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South-South Ideas

Mapping South-South Cooperation in Science, Technology and Innovation for Theory and Practice

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NeST
Network of Southern Think-Tanks

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Acronyms and Abbreviations

AEI	Access, Equity and Inclusion
AISJCC	ASEAN-India Joint Cooperation Committee
AISTDF	ASEAN-India Science & Technology Fund
BAPA	Buenos Aires Action Plan
BRICS	Brazil, Russia, India, China and South Africa
CBDR	Common but Differentiated Responsibilities
ENSO	El Nino Southern Oscillation
eVIN	Electronic Vaccine Intelligence Network
IAEA	International Atomic Energy Agency
IBSA	India, Brazil and South Africa
IPR	Intellectual Property Rights
ISTIC	International Science, Technology and Innovation Centre for South-South Cooperation
LDC	Least Developed Country
LOC	Line-of-Credit
MOH	Ministry of Health
MoHFW	Ministry of Health and Family Welfare
NBER	National Bureau of Economic Research
NCSC	National Children Science Congress
NSC	North-South Cooperation
NTDs	Neglected Tropical Diseases
OECS	Organization of Eastern Caribbean States
PAHO	Pan American Health Organization
PPS	Pharmaceutical Procurement Service
RRI	Responsible Research and Innovation
S2S	South-to-South
SAP	Structural Adjustment Programme
SKAI	Scientific Knowledge Application Index
SDG	Sustainable Development Goals
SSC	South-South Cooperation
STI	Science Technology and Innovation
TCDC	Technical Cooperation among Developing Countries
TrC	Triangular Cooperation
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

Executive summary

Science, technology, and innovation (STI) are key to economic and social development, yet the capacity for scientific innovation remains unequally distributed across the globe. Working from the perspective of access, equity and inclusion (AEI), the present study analyses the state of STI in the Global South and the potential challenges associated with creating an effective linkage between STI and South-South Cooperation (SSC). Our objectives are to assess the state of STI in the Global South from an analytical perspective, determine its importance, identify the challenges and issues faced by stakeholders as they strengthen their STI architecture, and generate a template for a database and inventory of SSC-STI linkage initiatives so as to track STI collaboration through SSC.

We begin with a fundamental premise: a vicious circle affects technological development in the Global South. Technology and economic development are engaged in a bidirectional causal relationship in which one reinforces the other in a constant feedback loop. It is imperative that the countries of the Global South break out of this vicious circle at the earliest possible opportunity, following in the footsteps of peer countries who are now in a position to show the way. We argue that such efforts may bear fruit through the adoption of a cooperative approach working in the spirit of solidarity that underlies the well-accepted concept of the Development Compact.

The present study is divided into six sections. The introductory section presents the context and background of the study while the second section provides an analytical view of the importance of STI in developing countries. The third section gives a brief review of the existing literature on the linkage between SSC and STI. The fourth section assesses the existing status of STI infrastructure in terms of a number of the standard quantitative indicators used in the literature to estimate the robustness of scientific, technological and innovative capabilities in developing countries and the challenges that need to be addressed so as to strengthen them. The fifth section develops an operational structure to situate STI vis-à-vis the developmental aspirations of the Global South, using the Development Compact conceptual framework linked to the operationalization of SSC, and identifies the implications of that concept through selected case studies. In conclusion, the final section provides a number of actionable policy recommendations.

Some of the key observations that emerge from our study may be briefly summarized here. Although efforts have been made to implement technological cooperation among nations in the Global South ever since the concept of SSC was concretized and given a collective vision in the Buenos Aires Action Plan (BAPA) in 1978, the emerging importance of knowledge-based economics, as opposed to the earlier paradigm of physical capital accumulation, has changed the entire dynamics of the global economic structure. Endogenous models of economic growth and development have created an important space for STI based on a global approach to move forward, resulting in the move towards a process of globalization, while robotics, nanotechnology, genetic engineering and big-data analysis are believed to be the pathway to follow in coming years, as can be seen from the recent emphasis on Industrial Revolution 4.0. Lagging behind in terms of their STI architecture, countries in the Global South face considerable challenges in their pursuit to catch up with their industrialized peers, although a small number of emerging economies are visible exceptions.

The present study offers insights into the nature of the gap that exists in STI infrastructure between the industrialized and the developing worlds, particularly in countries considered as the least developed, through the analysis of a number of the standardized indicators used to quantify achievement in knowledge and technology. It further considers a number of instances of cooperation between countries in the Global South through sharing technology, and attempts to identify the existing cooperation patterns. The patterns thus identified form the basis for a template that may be used to document the kinds and variations in technology sharing among partner countries in the Global South that can serve as reference points for further collaboration and sharing. The template will also help to create an inventory of technologies that could potentially be improved or modified to meet the specific requirements of interested partners.

Finally, the document offers policy recommendations that may enhance STI architecture in the Global South through SSC. The policy framework has been considered at the individual country level as well as at the collective level of country groupings. Time frames have also been delineated for short term, medium term and long-term implementation. Some of the suggested key policy reforms concern the creation of a Southern STI Fund with contributions from Global South partners based on the principle of Common but Differentiated Responsibilities (CBDR), and the creation of specialized technology resource centres in partner countries chosen for their respective comparative capabilities. The centres would be called upon to function as nodal technology hubs to share knowledge and technology with countries in need.

At the national level, countries may consider linking their STI and sectoral policies, by encouraging inter alia university-business linkages so as to co-create technology and subsequently transfer it to small- and medium-scale industrial units, or by creating stimulus for STI system development through forward and backward linkages, decentralizing STI infrastructure, dispersing technology to facilitate the creation of South-South value chains, creating effective, measurable indices to track the depth of STI linkages, and promoting public science to mitigate social crises. Needless to say, it will take considerable effort to bring about the desired outcomes

1. Introduction

The importance of Science, Technology and Innovation (STI) as an emerging feature in the global governance of development cannot be overemphasized. However, its growing significance has been accompanied by a number of associated challenges, some of which have been brought to the fore by the global COVID-19 pandemic.

Indian Development Cooperation History

The overwhelming advances in STI made during the last few decades cannot simply be ignored when framing an effective global governance architecture mechanism that will ensure access, equity and inclusion (AEI) with regard to scientific and technical knowledge. That key challenge must be overcome in the near future.

The present study is an attempt to map STI activities as they pertain to South-South Cooperation (SSC) so as to provide both a theoretical and a practical perspective on the desirable connection between the two.

Karl Polanyi (1944) argued that land, labour, money and even knowledge are fictitious commodities in the sense that, by themselves, they are not regarded chiefly as commodities to be bought and sold. They are embedded in social relationships, and subject to moral considerations, religious beliefs and community management. These fictitious commodities are not amenable to exchange using a market-led system alone. Their exchanges involve non-market processes such as politics, sociology, culture, history and ultimately, the value system influencing the behaviour of the individuals engaged in such sharing. STI, as part of the knowledge system, may also be categorized as a fictitious commodity.

Since the early 1980s, endogenous growth theory has identified the important role of governance in pushing a society forward on its path to development. The fundamental lesson learned from the emergence of the endogenous growth theory is its emphasis of the role of an economy's internal growth drivers. In this way we have become conscious of the need to ensure an effective governance of the whole set of fictitious commodities – land, labour, money, knowledge and STI – rather than merely leaving them to unfettered market control.

The plethora of global crises, including the COVID-19 pandemic, has revealed a number of gaps and shortcomings in global governance, in contexts ranging from global warming and climate change, protection of the gene pool and biodiversity, the financial crisis of 2007-2008, increasing wage-wealth-income inequalities across the globe or concerns about easy and affordable availability of and access to COVID 19 vaccines once they are ready to be distributed worldwide.

It is clear that while the exchange of commodities through a market system is still expected to be guided to a large extent by the brute forces of competition, the sharing of fictitious commodities cannot be governed by "invisible hands" alone. STI knowledge bases must be treated as public goods in a spirit of collaboration and cooperation and ideally be made accessible to all, equitably and inclusively. Knowledge-led growth has brought this issue to the fore and given significance to the challenges of STI governance from the perspective of access, equity and inclusion.

It should be noted, however, that there is a considerable gap between industrialized and developing societies in terms of their access to technology, due in large part to the prevailing divide in their abilities to create new technologies[1] and the clear lack of a governance mechanism that would enable technologies to be shared broadly in a spirit of cooperation and collaboration.

The acceptance of Intellectual Property Rights (IPR) as the fundamental driver in incentivizing STI efforts has encouraged durational monopoly, created opportunities for generating abnormal profit and halted prospects of such collaborative practices. As Mormina (2018) argues, efforts at international collaboration have been effective in enhancing the knowledge and technical competence of researchers from developing countries but failed to facilitate the investments needed simultaneously to create and sustain the necessary institutional and governance structures, both socioeconomic and political, and thus has effectively stymied the creation of knowledge in the Global South.

In the absence of a mechanism – either internal or in combination with external support – that would facilitate affordable access to knowledge in an equitable and inclusive matter, domestic efforts in the Global South to create a robust, knowledge-driven society remain inadequate. The present study underscores the need to institutionalize a Southern STI infrastructure that will be inclusive and equitable and provide the citizens of the Global South with affordable access to the knowledge STI generates. Such an AEI framework would facilitate their "drive to maturity" – to quote W.W. Rostow (1962). It is clear that States have a vital role to play in providing the necessary supportive governance structure.

The present study underscores the need to institutionalize a Southern STI infrastructure that will be inclusive and equitable and provide the citizens of the Global South with affordable access to the knowledge STI generates.

Two important ideas should be developed in this context. First, a vicious circle affecting technological development is at work in the Global South. Just as Polanyi (1944) contended that the creation of knowledge is conditioned by the socioeconomic, historical and political features of a society, Arthur (2009) also found that there is an effective flow of causality connecting technology – the result of knowledge – to sociopolitical and economic change. He argues too that technology has the capacity to change the overall structure of a given society. If these two arguments form a negative feedback loop, a vicious circle may be created in the Global South alongside a simultaneous virtuous circle in the industrialized world.

Breaking out of the vicious circle in the Global South would require a conscious effort to govern knowledge creation in general and STI in particular. Collaborative action in the spirit of South-South solidarity should be strong enough to break the vicious circle, especially as it has been observed that the extant structure of a North-dominated model of STI cooperation is not be able to deliver the desired results. A number of emerging economies that are capable of ending the vicious circle of poverty have been found to have succeeded to some extent in breaking out of the vicious circle surrounding knowledge creation as well.

Research and development enhance the scientific and technological prowess of a society and its consequent ability to innovate. However, a dynamic power struggle is going on among companies, investors and States, and the results of that struggle will affect whether or not the vicious circle is maintained. As Chang and Andreoni (2020) argue, the power relations that exist among the major companies that govern the global value chain (users of knowledge and technology), the providers of finance and productive capital that govern the process of global financialization, and the States will control the ability of the companies and governments to become more inclusive and create more jobs through new knowledge. The consequent technological breakthrough will decide how much push is needed to break the vicious circle in knowledge and technology that affects the Global South. A South-South approach to STI has to reflect an acute awareness of these realities.

[1] See the discussion in Chapter 3.

Can the collaborative, cooperative approach to development through the principles of solidarity that underlie South-South Cooperation be the foundation for building the architecture needed to facilitate access, equity and information in STI? By examining current key experiences and analytical frameworks, the present study seeks to set out a road map for the development of an effective linkage between South-South Cooperation and STI.

The study aims to assess the current state of STI in the Global South and determine its importance from an analytical perspective, identify the challenges and issues faced by stakeholders in strengthening their STI architecture, and finally, generate a template for the creation of a database or inventory on SSC-STI linkage to keep track of STI collaboration through SSC.

The present study is divided into six sections. The introductory section presents the context and background of the study while the second section provides an analytical perspective on the importance of STI in developing countries. The third section gives a brief review of the existing literature on the linkage between SSC and STI. The fourth section identifies the existing status of STI infrastructure in terms of a number of the standard quantitative indicators used in the literature to estimate the robustness of scientific, technological and innovative capabilities in the developing countries and the challenges that need to be addressed so as to strengthen them. The fifth section develops an operational structure to situate STI vis-à-vis the developmental aspirations of the Global South through the conceptual framework of a Development Compact linked to the operationalization of SSC, and identifies the implications of that concept with the help of selected case studies. The final section provides actionable policy recommendations.

2. The importance of STI in developing countries: an analytical perspective

Linking SSC and STI — a brief overview

In view of the need to break the vicious circle in technological capabilities, South-South Cooperation (SSC) in STI has been under discussion for some time.[2] References to it can be found at least as early as Technical Cooperation among Developing Countries (TCDC) put forward in 1974 and formalized in the Buenos Aires Plan of Action (BAPA, 1978). Our survey of the literature found that the importance of linking SSC and STI has been mentioned or referred to in a number of documents, either in passing or to affirm its relevance or as an additional component along with others such as finance, capacity-building etc.

The literature cites evidence for and examples of linking in different sectors, in different contexts or to address specific issues or targets under a range of Conventions and Treaties[3]. At the same time as United Nations agencies engage in promoting SSC and STI in developing countries and the least developed countries (LDCs), they have evinced interest in formalizing the linkage and have promoted it as part of their mandate. The International Science, Technology and Innovation Centre for South-South Cooperation (ISTIC) under the auspices of UNESCO, is a prominent example of such an endeavour. United Nations agencies have promoted it, facilitated it and advocated it. The linkage is also considered an effective mechanism to achieve the Sustainable Development Goals (SDGs) that call for a world where no one is left behind. In a knowledge-governed society where high premiums are paid for creating knowledge, a lagging STI infrastructure cannot create the level playing field required for the achievement of those goals.

When SSC-STI linkage was proposed in BAPA 1978, the situation was very different. This was the era of the Cold War, with the USA and the USSR vying to influence both developing countries and the global order. Science and technology were dominated by the USA, Europe and the USSR while developing countries lagged far behind, although a few, such as India, China and Brazil, were making efforts to catch up wherever possible. Technology transfer from the Global North to the Global South was the dominant paradigm, and the importance of linking SSC with STI was limited to only a very few sectors.

Much has changed over the last four decades. Today, many developing countries, including India, China and Brazil, have made significant progress in STI and their technological capacities have risen substantially (Dehmer, Pardey, Beddow, & Chai, 2019; Wong & Wang, 2015; Zhou & Leydesdorff, 2006)

Given the rapid developments in science and technology, technological convergence and innovations such as Industry 4.0, the challenges facing the South are diverse, ranging from governance issues to harnessing development appropriately. Questions are being raised as to whether competitiveness in manufacturing will be eroded and/or result in massive unemployment and displacement of labour, as well as to whether an effective

[2] See, for example, the Resolution adopted by the General Assembly on 20 December 2017, Seventy-second session Agenda item 21 (b) A/RES/72/228.

[3] Some of these are the Convention on Biological Diversity, Paris Agreement on Climate Change, Addis Ababa Agenda for Action, Agenda 2030, and even WTO.

linkage between SSC and STI would be able to address these concerns. In such instances, the scope of the linkage has to expand so as to anticipate future developments and respond accordingly. Are the current approaches to cooperation in sharing of technology adequate? Will they remain so in the future?

Regional economic communities such as ASEAN and the African Union, and intercountry groups such as IBSA (India, Brazil and South Africa), BASIC (Brazil, South Africa, India and China) and BRICS (Brazil, Russia, India, China and South Africa) have been active in sharing technology among Southern partners, and implement programmes and projects on a number of themes and technologies[4]. UNESCO has noted that such regional economic communities "ha[ve] become a conduit for South-South cooperation in science, technology and innovation."[5]

Although the scale and focus of technology-sharing activities may vary, they are significant for a better understanding of the linkage between SSC and STI. However, in the aforementioned instances, there is hardly any conceptual analysis as to why the interconnection is necessary, an analysis which would enable us to highlight the lessons learned and their implications. The role of SSC in STI cooperation has gained further standing in addressing critical issues such as climate change, biodiversity conservation and most recently, the present global pandemic.

The role of SSC in STI cooperation has gained further standing in addressing critical issues such as climate change, biodiversity conservation and most recently, the present global pandemic.

In the literature we find discussions and case studies on SSC in low-carbon technology transfers or initiatives relating to climate change technologies.[6] The United Nations Framework Convention on Climate Change (UNFCCC) Secretariat has called for more SSC and trilateral cooperation[7]. There is a need to link SSC with the theoretical and practical issues in technology transfer and determine to what extent such a linkage could facilitate achieving the goals of agreements and treaties such as the Convention on Biological Diversity, Paris Climate Agreement, Agenda 2030 and the Addis Ababa Agenda for Action.

Although technology transfer is a term that appears frequently in the literature, in recent years SSC has mostly been confined to the type of technology sharing that does not involve any conditionalities. Moreover, as will be discussed in a later section, technology sharing is often accompanied by support in the form of other deliverables such as capacity-building, credit and grants, in line with the concept of a Development Compact. For example, the assistance India provided to Ethiopia in the sugar sector went beyond technology transfer and included assistance ranging from obtaining the right germplasm for sugar cane breeding to technology for packaging, together with training relevant personnel and providing soft loans. This indicates that, at least in some instances, development cooperation and STI activities go beyond the mere transfer of technology[8].

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4 See https://ris.org.in/pdf/IBSA%20Report%20Web.pdf; http://www.brics.utoronto.ca/docs/170904-xiamen.pdf, http://sabtt.org.za/wp-content/uploads/2017/11/BRICS-Action-Plan-for-Innovation-Cooperation-China.pdf See also Michael Kahn, *"Prospects for cooperation in science, technology and innovation among BRICS members"*, in Kirton, John and Larionova, Marina, (eds), *BRICS and Global Governance* (London, Routledge, 2018).

5 UNESCO, *Regional economic communities: a conduit for South-South cooperation in science* (2017), http://www.unesco.org/new/en/media-services/single-view/news/regional_economic_communities_a_conduit_for_southsouth_co/

6 See Jing Gua, Neil Renwick, Lan Xuec, *"BRICS and Africa's search for green growth, clean energy and sustainable development"*, Energy Policy, vol. 120 (2018), pp. 675–683.

7 "Potential application of South-South and Triangular cooperation to assist countries in implementing nationally determined contributions and national adaptation plans", Technology Executive Committee Seventeenth Meeting, Bonn, Germany, 25–28 September 2018; 11 September 2018.

8 See *South-South Ideas: Assessing impact of South-South cooperation: Variations in perspectives, select country case studies*, (New Delhi, RIS. 2019). https://www.ssc-globalthinkers.org/sites/default/files/2019-05/UNOSSC_GT_Assessing%20Impact%20of%20South-South%20Cooperation_web.pdf

STI: the big picture

In the fall of 1981, the Productivity and Technical Change Studies Program of the National Bureau of Economic Research (NBER) organized a conference on R&D, Patents and Productivity in Lenox, Massachusetts. The proceedings of the conference were later published under the editorship of Zvi Griliches (1984). The Lenox conference was said to be the first such endeavour since the conference held at the University of Minnesota in 1960, also under the auspices of the Universities-NBER Committee for Economic Research, which had resulted in the publication of the seminal study, The Rate and Direction of Inventive Activity (R. Nelson, 1962), that still serves today as a major statement of and source book for economic ideas in the field. As its fundamental argument asserts,

> The growing body of research findings on productivity turned the attention of economists interested in economic growth to the process of technological change. … [O]nly a small fraction of the total increase in output per worker which had occurred in the American economy since the late nineteenth century could be explained by increased capital per worker. The lion's share had to be attributed to something else: to increased productivity or efficiency. The term 'increased productivity' covers a wide number of different elements, and the operations by which increased productivity is defined and measured obscure a variety of economic phenomena. Better allocation of existing factor supplies (the process of dynamic adjustment) and capital formation in human beings (education, health, etc.) are two of the most important. But it seems obvious that technological change has also been an important ingredient.[9]

According to Griliches (1984), the Lenox conference clearly underscored

> [the] belief that invention and technical change are the major driving forces of economic growth; that economists have to try to understand these forces, to devise frameworks and measures which would help to comprehend them and perhaps also to affect them; that much of technical change is the product of relatively deliberate economic investment activity which has come to be labelled "research and development" and that one of the few direct reflections of this activity is the number and kind of patents granted to different firms in different years.[10]

A clear indication as to how convincing these arguments were to policymakers can be found in their subsequent efforts to enhance their national R&D capacities and gather the resources needed to move forward and introduce a knowledge-based economic system far ahead of the rest of the world. (Griliches (1986), Danguy, de Rassenfosse & van Pottelsberghe de la Potterie (2009), Westmore (2013), Altuzarra (2019)).

The theoretical basis for the emphasis on technology as a major driver of growth emerged from the theories of endogenous growth that went beyond the assumption that change in productivity-enhancing technology was a given in the dynamics of economic growth. Both neoclassical and alternative theories of endogenous growth underscore the fact that long-run growth (i) is sensitive to investment decisions, and (ii) relies on a linear spillover from the stock of knowledge to the production of innovations (Tavani & Zamparelli, 2017).

The new endogenous theory of growth emerged in the late 1980s, especially through the contributions of Romer (1986, 1987) and Lucas (1988), which deviated from the neoclassical growth models pioneered by Solow (1956) and Swan (1956). Such deviations, however, did not imply that they had lost faith in the capacity of markets to take care of these requirements.

9 Nelson, R., *The Rate and Direction of Inventive Activity*, (Princeton University Press, 1962), p.3.
10 Ibid, p. 3.

Despite the dominance of market-led theories, a significant number of economists continued to develop what may be described as "heterodox" growth theories in the classical Marxist, Keynesian, Cambridge and related traditions. Nelson and Winter (1977) is an early effort to develop an evolutionary theory of innovation, breaking away from neoclassical orthodoxy on technology. Dutt (2017) discusses the several perspectives of heterodox growth theories, including growth models of global trade and payments, to examine the implications of the interactions between rich and poor countries. He uses what have been termed North-South models to show how trade, according to short-run comparative advantage, results in the export from the North to the South of technologically sophisticated goods that have strong learning-by-doing effects, while the export of simpler goods from the South to the North results in uneven development, even without there being any other differences between the two regions.[11]

The role of technology in defining the growth path of an economy, whether from a Northern perspective or on a Southern scale, cannot be overemphasized.

The role of technology in defining the growth path of an economy, whether from a Northern perspective or on a Southern scale, cannot be overemphasized. That role was further elaborated by Dahi and Demir (2017) when they argue that:

> [T]he rise of the Emerging South has opened up new lines of inquiry to include not just the traditional topics of trade and preferential trading agreements, but also cover technology transfer, capital flows, labour migration, institutions and environment.[12]

The long-run growth theories espoused by Romer and Lucas are grounded on their argument that technological advance is based on the creation of new ideas or knowledge (a fictitious commodity in Polanyi's view). This concept was first initiated by Arrow (1962) when he launched the idea of learning by doing. The emerging concepts of the importance of the contribution of knowledge to the long-run growth of an economy and the role of governments in facilitating such a process, led to the present era of the knowledge economy, culminating in what today is termed Industrial Revolution IV.

Aghion and Howitt (1999) link endogenous growth theory to the Schumpeterian concept of creative destruction, according to which technological progress will emerge as a potent force of growth when innovation is considered as one of many forms of capital accumulation. They argue that there is continuous interaction between growth and technological change, wherein each reinforces the change in the other, hence the technological base of developing countries must be broadened so as to put them on a sustained, long-term growth path. Singer (1999), the co-formulator of the well-known Prebisch-Singer Hypothesis, takes their argument further, noting that in the absence of technical capacities, developing countries would find it difficult to move beyond their dependence on aid and/or direct foreign investments.

Another distinctive feature concerning the course of development to be pursued by developing countries should now be examined. Despite the accepted wisdom that growth and development are not synonymous, there is often a tendency to act as if they were when operationalizing development cooperation. The quest for development has often been merged completely with the quest for growth. In the context of development, it should be borne in mind that development demands that something beyond growth happen in developing economies. In terms of their structural characteristics, such changes are often marked by sectoral dualism. STI, as seen through existing growth theories, suggests that improvement in science, technology and information would contribute to growth through increased productivity and thus contribute to the continuous growth of income.

[11] See Krugman (1979) and Dutt (1990).

[12] Dahi, O. S, Demir, F., "South-South and North-South Economic Exchanges: Does it matter who is exchanging what and with whom?" Journal of Economic Surveys, 30 October 2017, abstract. https://onlinelibrary.wiley.com/doi/abs/10.1111/joes.12225.

The significant role of STI in bringing about development, in a way that is distinct from introducing and fostering growth, is not the subject of much discussion in the literature. SSC and STI may be considered together as a vehicle to move beyond growth and facilitate the development of the countries identified as the Global South. That vehicle would be called on to break out of the current structural bottlenecks – the vicious circle of technology -- through the triad of access, equity and inclusion.

Accelerating the growth of technological resources is a significant matter of concern for the Global South, as they find that the Solovian convergence has been continuously eluding them. As shall be seen in the next section, the divergence between the North and South persists, although emerging economies are successfully and convincingly reducing the gap. Section 6 discusses the partnerships that have been formed among southern countries that attempt to reduce that gap in sustainable, meaningful ways.

3. SSC-STI linkage: a brief review of the literature

The Buenos Aires Plan of Action (BAPA) endorsed the view that the gaps in capacity in developing countries were aggravated by the uneven distribution of resources which competitivity-driven trade and financial flows were unable to mitigate.

BAPA called for robust technical cooperation among developing countries as a means of building communication and promoting broader, more effective cooperation with one another. The BAPA plan emphasized that such processes are vital for initiating, designing, organizing and promoting cooperation among developing countries so that they can create, acquire, adapt, transfer and pool knowledge and experience for their mutual benefit and achieve the national and collective self-reliance essential to their social and economic development.

BAPA set out the road map for the cooperation in knowledge and capacity-building that was already taking place among the countries of the Global South. It should be noted that such collaboration and cooperation were spontaneous in many ways and adhered strongly to the principle of mutual benefit.

Already during the years that followed decolonization, many developing economies that had acquired better scientific and technical expertise had been offering technical solutions as well as skill development to partner countries. Increasingly since then, SSC in areas such as technology sharing, the sharing of scientific expertise and capacity-building can be identified broadly as a sectoral approach. Amid rapid technological advances and ongoing changes in the industrial paradigm, cooperation on technology and innovation has emerged as one of the most relevant components of SSC, offering the promise of rapid economic development (Guterres 2018; Gray & Gills 2016).

While SSC has played a positive role in improving STI capabilities in the South, the knowledge gap between North and South, as well as within the South itself, has continued to be stark and stubborn. The fast-moving technology frontier, although offering some developing countries the opportunity to leapfrog, has raised considerable challenges for many others who lack the capacity to innovate, adapt or assimilate new and emerging technologies. The situation is all the more critical as technology-led solutions are in high demand in order to address development gaps and ensure that development is environmentally sustainable.

The fast-moving technology frontier, although offering some developing countries the opportunity to leapfrog, has raised considerable challenges for many others who lack the capacity to innovate, adapt or assimilate new and emerging technologies.

In 2019, forty years after the adoption of BAPA, and with new opportunities and challenges in mind, the Buenos Aires Outcome Document of the Second High-level United Nations Conference on South-South Cooperation (BAPA+40) encouraged industrialized and developing countries to use South-South and triangular cooperation to promote access to and transfer of technology on mutually agreed terms, taking into account the developing countries' national legal frameworks,. It further encouraged broader South-South collaboration on technological development, including collaboration on the acquisition of R&D capabilities, and technology and information network management that would include technology producers and users as well as those working on infrastructure and human resources development. BAPA+40 also emphasized the need to promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on mutually agreed terms.

The existing literature on technological development and South-South Cooperation sets out a number of conceptual and policy issues that arise in the pursuit of STI-related cooperation among the countries of the Global South.

The existing literature on technological development and South-South Cooperation sets out a number of conceptual and policy issues that arise in the pursuit of STI-related cooperation among the countries of the Global South. The present literature review is relevant to an understanding of the dynamics of the different new or strategic technologies, in which the pressures of technological regulation and intellectual property rights (IPRs) are high in comparison to generic and matured technologies.

For instance, in the context of the industrial development of countries in the Global South, developmental theorists have long rejected the notion that technology is "freely" available to all countries, and that developing countries choose technologies on the basis of "their factor price ratios, determined by their relative endowments of physical capital and labour" (Lall, 1992; Katz, 1987; Wignaraja, 2008).

The literature in development studies has viewed innovation in late industrializing countries as "mostly incremental and imitative" in nature, with strong adaptive bias rather than newer creations (Katz, 1994; Bell and Pavitt, 1993; Dosi et al., 1988; Lall, 1992). Innovation in the context of developing countries mainly reflects their desire to catch up with advanced industrialized countries by carrying out extensive import substitutions (Lall and Teubal, 1998) and thus successfully competing on local markets. In so doing, companies in developing countries are constantly learning to build their technological and innovation capabilities. As a result, these companies' innovative activities are often deemed to be an "imitation" of the technologies that already exist in the industrialized world, rather than a sign that they have reached advanced technological levels (Nelson 2004). In this regard, Ribeiro and Furtado (2015) present a broader conception of innovation-related activities, ranging from "copying, imitation, enhancement and experimentation to more value added activities such as the development of new products and processes."

Because imported technologies are often inappropriate to the context of the developing countries that import them, the challenges associated with their absorption and assimilation are often far greater than is commonly understood. In light of this, the proponents of SSC call on developing countries to take advantage of their "similar factor endowments" and work together to address the development challenges they are facing (Parthsarathi, 2006). Since the technologies available in developing countries are more likely to be subject to somewhat similar conditions of development, SSC has been perceived as highly relevant to addressing the adaptation and replication of technologies to fit the societal needs and climate conditions of the Global South. (Sampath et al., 2012).

Owing to such similar pathways of learning and capability building, technologies available within the Global South (developed locally) are far more appropriate, cost-effective, and readily accessible for other developing countries and help to redress challenges to technological development which are unique to their context. This view also holds strongly in the context of cooperation in various strategic as well as new technologies, which are critical for rapid socioeconomic progress of developing countries (UNCTAD, 2012).

Development studies literature has long argued for the importance of leveraging South-South collaboration to develop and implement new and emerging technologies. Traditionally, many of the innovation-related exchanges under SSC had been limited to generic technologies with a so-called low science input. In recent years, the notion of leapfrogging has triggered significant discussion on acquiring new technologies as well as those involving high science inputs. Although instances are fewer in number, cooperation in high technology areas have reportedly generated useful outputs.

In the context of strategic technologies however, the literature offers several important caveats. First, in order to leapfrog in strategic and new technologies, LDCs need to possess local technological and absorptive capacities (Cohen & Levinthal, 1990). Such capacity is essential to assimilate technological knowledge and imitate best practices and strategies. Second, in view of the fact that high technologies are R&D intensive and far more expensive to develop, it is crucial to assess the capacity of societal and industrial ecosystems to absorb such technologies (Dahlman, 1984; Davies & Brady, 2000). Third, the challenges arising from international trade agreements and IPR regimes need to be factored in (Dicaprio & Gallagher, 2006; Kattel & Lember, 2010). Finally, the weaker institutions and poor supply-side inputs in many developing countries are a serious obstacle to the use of South-South investments to ramp up those countries' technological capabilities (Fagerberg et al., 2007).

Notwithstanding such barriers, the early stage of emerging technology development makes it relatively easy for developing countries to imitate and use those technologies in their production processes.

Notwithstanding such barriers, the early stage of emerging technology development makes it relatively easy for developing countries to imitate and use those technologies in their production processes. While new or strategic technologies enable LDCs to exploit vast opportunities to accelerate their economic progress and leapfrog to more advanced levels of technology, accessing these technologies requires significant investment in R&D and institutions so as to build absorptive capacities and nurture knowledge networks. Development scholarship is thus calling for concerted and proactive policies at different levels of South-South exchanges in order to overcome such structural barriers.

In the following sections, we will present instances of technology transfer and/or sharing through SSC in a number of select sectors such as agriculture and health. We should clarify the reasons behind our choice of examples, however. In the absence of any systematic recording of technology-sharing efforts at the pan-South level, the authors have relied disproportionately on Indian efforts for reasons of ease of availability. Examples of SSC in technology sharing among other countries have also been included.

Agriculture

The role of SSC in agriculture has been recognized as a key factor in the development of the sector in many developing countries and LDCs, especially with reference to achieving United Nations SDG Goal 2: Zero Hunger. FAO has clearly stated that it was playing a greater role than ever before in the international development cooperation landscape and innovation in the South is generating new tools and partnerships for tackling issues of food insecurity, poverty and sustainable agriculture.[13]

As the Buenos Aires Outcome Document of the Second High Level United Nations Conference on South-South Cooperation (BAPA+40) emphasizes:

> [T]he need to leverage the role of South-South cooperation and triangular cooperation as a means to ensure food security and nutrition, including through the promotion of sustainable agriculture and food systems, food processing and agro-industries, which have the potential to link with global value chains and effectively address the market needs of developing countries (UNGA, 2019).

[13] http://www.fao.org/partnerships/south-south-cooperation/en/#:~:text=South%2DSouth%20Cooperation%20is%20a,dichotomy%20between%20donors%20and%20recipients.

While highlighting the significance of SSC during the interactive dialogue organized by the President of the General Assembly on 12 February 2020, Jorge Chediek, former UNOSSC Director and Envoy of the Secretary-General on South-South Cooperation, said there was a wealth of agricultural experience existing in the South that had the potential to transform the state of food security and hunger in other countries of the South.[14]

In Technology Executive Committee Brief (2017), UNFCCC asserts that the potential for South-South Cooperation and Triangular Cooperation (TrC) on technologies for adoption in the agriculture and water sectors has remained largely untapped. As it goes on to state:

> In order to meet the potential demand for technologies for adaptation and to enhance support for SSC initiatives, SSC partners must address challenges such as: limited knowledge of southern adaptation technologies and initiatives; lack of or inadequate access to financial resources; inadequate legal and regulatory frameworks; and insufficient organizational and technical capacity, all limiting the transfer of technologies for adaptation among developing countries.

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Chaturvedi (2015) provides a number of such instances in various sectors, including agriculture, while elaborating on the Indian approach towards South-South Cooperation. Chaturvedi, Glover and Scoones (2016) discuss the latitude for enhancing trade and technical collaboration in the seed sector between India and Africa. Rajendran and Kumar (2016) also examine the prevailing framework and emerging prospects in seed sector collaboration between India and Africa. Kumar (2015) provides a detailed account of how India assisted Ethiopia in resurrecting its sugar industry by providing critical support and technological inputs such as germplasm, capacity-building and value chain development.

Janaiah and Mohanty (2018) argue that India supports and contributes to agricultural R&D in some 40 countries through various bilateral, regional and multilateral platforms. The authors explore the contribution India has made in rice development in South and South-East Asian nations such as Nepal, Bangladesh, Myanmar and Viet Nam, through capacity-building and technology transfer.

Both Farani and Arraes (2012) and Schlesinger (2014) discuss Brazil-Africa agricultural cooperation under the broader theme of South-South agricultural cooperation and list the number of initiatives taken by Brazil in order to assist many African nations to enhance their agriculture production.

Amanor and Chichava (2016) reflect on the SSC, agribusiness and African agricultural development from the perspective of Chinese and Brazilian programmes in Ghana and Mozambique.

Buckleyet al. (2017) and Qi (2012) study the increasing engagement of China in agriculture in Africa and discuss the opportunities and challenges it presents.

There have also been instances of two Southern countries joining forces to assist and support another Southern country in the development of its agricultural sector. From 2009 to 2015, India and Brazil came together through the IBSA Fund to support Guinea-Bissau in reducing food insecurity by enabling its farmers to improve their agricultural productivity by means of the provision of a high-yield variety of rice seeds. The two countries also provided solar energy equipment to meet the need for energy sources to improve education and the quality of life in Guinea-Bissau (UNOSSC, 2016).

[14] https://www.unsouthsouth.org/2020/01/20/targeting-hunger-south-south-and-triangular-cooperation-for-transforming-agriculture/

Similarly, through its FAO-South-South Trust Fund, China has provided high-yield varieties of seeds and training in more efficient farming techniques to increase productivity in rice, field crops, vegetables and agroforestry in Sierra Leone (UNOSSC, 2016). China has also partnered with FAO to implement a project for increasing the agricultural production, productivity and profitability of farmers in Madagascar through the transfer of knowledge and technologies (UNOSSC, 2020).

The +Cotton Project in Latin America, in which Brazil shares its experience and expertise in cotton production with seven countries -- Argentina, Bolivia, Colombia, Ecuador, Haiti, Paraguay and Peru -- is another successful instance of SSC in agriculture (UNOSSC, 2020).

Kenya has partnered with India in order to improve its agricultural productivity and food security by fostering mechanization among smallholder farmers through the use of Indian grass-roots innovations. The project fosters climate resilience in Kenya by improving local agricultural productivity and food security through replicating the success India has had in adopting grass-roots innovations in farm mechanization (UNOSSC, 2018). India has also shared its success in rice fortification with neighbouring Southern countries such as Bhutan and Sri Lanka with the support of WFP (UNOSSC, 2020).

It has also been noted that the modalities and instruments involved in promoting SSC in technology, such as short-term capacity-building initiatives like training and study tours or the transfer of technologies, are ad hoc in nature for the most part.

Despite many such examples of successful SSC in agriculture, it has also been noted that the modalities and instruments involved in promoting SSC in technology, such as short-term capacity-building initiatives like training and study tours or the transfer of technologies, are ad hoc in nature for the most part. There is a need to build relationships and capacity beyond the lifespan of the projects through initiatives such as train-the-trainer programmes, joint research activities and building knowledge and technology networks. Nevertheless, such instruments are gaining traction in order to achieve more structured and effective SSC programmes (UNFCC, 2017).

Health

On a large number of occasions, SSC in the health sector has played a key role in handling a health crisis or in providing and building a preventive health care infrastructure in many developing countries and LDCs. The calls for and need of close technological cooperation through SSC in order to cope with the present COVID19 pandemic are particularly noteworthy. UNCTAD clearly affirms that SSC is essential for the sustainable recovery of the South in a post-COVID19 world (UNCTAD, 2020).

There have been many successful instances of SSC in the health sector. Both bilateral and multilateral platforms have been active in facilitating SSC in the domain.

Chaturvedi (2011) and Chaturvedi and Thorsteinsdóttir (2013) discuss the emerging trends in South-South Cooperation in the health and pharmaceutical sectors between India and Brazil in detail. Chaturvedi et al. (2012) also provide a detailed account of South-South collaboration in health biotechnology among developing countries. The authors highlight a number of case studies drawn from Southern countries such as Brazil, China, India, South Africa and Egypt.

One of the successful SSC initiatives led by India has been the Pan African e-Network Project. In this project, launched in 2009, India set up a fibre-optic network to provide satellite connectivity, telemedicine and tele-education to countries of Africa. The project aims to create robust linkages for tele-education and telemedicine, Internet, video-conferencing and VoIP services, making the facilities and expertise of some of the best universities and super specialty hospitals in India available to the people of Africa.[15]

[15] https://www.statecraft.co.in/article/mapping-india-s-pan-africa-e-network-project-pae-np

James and Bhatnagar (2019) cite a number of instances of the cooperation between India and many African and South Asian countries in the domain of health care. Chakrabarti (2020) gives an account of the medical cooperation and diplomacy efforts led by India through South-South Cooperation during the COVID 19 crisis.

Olu et al. (2017) discuss seven case studies in Africa where South-South Cooperation has been a key mechanism in strengthening public health services, including cooperation with Latin American countries such as Cuba. Sáenz et al. (2010) investigate entrepreneurial cooperation between Cuba and Brazil in health biotechnology.

The Mais Medicos (More Doctors) programme, through which Brazil, Cuba and the Pan American Health Organization (PAHO) cooperate to bring medical health services to remote places, is a good example of South-South Cooperation. Through PAHO, Cuban doctors are selected and integrated into basic health care teams. As a result, at the time of the UNOSCC report in 2016, more than 11,000 Cuban doctors had been designated to serve in specific communities (UNOSCC, 2016).

Tambo et al. (2016) examine the cooperation between China and Africa in supporting the global health agenda on infectious diseases such as malaria, schistosomiasis, Ebola, TB, HIV/AIDS, and neglected tropical disease (NTD) prevention.

In its 2018 report, UNOSSC cites a number of instances where Cuba plays a key role in providing health care to many developing countries in times of crisis. In response to the Ebola Outbreak in West Africa in 2014-2016, the Government of Cuba sent 268 Cuban health workers to the affected countries to provide direct patient care. They remained on site for six months, working in community clinics and treatment centres for Ebola virus disease patients.

The nine member states in the Organization of Eastern Caribbean States (OECS) created the Pharmaceutical Procurement Service (PPS), as a collective means to reduce the costs of health care services for their citizens by pooling the procurement and management of pharmaceutical and medical supplies for use in the public sector.

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Another successful instance of SSC is the South-to-South (S2S) Learning Exchange on HIV initiative. This is a partnership between Cambodia, Indonesia and Thailand focusing on HIV prevention outreach and community-based HIV testing approaches for key affected populations, with particular emphasis on adaptation in the case of Indonesia (UNOSSC, 2016).

SSC in health is also taking place between Bhutan and Thailand. Thailand shares its knowledge, experience and best practices in safe motherhood with Bhutan in order to improve women's and girls' health and well-being and thus reduce the maternal mortality rate (UNOSSC, 2016).

Palestine has recently started a project in Guinea and Sierra Leone to provide specialist medical practitioners to perform examinations and surgery as well as train local doctors though the transfer of specific knowledge, thus ensuring sustainability (UNOSSC, 2020).

Cooperation between Argentina and Guyana is another successful instance of SSC in health care. From 2015 to 2018, Argentina assisted Guyana in its effort to strengthen its blood transfusion system. The programme was designed to build the country's blood management knowledge base and strengthen the professional skills of key staff working in its blood transfusion system. (UNOSSC, 2020).

In the same vein, in order to improve immunization coverage in Indonesia, the Ministry of Health of Indonesia partnered with the Indian Ministry of Health and Family Welfare (MoHFW), to access to the Electronic Vaccine Intelligence Network (eVIN), which is a digital, mobile and web-based system that enables the vaccine supply chain and cold-chain logistics to be visualized in real time. With support from the United Nations Development Programme, India and Gavi, the Vaccine Alliance, India shared the technology with Indonesia in 2018 and is providing them with assistance in the form of mentorship and training to build their capacity.

Although there is much discussion on STI in SSC, there are many unexplored questions and issues that need further analysis. For example, there is no conceptual clarity in SSC as to what constitutes the science component in STI. Cooperation in science is possible in many ways, including joint research, exchange programmes and research programmes to address questions in basic science or to carry out theoretical work in the sciences. These initiatives result in a range of outcomes such as publications, patents and project-built instruments. However, in the case of publications, there is no way of knowing how many are in fact the outcome of SSC. This may seem paradoxical given that science today is increasingly globalized and the number and scope of collaborative research programmes is constantly growing, with inter-institutional and interdisciplinary research becoming the norm rather than the exception.

A great many initiatives requiring scientific cooperation have been undertaken by country groupings such as IBSA and ASEAN, covering such diverse subjects as nanotechnology and solar energy. However, the data necessary to assess the scope and range of SSC and the impact of such cooperation in terms of key indicators is not being made available. Moreover, a second issue that arises in assessing SSC is that frequently what is counted under the category of science in SSC includes fellowships, grants, exchange programmes. Should they be included in capacity-building or as scientific cooperation? What subcategories are there in fact under the heading of scientific cooperation? We will use two examples of SSC in science to illustrate the issue, one in agriculture (India) and the other in nuclear technology (IAEA).

A great many initiatives requiring scientific cooperation have been undertaken by country groupings such as IBSA and ASEAN, covering such diverse subjects as nanotechnology and solar energy.

In sectors such as agriculture, we can find data regarding the plant varieties developed and their impact. For example: “In financial terms, the value of rice production from the adoption of Indian-linked modern varieties of rice during 2015 at current prices is estimated at nearly $4 billion in Bangladesh and about $2 billion in Myanmar and Viet Nam”. (Janaiah & Mohanty 2018). However, the indicators of the adoption of those rice varieties in terms of publications, intellectual property rights and over a period of years are not available.

Although there may be issues in valuing germplasm, contributions made to various gene banks and exchanges of germplasm, the problem remains that we have neither the data nor the methodology necessary to address such issues in the agricultural sector.

Then there is the matter of triangular cooperation in agriculture. The picture is complicated when CGIAR research centres are involved because, besides capacity-building and transfer of technology, there may often be a transfer of germplasm or seeds. Such activities should be disaggregated into precise subcategories of cooperation in science but there is no methodology available to do it.

When South-South cooperation involves the private sector as part of government to government cooperation, it is not clear to what extent it is an instance of cooperation in science or of cooperation with the private sector. For example, according to ICRISAT (2016), India can provide a pathway for the identification and upscaling of pearl millet hybrids in sub-Saharan Africa. From a meagre yield of 0.2 t/ha in the 1960s, to the present average grain yields of about 1.2 t/ha with the help of hybrid seed technology and public-private sector partnership, the growth of pearl millet production is a success story that could be reproduced in Africa effectively. The public-private partnership referred to in the report will involve public sector research centres together with private companies, and thus the cooperation involved is neither fully scientific nor fully commercial. Obviously, certain components will be science-based, but whether this is purely an instance of South-South Cooperation in science is a legitimate question.

We encounter similar issues in cases of cooperation in nuclear technologies. For example, South-South in Action: Sustainable Development through the Peaceful Uses of Nuclear Science and Technology gives statistics for technical fields (p. 15) but we are given no idea as to how much is cooperation in science and how much is, inter alia, capacity-building. In the absence of such data, grouping all of it under the heading of SSC in science is problematic. Moreover, in fields like nuclear technologies, the dividing line between science and technology may be very narrow at times as technical cooperation may involve science components. But when everything is lumped together under SSC in STI, it is nearly impossible to distinguish how much is science, how much is technology and how much is innovation.

Thus there is a critical need to generate a detailed, disaggregated database that captures and reflects the full extent of South-South partnership, not only in technology transfer and sharing but also in the pursuit of basic and applied scientific research.

How India approaches the facilitation of SSC-STI linkage

At this point, some of the efforts India has made to facilitate an effective linkage between STI and SSC should be discussed in more detail. We will first focus on a few bilateral initiatives and then examine a multilateral one.

Bilateral initiatives

As Saha (2018) notes,

> The spread of technical cooperation among developing countries has laid a solid foundation for deeper engagement and multiple modalities of South-South Cooperation which would prove immensely useful in the following years. Today, technical cooperation and capacity-building efforts under the SSC have become much more sophisticated and technically robust and are nearly approaching an ecosystem approach where development partnerships have extended to sharing of ideas and collective efforts at creating accommodating space for agriculture productivity, health sector cooperation, skill development, regional value chains, climate change, mitigation, etc. The variety in approaches and proliferation of partnerships is a definite acknowledgement of the fact that thematic development cooperation under the SSC is serving an important role in driving economic growth in developing countries. This is evident from the fact that South-South trade has significantly gone up and increasingly developing countries are relying on each other for attracting investments and development assistance. It has to be kept in mind that beyond trade linkages, development assistance and investment have formed a key source of South-South technological flows and skill development. This form of technical cooperation among developing countries breaks away from past experiences of technical cooperation. The challenge hereafter is to see that institutional linkages, both in the public and the private sector, are taken more seriously under SSC that goes beyond grants, loans and investment to foster knowledge and innovation linkages.

In the discussion below we will examine two such examples of development partnerships – India and Mozambique and India and Ethiopia. Both partnerships contained strong elements of technological cooperation, technology transfer and capacity-building, even as they aimed at leveraging all the instruments available under the Development Compact and at the same time ensuring a more convergent approach to achieve the desirable outcome.

As part of India's development assistance philosophy, which aims for the comprehensive development of a particular sector or industry in a partner country, the importance of knowledge-sharing and capacity-building in STI cannot be overemphasized.

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In its early attempts to attain a sustainable energy supply in the country, Mozambique implemented a solar power project with support from the World Bank, installing units in several locations. An agency named FUNAE undertook the pilot project. Mozambique, however, did not have local producers for such a system. The Government of Mozambique approached the Government of India for Line-of-Credit (LOC) support in order to set up a solar module manufacturing plant. Given low domestic demand in Mozambique, the LOC support also envisaged the export of made in Mozambique solar panels.

India explored the project's domestic supply capacity and the possibilities of future trade for mutual interest. The unit was established with the aim of manufacturing at-plate PV panels and concentrator PV (CPV) panels. In the spirit of SSC, this was expected to reduce the dependence of Mozambique on India.

Apart from sharing technology and hardware, there has been a strong emphasis overall on local capacity-building and technical support for implementation road maps in sectors such as rural electrification.

Similarly, at the request of the Government of Ethiopia, India provided support for the strengthening and development of the sugar industry in Ethiopia through an LOC for 2006-2012 of about US$ 640 million, the equivalent of 53 per cent of the sales revenue of the food processing sector and 57 per cent of employment in the same sector. This may be better understood by taking into consideration the importance of the agriculture sector in the GDP of Ethiopia.

India agreed to provide support for three different sugar factories, with a total production target of 1.58 million tonnes annually. India played a very important role in developing the complete value chain in the sugar sector and its related infrastructure in order to encourage the expansion of trade. India provided germplasm for sugar strains as well as new process technologies for processing plants and new railway tracks for transportation (connectivity to dry ports and to the seaport at Djibouti). Support for packaging came from a new plant to make jute sacks.

In this instance, the development cooperation provided by India encompassed the transfer of sugar manufacturing technology as well as building the capacities of the Ethiopian sugar experts. Attention was also focused on quality standardization, internationally compatible packing, market access and improved sugar productivity. The convergence of multiple modalities of the Development Compact and the central role played by STI ensured that the project would have a higher impact.

Multilateral initiative

Besides bilateral SSC, India has been proactive in regional developing country groupings. The India-ASEAN development partnership is notable in this regard. Perhaps the most significant development to date has been the change in its relationship with ASEAN: from the status of dialogue partner, India has risen to that of strategic partner. STI has been one of the most important pillars in this relationship.

The landmark development in S&T cooperation between India and ASEAN is the setting up by India in 2006 of the ASEAN-India S&T Fund (AISTDF) for R&D projects and S&T collaboration. While India had long supported S&T capacity-building in select ASEAN countries , and had been working actively through bilateral, multilateral and regional mechanisms, the creation of AISTDF is still a major achievement and ranks among the most successful SSC initiatives of any considerable scale in the field of STI.

As Saha (2014) pointed out, while the ASEAN-India engagement in S&T has made laudable efforts to identify complementarities and areas for cooperation, the channels are limited and narrow. Saha suggests that the potential for appropriate partnership and participation in robust ASEAN-India S&T cooperation still remains untapped by and large. The initial institutional mechanisms include the ASEAN-India Joint Cooperation Committee and the ASEAN-India Working Groups on Science & Technology and Trade & Investment.

In 1996, India proposed Technology Vision 2020, covering a number of sectors such as food processing, health, agriculture, engineering, electronics and communications. Some of the initial focus areas for cooperation were advanced materials, biotechnology and information technology (programmes monitored by the Working Group on Science and Technology).

The Joint Statement on India-ASEAN S&T Cooperation (dated 6 November 2006) listed the following objectives:

- Create a common India-ASEAN S&T Development Fund to undertake collaborative R&D and technology development in areas of common interests, including biotechnology and pharmaceuticals, agriculture for food security, and advanced materials;
- Establish an India-ASEAN Institute for Intellectual Property to build human resource and training capacities to serve the ASEAN region;
- Design a regulatory framework in relation to biotechnology products and the agricultural processing industry through harmonized standards, so as to ensure that the value addition resulting therefrom is beneficial to the ASEAN region;
- Popularize science through the interaction of Indian youth (including school children) with the ASEAN region and establish a suitable mechanism in this regard.

Projects and scientific activities supported and implemented under the ASEAN-India S&T programme

- ASEAN-India Collaborative R&D on Thermally Sprayed Ceramic-Based Coatings
- R&D project on the Extent of Transfer of Alien Invasive Organisms (Nuisance) in South/SE Asia Region by Shipping
- Training Course on the Analysis of Chemicals and Biological Contaminants in Raw and Processed Products for ASEAN Countries
- R&D project entitled The Indian Ocean Dipole Mode, El Nino Southern Oscillation (ENSO) and Monsoon Interactions and their Socioeconomic Impacts on India-ASEAN Nations

- ASEAN-India S&T Digital Library
- Training programme on Quality Systems in Manufacturing
- Participation of ASEAN school children in India's National Children Science Congress
- Organization of and participation in thematic workshops and technology missions, most recently on topics such as functional food, renewable energy, marine biotechnology and the ASEAN food conference

Science-based activities scheduled to receive support from the ASEAN-India S&T Development Fund (AISTDF):

- ASEAN-India Collaborative R&D projects
- ASEAN-India Research & Training Fellowship for ASEAN professionals
- Participation of ASEAN School Children in the National Children Science Congress
- ASEAN-India Innovation Platform
- Partnership Development Activities such as workshops, seminars, training programmes, technology exhibitions and fairs, S&T information dissemination and services

Source: Government of India

4. STI infrastructure in the South – a comparative perspective

STI efforts in developing countries have been for the most part attempts to break out of the vicious STI circle and catch up with their industrialized peers. These efforts have often been found wanting in areas such as the development of new technologies that are superior to those developed in the Global North.

Such a gap results in sustaining, if not expanding, the disparity between the Global North and South in the overall welfare of their populations. In this section, we will provide a comparative perspective on the relevance and contribution of STI in these two groups of economies – the industrialized North and the developing South – and focus on the nature of the existing gaps and their implications through the use of a number of standardized measures of key aspects of the existing STI infrastructure.

A point to be reckoned with is the fact that developing countries themselves do not share a common, homogeneous STI infrastructure. If divided into upper middle income, lower middle income and low income countries, STI-linked performance indicators decrease drastically as we move down the income ladders.

Several standard indicators are used to measure the STI status of a country and the patterns are more or less similar for all of them. The general features indicate a significant gap between the industrialized and the developing worlds, although the upper middle income group of countries appears to have been able to catch up with its high income peers over the last decade or so. The low income group of countries are almost invisible in the STI sphere, indicating that the flow of official development assistance may not have served to augment their STI capacities. Conscious efforts must be made so as to create an effective SSC-STI linkage, one that will enable the low income group of countries to appropriate the fruits of STI.

The general features indicate a significant gap between the industrialized and the developing worlds, although the upper middle income group of countries appears to have been able to catch up with its high income peers over the last decade or so.

One common measure that captures the status of STI in a given country is the share of R&D expenditure in its GDP. A higher proportion indicates that STI plays a greater role in the structural characteristics of the economy, while a lower share signifies a lower capacity to engage in STI. Sokolov-Mladenović et al. (2016) found that between 2002 and 2012 in the European Union 28 Region, an increase of 1% in R&D expenditure as a percentage of GDP would cause an increase of 2.2% in the real GDP growth rate, ceteris paribus. Akcali and Sismonoglu (2015) found that there was a positive and significant relationship between R&D and GDP growth in a number of industrialized and developing countries during the period from 1990 to 2013, echoing similar findings by Hu (2015) and Huggins et al. (2015). Pece et al. (2015) provided evidence of the positive relationship between economic growth and R&D in selected Central and Eastern European countries using data for the 2000-2013 period. On the global level, it is argued that every dollar invested in R&D generates nearly two dollars in return.

While rates may vary, R&D is indeed an important driver of economic growth.[16] Besides the share of R&D expenditure in the GDP, there are a number of other indicators that can provide some insight into a country's STI. They are:

1. R&D expenditure per capita
2. R&D expenditure per researcher
3. R&D expenditure from different sources
4. Registration of industrial designs, trademarks and patents by residents and non-residents
5. Charges paid and received for intellectual property rights
6. Number of publications and number of researchers engaged in R&D

To clarify, it should be noted that these indicators capture all the components of STI. While the first three measure the flow of resources into the STI system of an economy, the fourth may be interpreted as a proxy for quantifying the level of achievement in technology. The fifth indicator may be considered as capturing the innovation system, while the last is a measure of the science capabilities generated.

The World Bank divides all countries in the world into four distinct groups in terms of their economic capabilities as measured by their per capita income. The four groupings are (i) high income countries, (ii) upper middle income countries, (iii) lower middle income countries and (iv) low income countries. It is worth noting that the countries in the four groups can be clearly distinguished by their R&D expenditure as share of their GDP.

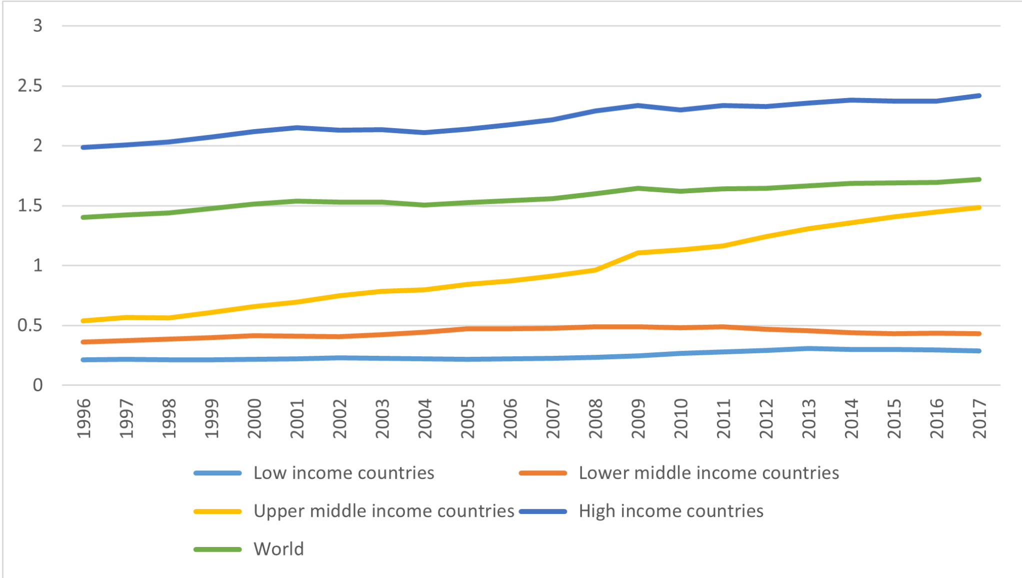
The remainder of the present section will be devoted to the status of developing countries with respect to their high income peers in terms of the indicators mentioned above. Overall, the analysis of nearly all of the indicators shows that over the last two decades, although high income countries are far ahead of the rest, the group of upper middle income countries has been able to narrow the gap quite quickly. The lower middle income group of countries are moving forward but at a very slow pace, while the least developed countries exhibit insignificant achievements in their STI capacities.

Expenditure in R&D as a share of GDP

Chart 4.1 below shows that expenditure in R&D as a share of GDP is highest in high income countries, where it remained more or less stagnant, at a rate between 2.2% and 2.55%, from 1996 to 2017. The group of countries identified as upper middle income countries made significant strides during the same period, logging an increase in their R&D expenditure share that grew from about 0.5% in 1997 to more than 1.65% by 2017. As is evident, lower middle income and low income countries spend too little a share of their GDP on R&D. Quite clearly, the upper middle income countries, although more or less at the same level as the lower middle income group at the beginning of the present millennium, surged ahead of their lower middle income counterparts in the following decades. This phenomenon has a positive implication for SSC in that there is great potential for a significant extension of STI support to low income developing countries, all the more so as most upper middle income countries adhere strongly to the principles of SSC. A solidarity-induced sharing of technology among partners in the Global South could play a very effective role in pulling the rest of the developing countries up the STI ladder. Some of the case studies regarding technology sharing among Global South partners presented below to such potential.

[16] UNESCO-UIS website http://uis.unesco.org/en/topic/research-and-development as retrieved on 13 May 2020.

Chart 4.1: *R&D Expenditure as a percentage of GDP*

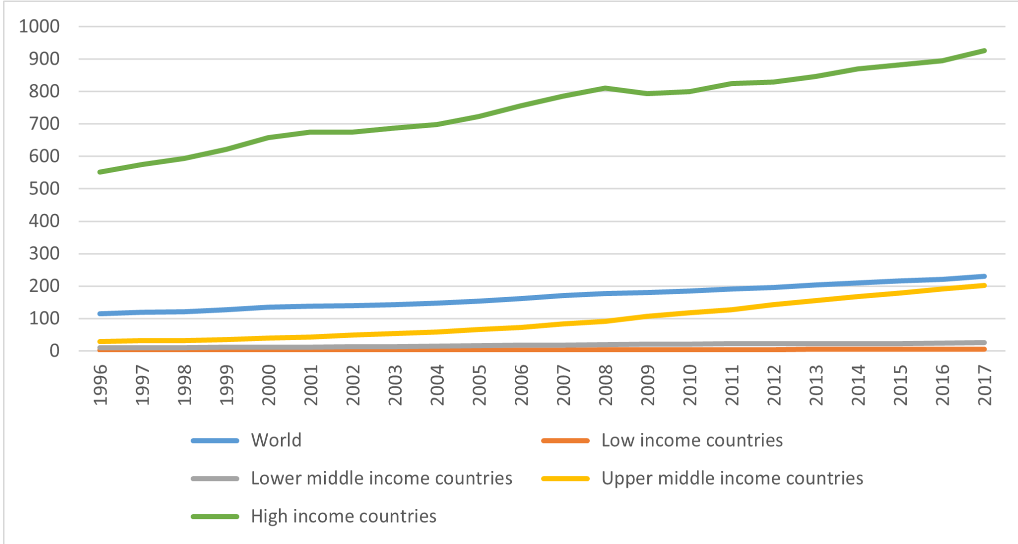


Source: UNESCO Institute of Statistics

R&D expenditure per capita and R&D expenditure per researcher

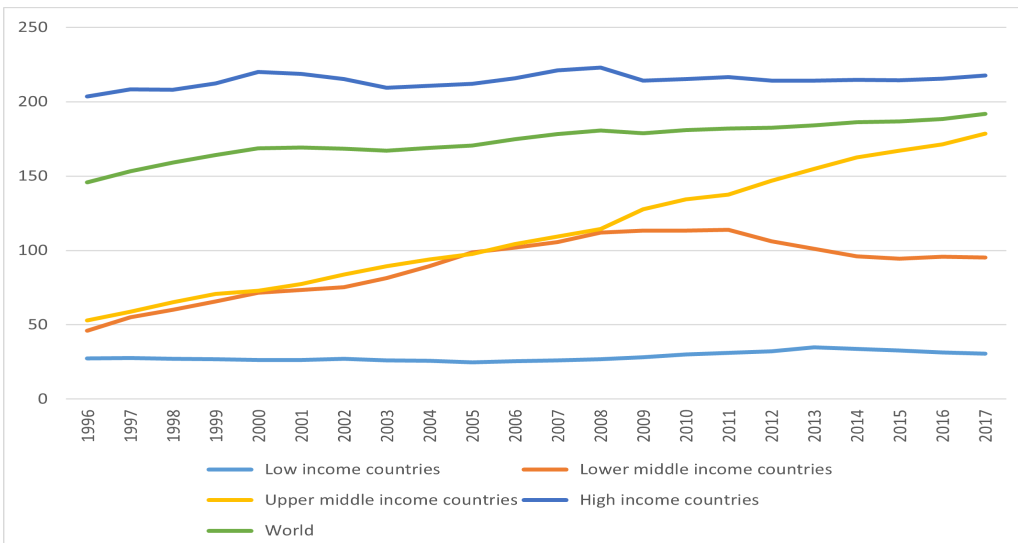
Two more indicators, namely R&D expenditure per capita (Chart 4.2) and R&D expenditure per researcher (Chart 4.3) can be used to quantify the intensity of R&D activities in a given country. While the first captures the capacity of a country to engage in STI activities, the second is an indicator of the support provided by the country to its researchers in terms of providing them with the necessary R&D infrastructure. These two indicators were found to tilt heavily in favour of high income countries, indicating the clear edge they enjoy in STI infrastructure in comparison to their developing peers. However, the countries belonging to the upper middle income group are moving steadily forward, indicating a potential for enhanced technological cooperation through SSC to assist those countries lagging behind in strengthening the foundations of their STI infrastructure. Such cooperation in STI capacity-building will generate a virtuous circle for those countries -- increased production efficiency leading to a higher GDP and contributing to a higher share of resources allocated to R&D – a necessary condition for achieving a world where no one is left behind.

Chart 4.2: *Gross expenditure in R&D per capita (in ppp$, constant prices - 2005)*



Source: UNESCO Institute of Statistics

Chart 4.3: *Gross expenditure in R&D per researcher, full-time equivalent (in thousands of ppp$, constant prices - 2005)*



Source: UNESCO Institute of Statistics

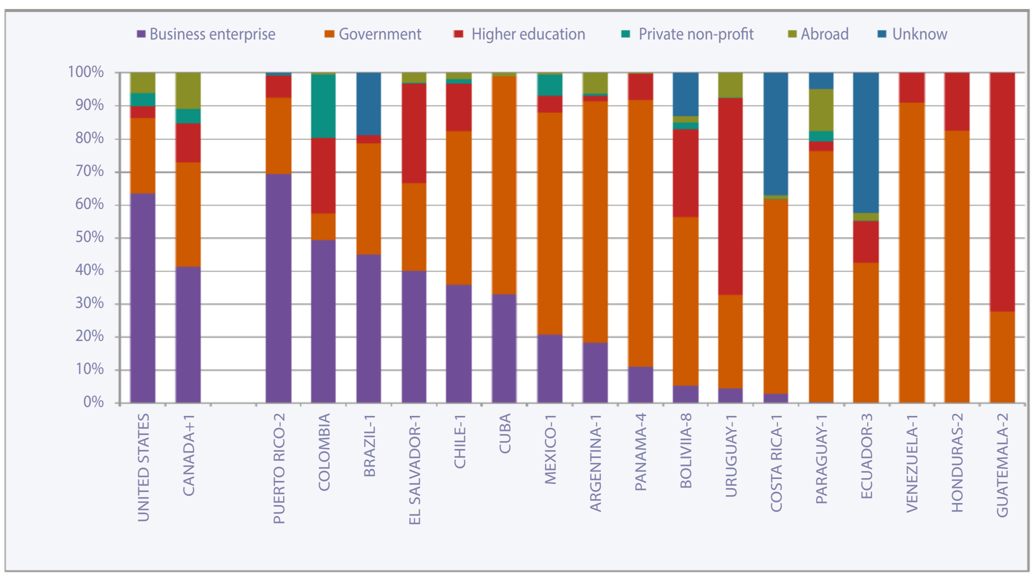
R&D expenditure from different sources

R&D expenditure is often classified under different headings. It includes enterprise-level expenditure, government, institutes of higher education, private not-for-profit organizations and investments from abroad. Charts 4.4 through 4.6 below capture the share of R&D expenditure from such a variety of sources in different parts of the globe.

From the charts, it may be observed that in the North, South and Central American region, (Chart 4.4) most of the investments come from the business sector in countries considered to belong to the higher and to some extent, the upper middle income groups of countries. The share of investments in higher education is also significant in some countries, receiving a high level of investment from business. The share of government investment increases as countries descend the income ladder, which may indicate a lower capacity to generate revenue in the states concerned.

A system of demand-driven technology sharing through SSC, one that is not always accompanied by IPR-influenced royalty payments, would go a long way to augmenting the domestic resource generation capabilities of low income countries. The same features can be seen more or less in Europe (Chart 4.5), even though R&D investments through higher education institutions are visibly lower than those observed in some countries in the Americas. Low levels of business participation in lower middle and low income countries and considerable dependence on public expenditure for R&D is more evident as we consider the situation in Asia, Africa and the Pacific regions (Chart 4.6).

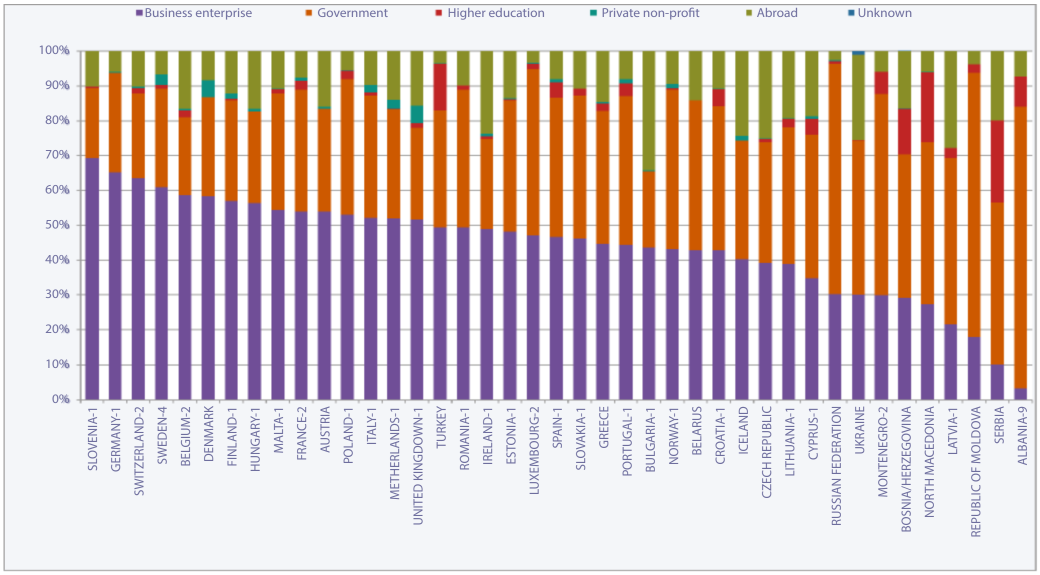
Chart 4.4: *R&D Expenditure by source of funds in the Americas: 2017 or latest year available*



Notes: +1 = 2018, -1 = 2016, -2 = 2015, -3 = 2014, -4 = 2013, -8 = 2009.

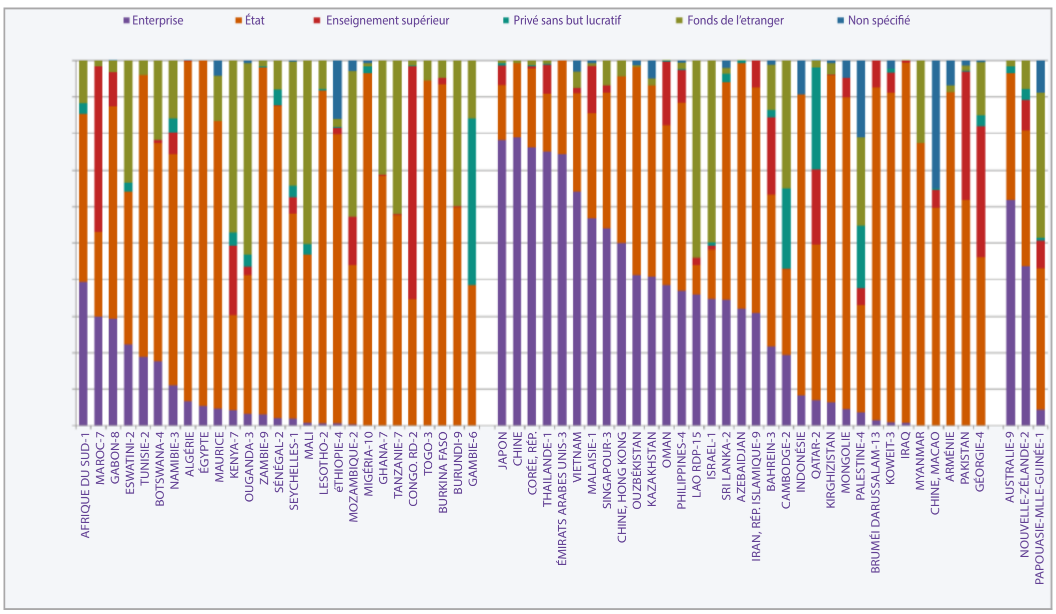
Source: UNESCO Institute for Statistics, June 2019

Chart 4.5: *R&D Expenditure by source of funds in Europe: 2017 or latest year available*



Notes: -1 = 2016, -2 = 2015, -4 = 2013, -9 = 2008
Source: UNESCO Institute for Statistics, June 2019.

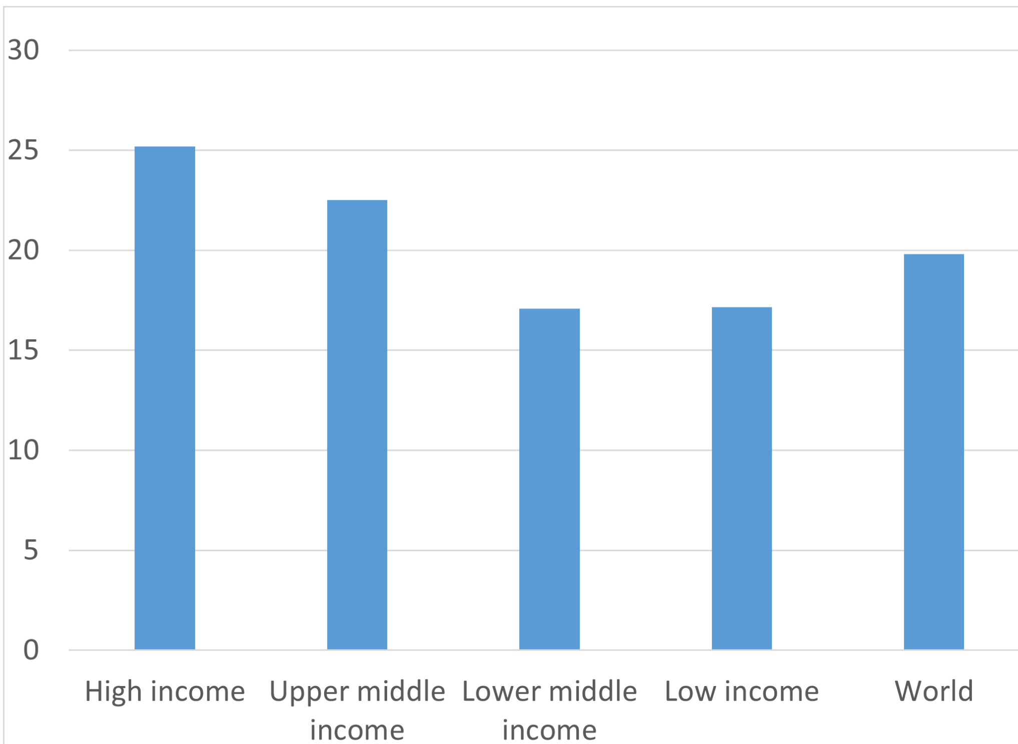
Chart 4.6: *R&D Expenditure by source of funds in Africa, Asia and the Pacific: 2017 or latest year available*



The role of business can be further captured as we look into the variations in the percentage of firms engaged in R&D expenditure in Chart: 4.7. It may be seen that in 2019, the percentage share of business enterprises engaged in R&D was higher in high income countries than in upper middle income countries. Both groups registered a share that was higher than the global average, while lower middle income and low income countries were situated below the global average.

Current mainstream research on the linkage between STI and higher education must emphasize the need to put a premium on the expansion of science- and technology-centred education in developing countries. The role of business in promoting STI should also be studied in greater depth as it may well provide a lucrative incentive mechanism to move forward in the desired direction. However, as we have argued before and will discuss further, the characteristics of knowledge that influence social values, culture and institutions in a community and are simultaneously and reciprocally influenced by them, call for a model in which technology is not merely transferred mechanically but is shared and co-created in a way that keeps it in touch with existing realities. Further research on these issues is absolutely necessary to identify relevant policy options.

Chart 4.7: *Percentage of firms engaged in R&D in 2019*



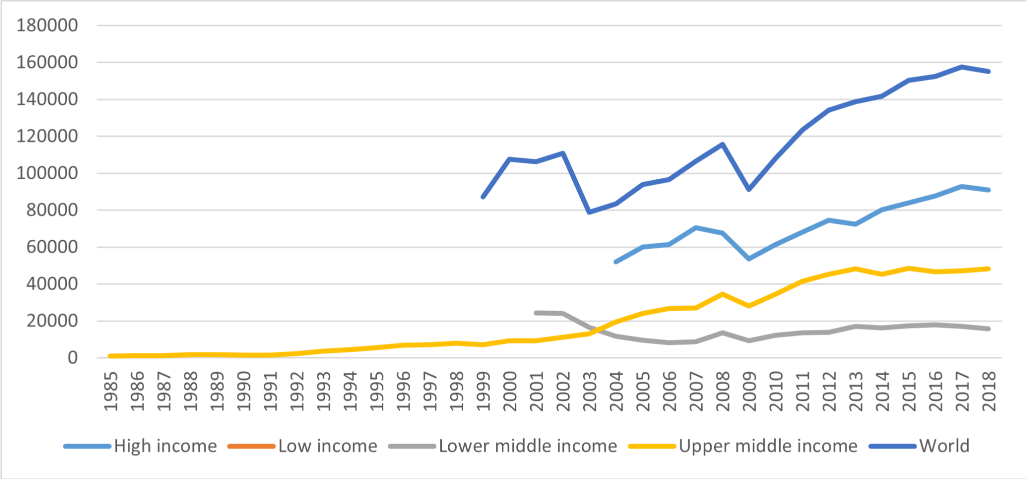
Source: World Development Indicators, World Bank

Registration of industrial designs, trademarks and patents by residents and non-residents

The effectiveness of R&D expenditure and its contribution to a country's system of innovation is reflected in the number of industrial designs, trademarks and patents registered in that country and indicates the degree of innovation and R&D capacity in the country in question. Registration facilities are available to two types of entities: resident and non-resident. Resident applicants are those who are domiciled in the country concerned while non-resident applicants are entities located outside the jurisdiction of the country. Obviously, the number of resident applicants will show the strength of the local R&D system. The number of non-resident applicants may indicate weakness in the local STI system, but it may be difficult to link them with full certainty to the strength of the R&D system in another country and/or group unless we have full information about the country of residence status of the non-resident applicant. A brief discussion on the definitions used for design, trademarks and patents is provided in the appendix.

Chart 4.8 shows a number of interesting features in the R&D systems operating in the four country groupings with regard to industrial design applications by non-residents. These features are discussed below.

Chart 4.8: *Industrial design applications by non-residents (Numbers)*



Source: World Development Indicators, World Bank

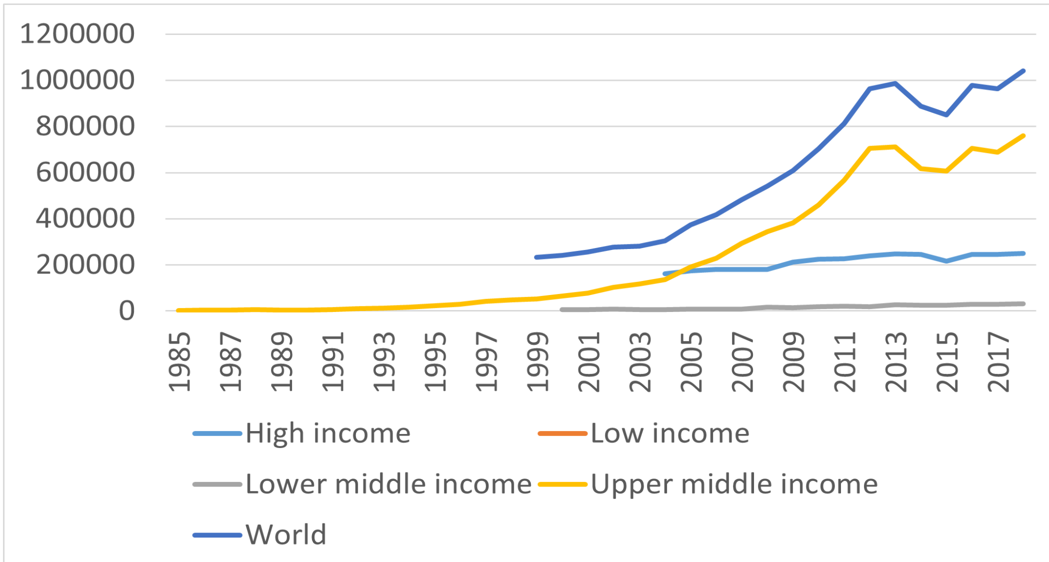
1. Non-resident applications in upper middle income countries began well before the phenomenon emerged in high income countries, which indicates the relative weakness of the R&D systems in upper middle income countries. However, the number of industrial design registrations by non-resident entities in high income countries then began to rise phenomenally. Further investigations may explain the phenomenon if we are also able to take the country of origin of the non-resident applicants into account. As it stands, this phenomenon seems to imply that either a resident of a high income country filed a design application in another high income country, which seems plausible, or a resident from some other group of countries filed the application in a high income country.

2. Low income countries are still not visible in the chart, implying that non-resident applicants may not be interested in registering their designs in these countries. Such a lack of interest may be the result of the poor manufacturing base in these countries, coupled with their small domestic markets.

3. Countries belonging to the lower middle income category began attracting applications for the registration of industrial designs by non-resident entities at the beginning of the millennium. A possible explanation for this phenomenon may be that some lower middle income countries, such as India, showed potential as steadily growing markets for industrial products. Due to the prevailing low wages coupled with a relatively strong skill base, these countries also showed potential as manufacturing hubs for products to be exported to other countries.

Chart 4.9 shows the domestic registration of industrial designs. The chart captures the extent of applications for registering designs by residents of a given group of countries. It can be seen that the number of domestic applications in the upper middle income category of countries has increased significantly since 2004-2005. This phenomenon may have been influenced by the performance of the R&D sector in China, a feature that will be discussed later in this section. On the other hand, resident registrations have fallen behind in high income countries, remaining more or less stagnant between 2005 and 2017. A stagnating, very low incidence of registration by local residents can be seen in low middle income countries, indicating the structural weaknesses of their R&D systems. Low income countries are missing altogether from the chart. No data for this group of countries was available in the database sourced for this analysis.

Chart 4.9: *Industrial design applications by residents (in numbers)*



Source: World Development Indicators, World Bank

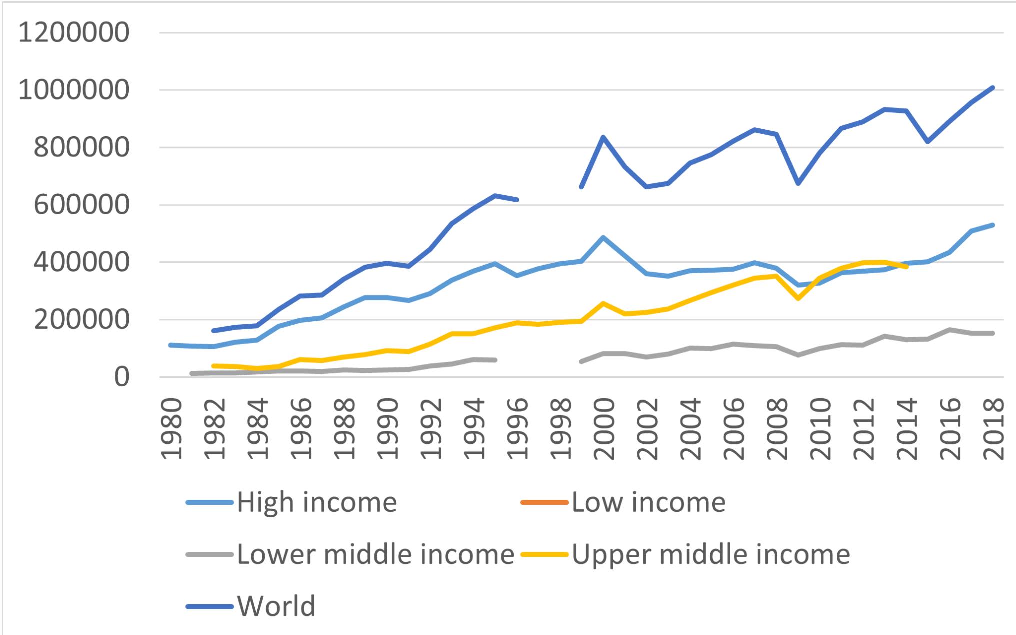
The next set of charts (4.10 through 4.14) considers the status of applications for trademark registration. Apart from the residential status of the applicant, some other differentiations are also made in terms of the nature of the application filed. Applications may be filed directly with the national IP office. The other category is the sum of the number of applications filed directly with the national IP authorities and those filed with regional authorities. We cannot overemphasize the overwhelming prominence of high income countries in filing trademark applications with non-resident status in both categories.

The interest shown by non-resident applicants in filing applications in lower middle countries was found to be steadily increasing. Once more, low income countries are off the radar.

As we move to the resident category, the performance of the upper middle income group of countries appears credible in both filing categories, particularly in the years since 2003. Lower middle income countries make their appearance while low income countries are still conspicuous by their absence.

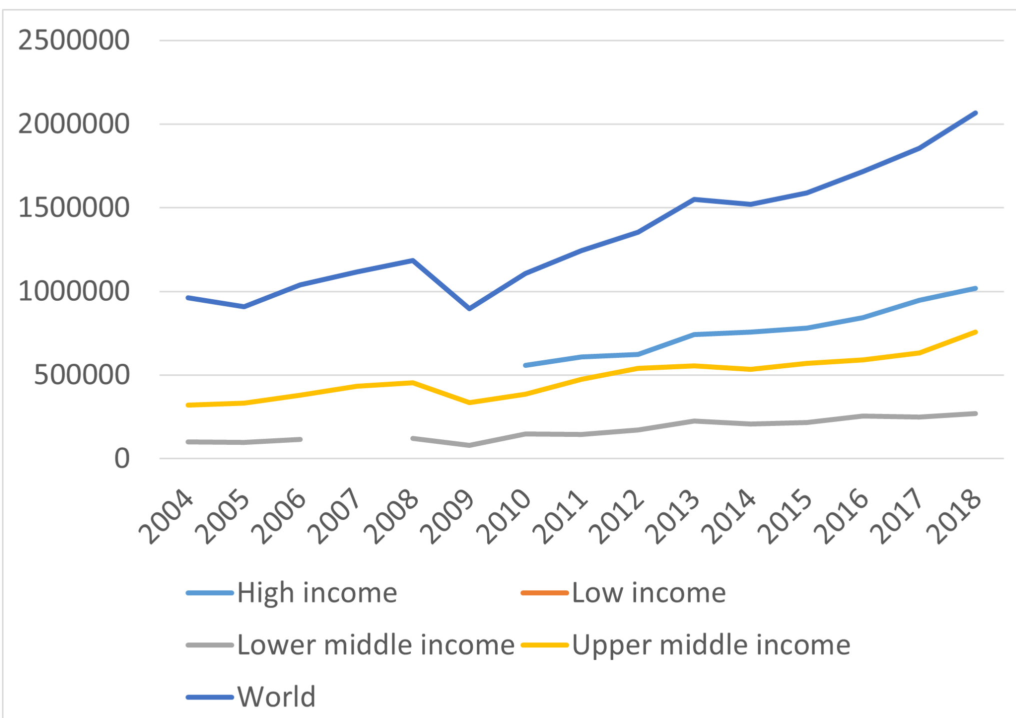
An aggregation of all of these different types of trademark applications – the total number of trademark applications, defined as applications to register a trademark with a national or regional IP office – shows that countries designated as members of the upper middle income group have surged ahead of their high income counterparts since 2006, indicating both a simultaneous strengthening of their R&D systems and their increasing attractiveness as investment destinations. Low income countries have also started to make their presence felt. However, the status of low income countries was found to be too insignificant to figure on the chart.

Chart 4.10: *Trademark applications filed directly by non-residents with national IP office (Numbers)*



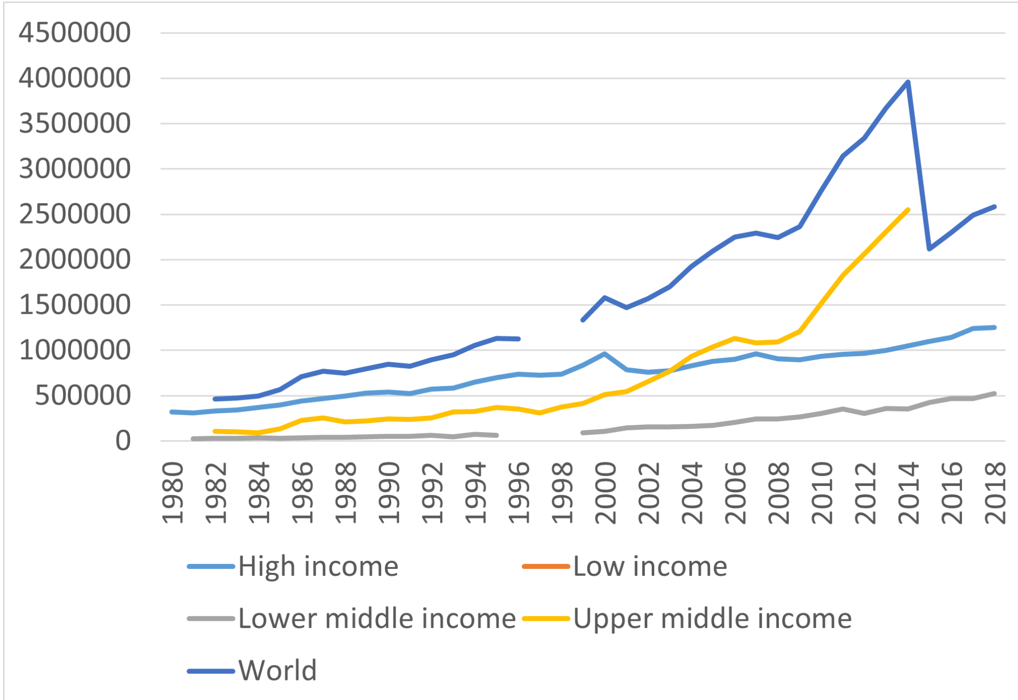
Source: World Development Indicators, World Bank

Chart 4.11: *Trademark applications by non-residents with national IP office and regional authorities (Numbers)*



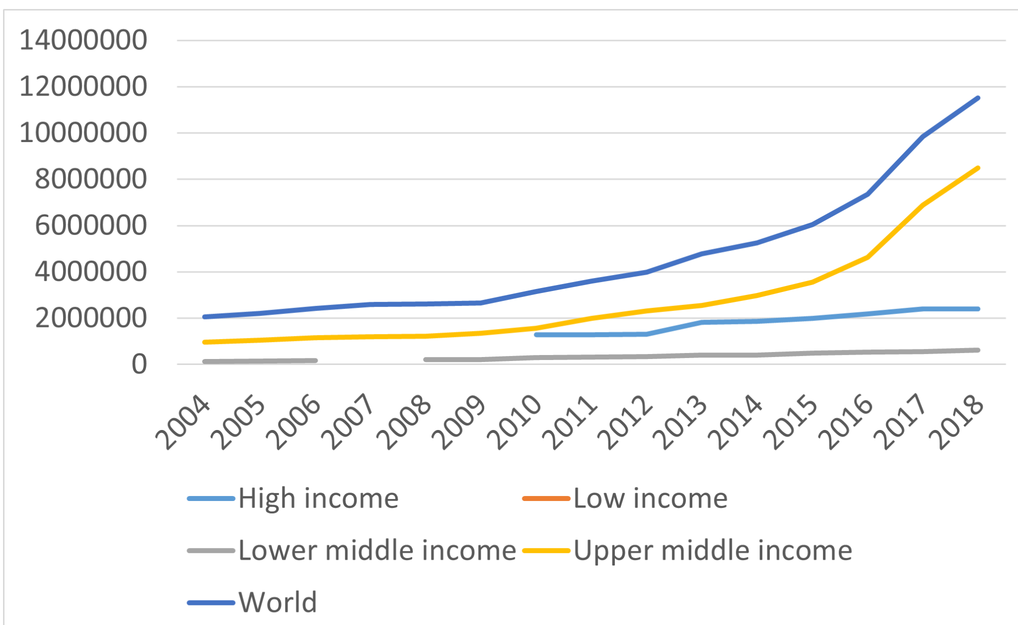
Source: World Development Indicators, World Bank

Chart 4.12: *Trademark applications filed directly by residents with national IP office (Numbers)*



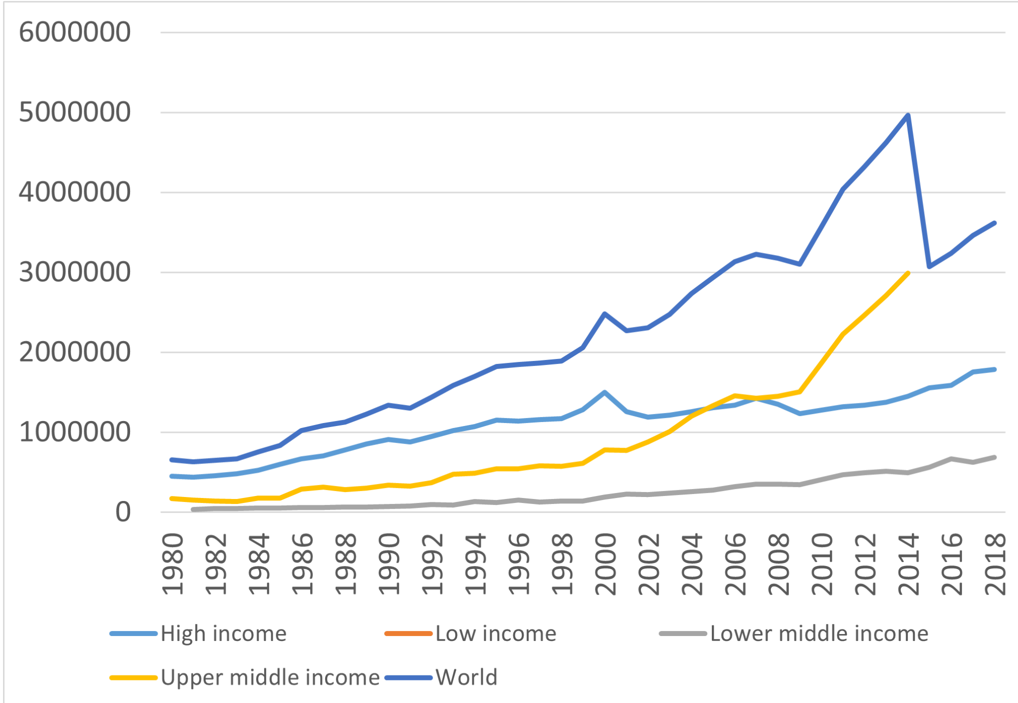
Source: World Development Indicators, World Bank

Chart 4.13: *Trademark applications by residents with national IP office and regional authorities (Numbers)*



Source: World Development Indicators, World Bank

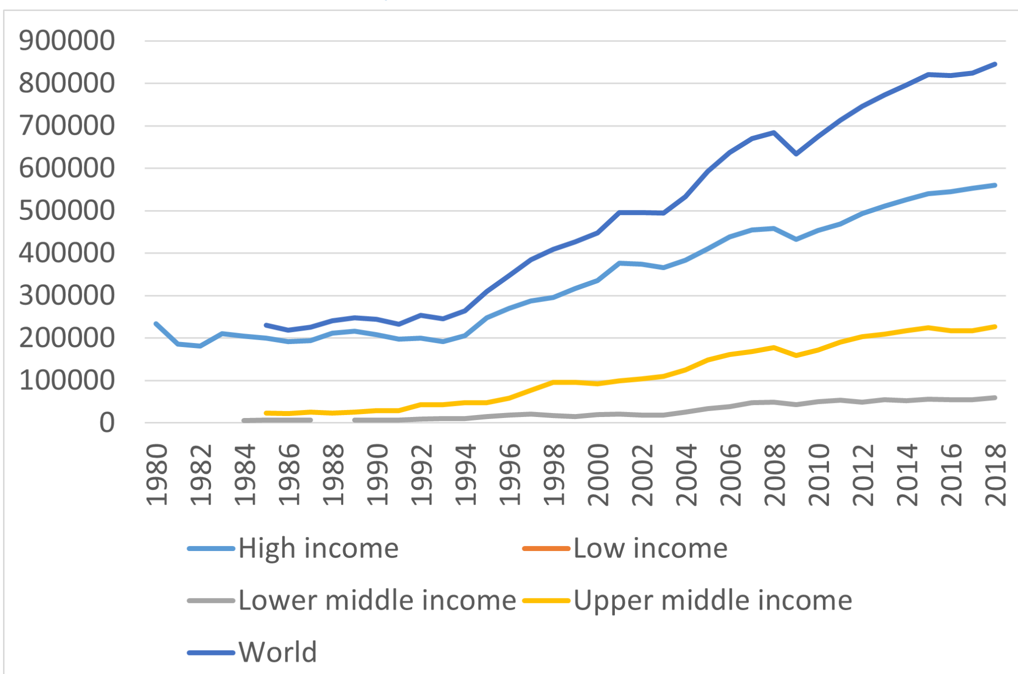
Chart 4.14: *Total trademark applications*



Source: World Development Indicators, World Bank

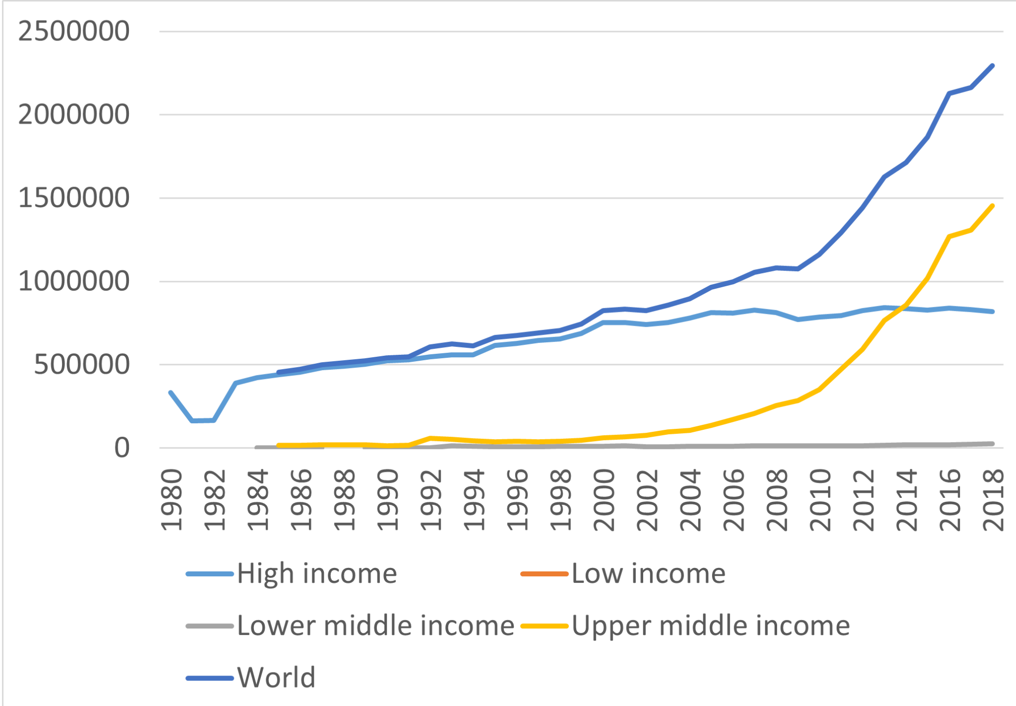
A predictable phenomenon can be seen as regards applications for patents. While applications for patents by non-resident entities are dominated by entities from high income countries, there has been a steady rise in the number of resident applications in upper middle income countries (Charts 4.15 and 4.16).

Chart 4.15: *Patent applications by non-residents*



Source: World Development Indicators, World Bank

Chart 4.16: *Patent applications by residents*



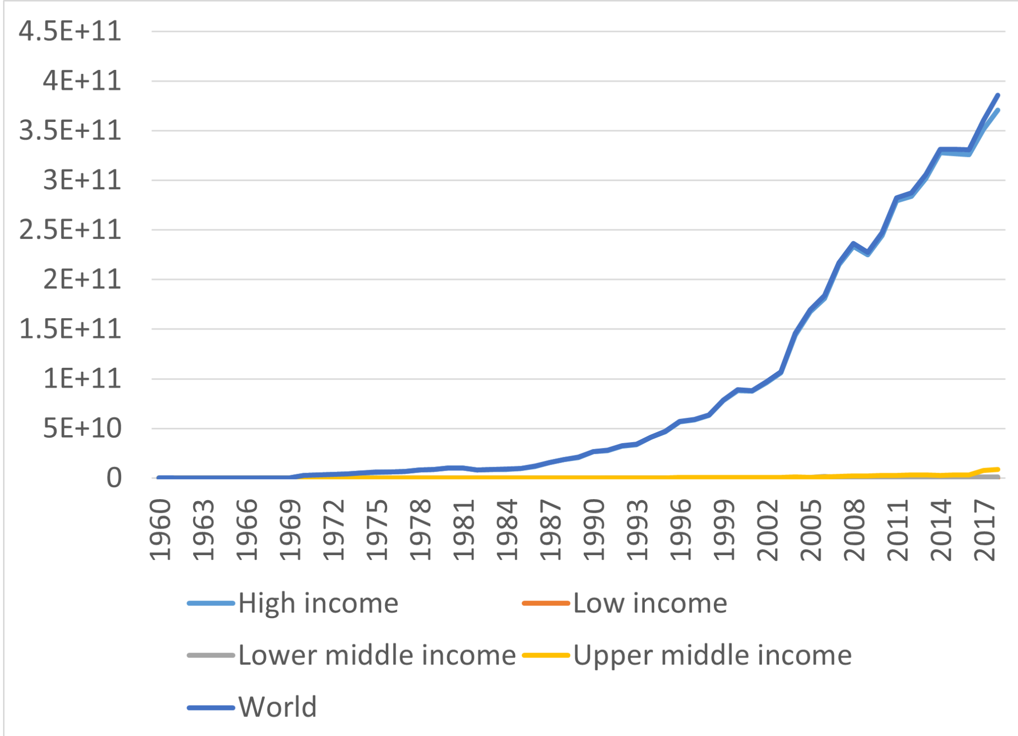
Source: World Development Indicators, World Bank

Charges paid and received for intellectual property rights

The strength of the R&D systems prevalent in high income countries becomes evident when we consider the fees paid and received for the use of intellectual property by the different categories of countries. It is clear that high income countries are far ahead in terms of the IPR revenue they receive from countries farther down the income ladder (Chart 4.17). In fact, the curve for the world as a whole nearly overlaps the curve for the group of high income countries. The other three groups of countries receive almost no return on the intellectual property they hold.

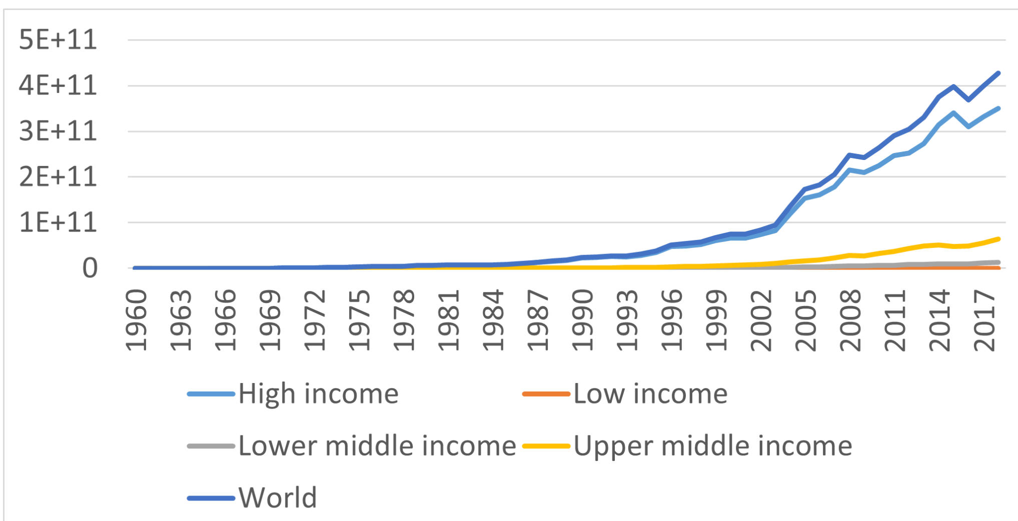
It is obvious that almost all the revenue for use of intellectual property is confined to the countries belonging to the high income category, as will be apparent from Chart 4.18 which shows the payments made for use of intellectual property rights. The lack of a complete overlap between the curve for the world as a whole and the curve for high income countries signifies that the countries from the other groups have been paying for the use of intellectual properties. Upper middle income countries have been paying increasingly visible IPR royalties since 2002, with the lower middle income countries now following suit. Low income countries are also visible on the chart, albeit minimally. As we look closer at the growth of net receipts, the divide between the high income countries and the other three groups is flagrant. With the exception of 2014, the countries belonging to the three lower GDP categories, have been net payers of IPR royalties, as can be seen in Chart 4.19 below.

Chart 4.17: *Charges for the use of intellectual property, receipts (BoP, current US$)*



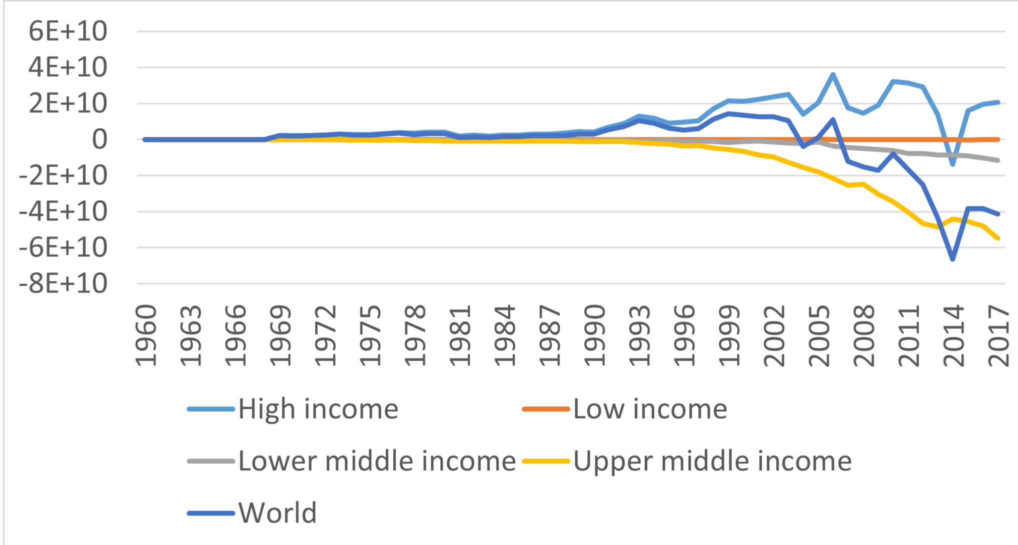
Source: World Development Indicators, World Bank

Chart 4.18: *Charges for the use of intellectual property, payments (BoP, current US$)*



Source: World Development Indicators, World Bank

Chart 4.19: *Net Receipt of Charges for Use of Intellectual Property*



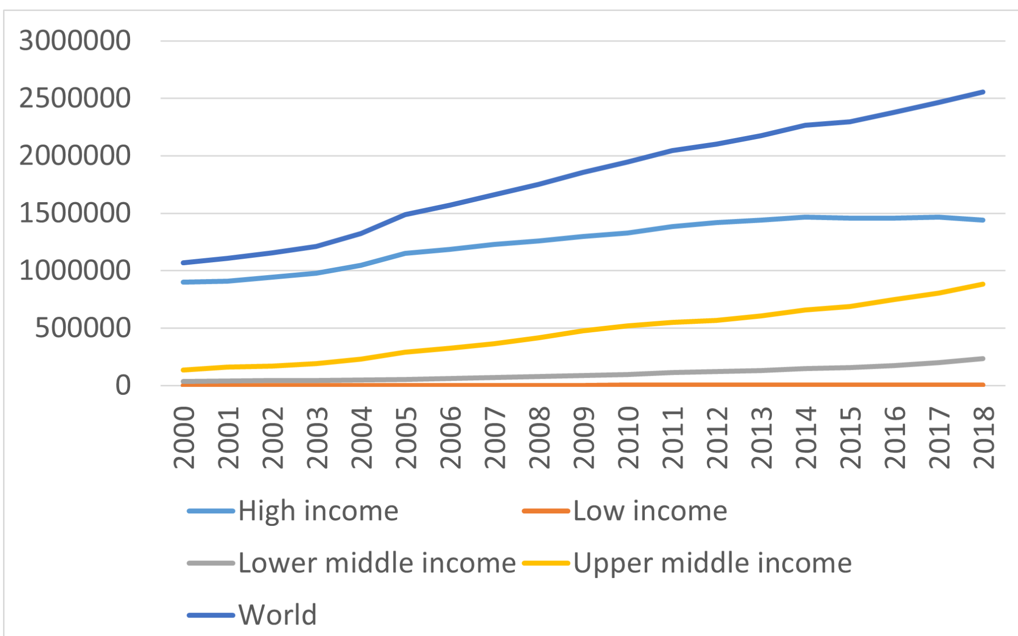
Source: World Development Indicators, World Bank

Number of publications and numebr of researchers engaged in R&D

The R&D capacity of a country is often indicated by the number of scientific papers published and the number of researchers engaged in R&D. Chart 4.20 provides at the comparative statistics with regard to journal publications. It should be noted that the gap between high income and upper middle income countries has been narrowing, although it is still significantly wide. Publication records from lower middle income countries show signs of increase, while the number of publications in low income countries is insignificant.

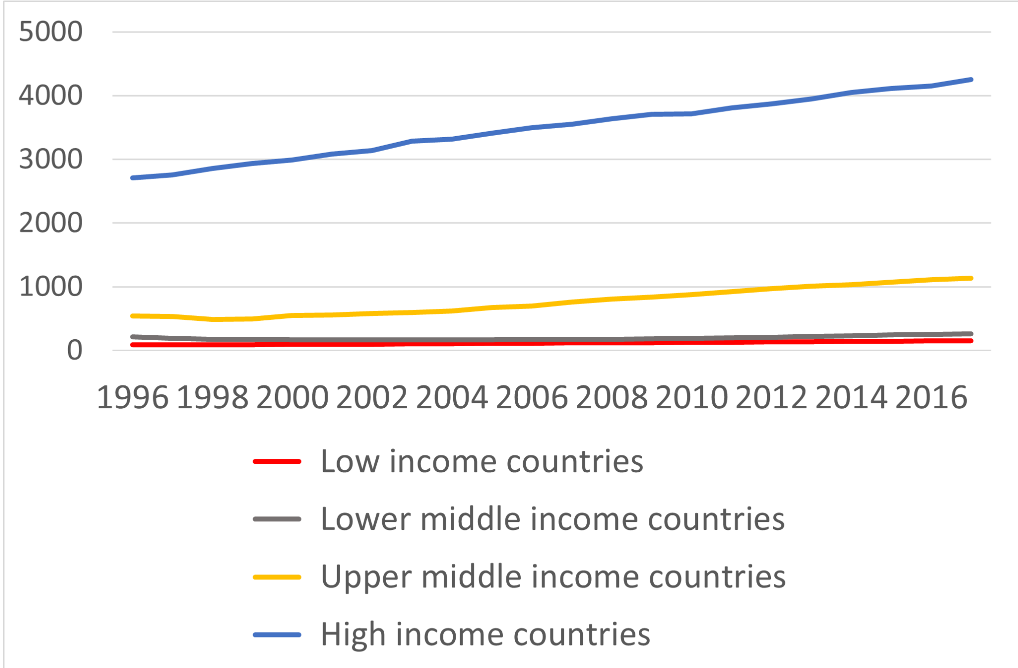
The number of researchers per million inhabitants (Chart 4.21) is also very low in the lower middle and low income countries, while the numbers are relatively high in the wealthier country groupings, with upper middle income countries showing a trend towards widening the gap with their high income peers.

Chart 4.20: *Scientific and technical journal articles*



Source: World Development Indicators, World Bank

Chart 4.21: *Researchers per million inhabitants (full-time equivalent)*



Source: UNESCO Statistical Institute

The present section provided a comprehensive examination of the gap existing between industrialized and developing countries with regard to their respective STI capacities. However, it also underscored the potential that lies in increased solidarity-based support for STI capacity-building through SSC on the part of upper middle income countries, in conjunction with sharing relevant technologies. We will analyse that potential in the next section.

5. The development compact and technology sharing through SSC

The Development Compact is the analytical framework often used to understand how SSC operates (Chaturvedi 2015). Incidentally, fostering STI infrastructure is also part of this concept.

The Development Compact identifies five distinct but interdependent modalities that facilitate cooperation among Southern partners in their mutual quest for development. The concept derives from Thorvald Stoltenberg's original proposal in 1989, and powerfully articulated by Arjun Sengupta in 1993 in the context of the hardships the developing countries faced in fulfilling their contractual agreements under the Structural Adjustment Programme (SAP), the cornerstone of what was to be labelled the "Washington Consensus". Sengupta proposed "that compacts (or agreements) be established between industrialized and developing countries to ensure that the latter received sufficient resources for development as they tried to reform their economies though programmes such as SAP, and in that way minimize the social costs of reform".

According to Chaturvedi (2015), Sengupta's concept of the Development Compact is based on the principles of mutuality of obligation and reciprocity of conditionality. Under the Compact, industrialized countries and international organizations will provide the assistance necessary for the successful implementation of development plans in poor countries, and in return, developing countries will cooperate in the process through bold reform programmes. In the absence of appropriate capacity within a developing country, industrialized countries have an obligation to provide whatever assistance may be necessary so that developing countries are in a position to achieve their targets. The Development Compact envisages a reciprocal obligation between developing countries and bilateral donors, international organizations and the UN system. It is a country-specific arrangement, rather than the traditional one-size-fits all solution applied across the board to all problems in developing countries.

The Development Compact envisages a reciprocal obligation between developing countries and bilateral donors, international organizations and the UN system.

The UNDP Human Development Report of 2003 further clarified the proposal, defining the Development Compact as an arrangement based on a system of shared responsibility, where all countries could orientate their efforts towards helping poor countries achieve their development goals. The Compact allows poor countries to advocate for higher assistance and improved market access, while provider countries can demand better governance and accountability in return.

It should be noted, however, that while Sengupta's call for a Development Compact was rooted in his understanding of North-South Cooperation (NSC), in the present context the term is used in connection with the modalities India has defined in order to implement its perception of SSC. The use of the concept as an operational framework for SSC is justified under the principle of mutuality of obligation, a principle that is clearly articulated in SSC.

The Development Compact provides the analytical framework for India's philosophy of development cooperation, composed of five distinct but very much interconnected components (Chaturvedi, 2015, p. 63): capacity-building, development financing (lines of credit), trade and investment, technology transfer and grants. The approach thus shifts from a "growth only" perspective of development towards a "mission mode", linking microeconomic issues to the overall macroeconomic issues. A schematic understanding of the Development Compact is given in Figure 5.1.

The approach to development cooperation under the Development Compact has distinct characteristics of its own. Its theoretical underpinnings strongly reflect the efforts aimed at empowering developing countries and supporting them as they break out of deprivation and engage in long-term, sustained development. This long-term development cooperation strategy has often been referred to as the "mission approach" (Mohanty, 2015). Conceptually, the mission approach aims to identify a set of growth drivers that support partner country development efforts, setting them on a high-growth path. Technically, an understanding of economic conditions in partner countries, based on macroeconomic paradigms, would help identify these economic drivers and key growth sectors. This would also be of assistance in devising a road map to provide consistent, predictable resources to selected areas, without conditionality and in the spirit of the partnership principle.

Some of the salient features of the mission approach stem from various past SSC initiatives to support developing countries in securing independence and leading their post-independence reconstruction efforts, and in carrying out their specific attempts to achieve steady progress during national development plan periods

Some of the salient features of the mission approach stem from various past SSC initiatives to support developing countries in securing independence and leading their post-independence reconstruction efforts, and in carrying out their specific attempts to achieve steady progress during national development plan periods (Chaturvedi 2015; Mohanty, 2015). For example, India has been engaged with Bhutan since 1955 and began extending yearly financial support to that country in 1960. In 1972, India also supported the establishment in Nepal of two industrial estates, Nepalganj and Dharan, and from 1968 to 1973 provided financial support to promote Nepalese cottage industries. In follow-up, India also agreed to fully support these countries' national five-year plans (Chaturvedi 2015). The mission thus looks beyond mere debt servicing and undoubtedly will have to face the challenge of procuring constant resource flows – a pressing issue for Indian development cooperation in its present form.

In this context, we should address other influential approaches to development cooperation. Japanese economist T. Yanagihara has developed a comparative analysis to distinguish different cooperation modes. He identifies two broad types of engagement, the 'framework' approach and the 'ingredient' approach. According to his definition, the framework approach represents the 'rules of the game': economic agents make decisions and take action in a given economy, itself conceived in terms of the functions of institutions and mechanisms, thereby underscoring the need to enforce conditionalities. In contrast, the ingredient approach refers to tangible organizational units, such as enterprises, official bureaux, and industrial projects, together with their aggregations in industries, sectors and regions. Wonhyuk Lim ascribes the framework approach to North-South engagements and the ingredient approach to South-South ones (Lim, 2012).

The mission approach, as encapsulated in the Development Compact, differs distinctly from the framework approach, but has some elements that are similar to those found in the ingredient approach. It defines development cooperation as demand-driven, impelled by the requests and needs of aid recipients. In this view, development cooperation should adopt sectoral-support programmes based on specific projects, rather than providing broader budgetary support. These projects need not be highly capital-intensive in nature, but should cover several sectors, depending on the partner country's request. Projects should also be designed to improve the supply conditions in partner countries.

The mission approach thus emphasizes sectors such as agriculture and manufacturing, which create large forward and backward linkages in the partner country (Mohanty, 2015).

In detailing delivery modalities at the practical level, the broad goals of the mission approach dovetail with what Chaturvedi terms the Development Compact. As mentioned earlier, the Compact is built on five pillars of action: capacity-building and skills transfer, concessional finance (further divided into grants and lines of credit), preferential trade, investment and technical cooperation. It depends implicitly on the principle of equitable access to trade, investment and technology in SSC initiatives. India's deployment of a broad spectrum of modalities allows for the kind of flexibility that makes it much more attractive and appropriate for partner countries in the South. As Chaturvedi (2015) argues, India and other emerging donors have a broad concept of aid that goes beyond hand-outs and generates concrete economic activities in recipient countries. Significantly, the Development Compact is solidly grounded in the concept of mutual gain. The Development Compact is, therefore, something less than the articulated policies of Development Assistance Committee member states, but more than simply a string of unrelated aid programmes, and is intimately connected to the broader economic strategies of the recipient countries.

In short, we see the mission approach as articulating the broad theoretical basis for SSC cooperation, while the Development Compact represents the broad strategies that emanate from that approach.

Some selected cases of technology sharing through SSC

We have chosen a set of 26 cases designed to illustrate technology-sharing initiatives through SSC and enable us to develop a candidate database and inventory template to record and track such activities. Since arriving at a quantitative estimation was not the goal of the exercise, we did not feel that it was necessary to undertake a scientifically designed sampling of cases. Efforts were made to represent as many Southern countries as possible, both as providers and recipients, so as to capture the pluralities of technological support. Brief descriptions of the cases have been given in the Appendix to this section.

A perusal of the cases reveals that most programmes were not confined to technology-sharing activities alone. They were accompanied and complemented by support through other Development Compact modalities. Table 5.1 summarizes the main features of each case. All cases of technology sharing involved at least one complementary modality and most of them involved support in two or three. In one case, the project integrated four modalities. The table also shows the variety of sectors covered by the selected programmes. It brings to light the engagement of multilateral organizations in some of the programmes and the involvement of a large number of Global South countries in others. The sectoral diversity in technology sharing is equally noteworthy, ranging from agriculture and health to cutting edge technologies in energy, biotechnology and genetic engineering.

Interestingly,

- In 6 cases multilateral organizations were involved;
- 25 out of 26 cases of technology sharing involved a simultaneous capacity-building component;
- 12 cases of technology sharing also featured a grant component;
- In 7 cases trade opportunities between the cooperating partners were opened up.

Table 5.1: *Technology sharing in SSC through the lens of the Development Compact*

Partner Countries	Multilateral Organization (if any)	Sector	Subsector	Methodological structure	Tech. transfer	Capacity-Building	Grant	Trade	Modalities
Egypt, China		Infrastructure	Biotechnology, Genetic Engineering, etc.	Cooperation through joint research and development	✓	✓	✓	✓	4
Indonesia, Kyrgyzstan	Islamic Development Bank (IsDB)	Agriculture	Livestock	Research cooperation to enhance institutional capacity and production value chain	✓	✓	✓	·	3
China, Cuba		Health	Biotechnology	Cooperation through forming joint ventures around technology transfer	✓	✓	·	✓	3
Guyana, Malaysia		Agriculture	Foodgrain	Collaboration through adaptation trials, research and site visits	✓	✓	✓	·	3
Suriname, Indonesia		Agriculture	Livestock	Institutional capacity- building and supply chain enhancement	✓	✓	✓	·	3
Guinea, Tunisia		Agriculture	Fruit	Cooperation through developing value chains and technical capacity-building	·	✓	✓	✓	3
Mexico, Kenya		Agriculture	Foodgrain	Cooperation through training and workshops in scientific processes leading to health and nutritional benefits	✓	✓	·	✓	3
Nigeria, India		Health	Traditional Medicine	Joint research and development	✓	✓	·	✓	3
Guinea-Bissau	IBSA Fund	Energy	Solar	Teacher training, workshops, transfer of technology	✓	✓	✓	·	3
India	African Union	Infrastructure	ICT	Expansion of ICT infrastructure and training of students, doctors and nurses	✓	✓	✓	·	3

Partner Countries	Multilateral Organization (if any)	Sector	Subsector	Methodological structure	Tech. transfer	Capacity-Building	Grant	Trade	Modalities
India, Ghana		Agriculture	Fruit	Research and marketing of high-quality seeds, joint research and open field experiments	✓	✓	·	✓	3
India, Afghanistan, Bangladesh, Bhutan, Maldives, Nepal and Sri Lanka		Technology	Satellite	Launching of satellite to provide multiple applications	✓	✓	✓	·	3
China, Brazil		Technology	Satellite	Joint programme pooling technical skills and financial resources, joint construction of technology	✓	✓	✓	·	3
Burkina Faso	African Union (NEPAD)	Agriculture	Biosecurity	Workshops, training, study tours and field trials	✓	✓	✓	·	3
Kenya, Rwanda	IFAD	Energy	Biogas	Training farmers, cross-country knowledge sharing, testing and replication of technology and site visits	✓	✓	✓	·	3
Morocco, Chad	Islamic Development Bank (IsDB)	Energy	Renewable	Sharing of knowledge and expertise in renewable energy	✓	✓	✓	·	3
Cuba, Brazil		Health	Vaccine	Collaboration between research institutes and manufacturers in the Global South to produce a vaccine	✓	✓			2
Cuba, Brazil		Health	Biotechnology	Technology transfer for mutually beneficial improvements in domestic manufacturing and technological capacity	✓			✓	2

Partner Countries	Multilateral Organization (if any)	Sector	Subsector	Methodological structure	Tech. transfer	Capacity-Building	Grant	Trade	Modalities
Iran, Afghanistan, Azerbaijan, Kazakhstan, Kyrgyzstan, Pakistan, Tajikistan, Turkey, Turkmenistan and Uzbekistan		Industry	Nano-technology	Cooperation through exchange of knowledge and technical skills in nanotechnology resulting in the creation of domestic and international markets for nanotechnology products	✓	✓			2
India, Sri Lanka		Technology	Nuclear, Biotechnology, Space, etc.	Research cooperation in multiple STI areas in the form of joint research programmes and bilateral workshops	✓	✓			2
China, Russia		Technology	Satellite navigation, Computer, etc.	Collaboration in through joint research, student exchanges and conferences in multiple STI areas	✓	✓			2
Sudan, Turkey		Infrastructure	Technology incubation	Collaboration through technology incubation, infrastructure building and human resources	✓	✓			2
China, Thailand		Health	Traditional Medicine	MOU signed to conduct joint research and development of a medicinal drug	✓	✓			2
South Africa, China		Health	Biotechnology	Cooperation through manufacturing, vaccine research, bioinformatics and collection of data for clinical trials	✓	✓			2
Argentina, India		Energy	Biomass	Exchange of scientists, researchers and experts, joint R&D activities and exchange of technical information	✓	✓			2
China, India		Health	Genomics	Research and technical collaboration between scientific institutes in the field of genomics		✓			1

6. In conclusion: some policy recommendations

The present study underscores the importance of a robust STI system in facilitating the development of the economies of the Global South. In the course of our discussion, we have noted the considerable gap that exists between high income countries and their developing counterparts in terms of their respective STI structures, although trends in the indicators show that the upper middle income group of developing countries is now on its way to catching up.

Bridging the gap provides an effective opportunity to establish a technology-sharing mechanism among developing countries, inspired by SSC. However, unlike single-focus technology transfer, SSC-inspired technology sharing would follow the Development Compact, which calls for complementary support in other modalities such as capacity-building, grants and trade opportunities. The ultimate objective from a Global South perspective would be to break out of the vicious circle in their STI infrastructure – a goal that would entail significant efforts on the part of every country individually, backed by a collective effort at the level of the whole Global South.

Policy efforts are required at both the national and global levels and the time frames for change should include short term, medium term and long-term outcomes.

Arthur (2009) and Chang and Andreoni (2020) demonstrate with great clarity that a country's STI policy cannot stand alone, and must be complemented by policies in such sectors as education, health, manufacturing, agriculture, water and forestry, to name just a few. To break the vicious circle, the long-term goal must be attaining transversal sectoral policy coordination and embedding an STI policy at the national level in them all. Simultaneously, efforts to create a pool of resources at the global level in the form of a Southern STI Fund should be initiated so as to coordinate the individual national efforts to foster STI capabilities. Such a fund could potentially facilitate the creation of a global network of R&D institutions tasked with sharing and co-generating knowledge and technology, as well as contributing to building the skills of the citizens of the Global South. All contributions would of course function in keeping with the principles of Common but Differentiated Responsibilities. Private entities, motivated by the growing volume of South-South trade that has been seen over the last decade and thus very interested in developing a South-South value chain, could also be encouraged to join the initiatives.

Countries interested in leapfrogging to renewable sources of energy should consider tailoring their STI policies to strengthen their R&D capabilities in solar energy, wind and other renewable ources.

Medium range policy programmes at the national level should entail the identification of a number of priority sectors to strengthen through enhanced STI efforts. For example, countries interested in leapfrogging to renewable sources of energy should consider tailoring their STI policies to strengthen their R&D capabilities in solar energy, wind and other renewable sources. The concept of developing country-specific resource centres of excellence as currently practised by Islamic Development Bank in the form of reverse linkage – in other words, identifying the existing know-how, expertise, technology and resources within member countries and transferring them to those in need, with the objective of achieving sustainable development outcomes – could be adopted as a model for adaptive replication (IsDB 2018). The country prioritizing a particular sector would thus serve as the relevant resource centre to provide STI support to other partner countries.

Medium term strategies at the national level should include developing a strong connection between research universities and businesses in small- and medium-scale industries, as is currently practised in Italian viniculture (Abbate et al., 2020) for example. The role of universities as source of commercial technology was analysed by Henderson et al. in 1998. Sterzy (2013) reviews the importance of university patenting in the United Kingdom. Van Looy et al. (2006) suggest that the coexistence of inventing and non-inventing activities among universities may actually serve to reinforce both, although the academic inventors at Katholieke Universiteit Leuven (Belgium) were found to be more active in terms of their publication results.

The present cutting edge technology creation ecosystem has been found to be engaged mostly at corporate levels, as was discussed in an earlier section. Rosenberg (1990) provides an interesting insight into the factors that propel firms to engage in R&D as a form of investment, creating stimulus through backward and forward linkages in the economy. Taalbi (2020) arrives at similar conclusions from his study of Swedish experiences. Guerrero et al. (2019) underscore the same phenomenon in emerging market economies such as Mexico. In Spain, several autonomous regions have organized and coordinated their efforts in science and technology through the adoption of regional R&D plans (Acosta & Coronado 2003) which may also be adapted to suit the specific requirements of developing countries.

In a recent study by Wang and Lee (2018) of the transfer of knowledge from science to technology in the field of nanotechnology, a scientific knowledge application index (SKAI) was built to measure the degree to which science has contributed to the development of nanomedical device technologies. Creating a database for the Global South and periodically estimating sector-specific SKAIs would help track the degree of conversion of knowledge into technology and could subsequently be used to facilitate innovation in new products and services.

Science education must also be strengthened. Appio et al. (2017) give empirical evidence that inventors with a background in science are more likely to create patentable inventions that span technological boundaries than inventors with an engineering degree. Mansfield (1980, 1991), Malo and Geuna (2000) and Sorenson and Fleming (2004) argue in a similar vein. Narin et al. (1997), McMillan et al. (2000) and Meyer (2000) chronicle the role of public science in encouraging technological advances and innovation. Popp (2017) highlights the important role of public-funded R&D organizations in generating technological insights relating to such societal concerns as climate change. It is therefore of critical importance that all Southern countries create a larger space for public science in their respective development strategies.

It is therefore of critical importance that all Southern countries create a larger space for public science in their respective development strategies.

In the short term, measures should be taken to increase cooperation among partner nations in the Global South in sharing technologies based on demand and immediate need. Sharing technology has been growing in frequency for quite some time, as has been documented in this study. The template we suggest may be used to identify and track the dynamics of technology sharing among countries so as to create an inventory of useful, ready-made technologies that partner countries may offer or choose from. It may also be used to map technologies and identify value chains that could potentially be game changers in the dynamics of the global economy. The template may also serve as the basis for a database of technologies to identify those that are in high demand but that might require modification to make them more efficient and effective.

Increasingly, knowledge-intensive development pathways show how vital STI is to fostering the capabilities of the Global South. Given the constraints on resources faced by many developing countries and the current mainstream developmental paradigm that is weighted heavily toward the economics of IPR-type technology transfer, pooling investment and human resources to create and share technologies among partner countries engaged in SSC is emerging as a viable alternative solution. Efforts in that vein will ensure that cost-effective, efficient STI systems can be widely disseminated throughout the developing world. The countries at the forefront of technology in the Global South have already initiated the process, as our selected cases studies show. Moreover, it is a mechanism that can strengthen the access-equity-inclusion axis of the development pathway. Sharing technology may be considered as a launching point for the creation of new products, new processes and new supply chain networks that will encourage a larger share of countries in the Global South to engage and participate.

However, it will take considerable effort to bring about the desired outcomes. SSC in technology creation and sharing is still very scattered. The cases discussed in this study are neither representative nor are they exhaustive in terms of coverage. Large-scale data collection is imperative if we want to understand the present status of technological cooperation among countries in the Global South. The prospects, challenges and existing weaknesses in the STI systems of every developing countries and their contribution to the technology-sharing platform must be ascertained in order to build the road map for the future. It calls for an exhaustive inventory, country by country, of the technologies available for sharing, matched with the demand profiles of partner countries.

Knowledge systems are deeply embedded into the social psyche of communities, and while technology is obviously a part of this elaborate knowledge system, it cannot be created nor can it be transferred mechanically from community to community through a mere "transfer of technology" approach. Effective, sustainable knowledge transfers require strong institutional and cultural support. It is evident from the experiences available that as a strategy, the Development Compact has the potential to facilitate the processes of sharing or co-creating knowledge and technology, going far beyond merely mechanical transfers. The case studies presented attest to the early stages of operationalization. Further work is needed to determine what challenges and what opportunities may arise along the way.

Only through responsible research and innovation, which "anticipates and assesses potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation" will we be able to find an accessible, equitable and inclusive way forward.

With less than a decade to go, we are all eager to reach the United Nations Sustainable Development Goals and create a world where no one is left behind. Unfortunately, the COVID 19 pandemic is threatening our prospects for the timely achievement of the SDGs. Global warming and climate change threaten our very survival and the survival of the planet. Only through responsible research and innovation, which "anticipates and assesses potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation"[17] will we be able to find an accessible, equitable and inclusive way forward. Establishing a robust interconnection between science, technology and information and South-South cooperation is a vital part of that endeavour.

[17] See https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation for further detail.

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APPENDIX:
Section 4, Terminology and concepts

The holder of a registered industrial design has exclusive rights protecting against unauthorized copying or imitation of the design by third parties.

Industrial design applications, non-resident, by count: Industrial design applications are applications to register an industrial design with a national or regional intellectual property (IP) office and designations received by relevant offices through The Hague System. Industrial designs are applied to a wide variety of industrial products and handicrafts.

They refer to the ornamental or aesthetic aspects of a useful article, including compositions of lines or colours or any three-dimensional forms that give a special appearance to a product or handicraft. The holder of a registered industrial design has exclusive rights protecting against unauthorized copying or imitation of the design by third parties. Industrial design registrations are valid for a limited period. The term of protection is usually 15 years for most jurisdictions. However, differences in legislation do exist, notably in China (which provides for a 10-year period from the application date). Non-resident application refers to an application filed with the IP office of or acting on behalf of a state or jurisdiction in which the first-named applicant in the application is not domiciled. Design count is used to render application data for industrial applications across offices comparable, as some offices follow a single-class/single-design filing system while other have a multiple class/design filing system.

Industrial design applications, resident, by count: Resident application refers to an application filed with the IP office of or acting on behalf of the state or jurisdiction of which the first-named applicant in the application is a resident. Design count is used to render application data for industrial applications across offices comparable, as some offices follow a single-class/single-design filing system while other have a multiple class/design filing system.

Trademark applications, direct non-resident: Trademark applications filed are applications to register a trademark with a national or regional IP office. Direct non-resident trademark applications are those filed by applicants from abroad directly at a given national IP office.

Trademark applications, direct resident: Trademark applications filed are applications to register a trademark with a national or regional IP office. Direct resident trademark applications are those filed by domestic applicants directly at a given national IP office.

Trademark applications, resident, by count: Depending on the legal system involved, one or more classes can be specified in a trademark application, with the intent to obtain protection of the mark across different goods and/or services. For cross-country comparison purposes, users are advised to refer to the trademark data rendered by the class count in the database 2004 onwards. Data are based on information supplied to World Intellectual Property Organization (WIPO) by IP offices in annual surveys, supplemented by data in national IP office reports. Data may be missing for some offices or periods.

Trademark applications, total: Trademark applications filed are applications to register a trademark with a national or regional IP office.

Patent applications, residents: Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office.

Patent applications, non-residents: Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office.

A patent is an exclusive right granted for a specified period (generally 20 years) for a new way of doing something or a new technical solution to a problem - an invention. The invention must be of practical use and display a characteristic unknown in the existing body of knowledge in its field. Most countries have systems to protect patentable inventions. Unless otherwise stated, statistics on the number of resident and non-resident patent applications include those filed via the Patent Cooperation Treaty (PCT) system as PCT national/regional phase entries.

Difference between an industrial design right and a patent: An industrial design right protects only the appearance or aesthetic features of a product, whereas a patent protects an invention that offers a new technical solution to a problem.

Difference between trademark and patent: A trademark protects a symbol, name, word, logo or design used to represent the manufacturer of goods. A patent gives property rights to an inventor for a new product, preventing others from making an identical product. Many companies use both to protect intellectual property, although the two are not interchangeable.

APPENDIX:
Section 5, Case Studies

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
4	✓	✓	✓	✓	Collaboration between Egypt and China in science park development The Mubarak City for Science and Technology (MuCSAT), located in New Borg El Arab City, Alexandria, Egypt, was created as a result of an agreement signed in 1996 between the Ministry of State for Scientific Research of Egypt and the State Science and Technology Commission of China. China donated roughly US$ 0.5 million to Egypt in support of the project. The Park works in close cooperation with Shenzhen High-Tech Industrial Park (SHIP) in China and emphasizes the development of biotechnology and its commercialization. Through international technical development, SHIP contributes to promoting its national advances in technology. The Genetic Engineering and Biotechnology Research Institute was one of the first research centres to be established in the park. In 2003, Shenzhen's Department of Science and Technology provided additional financial assistance to MuCSAT to support new initiatives. Science Park development is an important example of the methods used to commercialize biotechnology in the health sector. Source: https://www.idrc.ca/sites/default/files/openebooks/909-9/index.html
3	✓	✓	✓		Reverse Linkage project with Kyrgyzstan to strengthen the artificial insemination of livestock The project is the result of cooperation between Indonesia, Kyrgyzstan and the Islamic Development Bank (IsDB). Other partner institutions include Singosari National Artificial Insemination Centre (SNAIC) and Kyrgyz Scientific Research Institute of Livestock and Pastures (KSRILP). The main objective of the project was to enhance the institutional capacities of Kyrgyzstan so that it could manage an artificial insemination programme, improve the quality of frozen semen and reform the production value chain. Ultimately, the project is expected to lead to enhanced livestock productivity due to the genetic improvement of local breeds. This will also result in the creation of an efficient distribution network for end users. Carried out from 2015 to 2017, the project had a budget of US$ 1,370,000. Indonesia has acquired significant expertise in the development of artificial insemination for livestock through its centre of excellence, Singosari National Artificial Insemination Centre (SNAIC). SNAIC was mandated by Indonesia to provide technical assistance to KSRILP within the scope of the project. SNAIC also ensured that cooperation would be sustainable through a business-to-business approach. Source: https://www.oecd.org/dac/triangular-co-operation/Project%201_IsDB_Indonesia%20Kyrgyzstan.pdf

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
3	✓	✓		✓	Cooperation between China and Cuba in biotechnology Because firms in Cuba wanted to expand their market share in China and Chinese firms sought to access the technologies and prowess of Cuba in biotechnology, the governments of China and Cuba established a series of joint ventures in the realm of technology transfer from Cuba to China. Changchun Heber Biological Technology Ltd. (Chang Heber) is one such joint venture, formed by Changchun Biological Products Institute in Changchun, China and a Cuban firm, Heber Biotec (Havana, Cuba). Heber Biotec transferred the technology needed to produce recombinant human interferon alpha-2b to China and together with local partners in China, built the factories to manufacture the drug there. In this way Cuba was able to expand its market share in Asia while Chinese firms were able to develop their knowledge and expertise in health biotechnology and build their capacity to produce biosimilars. Biotechnology Pharmaceutical Co. Ltd. (BPL), located in Beijing, is another example of a China-Cuba joint venture, bringing together CIMAB SA (Havana, Cuba) and the Chinese firms Beijing Jingyitaixiang Technology Development Co. Ltd. (Beijing), Shanxi Xinyutong Material Commerce Co. Ltd., and China International Centre (Beijing). Through the joint venture, the technology for manufacturing monoclonal antibodies was transferred from Cuba to China. In this way BPL has been able to expand its own product portfolio by working conjointly with its Cuban partners to produce of cancer vaccines based on monoclonal antibodies. Source: https://www.idrc.ca/sites/default/files/openebooks/909-9/index.html
3	✓	✓	✓		Reverse Linkage project between Guyana and Malaysia to strengthen the rice industry Jointly financed by Islamic Development Bank (IsDB), Malaysian Agriculture Research & Development Institute and the Government of Guyana, the project was approved by Islamic Development Bank in 2018. Projects of this kind encourage the introduction of more resilient rice varieties, resulting in higher yields. The project has two pillars: introducing new varieties of rice and research on value added rice products. Within the project framework, Malaysian rice experts will introduce eight varieties of rice in three categories (high-yield, aromatic and salt-tolerant) for adaptation trials at the Burma Rice Research Station in Guyana. Research on downstream or value added rice products will be carried out. To ensure proper implementation of the project, a Joint Coordination Committee and a Project Management Unit were formed. The project team visited a rice mill and the Burma Rice Research Station to gain an understanding of Guyanese commercial rice products, held discussions regarding collaboration with local farmers and determined possible project sites for the project's production trials. Source: https://agriculture.gov.gy/2019/03/16/guyanamalaysia-to-commence-reverse-linkage-project-to-boost-rice-industry/

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
3	✓	✓	✓		Reverse Linkage project between Suriname and Indonesia for the artificial insemination (AI) of livestock The project's main objectives include enhancing and strengthening the existing artificial insemination service centre as the livestock breeding station, enhancing and strengthening the AI supply chain and building the capacities of institutional agencies so as to develop an efficient, effective AI system. Launched in April 2019, the project is expected to cost US$ 280,000. Source: https://www.isdb.org/projects/data/uid-pj0033028
3		✓	✓	✓	Reverse Linkage project between Guinea and Tunisia to enhance the value chain for the export of Guinean agricultural products The main objective of the project is to support and strengthen the efforts of the Government of Guinea to develop and enhance the food product export value chain, particularly as concerns principal exports such as mangoes and cashew nuts. The project will lead to strengthening the technical and organizational capacities of the institutions involved in the promotion of mango and cashew exports. Launched in January 2020, the project has a total cost of US$ 280,000. Source: https://prod.isdb-org-d8.goodcaesar.org/projects/data/uid-pj0033212
3	✓	✓		✓	Mexico-Kenya Maize Nixtamalization Project In Kenya, maize is a basic food item although it is used in only 10 food items. In Mexico, maize is used in more than 600 food items. Due to its relatively few uses in Kenya, the demand for maize production is low at the level of farm production. Moreover, because of its limited processing, the maize value chain is also restricted. In addition, aflatoxin contamination has had adverse effects on the health and nutrition of the population. In contrast, Mexico has acquired wide experience in using maize and in nixtamalization. The process of nixtamalization involves cooking the grain in a lime solution and soaking it for a number of hours to remove any remaining organic components and excess alkali. Nixtamalization has a number of significant nutritional benefits, which include reducing the risk of pellagra, increasing the ingestion of calcium, increasing fibre intake and reducing the level of mycotoxins in maize. It is clear that the populations of countries such as Kenya could benefit from using of the process, and for this reason Mexico proposed its assistance. In 2014 a project steering committee was formed. In 2016, a Mexican delegation travelled to Kenya to provide training on maize storage and the nixtamalization process. Two mills were provided by the Mexican Agency of International Cooperation for Development (AMEXCID). "One was installed at the Kenyan Agricultural and Livestock Research Organization laboratory, which was used by Kenyan scientists to carry out nixtamalization, lime quality testing and milling exercises to produce corn flour to prepare *ugali* (a traditional cornmeal porridge). AMEXCID is in the process of delivering a second mill, with support to be provided by visiting Mexican experts, who will conduct workshops and also provide training in nixtamalization" (South-South Galaxy Solution). Thanks to the success of the project, nixtamalization workshops have also taken place in other countries such as Ghana and South Africa. Source: https://www.southsouth-galaxy.org/solution/mexico%C2%92s-maize-nixtamalization-project-in-kenya/

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
3	✓	✓		✓	Nigeria-India collaboration in traditional medicine The National Institute for Pharmaceutical Research and Development of Nigeria is cooperating with herbal scientists from India's Council of Scientific and Industrial Research (CSIR) on a number of research projects focusing on exploring the efficacy of compounds identified in Nigerian flora. Researchers are particularly interested in the use of Neem oil properties to produce a range of antiviral and antifungal products domestically. "They have focused both on isolation and screening of active constituents in plant extracts and also on synthesis of compounds. Apart from this, an Indian firm has also worked with researchers from the University of Ahmadu Bello, Zaria, Nigeria to transfer knowledge and technology related to the Neem plant. These researchers wanted to increase their learning in how to take advantage of the locally grown plant that has been used in Indian Ayurvedic medicine for centuries and have been working on transferring extractive technology, purification protocols, product formulations, and packaging" (Kapoor, Singer, Wong, & Thorsteinsdóttir, 2012). Nigerian researchers believe that the African traditional medicine system is informal and lacks scientific grounding. They see India as a major partner that could assist African scientists in building a strong scientific basis for a traditional medicine industry. Such collaboration could have economic benefits as well, through the licensing and commercialization of compounds screened for drug development in countries such as India or China. Source: https://www.idrc.ca/sites/default/files/openebooks/909-9/index.html
3	✓	✓	✓		Rural electrification through solar energy systems in Guinea-Bissau As a result of this IBSA Fund initiative, solar energy was brought to 20 villages in Guinea-Bissau. The project was launched in July 2011 and ended in May 2015. Its total budget was US$ 596,305. The project provided access to solar energy for 20,000 people living in rural villages, enabling the villagers to benefit from solar equipment such as street lights, indoor lighting for schools and community centres, cell phone chargers and other light battery-operated equipment and solar water pumps. Through the solar energy powered water pumping system, 600 families (consisting of more than 6,000 people) gained access to drinking water. As a result, community education, sanitation and safety were improved. As part of the project, a partnership programme in conjunction with the Ministry of Education provided training for 24 teachers and enabled some 1,100 people to participate in functional literacy courses in their villages, with a 90% participation rate among women. In light of the results of the initiative, community engagement increased, leading to more inclusive project output governance practices such as solar power and micro-utilities management. *(Continued on the next page)*

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
					The project contributed greatly to capacity-building in Guinea-Bissau. Workshops on village mobilization and pro-activism were held in which 120 beneficiaries participated (five per village, 62% women). Partner villages carried out the civil works projects needed for the installation of solar equipment. “This included construction of fountains linked to solar water pumps, repairs of school and community centre walls and ceilings, and fencing for protection against theft” (IBSA, 2018). The illiteracy rate in Guinea-Bissau stands at nearly 45% and is higher in rural areas, especially for women. Thanks to solar energy powered lighting in schools and youth centres, women have been able to learn to read and write in the evening, while previously they had had only very limited educational opportunities. Moreover, the participation of women in village associations has been set as a priority. The adoption of solar energy has led to environmentally sustainable development and has also contributed to human development and increased village security. The lessons learned during previous IBSA Fund projects in Guinea-Bissau benefited the current project. “Concerns about community organization were incorporated for the management of micro-utilities and safety and security of solar energy systems” (IBSA, 2018). One of the challenges encountered during project implementation was the damage to solar panels in one of the partner villages as a result of heavy rainfall. “As a result of it, a partnership was established with the Secretary of State for Energy for the assistance in review and maintenance of solar panels installed under the project” (IBSA, 2018). Source: IBSA Fund Report, 2018
3	✓	✓	✓		Pan African e-Network project The Pan African e-Network project is an information and communications technology (ICT) initiative partnering India and the African Union. The objective of the project is to connect the 53 member states of the African Union to India and to each other through a satellite and fibre-optic network, in order to enable access and sharing of expertise between India and African nations in the fields of tele-education, telemedicine, voice-over IP, infotainment, resource mapping, meteorological services, e-governance and e-commerce services. The project aims to expand ICT infrastructure to rural and underserved areas and is often described as Africa’s biggest ever project in the ICT sector. It helps to overcome the digital divide in Africa and serves as a useful example of how India is using its soft diplomacy to support its economic and strategic interests in Africa. In 2004, the former President of India, APJ Abdul Kalam, proposed the idea of forming such a network in his address to the Pan-African Parliament in Johannesburg. In 2007, the Indian government announced its support for the idea and gave it US$ 100 million in funding. The total cost of the project amounts to Rs. 542 crores, borne by the Indian government through grants. The first phase of the project was launched in February 2009 and included 11 countries: Benin, Burkina Faso, Gabon, the Gambia, Ghana, Ethiopia, Mauritius, Nigeria, Rwanda, Senegal and Seychelles. The second phase of the project was launched in 2010 and covered 12 countries: Botswana, Burundi, Cote d’Ivoire, Djibouti, Egypt, Eritrea, Libya, Malawi, Mozambique, Somalia, Uganda and Zambia. By 2010, implementation had been completed in 34 of the 47 countries participating in the project.

(Continued on the next page)

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
3	✓	✓	✓		The e-network consists of a large undersea cable network and satellite connectivity which is provided through the C-Band transponders of the INTELSAT-904 or RASCOM satellites. A project Hub Earth Station is located in Senegal. An International Private Leased Circuit links the Hub Earth Station to a submarine cable landing station in India, thus connecting it to the participant universities and super specialty hospitals. Every African partner nation has a tele-education terminal, a telemedicine terminal and a VVIP communication node for the Head of State linked to the network. The network is designed to have 169 terminals. It also has a central hub that not only delivers services but also uses state of the art technology compatible with broadband technologies such as Wi-Fi and WiMax. The network can be scaled up if the number of users increases or to cater to different applications. The Telecommunications Consultants India Limited is implementing the project and is responsible for its design, operationalization and maintenance. A data centre at its office in New Delhi functions as a hub for all Indian sites. A pilot project that provided education services from IGNOU in New Delhi and telemedicine services from CARE Hospital, Hyderabad was successfully undertaken in Ethiopia in 2006, as a precursor to the e-Network project. The project links 7 Indian and 5 African universities, 12 Indian and 5 African super specialty hospitals and 53 telemedicine and tele-education centres in Africa. The Indian educational institutions partnering in the project include Amity University, Noida, University of Madras, Indira Gandhi National Open University, Birla Institute of Technology and Science and the University of Delhi. The Indian medical service providers partnering in the project include the All India Institute of Medical Sciences, the Escorts Heart Research Centre and Moolchand Hospital, New Delhi, Apollo Hospitals and Sri Ramchandra Medical College and Research Centre, Chennai, Care Hospitals in Hyderabad, Amrita Institute of Medical Sciences, Kochi, Narayana Hrudayalaya and Health Care Global Hospital, Bengaluru, KEM Hospital, Mumbai, Fortis Hospital, Noida and Sanjay Gandhi Postgraduate Institute, Lucknow. Partners in the project on the African continent include Makerere University, Kwame Nkrumah University of Science and Technology, the University of Yaounde, Cameroon, Ebadan Hospital, Nigeria and the Brazzaville Hospital in the Congo. The e-Network project is designed to benefit 10,000 students in certificate, graduate and postgraduate courses over a period of 5 years. Through this project, skills are transferred to African nations, particularly through Continuing Medical Education programmes which help train doctors and nurses in remote African centres. In 2010, the Pan African e-Network project won the Hermes Prize for Innovation awarded by the European Institute of Creative Strategies and Innovation. In 2011, in his address to the India-Africa Forum Summit in Addis Ababa, former Indian Prime Minister Manmohan Singh proposed the establishment of an India-Africa Virtual University in light of the successful implementation of the Pan African e-Network project. Source: https://mea.gov.in/Portal/ForeignRelation/Pan_African_e_docx_for_xp.pdf; https://web.archive.org/web/20140714220207/http://www.pambazuka.org/en/category/media/55920

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
3	✓	✓		✓	India-Ghana pilot project for tomato production in Ghana In 2015 a pilot project was launched to assist Ghanaian farmers to produce high-yield, pest-resistant tomato varieties. The project was sponsored by the Ministry of External Affairs of the Government of India in New Delhi, and implemented by the National Research Development Corporation, in collaboration with CSIR-CRI, Government of Ghana. The key objective of the project was to identify and release improved tomato hybrids and varieties with features like high yields, disease and pest resistance, climate resilience and the potential to drive value chain activities. The technology partner in the project is Ananya Seeds Pvt. Ltd, New Delhi, which also provided the tomato seeds for the pilot study. Ananya Seeds is owned by techno-commercial entrepreneurs with more than thirty years of experience in the seed industry. The company aims to become a leader in the Indian seed industry through the research and marketing of scientifically produced high-quality seeds. Within the framework of the pilot project, the first phase was put in place in Kumasi to demonstrate greenhouse agriculture and how it could contribute to increasing the yields of fruits and vegetables, and thus be of long-term benefit to Ghanaian farmers. Increasing tomato productivity in Ghana would also leading to savings on imports. The pilot programme also aims to adapt current best practices to local conditions. "Ananya Seeds developed standard manual as a guideline for progressive farmers using recent advancements in agriculture. Tomato hybrids and varieties were tested in three different locations like Kumasi, Ada and Novrango. All three projects were completed and handed over to CRI-CSIR, Ghana. Research related to effect of spacing, irrigation methods and intervals, sowing methods in open field experimental blocks were conducted by the company. It also conducted and standardized seed production methods and demonstrated to farmers to encourage them to adopt the same. Six hybrids and six open pollinated varieties were used and tested and their performance was observed under varying climatic conditions at three different locations. The company's experiment with Hydrogel (water super absorbent) has also shown positive results on water stress management. It was concluded by the company that by using Ghanaian local lines and Indian varieties, they can breed new kind of more acceptable tomato hybrids with desired features that include taste, shelf life, size, shape, biotic and abiotic stress tolerances, etc." (National CSR Network). As part of the project outcomes, and to increase the confidence level of farmers to invest in tomato cultivation through the acquisition of advanced knowledge and practical skills, a number of actionable recommendations were made: using economical poly-houses to promote tomato cultivation under protected conditions; avoiding extreme weather periods when practising open field cultivation; distributing subsidized seeds for selected, promising varieties and hybrids; conducting more demonstration workshops throughout the tomato growing season and expanding regional coverage. Field trials showed that poly greenhouses performed better than open field cultivation. *(Continued on the next page)*

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
3	✓	✓		✓	On the policy level, the project results emphasize the need to choose the right quality of seeds and the best practices adapted to the specific conditions in Ghana. A comprehensive agricultural strategy must be implemented in order to encourage year-round agriculture. There should also be sustainable public and private partnerships in the sector to ensure food security and socioeconomic transformation. Source: http://nationalcsrnetwork.in/images/case_study/Ananya_Seeds_Tomato_Pilot_Project_in_Ghana.pdf
3	✓	✓	✓		South Asia Satellite (GSAT-9) for the South Asian Association for Regional Cooperation (SAARC) region The South Asia Satellite is a geostationary communications and meteorology satellite operated by the Indian Space Research Organisation (ISRO) for the South Asian Association for Regional Cooperation (SAARC) region. The satellite was launched on 5 May 2017. The idea of a satellite to serve the needs of SAARC member nations was first proposed by Prime Minister Narendra Modi of India at the 18th SAARC Summit held in Nepal in 2014, as a part of his Neighbourhood First policy focusing on India's South Asian neighbours. The multidimensional facilities provided by the satellite are now being used by Afghanistan, Bangladesh, Bhutan, Maldives, Nepal and Sri Lanka. The GSAT-9 satellite weighs 2,230 kg and has 12 Ku-band transponders (devices for forming a communication channel with radio signals). Cuboid in shape and built around a central cylinder, it has a mission life of more than 12 years. It provides a complete range of telecommunication and broadcasting applications and services, including television, direct-to-home (DTH), very small aperture terminals (VSATs), tele-education, telemedicine and disaster management support. Other potential uses of the GSAT-9 include broadcasting meteorological data and networking academic, scientific and research institutions in order to strengthen regional cooperation among SAARC member countries. The cost of launching the SAARC satellite was about Rs 235 crore. GSAT-9 is the first Indian satellite to use electric propulsion, although only partially, while GSAT-20 is expected to be the first fully electric propulsion system enabled satellite. GSAT-9 carries 25% of the normal chemical fuel package as compared to other Indian satellites and employs a xenon-based electric propulsion system for its orbital functions. The satellite was launched on 5 May 2017 aboard the GSLV-F09 rocket from the Second Launch Pad at the Satish Dhawan spaceport in Sriharikota, in Andhra Pradesh. The launch was followed by a series of orbit-raising operations (using an on-board Liquid Apogee Motor (LAM) and chemical thrusters) to place the satellite in the intended geostationary orbital slot. *(Continued on the next page)*

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
3	✓	✓	✓		"The two solar arrays of GSAT-9 consisting of Ultra Triple Junction solar cells generate about 3500 Watts of electrical power. Sun and Earth sensors as well as gyroscopes provide orientation reference for the satellite. The Attitude and Orbit Control System (AOCS) of the satellite maintains its orientation with the help of momentum wheels, magnetic torquers and thrusters. The satellite's propulsion system consists of a LAM and chemical thrusters using liquid propellants for initial orbit-raising and orbital station-keeping. The satellite also carries plasma thrusters which will assist in station-keeping. Four Stationary Plasma Thrusters (SPTs) constituting the electrical propulsion system of the satellite are intended for technology demonstration and as a backup to the satellite's chemical propulsion system. GSAT-9 was launched into a Geosynchronous Transfer Orbit with a 170 km perigee (nearest point to Earth) and 35,975 km apogee (farthest point to Earth) with an inclination of 20.61 degrees with respect to the equatorial plane" (ISRO, 2017) The GSAT-9 could be used for a range of broadcasting and interactive telecommunication applications which would benefit member countries by addressing their specific needs. The satellite will also be used to support applications that include disaster management support, broadcasting meteorological data and networking academic, scientific and research institutions in order to strengthen regional cooperation among SAARC member countries. India has been involved in an active space programme since 1965. In 1975, the country became the first South Asian nation to launch a satellite. It is the only country in South Asia to have successfully launched and operated satellites in space while other South Asian nations have struggled and lagged behind. Pakistan opted out of the programme, suggesting at the planning meeting on June 22, 2015 that it had its "own space programme" under its Space and Upper Atmosphere Research Commission. Pakistan has five satellites which lack heavy duty launchers and satellite fabrication facilities. Source: https://www.isro.gov.in/sites/default/files/flipping_book/GSLV_F09/files/assets/common/downloads/GSLV%20F09%20Brochure.pdf
3	✓	✓	✓		China-Brazil Earth Resources Satellite Programme In July 1988, the Brazilian and the Chinese governments signed an agreement under which they would launch a programme to develop two advanced remote sensing satellites. Under the joint China-Brazil Earth Resources Satellite (CBERS) programme, the technical skills and financial resources of the two countries were pooled to establish a complete remote sensing system that is both competitive and compatible with current international needs. Following the country's engagement in the CBERS programme, the Brazilian space programme entered a new era, resulting in the diversification of its partnerships in science and technology. The Chinese Academy of Space Technology is tasked with implementing the CBERS programme in China while the Institute for Space Research (INPE) is responsible for its implementation in Brazil. *(Continued on the next page)*

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
3	✓	✓	✓		"Brazil and China have conceived a satellite with sensors specially designed for the management of the Earth resources, forests, geology and hydrology, besides providing a modern system to monitor the environment" (Sausen, 2001). This instance of cooperation between Brazil and China is a visible effort on both sides to set aside the industrialized countries' prejudice against advanced technology transfer. China and Brazil have put in place a new model of cooperation, the concrete aim of which is the joint construction of two large operational satellites. This is in stark contrast to the standard model of cooperation in which countries only exchange technical assistance. The cost of the programme was originally estimated at approximately US$ 150 million. Brazil is to contribute 30%, equivalent to US$ 45 million. Under the terms of the programme, two identical satellites will be built at a cost of US$ 100 million and launched aboard the Long March 4 series vehicles from the Chinese base in Taiyuan. A clause was included in the agreement under which China would reinvest the entire amount that it received from Brazil in the importation of Brazilian products. The aim of the clause was to optimize the monetary exchange between the two countries and strengthen national industry. "The first CBERS satellite was launched on 14 October 1999, aboard the Chinese rocket Long March 4B, from the Launch Center in Taiyuan, Shanxi Province, approximately 750 km southwest of Beijing. The technicians from both countries finished studies of feasibility for the construction of two more satellites, from the CBERS series, CBERS 3 and CBERS 4, substituting the present CCD camera with another of 5 metres resolution. The multi-sensor payload of CBERS with different spatial resolutions and data collecting frequencies is its unique characteristic. The Wide Field Imager (WFI) has a ground swath of 890 km which provides a synoptic view with spatial resolution of 260m.The Earth surface is completely covered in about 5 days in two spectral bands: 0.66 mm (green) and 0.83 mm (near infrared). The high-resolution CCD Camera provides images of a 113km wide strip with 20m spatial resolution. Since this camera has sideways pointing capability of + 32 degrees it is capable of taking stereoscopic images of a certain region. In addition, any phenomenon detected by the WFI may be "zoomed" by the oblique view of the CCD camera with a maximum time lag of 33 days. CCD camera operates in 5 spectral bands that include a panchromatic band from 0.51mm to 0.73mm. The two spectral bands of the WFI are also present in the CCD camera to allow complementing the data of the two types of remote sensing images. A complete coverage cycle of the CCD camera takes 26 days. The Infrared Multispectral Scanner (IR-MSS) operates in 4 spectral bands such as to extend the CBERS spectral coverage up to the thermal infrared range. It images a 120 km swath with a resolution of 80m (160m in the thermal channel). In the 26 days, a complete Earth coverage can be obtained that can be correlated with the images of the CCD camera. The orbit of CBERS is sun-synchronous at an altitude of 778 km, completing about 14 revolutions per day" (Sausen, 2001). Source: https://www.isprs.org/publications/highlights/highlights0602/27-28_HL_06_01_CBERS.pdf

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
3	✓	✓	✓		African Biosafety Network of Expertise The African Biosafety Network of Expertise was launched in February 2010 with the signing of a host agreement between the New Partnership for Africa's Development (NEPAD) and the Government of Burkina Faso. First conceptualized in Africa's *Science and Technology Consolidated Plan of Action* (2005), it is funded by the Bill and Melinda Gates Foundation. The Network serves as a resource for regulators dealing with the safety issues potentially associated with the introduction and development of genetically modified organisms. It provides regulators access to policy briefs and other information online in both English and French and organizes national and subregional workshops in specific areas. For example, one-week biosafety courses for African regulators were held by the Network in Burkina Faso in November 2013 and in Uganda in July 2014, in partnership with the University of Michigan (USA). In the latter course, 22 regulators from Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Uganda and Zimbabwe participated. In 2014, at the request of the Federal Ministry of Environment, the Network undertook a training workshop in Nigeria for 44 participants drawn from government ministries, regulatory agencies, universities and research institutions. The workshop was designed to expand the regulatory capacity of institutional biosafety committees. "This training was significant to ensure continued regulatory compliance for ongoing confined field trials and multilocation trials for Maruca-resistant cowpea and biofortified sorghum. The workshop was held in partnership with the International Food Policy Research Institute's *Program for Biosafety Systems*" (UNESCO, 2015) Also in 2014, the Ministry of Environment and Forest Resources of Togo held a consultation with stakeholders to validate the country's revised biosafety law. 60 participants took part, including government officials, researchers, lawyers, biosafety regulators and members of civil society. The workshop was chaired by a member of the National Biosafety Committee. "The aim of the draft bill was to align Togo's biosafety law (signed in January 2009) with international biosafety regulations and best practices. This was especially true for the *Nagoya Kuala Lumpur Supplementary Protocol on Liability and Redress* that Togo had signed in September 2011. The validation workshop was a crucial step before the new bill could be tabled at the National Assembly for adoption. In June 2014, the network organized a four-day study tour to South Africa for 10 regulators and policymakers from countries that included Burkina Faso, Ethiopia, Kenya, Malawi, Mozambique and Zimbabwe. The main objective was to encourage their direct interaction with their peers and industrial practitioners in South Africa. The study tour was organized under the auspices of NEPAD Planning and Coordinating Agency, in partnership with the Southern Africa Network for Biosciences (SANBio)" (UNESCO, 2015). Source: https://unesdoc.unesco.org/ark:/48223/pf0000235406/PDF/235406eng.pdf.multi

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
3	✓	✓	✓		Kenya, Rwanda and IFAD collaborate to create portable biogas systems Approximately 2.5 billion people depend on such conventional biomass fuels as charcoal, dung, and firewood as their main sources of energy for cooking and heating. A large proportion of that number live in sub-Saharan Africa and Southeast Asia. Burning those fuels causes respiratory diseases and eye infections. From 2011 to 2015, in response to the challenge, Kenya and Rwanda tested a new group of portable biogas systems in collaboration with International Fund for Agricultural Development (IFAD) to provide their rural populations with alternative sources of energy. The main beneficiaries of the project were smallholder producers. The project led to the empowerment of women and their capacity-building while the living standards of the community were significantly improved. Initially, a number of biogas technologies were tested in Kenya. Of the technologies tested, Flexi Biogas technology was endorsed by farmers. It was then decided to test and replicate the technology in Rwanda and in different agroecological environments. Methodology included baseline surveys, progress reports and scientific data collection. The project led to technology transfer, cross-country knowledge and capacity-building through training of trainers, farmer field schools, demonstration units and farmer-to-farmer site visits. A partnership was formed with a private company that supplies technology that smallholder farmers can understand and operate. The project produced positive results. Its benefits include an improvement in the health of users, increased food production due to the use of high-quality fertilizer, higher income levels, women engaging in other activities thanks to more free time available and a better quality of life for women and children. Easy to install, low-cost, portable biogas technologies are now available to small farmers who had previously been dependent on charcoal or firewood, their traditional biomass fuels. The project has also faced challenges such as poor rural infrastructure, the shortage of financial resources for renewable energy projects and weak institutional capacities, among others. The project mobilized small and medium-sized private sector enterprises, governmental agencies, non-governmental institutes and research institutes. Source: https://my.southsouth-galaxy.org/en/solutions/detail/making-biogas-portable?fbclid=IwAR3mkaCNRhpN6RV-FV26RIZLU7cOvjYXoOyDJe2Z5Qg6ogPTX8P-DL-5BfM
3	✓	✓	✓		Morocco shares its expertise in renewable energy with Chad Morocco will share its expertise and knowledge in renewable energy with Chad within the framework of South-South Cooperation, pledged the Moroccan Ambassador to N'Djamena, Abdellatif Erroja. Morocco is well-known for having some of the largest solar parks in the world. The project will involve the participation of the Moroccan National Office of Electricity and Drinking Water (ONEE) and will be supported by the Islamic Development Bank. *(Continued on the next page)*

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
3	✓	✓	✓		The electricity sector is critical to regional integration within Africa and to sustainable development. The solar energy and the electricity sectors in Africa offer a number of opportunities for investment and win-win partnerships. The Noor Ouarzazate solar complex in Morocco is one of the largest solar farms in the world and is built on an area of more than 3000 hectares. It provides 580 MW of electricity and reduces carbon emissions by 760,000 tons. For Chad, the solar energy project for rural development will provide reliable and affordable electricity to its citizens. Source: https://northafricapost.com/42472-solar-energy-morocco-ready-to-share-its-experience-with-chad.html#.XxHg0YNTBig.twitter
2	✓	✓			Cooperation between Cuba and Brazil to develop a vaccine for Africa's meningitis belt The meningitis belt in Africa covers a number of low income countries, stretching from Senegal in the west to Ethiopia in the east, and has a combined population of around 300 million. In its efforts to stem the outbreak of meningitis in the belt in 2007, WHO assessed the status and production capacities of polysaccharide vaccine manufacturers worldwide. Bio-Manguinhos (Brazil) was identified, in collaboration with the Finlay Institute (Cuba), as the most efficient supplier since it was able to provide the needed vaccines at a price much lower than other manufacturers. The Finlay Institute is known for its meningitis research. In the 1980s it developed a first-of-its-kind vaccine to halt an outbreak of meningitis in Cuba. Bio-Manguinhos, which is also known for its experience in vaccine research and manufacturing, has developed its strengths in the lyophilization process. By joining forces, the two organizations were able to respond swiftly and supply WHO with the much-needed vaccine. According to the Finlay Institute, around 19 million doses of the vaccine were produced and supplied to countries such as Burkina Faso, Ethiopia, Mali and Nigeria from 2007 to 2009. Source: https://www.idrc.ca/sites/default/files/openebooks/909-9/index.html
2	✓	✓		✓	Technology transfers between Cuba and Brazil In recent years, Brazil has signed agreements for technology transfer with Cuban organizations so as to improve its domestic manufacturing and technological capabilities and reduce its dependence on health biotechnology imports. Cuba has a strong record in innovation and has been involved in the production of affordable biosimilars to supply its own health system and increase export revenues. Bio-Manguinhos (Brazil) signed technology transfer agreements in 2003 with Heber Biotec for the production of the antiviral drug interferon alpha-2b, and in 2004 with CIMAB (Havana) for the drug EPO. Under the terms of both agreements, the technology transfer to Brazil was to be carried out in stages. First, the Cuban organizations supplied packaged finished product to Bio-Manguinhos to be sold under the latter's trademark. During the second phase, packaging was done at Bio-Manguinhos. In the final phase, Bio-Manguinhos was able to ensure the entire production process, while paying royalties to the Cuban organizations. The agreements led to lower prices in Brazil for crucial drugs and also reduced its dependence on imports. At the same time, Cuba benefited through the payment of royalties. Source: https://www.idrc.ca/sites/default/files/openebooks/909-9/index.html

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
2	✓	✓			South-South Cooperation in nanotechnology led by Iran Nanotechnology is one of the focus areas of the South-South Cooperation initiatives led by Iran. In 2008, the Nanotechnology Initiative Council of Iran established the Econano Network. It was created in order to promote the scientific and industrial development of nanotechnology among fellow members of the Economic Cooperation Organization (ECO), including Afghanistan, Azerbaijan, Kazakhstan, Kyrgyzstan, Pakistan, Tajikistan, Turkey, Turkmenistan and Uzbekistan. The main objective of the project is to exchange technical expertise and experience, develop the economic share of ECO member countries in knowledge-based exchanges, create domestic and international markets for nanotechnology products, and ultimately raise the standard of living in these nations. In the domain of nanotechnology, Iranian national priorities are energy, health, water and the environment, construction and the nanomaterials industry. In the field of nanotechnology research, energy constitutes the main priority since petroleum and gas are the major industries in Iran. Some of the major players in nanotechnology in Iran include the Iran Nanotechnology Initiative Council and the Nanotechnology Laboratory Network. Source: https://statnano.com/news/46981/Nanotechnology-in-Iran, https://unesdoc.unesco.org/ark:/48223/pf0000235406/PDF/235406eng.pdf.multi
2	✓	✓			India-Sri Lanka South-South Cooperation In 2011, an Indo-Sri Lankan Joint Committee on Science and Technology was set up to create and oversee an Indo-Sri Lankan Joint Research Programme. In 2012, the first call for research proposals was made in the domains of food science and technology; nuclear technology applications, oceanography and Earth science, biotechnology and pharmaceuticals, materials science, medical research including traditional medical systems, spatial data infrastructure and space science. In 2013, two bilateral workshops were held to discuss potential research cooperation on transdermal drug delivery systems and clinical, diagnostic, chemotherapeutic and entomological aspects of Leishmaniosis. Leishmaniosis is a disease caused by the protozoan Leishmania parasite and transmitted by the bite of infected female phlebotomine sand flies. It is widespread in both India and Sri Lanka. Source: https://unesdoc.unesco.org/ark:/48223/pf0000235406/PDF/235406eng.pdf.multi
2	✓	✓			STI collaboration between China and the Russian Federation Cooperation between Russia and China was formalized by the *Treaty on Good Neighbourliness, Friendship and Cooperation* signed by the two countries in 2001. Roughly 40 collaborative projects, student exchanges at the secondary and tertiary levels and the joint organization of conferences have resulted from its implementation. *(Continued on the next page)*

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2	✓	✓			"Some of the large-scale projects being carried out include construction of the first super-high-voltage electricity transmission line in China; the development of an experimental fast neutron reactor; geological prospecting in the Russian Federation and China; and joint research in optics, metal processing, hydraulics, aerodynamics and solid fuel cells. Other important areas for cooperation include industrial and medical lasers, computer technology, energy, the environment and chemistry, geochemistry, catalytic processes, new materials, including polymers, pigments, etc. Russia and China are also cooperating in the domain of satellite navigation, through a project involving Glonass (the Russian equivalent of GPS) and Beidou (the regional Chinese satellite navigation system). The two countries are also involved in the joint study of the planets of our Solar System" (UNESCO, 2015). In 2014, Moscow State University, the Russian Venture Company and the China Construction Investment Corporation (Chzhoda) signed an agreement to increase cooperation in the development of technologies for smart homes and smart cities. Source: https://unesdoc.unesco.org/ark:/48223/pf0000235406/PDF/235406eng.pdf.multi
2	✓	✓			Reverse Linkage project between Sudan and Turkey: *Capacity Development of the Africa City of Technology (ACT)* The main objective of the project is to encourage the localization of technology in Sudan. Designed and implemented to expand the potential of Africa City of Technology in the domain of technology incubation, other domains of endeavour will include infrastructure, guidelines and business plans, and human resources. The main provider institutions include ULUTEK Technology Development Zone (ULUTEK) and TUBITAK Marmara Technopark (MARTEK). Partner institutions include IsDB, the Turkish Cooperation and Coordination Agency (TIKA) and the, Ministry of Finance and Economic Planning of the Republic of the Sudan. The project will help the Government of Sudan to enhance the capacities of ACT in technology incubation. Through the project, ACT will not only develop its incubation centre and technopark model, but also build its human capital, leading to significant scientific and economic growth in Sudan. Launched in January 2019, the project will cost US$ 270,000. Source: https://www.sesric.org/reverse-linkage-sudan.php, https://www.isdb.org/projects/data/uid-pj0033023
2	✓	✓			Sino-Thai cooperation in the development of HIV drug The Ministries of Public Health of China and Thailand signed an MOU in 1997. Within the framework of their collaboration, the two countries began joint development of an herbal remedy based on the principles of traditional Chinese medicine that could potentially be effective in treating HIV/AIDS. "Now the product, Complex SH, is the first herbal anti-HIV drug to have undergone Phase I, II and III clinical trials in China and Thailand. This was possible entirely with the support of the Ministry of Public Health in Thailand (Sangkitporn et al., 2005)" (Ke et al., 2012). *(Continued on the next page)*

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
2	✓	✓			The Department of Medical Science within the Thai Ministry of Public Health worked in conjunction with the Kunming Institute of Botany at the Chinese Academy of Sciences. In the late 1990s, Luo Shide, professor of phytochemistry at the Kunming Institute began ex vivo experiments designed to test product efficacy and analyse the pharmacological and toxicological properties of the compounds. The tests were carried out again later in Thailand, before clinical trials began. Because Thailand has a greater reported prevalence of HIV/AIDS than China, Thailand became a preferred partner for China. China also appreciated the Thai government's focus on addressing the growing health threat posed by HIV/AIDS and its broader patient base, which facilitated clinical trials. "All this led to the creation of a patented compound which is known to inhibit growth of HIV and kill the virus by interfering with its protein hydrolysis and transcription enzymes" (Ke et al., 2012). Source: https://www.idrc.ca/sites/default/files/openebooks/909-9/index.html
2	✓	✓			South Africa-China collaboration in biotechnology South African collaboration with Southern partners involves activities beyond marketing and distribution to include manufacturing, vaccine research, bioinformatics and data collection for clinical trials. "The South African firm Altis Biologics Ltd. (Pretoria, South Africa) has worked with the First Affiliated Hospital of Xinjiang Medical University (Xinjiang, China) on bone morphogenetic proteins and their effects on bone induction and bone remodelling in rabbits in order to gather pre-clinical data. The firm Altis Biologics specializes in the R&D of osteogenic biomaterials for use in skeletal regeneration therapies and has developed a new osteogenic biomaterial that could be used in healing fractured bone" (Kapoor, Singer, Wong, & Thorsteinsdóttir, 2012). Altis began to collaborate with Xinjiang Medical University due to high costs and limited local expertise. It supplied its most recently developed bone regeneration material to Chinese researchers who have expertise in orthopaedics and for the purpose of carrying out in vivo animal trials to further develop their understanding of the material's capabilities. In this way the South African firm was able to source significant pre-clinical data and meet the requirements for funding for subsequent clinical trials from the South Africa Innovation Fund (now part of the Technology Innovation Agency). Source: https://www.idrc.ca/sites/default/files/openebooks/909-9/index.html
2	✓	✓			Biomass bilateral cooperation between India and Argentina The National Industrial Technology Institute, INTI, is a federal agency of Argentina established in 1957, and is responsible for the development of industrial technology at the national level. INTI focuses on the development of science and industrial technology and also serves as an innovation network with 60 centres employing more than 3000 workers. It has centres in a number of industrial sectors and in areas such as chemistry, biotechnology and physics. *(Continued on the next page)*

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
2	✓	✓			Around 80% of INTI financing comes from the state. INTI cooperates with other Latin American countries such as Uruguay, Chile, Paraguay, Honduras and Cuba among others, to provide services and technical assistance to the region, financed by the Foreign Ministry through the South-South Cooperation and Triangular Cooperation fund. It also collaborates with Brazil through EMBRAPA, and IMETRO, and with the Inter-American Development Bank. INTI works in more than 20 international projects with developed nations such as Japan, Germany, China and Slovenia, and with institutions such as the International Atomic Energy Agency, Europe AID and Horizon 2030. "INTI signed a cooperation agreement in 2009 with the National Research and Development Corporation, India in the industrial technology sector in order to promote exchange of scientists, researchers, technicians and experts, exchange of information on scientific and industrial technology, promote joint research and development activities (R&D) of mutual interest and exchange of the corresponding results, contract services or technical assistance, encourage technology transfer, etc." (Sly, 2019). In 2010, the first biomass gasifier in Argentina, with a capacity to produce 250kW of electricity, was installed by INTI in cooperation with the Presidencia La Plaza municipality in Chaco Province, AGVE, a national company working in biomass projects, and an Indian company, Ankur Scientific Energy Technologies (Ankur Scientific). The economy of the Presidencia La Plaza municipality is based on forestry. There are 70 resident families who earn their livelihood in the district's sawmills but the furniture production they engage in produces quantities of waste that have been contaminating the region. Because the economy of Argentina is largely based on forestry and agricultural activities, encouraging projects based on biomass energy is an important national strategic goal. Thanks to the high level of biomass-rich resources in North and Central Argentina, the country has a huge potential for biomass projects. "The INTI renewable energy departments situated in Tucuman, were in charge of the consulting, conceptual engineering and mounting of the plant" (Sly, 2019). They researched the international developments taking place in biomass technology and visited Germany and India looking for the best available technological option for the project. Finally the Indian technologies were chosen because of their favourable cost-benefit ratio. The technologies provided by Ankur Scientific in India were more suited to the Argentinian context, according to INTI researchers. The land and labour hours needed to setting up and install the gasifier were provided free of charge by the municipality and financed by AGVE. The technology and expertise for the biomass gasifier was provided by the Indian company. In terms of the advancement of biomass production in Argentina, the biomass gasifier represents a huge, crucial step, although it is a medium-scale demonstration plant. A range of training courses were developed by INTI in conjunction with universities, research institutes and companies. INTI also established very good relations with Ankur Scientific, and continues its scientific and technical cooperation with the company. *(Continued on the next page)*

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
					“Both of them mostly exchange data on different biomass resources quantifying calorific value, ash content, humidity, photometry, and the technical specificities of each biomass in order to adapt gasifier’s technology” (Sly, 2019). However, this first gasifier encountered a number of issues. Most related to a lack of financing and the difficulties in cooperating with the municipality. Complementary equipment designed to dry and crush the biomass input, which was a central requirement for the plant’s optimal functioning, could not be purchased due to the limited financing available. Moreover, the connection between the plant and the electric company supplier did not function properly. Later, a new biomass gasifier was installed in Cordoba, to produce 600kW of power from peanut shells, thus strengthening the links between INTI and Ankur Scientific. “This private peanut factory applied for the RENOVAR, a national programme for promotion of renewable energies in the country” (Sly, 2019). Under the programme, price benefits in long-term deals to buy the energy produced from renewable sources are guaranteed. INTI visited China, Thailand and India in order to find the most updated international technologies and again chose Ankur Scientific. Indian technology in this sector was once again better suited to the needs of Argentina, as Indian technologies are less mechanized and encourage human labour techniques, an aspect that is crucial for Argentina due to its increasing unemployment rates. Finally, Ankur Scientific engineers went to Argentina and successfully installed the plant in conjunction with INTI and the infrastructure company. The plant is equipped with an electric generator supplied by SIEMENS, Brazil. Although there were intercultural and language barriers between Indian engineers and the construction workers, the plant has been successful in selling energy to the electricity grid. “Due to the cooperation provided by Ankur Scientific, INTI’s research department on renewable energy is one of the most experienced in Argentina today, and is being consulted to make Lab proofs of biomass sources and biomass gasifiers” (Sly, 2019). In cooperation with a national company, INTI is also developing the prototype for a small movable gasifier to treat agricultural residues from the sugar cane crop, and which should have the capacity to produce 15-20kW. This movable gasifier will not only be economically accessible but will also make electricity accessible in rural areas that previously had no electrical infrastructure. Farmers will now be able to connect their irrigation pumps using the energy produced from their own crop waste instead of using diesel fuel. This will help to contribute to a better environment and will also increase savings. “INTI is also trying to develop a prototype of a gasifier able to generate biogas from olive production waste along with the National University of La Rioja” (Sly, 2019). Although the project is still in its early stages, it serves as a crucial example of how bilateral cooperation with India has led to the generation of important know-how which may be adapted to previously unmet national needs in strategic areas. Source: https://www.ris.org.in/sites/default/files/DCR%20July%202019.pdf

Total No. of Modalities	Technology Transfer	Capacity-Building	Grant	Trade	Case Studies
1		✓			Chinese and Indian ties in the field of Genomics China is the only developing country in the world which has contributed to the Human Genome Project and has developed great strength in the area of genomics research. “China has worked on a project involving sequencing of the mitochondrial DNA (mtDNA) of Indian samples. It was done to compare them to phylogeny of Eurasian samples and for phylo-geographic screening in the future. However, the findings from this project could be used for studies of mitochondrial diseases, leading to potential health benefits for the population being studied. According to the authors of one of the three published papers originating from this work, ‘In patients with South Asian matrilineal ancestries, at least a basal outline of the total mtDNA phylogeny in this subcontinent is indispensable’ (Palanichamy et al., 2004)” (Ke et al., 2012). The project was carried out by Indian researchers from the Sanjay Gandhi Institute of Medical Sciences (Lucknow) together with researchers from the Kunming Institute of Zoology (Kunming) at the Chinese Academy of Sciences. China assisted by providing the sequencing equipment and technical expertise, while India provided mtDNA samples. Both countries provided primers, methods, and complementary expertise. This project has also helped India develop its potential in the field of genomics. Source: https://www.idrc.ca/sites/default/files/openebooks/909-9/index.html

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