CHAPTER 8

Science, Technology, and Innovation in Sustainable Development Cooperation: Theories and Practices in South Korea

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1 Introduction

This chapter discusses South Korea's development cooperation policy with a particular focus on science, technology, and innovation (STI) and examines Korea's unique opportunities and challenges in that field. STI have been recognized as key areas in achieving development. There have been a significant number of scholarly works examining how STI promote development, drawing upon various fields including economics, development studies, science, and technology policy. Earlier literature has discussed the effects of STI on economic growth, suggesting that STI developments increase productivity and efficiency as well as hasten societal progress.

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Building on these studies, more recently the focus has been on how STI in sustainable development not only require appropriate research and development (R&D) strategies, infrastructure, and capabilities to enhance innovation, but also the contribution of individuals, universities, and private sector stakeholders. In parallel to this development, in the international development arena, governments and international development agencies have developed agenda settings and policies for STI-driven development initiatives. Following the recent establishment of the United Nations Sustainable Development Goals (SDGs), the Technology Facilitation Mechanism (TFM) and STI roadmaps and action plans have been widely implemented.

STI policies have played a significant role in the socio-economic transformation of developing countries. This is particularly true in the case of Korea. One of Korea's outward-looking strategies in the previous developmental stage was to facilitate foreign capital investment and technology assistance while constantly cultivating the domestic capacity for economic development (Nam, 1997). During the industrialization period of Korea from the 1960s to the 1980s, key science and technology policies in this catch-up phase included promoting technology transfer from advanced countries and international development agencies; importing knowledge to build domestic capacity; and supporting conglomerates to strengthen industrial capacity (Nam, 1997). In the post-industrial era, the emphasis of national STI policy has been shifting from solely economic growth toward achieving inclusiveness and sustainable prosperity. STI policy began to play an active role in tackling societal problems and promoting healthcare and environmental sustainability with the aim of improving the quality of citizens' life.

STI became increasingly important in Korea's official development assistance (ODA) since it joined the Organisation for Economic Co-operation and Development's (OECD) Development Assistance Committee (DAC). The government of Korea enhanced domestic technological capacity by promoting efficient technology policies and engaging the private sector as a major force for improving national capability. However, the role of STI in development cooperation is neither theoretically well understood nor strategically implemented in Korea's ODA policy process. At the policy and institutional level, STI have not been fully articulated in Korea's ODA, while tensions have been mounting between STI-focused ministries and ODA-related ministries. The design and implementation of an STI-focused ODA require engaging multiple stakeholders with an appropriate governance structure reflecting domain knowledge and specific development sectors in line with national priorities. In enabling STI initiatives through policy change and institutional reforms, stakeholders should consider trade-offs to be made as well as synergies to be realized. Another important challenge is the lack of a common definition of science and technology ODA due to its cross-cutting nature, while this same cross-cutting nature of STI make them an important factor in reaching nearly all the ODA as well as the SDGs. Developing a statistical measurement of STI-related development cooperation remains a major challenge to be solved for better development effectiveness.

Building on the earlier theoretical and empirical discussions of international development cooperation, this chapter focuses on the role of STI in development cooperation and investigates policy and practices in South Korea. First, this chapter reviews the theoretical underpinnings of the relationship between STI and development. Second, building on a brief history of Korea's STI-related ODA, it investigates how South Korea utilizes science and technology in development cooperation and identifies opportunities and existing institutional and policy challenges. Third, it identifies emerging issues and discusses recent policy changes by examining the implementation of the Korean-SDGs and the effects of the COVID-19 pandemic.

2 Theorizing STI and Development

2.1 Defining STI in Development

STI policy as an integral component of national development strategies is widely recognized as a key enabler for economic growth and sustainable development (Miedzinski et al., 2019; IATT, 2020). The notion of STI has evolved over the last 50 years as one of enabling components in economic growth. Growing recognition of the importance of STI has resulted in diverse policy initiatives in the field of international development including those in the OECD and advanced countries (Soete, 2019). However, drawing a boundary of STI from a development perspective is not easy. One of the most commonly used conceptual terms in the discussion of STI and development is technological innovation. Major leading economic growth paradigms including the neo-classical Solow model, the Schumpeterian, and the endogenous growth theory have attempted to investigate the effects of technological progress and productivity on development (Furman et al., 2002; Rostow, 1960; Solow, 1956). Notably, Romer's product-variety model suggests technological innovation results in productivity growth while creating diversities of products (Romer, 1990). He argues that technological innovation is not an exogenous byproduct of scientific research, but rather, sheds light on the importance of government R&D policy and intellectual property rights in endogenous growth. Schot and Steinmueller (2018) suggest that STI can be understood in terms of three framings as they evolved over the past decades. The first framing was identified as beginning with the institutionalization and legitimization of government support for STI in the era of 'modernization.' It focuses on innovation for growth and is mainly directed toward mass production and consumption. The second framing emerged in the 1980s with globalization and focused on competitiveness engendered by national innovation systems for knowledge creation. The third and emerging framing is linked to contemporary social and environmental challenges including the latest global agenda—the SDGs—and calls for transformative change in a country. This framing has become clearer in recent years. Developing countries may be able to build on the experience from other countries to catch up and generate accelerated development by leapfrogging (Juma et al., 2005). Although some developing countries have managed to significantly improve their STI capacity, many continue to struggle to meet basic needs such as adequate health, education, electricity, and information and communication technologies (ICTs) infrastructure. Not only is there a lingering technology gap between countries, but there are also significant differences within their demographics. Among the diverse forms of STI, ICTs have been increasingly important and are considered one of the most powerful tools that can contribute to not only progressive, but also disruptive transformation in development (Avgerou, 2003; Heeks, 2008). Notably, scholarly works in the field of ICT for development (ICT4D) have explored incremental and disruptive mechanisms of ICT-enabled transformation in developing countries (Avgerou & Walsham, 2000; Heeks, 2008; Sahay, 2017). ICTs have created new avenues for making development projects more transparent, cost-effective, and engaging to development partners and citizens in developing countries (Wittemyer et al., 2014). However, implementing new technologies does not simply result in economic and social development for all and can often amplify the existing inequality in the local context (Avgerou, 2010).

2.2 Technical Assistance and Technology Transfer

Technical assistance was the earliest form of science and technology related ODA to developing countries by donor countries and international organizations. The European Recovery Program (ERP) after the Second World War, commonly called the Marshall Plan, was a financial aid program sponsored by the United States that also provided technical assistance. Although it is estimated that only less than 1% of all ERP aid was spent on technical assistance, its effect was significant in promoting industrial and agricultural productivity in the recipient countries (Tarnoff, 2018). The foci of scholarly works also include not only the industrial and economic impact of technical assistance (Gamser, 1988; Godfrey et al., 2002), but also its effect on socio-political capacity and democracy (Gibson et al., 2015). Tracing the evolution of technical assistance, Wilson (2007) presents a conceptual link between technical assistance, knowledge management, and national innovation systems and calls for more cooperative learning in STI-related development initiatives.

Another topic that has attracted attention from practitioners in development policy and academics is technology transfer (Correa, 1994), which is recognized as the main determinant in the economic growth of developing countries (Glass & Saggi, 1998; Reddy & Zhao, 1990). Compared to technical assistance, technology transfer refers to a wide range of international cooperation between governments and also firms through a variety of modalities including ODA, foreign direct investment (FDI), firm acquisitions, licensing agreements, and joint ventures. Scholarly works have been engaged in diverse development sectors such as in the field of climate change (Forsyth, 2007; Karakosta et al., 2010), the Clean Development Mechanism (CDM) (Murphy et al., 2015), renewable energy (Wilkins, 2002), and more recently, ICTs (Avgerou, 2003; Baark & Heeks, 1999). In the process of technology transfer at the national as well as international levels, socio-political factors and complex dynamics of local institutionalization are also discussed in scholarly debates (Guston, 1999; Oda, 1991). Analyzing the technology transfer patterns from the United States and Japan to South Korea during its industrialization period, Hahm et al. (1994) also investigate its dynamics and suggest a shift of focus on the host developing country and the contextualization of the domestic process of technology implementation. In addition to this perspective on technology transfer from the recipient side, Kapur (2001) provides a unique contribution and opens up a debate to theoretically discuss the complex relationship between technology transfer, 'brain drain,' and migration based on the human development approach.

2.3 Increasing Role of Innovation in Development

Innovation is commonly defined as 'a new or improved product or process (or a combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)' by the Oslo Manual (OECD and Eurostat, 2018). This definition comprises more than just the research and development phase, as scholars and practitioners aiming to build capacity or change the work approach can also be understood to be included in it. The concept of national innovation systems (NIS) has been widely adopted by both academics and practitioners to account for complex dynamics between diverse stakeholders from a more holistic socio-technical perspective (Nelson, 1993; Sharif, 2006). Criticizing the negligence of technological innovation in neoclassical growth models, Nelson (1993) notably suggests that the science and technology-driven national innovation system is crucial and needs to be understood as part of a large institutional system composed of different sectors including government, academia, and industry. The concept of NIS suggests a policy framework that less developed countries can apply to their development strategies, which would need diverse institutional interactions in local innovation systems.

Development agencies and international organizations have also recognized the key role of innovation systems for development and their responsibility for increasing efforts to support R&D (OECD, 1996; World Bank, 2011). Worldwide patent data has mainly been used in much academic research as a means of measuring innovation. The World Intellectual Property Organization (WIPO) leads the development of an effective international intellectual property (IP) system. The Addis Ababa Action Agenda (AAAA) endorsed by UN member states in 2015 also stresses the importance of such efforts to stimulate a culture of incentivized innovation. Measuring the expenditure of innovation remains a challenge, as firms do not specify this in their financial accounts and countries do not effectively compile such statistics (Furman et al., 2002). In addition, it can be difficult to differentiate between development activities that support innovation and activities that are innovative in the way they support development. Although DAC's systems were not set up to measure innovation expenditure, there has been progress made in the recognition of national innovation systems and R&D as potential new approaches to measuring innovation.

In 2015, countries spent on average 1.7% of their GDP on R&D (Ericsson & Mealy, 2019). However, there are large differences between individual states. While higher-income countries already spent an average of 2.4% on R&D and continue to increase investments, lower-income countries remain static with only 0.4% of their GDP being used for R&D (Ericsson & Mealy, 2019). With no STI strategies in place, these countries miss out on the high potential for economic growth. With economic growth, R&D tends to become increasingly privatized, whereas in low-income countries funding comes almost entirely from the government or international sources. Although even in the most high-income countries the government remains the main funder of R&D, Korea and Japan received approximately 75% and 78%, respectively, of their R&D funding from businesses in 2016, making them worldwide frontrunners in the privatization of R&D. It is interesting to note that the remaining portion of the funding in Korea is predominantly sourced by the government, whereas in Japan higher education has a significant share (roughly 5%) as well. Investments in R&D for STI have been considered an established path toward robust economies and sustainable development. However, critics argue that higher R&D spending does not necessarily mean greater innovation. More investments in developing countries are required to further develop infrastructure and technological capacity as well as to finally leapfrog development. Notably, expanding access to ICTs and, more importantly, contextual considerations for local innovation are expected to increase connectivity and knowledge transfer between development partners.

2.4 Institutionalizing STI in Sustainable Development Goals

The SDGs are designed to tackle key barriers to sustainable development by ending poverty, protecting the planet, and ensuring prosperity for all. In comparison with the Millennium Development Goals (MDGs) targeting 2015, which paved the fight against poverty in developing countries at the beginning of the century, the SDGs have a broader scope (Fukuda-parr & Muchhala, 2019). The SDGs framework is made up of 17 goals, 169 targets, and 304 indicators to monitor the progress of the goals and provide accountability for the implementation of the SDGs. The means of implementation (MoI) of the UN 2030 Agenda specify finance, technology, capacity building, trade, policy and institutional coherence, multi-stakeholder partnerships and data-driven monitoring and accountability as key means of implementation to achieve the SDGs and highlight STI as the central tool for SDG implementation (Walsh et al., 2020). Compared to previous agendas in the field of international development including the MDGs and the series of Aid Effectiveness agendas, the adoption of the SDGs recognized the importance of the cross-cutting qualities of STI in global sustainable development.

On the way to the establishment of the SDGs as a global norm, in 2014, the United Nations Interagency Working Group on a Technology Facilitation Mechanism (TFM) identified opportunities to collectively achieve more significant impacts by mapping all relevant STI initiatives, stimulating cooperation, and sharing information (United Nations, 2018). The TFM was set up to facilitate multi-stakeholder cooperation and collaboration toward access to STI through the sharing of information, experiences, best practices, and policy advice among member states to achieve the SDGs. The TFM also calls for the promotion of development, transfer, and dissemination of STI to developing countries, as well as capacity development in STI to help them achieve the SDGs (Walsh et al., 2020). New mechanisms to support countries' STI capacities were put in motion through the Third International Conference on Financing for Development (F4D) in Addis Ababa in July 2015 and later in the United Nations Sustainable Development Summit in September in New York. Notably, in the Addis Ababa Action Agenda (AAAA) endorsed by UN member states, the TFM was established to support the SDGs, which were later officially adopted in the United Nation General Assembly. It was institutionally formalized and outlined in paragraph 123 and 124 of the Addis Ababa Action Agenda and paragraph 70 of the Post-2015 Development Agenda Outcome Document.

We decide to establish a Technology Facilitation Mechanism. The mechanism will be launched at the United Nations summit for the adoption of the post-2015 development agenda in order to support the Sustainable Development Goals.

- We decide that the Technology Facilitation Mechanism will be based on a multistakeholder collaboration between member states, civil society, the private sector, the scientific community, United Nations entities and other stakeholders and will be composed of a

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United Nations Inter-Agency Task Team on Science, Technology and Innovation for the Sustainable Development Goals, a collaborative multi-stakeholder forum on science, technology and innovation for the sustainable development goals and an online platform.

(*Source*: Addis Ababa Action Agenda, Paragraph 123, pp. 55, 2015)

While defining the 2030 agenda at the UN Conference on Sustainable Development in 2015, member states placed more emphasis on STI and identified options for TFM that would help national governments reach 'the future we want.' SDG 9 declares that technological progress is the foundation of efforts to achieve sustainable industrial and environmental development: "[…] Without technology and innovation, industrialization will not happen, and without industrialization, development will not happen." SDG 17 stresses the need for action in partnerships between governments, the private sector, and civil society—the stakeholders of a national system of innovation. SDG 17 explains that urgent action is needed to mobilize private resources toward long-term investments addressing issues such as sustainable energy, infrastructure, and transport, as well as ICTs. Policymakers will need to set a clear direction and review policy frameworks, regulations, and incentive structures.

3 Korea's Development Cooperation with STI

3.1 Emergence of STI in Korea's ODA Policy

Korea joined the OECD's Development Assistance Committee (DAC) in 2010. Korea's accession to the DAC was significant in several ways. First, the government played a leading role with the objective of heightening Korea's national status as an emerging donor country. Second, in addition to the endorsement of the Paris Declaration on Aid Effectiveness in 2005, membership in DAC was meaningful for the Korean government to comply with various norms of international development cooperation, such as the commitment to enhance development effectiveness and increase ODA and untied aid. Finally, building on the confidence of having transformed from one of the poorest countries in the world to a DAC member, the Korean government has tried to establish a Korean ODA model to share development experiences and knowledge with developing countries

(Korea Institute for International Economic Policy, 2015; Lee, 2011; Yim, 2015).

Recognizing the importance of science and technology as well as the roles of government research institutes in the maturity stage of Korea's economic development, STI have gradually attracted attention as one of the competitive strengths in Korea's ODA. On the ODA policy side, in 2011, the then Ministry of Education, Science, and Technology announced the 'national strategy of science, technology and education ODA for enhancing developing countries' capacity and supporting sustainable development.' The suggested main focuses of the government were (1) increasing ODA and strategic support, (2) enhancing developing coun- tries' capacities through a Korean ODA model, (3) improving ODA to increase development efficiency, and (4) developing a foundation for STI-based ODA for the first time (Ministry of Education, Science, and Technology, 2011). Apart from these efforts that have been driven by STI-focused ministries including the Ministry of Science and ICT, the overall ODA strategies are discussed under the leadership of the Ministry of Foreign Affairs and the Prime Ministerial Committee of International Development Cooperation.

3.2 *Prioritization of ICTs*

Since Korea joined the OECD's DAC, Korea has been considered one of the top providers of ICT ODA, including e-government programs, ICT education, and infrastructure. As ICT also has a cross-cutting nature, it may not be easy to disentangle technological components from the ICT ODA program. However, as ICT has been one of the top priorities in Korea's ODA program, it is meaningful to discuss its trends and policy changes in the past years by investigating the size of ICT ODA compared to the total ODA based on Korea's Annual ODA Plan which is determined by the International Development Cooperation Committee. KISDI (2018) and Yoo & Yoo (2019) provide the latest overview of ICT ODA and identify the access-related 'pure' ICT ODA in Korea. With the sole purpose of enhancing ICT infrastructure, pure ICT ODA accounted for 242.9 billion Korean Won (KRW) during the four years from 2015 to 2018, or 2.3% of the total ODA of 10.5 trillion KRW (KISDI, 2018). However, ICT ODA can be defined more broadly to include all the ODA that incorporates ICT components since it can contribute to various sectors in different ways due to its cross-cutting characteristic.

While there were fluctuations in the size of pure ICT ODA over the four years, the study shows that ICT ODA in general continued to grow from 4.8% in 2016 to 8.7% in 2017 and 8.8% in 2018. This shows that the trend in ICT ODA is focused on the convergence of ICT with various fields other than pure ICT ODA as shown in Table 1.

Breaking down the total sum of four years shows that ICT and public administration accounted for the largest share in ICT ODA (254.2 billion KRW, 32.1% of the total ICT ODA), followed by pure ICT ODA (242.9 billion KRW, 30.7%), ICT and economic–industrial infrastructure (130.6 billion KRW, 16.5%), ICT and education (78.3 billion KRW, 9.9%), ICT and environment, energy (40 billion KRW, 5.1%), and ICT and agriculture, forestry, and fisheries (1.7%) (KISDI, 2018). This shows the dominance of e-government related projects in ICT ODA in Korea. Notably, there were growing trends in ICT and education as well as ICT and economic and industrial infrastructure—they only accounted for 3.8% of the total ICT ODA in 2015 but rapidly grew to account for 29.2% in 2018, the largest share in that year. On the other hand, there was a significant decrease in pure ICT ODA, which accounted for 48.2% of the total ICT ODA in 2016 but dropped to 23.3% in 2017 (KISDI, 2018). This implies that while infrastructure and ICT and public administration (e-government) projects were at the center of ICT ODA in the past, ICT ODA is now expanding its portfolio to other fields as well.

Table 2 shows the ICT ODA provided to different regions. Asia accounted for the largest portion with 37.6% (297.8 billion KRW) of the total ICT ODA, followed by Africa with 30% (213.5 billion KRW) and the Middle East and CIS with 17.2% (136.4 billion KRW) during the four years. However, while Asia accounted for 53% of the total ICT ODA in 2015, it was reduced to 40% in 2016 and 31.1% in 2017. In contrast, ICT ODA in the Middle East and CIS has steadily increased from 6.1% in 2015 to 10.1% in 2016, 18.7% in 2017, and 27.7% in 2018 (KISDI, 2018). This implies that while the major recipient countries of ICT ODA were located in Asia in the past, ICT ODA now has a diversified portfolio that includes other regions.

Korea is already acknowledged as the leading country in e-government as well as being the top provider of ICT ODA to recipient countries, with nearly 55% of the OECD's DAC's aid in the ICT sector according to the creditor reporting system (CRS). Korea is evaluated as having a comparative advantage, particularly the in ICT fields such as e-government and e-learning. These sectoral priorities have already taken

Table 1 ICT ODA Budget by sector (One hundred million KRW, KISDI 2018)

	2015	*2016*	*2017*	*2018*	*Total*
ICT ODA	1,735	1,183	2,297	2,695	7,910
Pure ICT ODA'	836 (48.2%)	836 (48.2%)	534 (23.3%)	630 (23.4%)	2,429 (30.7%)
ICT & Public Administration	598 (34.5%)	435 (36.7%)	878 (38.3%)	631 (23.4%)	2,542 (32.1%)
ICT & Education	92 (5.3%)	93 (7.8%)	185 (8.1%)	413 (15.3%)	783 (9.9%)
ICT & Environment and Energy	77 (4.4%)	69 (5.8%)	97 (4.2%)	157 (5.8%)	400 (5.1%)
ICT & Economic and Industrial Infrastructure	66 (3.8%)	122 (10.3%)	330 (14.3%)	788 (29.2%)	1,306 (16.5%)
ICT & Agriculture, Forestry, and Fisheries	14 (0.8%)	6 (0.5%)	85 (3.7%)	30 (1.1%)	135 (1.7%)
ICT & Others (Health, etc.)	52 (3.0%)	30 (2.5%)	187 (8.1%)	46 (1.7%)	315 (4.0%)

Table 2 ICT ODA Budget by region (One hundred million KRW, KISDI 2018)

	2015	*2016*	*2017*	*2018*	*Total*
ICT ODA	1,735	1,183	2,297	2,695	7,910
Asia	919 (53.0%)	474 (40.0%)	714 (31.1%)	871 (32.3%)	2,978 (37.6%)
Africa	335 (19.3%)	309 (26.1%)	871 (37.9%)	620 (23.0%)	2,135 (30.0%)
Middle East/CIS	196 (6.1%)	126 (10.7%)	430 (18.7)	612 (22.7%)	1,364 (17.2%)
Latin America	126 (7.3%)	119 (10.1%)	114 (5.0%)	364 (13.5%)	723 (9.1%)
Others	249 (14.4%)	155 (13.1%)	168 (7.3%)	228 (8.5%)	800 (10.1%)

up large segments of Korea's ODA carried out by EDCF loans and Korea International Cooperation Agency (KOICA) grants. However, there is still a missing empirical link between the prioritization of ICT and better outcomes in the local context. Schopf (2019) argues that Korea's ICT ODA lacked governance, transparency, clear goals, quantifiable measurement, and independent evaluation. Still, Korea's recent prioritization of ICT has brought international attention. Enhancing good governance and implementing ICT innovaitons followed by a result-based framework will make Korea further realize its potential to utilize ICT for development effectiveness.

3.3 *Implementation of K-SDGs and STI*

The K-SDGs were implemented in 2018. The 17 goals and 122 targets of the K-SDGs, which aim to effectively implement the SDGs within the domestic politico-economic circumstances of Korea, were set under the supervision of the Commission on Sustainable Development in Korea. Given the cross-cutting nature of STI, a wide range of potential roles that STI can play have been recognized in government. A couple of specific SDGs are directly related to STI, such as health (SDG3), education (SDG4), water (SDG6), clean energy (SDG7), work and economic growth (SDG8), industry, innovation and infrastructure (SDG9), sustainable cities (SDG11), responsible consumption and production (SDG12), and climate change (SDG13). STI are also incorporated as leverage for building capacity and knowledge sharing in other goals including peace, justice, and institutions (SDG16); and global partnerships (SDG17).

In Korea, the Ministry of Science and ICT (MSIT) is the leading government body of R&D and innovation policy. In the implementation process of the K-SDGs, the MSIT participated in the Consultative Committee of the Related Ministries, but did not play a vital role in shaping the targets and indicators of the K-SDGs. Only the target of the improvement of national STI competitiveness by increasing STI resources (SDG9.4) was assigned to the MSIT. In addition, the MSIT has been involved with other targets such as to 'promote mental health and reduce drug abuse and misuse' (SDG3.4 & 3.5) with the Ministry of Health and Welfare; 'accessibility to sustainable infrastructure' (SDG9.1) with the Ministry of Land, Infrastructure, and Transport (MOLIT) and Statistics Korea; 'establish and carry out policies for sustainable consumption and production' (SDG12.1) with the Ministry of Economy and Finance (MOEF), the Ministry of Environment, the Ministry of Trade, Industry, and Energy, and the Ministry of SMEs and Startups, and finally 'support developing countries to strengthen systems for science and technology innovation' (SDG17.3) with the Ministry of Foreign Affairs, the MOEF, and the Commission on Sustainable Development. This type of complex responsibility has been a criticism of the fragmentation in Korea's development, which will be discussed in the next section.

In terms of budget and strategy, STI have not been a major concern in Korean ODA policy compared to other main donor countries. As explained above, the MSIT's assigned engagement in the SDGs from the K-SDG framework looks quite limited, despite high expectations for STI's contribution to achieving the SDGs. Furthermore, the ODA budget in the MSIT has been marginal in Korea, whereas the growing importance of STI in the SDGs has been more recognized in recent years. From an institutional view, the MSIT may not be the major body of the K-SDGs nor Korea's ODA policy. However, it is generally understood that the MSIT is the core of national STI and development policy because of its traditional role of promoting science and technological capabilities in the process of national economic development.

3.4 *Toward Integration in STI-related ODA*

There has been criticism of the fragmentation between the Ministry of Foreign Affairs (MOFA), which has pushed a 'science for diplomacy' agenda, and the Ministry of Science and ICT (MSIT), which has led science and technology-related international cooperation. The MOFA has tended to use science and technology as a foreign policy tool and soft power, whereas the MSIT has regarded cooperation with developing countries as a minor policy priority compared to R&D and high-tech cooperation with advanced countries and industrial-university cooperation (Chang, 2012).

In this regard, the MSIT and MOFA began discussions in October 2018 and announced the 'National Science and Technology Diplomacy Strategy for an Innovative and Inclusive State' on October 30, 2019, which highlights the role of STI-related ODA and international cooperation in achieving the SDGs. This plan was a joint strategy established by MSIT, the STI-driven ministry, and MOFA, the ODA-managing ministry. This plan sets three main goals to co-create a future for humanity, promote global shared growth, and lastly safeguard citizens' everyday life (Ministry of Science and ICT, 2019). These goals are to be pursued along four main strategies: (a) leading the global agenda and promoting national interests; (b) contributing to sustainable development in the international community; (c) improving national security and the quality of life of the people; and (d) institutionalizing the governance structure. In order to implement these strategies, the government aimed to (i) gradually establish a science and technology diplomacy support system that embraces science and technology expertise and diplomatic networks; (ii) expand cooperation with other countries; (iii) support ODA by utilizing science and technology for shared global growth; (iv) enhance cyber security and disaster response systems of overseas consulates and government agencies; and (v) enhance ministerial coordination to solve the fragmentation issue. The introduction of this vision was relatively well-planned, yet tangible changes in policy and achievements were shown to be insignificant.

Due to the cross-cutting nature of STI-ODA, policy- and project- level integration between key supervisory ministries and executing governmental agencies for ODA has been encouraged in Korea. There are roughly four different cases of project integration in ODA: (i) sectorally similar projects joined together with those in neighboring regions; (ii) diverse projects to be converged in the same region; (iii) a sequential approach to regional integration of individual projects; and (iv) individual projects redesigned as one integrated program (Kim et al.,2019). Kim et al. (2019) provide examples including the agriculture sector, where agricultural technology education and consulting are adopted through the cooperation with the Ministry of Agriculture and Forestry, KOICA, and the Ministry of the Interior and Safety (MoIS); and the cultural sector, with heritage recovery, tourism, and education projects through the collaboration with the MoIS, Cultural Heritage Administration and the Ministry of Culture, Sports and Tourism. However, limitations on the integration of different governmental departments still exist. Unless there are specific implementation plans and well-designed guidelines from the early stages, the issues will remain unsolved.

In addition to the institutional building toward a coordinated mechanism for STI in ODA policy, there have been trials and efforts at the project level. Among project-based STI-ODA initiatives, KOICA's Creative Technology Solution (CTS) program—the main program of 'Inclusive Innovation'—is the most representative. The initiative targets the bottom of the pyramid (BOP) in developing countries, generating sustainable business models using creative and innovative technologies and also launching exemplary businesses through social entrepreneurship. Since 2015, 76 projects were implemented by CTS, and at the BOP in developing countries, 1.3 million people were direct and indirect beneficiaries (KOICA, 2021). KOICA (2019) has supported a total of 23 projects in 20 countries in 2018: 17 in Asia, five in Africa, and one in the Middle East. Due to the government's emphasis on New Southern Policy, Asia has been the main region in which to conduct the projects (KOICA, 2019). Although rigorous assessment of the local context is needed, there have been a couple of notable cases. For example, in the case of a mobile-based malaria diagnostic kit, which was selected as one of the CTS programs, the project is expected to expand an innovative way for start-ups to contribute to development cooperation and also devote its technology in achieving the SDG in developing countries (Lee & Yim, 2016).

Based on the positive internal evaluation of these initiatives in the agency, a longer-term plan has been suggested that scales up national-level businesses by connecting social and economic development initiatives. CTS is meaningful as an innovative and explorative approach for STI-ODA at the project level. However, impact evaluations on individual projects are still lacking, and there is little empirical evidence for better development effectiveness. A wider range of disruptive technologies such as artificial intelligence, big data, satellite imagery, remote sensing, drone technologies, and robotics have been extensively tested and applied to development projects by various development agencies (Park, 2020; Park et al., 2020). One of the key factors for success is the localization of technology considering contextual differences in developing countries. Also, it is crucial to emphasize the need for supporting the commercialization of innovative technologies and encouraging the active participation of local actors in the implementation process of technologies.

In STI-ODA, one of the most important stakeholders is the private sector. At the 2011 High Level Forum on Aid Effectiveness in Busan, public-private partnerships were highlighted as an important agenda in the Busan Partnership document. Various stakeholders' engagement suggested a new way to expand partnerships in development cooperation, share financial and human resources, and increase development effectiveness through risk-sharing. KOICA and the Export-Import Bank of Korea (EXIM Bank) also sought active participation from private sectors and social entrepreneurs through impact investment and corporate social responsibility (CSR). However, since the projects proposed in the public sectors were based on government-led contracts, some cases were subjected to criticism for being considerably time-consuming as well as lacking agility and efficiency.

4 Emerging Agenda in STI-driven Development Cooperation

4.1 Tackling the Pandemic with STI

The spread of COVID-19 around the world created an unprecedented health crisis globally and nationally. The COVID-19 pandemic has accelerated the shift in the focus of ODA to STI. While the implementation of the SDGs is a complex process, the global pandemic has added another layer of complexity and is threatening international and national development efforts. The pandemic has plunged global health, development, and humanitarian organizations into a prolonged crisis, and has begun to displace other global priorities. The World Bank/IMF Development Committee (2020) outlined in their communique the devastating impacts of COVID-19 on the global economy with disruptions to trade, supply chains, and investment flows as well as impacts on human well-being, income loss for households, and disruptions in the delivery of essential public services. COVID-19 has the potential to erase the existing development gains for many countries (IISD, 2020; World Bank/IMF Development Committee, 2020). In response to the COVID-19 pandemic, more than 50 countries have announced and implemented some form of disaster relief allowance and social assistance to tackle the immediate challenges faced by their citizens (Gelb & Mukherjee, 2020). Governments have also explored how the application of digital technologies can help to accelerate global efforts to achieve the SDGs.

Countermeasures for COVID-19 have revealed the Korean government's crisis response capabilities, resilience, and flexibility to adapt during the pandemic. South Korea was relatively successful in controlling and mitigating the pandemic without the need for a lockdown. The Korean government opted for unique agile-adaptive and transparent actions, as well as multi-collaborative governance, to mitigate the surge of the pandemic (Moon, 2020). The hyper-network environment between the government, businesses, and citizens led to Korea's success in 'flattening the curve' by enabling the 3T policy (test, trace, and treat) (Heo et al., 2020). The Korean government quickly shifted its focus to tracing and quarantine measures to contain the pandemic. The Ministry of Land, Infrastructure, and Transport (MOLIT) began developing the COVID- 19 Smart Management System through smart city hub technology in mid-February with the Korean Center for Disease Control (KCDC) and the MSIT (MSIT, 2020). The system collects big data, such as mobile phone locations, hot spot usage, CCTV recordings, and credit card usage within 10 minutes (Ministry of Land and Infrastructure, 2020). As a measure to protect personal information, the Epidemic Investigation Support System (EISS) allows limited access to epidemiology investigators to identity the routes of only positively tested cases (Park, 2020; Park et al., 2020).

As discussed above, in Korea, there has been a relative lack of attention to STI in ODA, in particular emerging digital technologies in ODA programs. The COVID-19 crisis revealed how digital technologies could be leveraged in managing the COVID-19 pandemic and promoting digital resilience in developing countries (Park et al., 2021). The MOFA shared Korea's experiences and lessons learned from the COVID-19 crisis by highlighting the application of data sharing platforms and artificial intelligence in response to the pandemic at the OECD's DAC high level meeting in November 2020. The development of policies and capacities for applying emerging technologies has also become a priority in development cooperation strategy in Korea. To reflect this shift and achieve new objectives in ODA policy, the government has shifted focus to digital transformation and more proactive engagement from the private sector. Investments in R&D, particularly in the ICT and energy sectors, and public-private partnerships will be aimed at leveraging the fourth industrial revolution in order to create better opportunities for development cooperation in the international arena and to foster inclusive and sustainable growth in the domestic arena. Recently, Korea introduced 'the Fourth Industrial Revolution for inclusive society' as part of its presidential agenda, while Japan introduced 'Future Vision Towards the 2030s' subtitled as the vision for a new industrial structure. This change has accelerated the implementation of STI, in particular, emerging digital technologies in Korean ODA. Policy for emerging technologies is a primary policy directive of the Korean government coordinated through presidential committees such as the Committee of the Fourth Industrial Revolution and the National Council of Science and Technology. The uniqueness of Korean STI policy includes large investments in R&D and incentives for attracting private sector investments in sector-specific areas. The scope and aims of research in science and technological innovation have been gradually broadened and greatly influenced the landscape of Korea's ODA policy.

4.2 Highlighting STI in the Strategic Plan for International Development Cooperation

These kinds of discussions regarding STI–ODA were reflected in the establishment of the Strategic Plan for International Development Cooperation in 2020. The Strategic Plan for International Development Cooperation clarifies the basic framework for Korea's ODA policy as: (i) to take responsibility as a member of the OECD's DAC, (ii) to meet its commitment of scaling up the ODA volume, and (iii) to strengthen integrated ODA governance. The third strategic plan (2021–2025) was approved by the National Committee for International Development Cooperation in 2020. Compared to previous plans, the third strategic plan highly emphasizes STI according to four main ideas. First, given the situation of the COVID-19 pandemic, Korea strongly emphasizes the provision of healthcare and multifaceted infectious disease response plans in recipient countries and will disseminate essential drugs and technologies related to testing, tracing, and treatment (3T). Second, in 2020, the Korean government announced the Digital New Deal based on the importance of contact-free industries and digital transformation. Based on this, some suggestions were made to introduce ICT in development cooperation, including the aforementioned health sector. In this way, the Korean government intends to foster ODA linked to the Digital New Deal to establish an ICT infrastructure by supporting an open data system and e-government in developing countries, in line with the digital transformation of the recipient country due to the rise of a contact-free economy and the expansion of culture. Third, considering the demand from recipient countries in energy-related industries, the government also encourages the transition to a low-carbon economy by focusing on green technologies such as smart farms and renewable energy, which could eventually be linked to the Green New Deal. Lastly, enhancing developing countries' overall science and technology human resources, developing infrastructure research capacity and policy, and addressing the countries' digital divide issues were also included as important agenda points.

4.3 Aligning Korea's Strategy to the Global Framework

It is crucial for the Korean government as an emerging donor to actively participate in the international debate on STI-driven development cooperation. As discussed in Sect. 2.4, a mechanism for incorporating STI components in development initiatives has been created for the global field of development. Based on the mandate discussed in paragraph 124 of the AAAA, the TFM as an implementing structure was established. In addition, according to the STI Forum, the initiative to develop STI for an SDG roadmap is being driven by the UN Interagency Task Team on Science, Technology, and Innovation for the SDGs (IATT). Members include key UN agencies such as UN-DESA, UNCTAD, UNESCO, UNWIPO, UNIDO, UN-ESCAP, and UNU as well as the World Bank. Substantial financial and political support has been offered by international stakeholders, including the Global Sustainable Technology and Innovation conference series, the European Commission's Joint Research Centre (JRC), the OECD, and Japan. The African Union Commission has endorsed the IATT and expressed interest in implementing the roadmaps in African countries.

Building on these global efforts, at the national level, national guidelines on STI for the SDGs have been suggested. It is key for a national government to implement a globally agreed framework for the SDGs as well as to further develop and internalize its own national STI agenda. With this backdrop, it is also important to utilize this framework and international guidelines in the implementation of Korea's STI–ODA in developing countries. From these efforts of the global community, the IATT has developed the 'Guidebook for the Preparation of Science, Technology and Innovation (STI) for SDGs Roadmaps' (IATT, 2020). The guidebook outlines the recommended guidelines for developing national STI for SDG roadmaps according to the six key steps described in Fig. 1, as well as reports on five countries with different SDG gaps and STI capabilities. There are currently ongoing pilot programs for the STI for SDGs roadmaps initiative in Ethiopia, Ghana, India, Kenya, and Serbia.

Furthermore, the IATT guidebook also outlines recommendations for the best approaches to STI road-mapping and recommends that the process be done at three main levels, from the subnational to the national and then to the international level, following the key steps outlined in Fig. 2. With better coordination across the different levels constituting a collective learning policy, these institutional frameworks can provide

Fig. 1 Newly proposed process flow of 6 key steps in the STI for SDGs roadmaps (IATT, 2020)

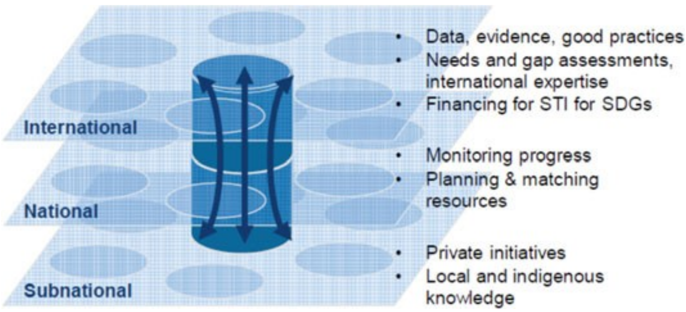

Fig. 2 Bridging the different institutional level for STI roadmaps (IATT, 2020)

policy implications and enhance the alignment between Korea's development programs and local governance.

4.4 Future Policy and Research Agenda

As discussed in Sect. 3, policy dialogue on the importance of STI in Korea's ODA began with the accession to the OECD's DAC in 2010 and hosting the High Level Forum on Aid Effectiveness in Busan in 2011. Since then, the proliferation of STI, particularly ICT-related development projects, has given rise to new opportunities and challenges in development cooperation. However, there have been very few scholarly works on STI-ODA in the context of Korea. Kim et al. (2019) note that domestically there are only 59 research articles on STI-related ODA as of 2019. Among them, there are very few peer-reviewed academic journal articles. They attribute this to the small scale of research projects, most of which are intermittent international development projects of government-funded research institutes in the Science and Technology sector. However, there are three general reasons for the lack of research on STI and development cooperation in the context of Korea. First, as it is in a global context, STI-related ODA statistics are difficult to produce with STI being a cross-cutting issue. Second, institutions carrying out STI-related ODA are very much fragmented in Korea, including not only the Korea International Cooperation Agency (KOICA), EXIM Bank, and the Ministry of Science and ICT (MSIT), but also the Ministry of Health and Welfare, Ministry of Interior (e-government), and other ministries. Third, and most importantly, a systematic understanding, research, and analysis of STI-related ODA has not been established.

Despite these challenges, there has been policy analysis on STI and international cooperation in a broad sense. Namely, the Science and Technology Policy Institute (STEPI), a government think tank, has consistently conducted policy projects relating to science and technology for diplomacy and international R&D cooperation since the 2000s. Also, the Korea Institute for International Economic Policy (KIEP) and the Korean National Diplomatic Academy among others have conducted related research (Chang, 2012). Discussion on STI-ODA has become more vibrant ever since 2010 when Korea joined the OECD's DAC. STEPI's initial set of policy research included case studies on ASEAN nations (Lee et al., 2010) and the establishment of strategic analysis on the Korean STI-ODA Roadmap (Lee et al., 2012; Lee, 2011; Yim, 2015). While the stream of research has focused on the establishment of a 'Korean ODA model' strategy, the limitations were that they were confined to a technology-centric perspective and its linear application to developing countries.

Moving from findings from Korea's case and the discussion of opportunities and challenges of STI in development cooperation, this study identifies major future policy and research agenda as below. First, developing measurement and indicators of STI-ODA is urgently needed. Second, agile policy and exploratory academic research on the impact of digital transformation and datafication will be increasingly important. Third, empirical evidence and impact evaluation on innovative solutions of technology such as KOICA's CTS program are needed. Fourth, there is also a need for contextualizing STI-ODA for local embeddedness and integrating strategic initiatives for better development management.

5 Conclusion

STI policies have played an irreplaceable role in socioeconomic transformation and industrialization. Korea has also progressed through different phases of socioeconomic and industrial development. During the industrialization period, the government of Korea enhanced domestic technological capacity by promoting efficient technology policies while facilitating foreign direct investment and technology assistance from developed countries. With the backdrop of national development in Korea demonstrating the significance of endogenous technological innovation, STI became increasingly important in Korea's ODA policy as well. In 2010, Korea joined the OECD DAC and prioritized ICT components in its ODA strategies. The increasingly rapid pace of technological change and Korea's global competitiveness in the ICT sector have driven the reorientation of ODA programs to promote an ICT-focused Korean ODA model.

However, compared to other major donor countries, STI has played a minimal role both financially and strategically in Korean ODA policy. The ODA activities related to STI have also sporadically followed policy changes in terms of the focus of aid from e-government, ICT, and health sectors in a fragmented manner. As Korea's response to COVID-19 in

2020 received global attention, especially from developing countries, the importance of digital and data-driven public health cooperation is in the spotlight. Based on the Green New Deal and Digital New Deal initiatives launched in June 2020, it is important to note that the government is currently structuring a three-pronged STI–ODA strategy based on the themes of digitization, green technology, and health technology. The Korean government announced in early 2021 that it will expand the share of ODA to climate and digital transformation from the current 6.4% to 22.7% of its total ODA as part of South Korea's Global Strategy on the Green and Digital New Deals. Building on the lessons from the case of Korea, four main policy and research implications are derived.

First, in spite of the recognition of the importance of STI in ODA, there is still a lack of clear understanding of STI in the national strategy for development cooperation. In the absence of a strategic approach to embracing STI in national ODA strategies, it is unlikely that Korea will be able to benefit from the potential of STI. STI-driven ODA programs need a comprehensive approach including financial resources, investment, and technology governance to apply such STI to the very complex local context.

Second, STI actors and agencies need to integrate a demand-driven perspective. The notion of technology transfer overemphasizes a technical and functional process, but often ignore socio-organizational context in developing countries. STI policy and strategies in developing countries are shaped in a very complex way that involves contextualization, incentive restructuring, and shifting power dynamics (Avgerou & Walsham, 2000; Orlikowski, 1992). The implementation process of technology is subject to internal and external events involving diverse local and international actors and their interaction. Thus, it is important to understand that the alignment of particular STI–ODA to local interests cannot be simply pre-planned and controlled following rational economic assumptions, but is constantly constructed through improvisations, political negotiations, bottom-up demand, and sometimes external shocks such as the global pandemic.

Third, in terms of the measurement and evaluation of STI–ODA, the cross-cutting nature of STI makes it an important factor in achieving nearly all the SDGs. The measurement of total STI development, however, remains a challenge. Ericsson & Mealy (2019) present an attempt to quantify STI efforts by estimating the financial resources dedicated to STI development activities through the creditor reporting system. Also, there have been attempts to set standards for measuring STI-ODA projects in Korea by Korean national research institutes (Kang & Yim, 2014; Kim et al., 2019). Significant differences in definitions and classification between data sources cause both underestimates and overestimates of the total financial resources spent on STI. Ericsson & Mealy (2019) high- light the need for the STI sector and development communities to start a dialogue to align their definitions and values toward effective STI devel- opment monitoring. Improvement of the CRS sector code is suggested as a possible solution, together with the use of machine learning and/or adopting other statistical methods.

Fourth, as discussed, science, technology, and innovation are overlapping concepts with strong interlinkages, making them crucial elements in achieving the SDGs. Many SDGs have objectives that are directly related to STI, while others rely on the development of knowledge and technology and are therefore indirectly connected to STI. As the AAAA calls for financial commitment and increased ODA and emphasizes public–private partnerships to create national STI strategies, investment in STI should not be regarded as a target itself, but more as a means to achieve the SDGs and ensure sustainable development in developing countries. In particular, increased investments in digital transformation, including in infrastructure and skills, as well as cooperation for the revision of regulations that impede technological innovation and new business models in developing countries, are crucial.

There is a shortage of empirical research on STI–ODA in Korea, with the discussion limited to policy research and strategic initiatives toward the Korean ODA model. This study provides a foundational discussion on Korea's future STI–ODA policy. Also, practices in Korea show how STI may create common interests for both developed and developing countries through multi-layered cooperation as well as delivering practical contributions to solving global challenges. Building on the lessons and challenges in the case of Korea, the implications for development policy may include: (1) improving policy integration and interlinkages between ODA and STI policies, including in financing and governance structures; (2) adopting STI for localized applications that meet the country's specific socioeconomic conditions and priorities; (3) developing national STI roadmaps and measurement frameworks; and (4) balancing the import of innovative solutions and local development, as well as encouraging private sector engagement.

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