generated during and/or analyzed for the current study are available from the corresponding author on reasonable request.

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Note

1 This is what a recent study on SKA's socio-economic impact suggests. It finds that SKA has had a positive impact on national and local economies, e.g. by providing training opportunities, strengthening tourism, and generating new jobs (Atkinson et al. 2017). Yet, like Walker and Chinigo (2018), this study underlines that the land acquisition process for SKA could lead to a production loss for some local farmers.

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