TECHNOLOGY FACILITATION MECHANISM | SUSTAINABLE DEVELOPMENT GOALS

In partnership with the Republic of Korea

Science, Technology and Innovation for Achieving the SDGs: Guidelines for Policy Formulation

United Nations Inter-Agency Task Team on Science, Technology and Innovation for the SDGs and UNIDO

WORK STREAM 6: UN capacity-building programme on technology facilitation for SDGs

APRIL 2022

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Acknowledgements

The United Nations Inter-Agency Task Team on Science, Technology and Innovation for the SDGs (IATT) **Work Stream 6: UN capacity-building programme on technology facilitation for SDGs (WS6)** is co-led by the United Nations Conference on Trade and Development (UNCTAD) and the United Nations Educational, Scientific and Cultural Organization (UNESCO). Participating agencies include United Nations Industrial Development Organization (UNIDO), United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT), World Intellectual Property Organization (WIPO), United Nations Environment Programme (UNEP), United Nations Economic Commission for Africa (UNECA), United Nations Economic Commission for Latin America and the Caribbean (UNECLAC), United Nations Economic Commission for Europe (UNECE), and Economic and Social Commission for Western Asia (UNESCWA). The team also acknowledges collaboration with the European Commission's Joint Research Centre (EC-JRC).The United Nations IATT Work Stream 6 wishes to thank the Government of The Republic of Korea - Ministry of Foreign Affairs for funding the development of this booklet. UNIDO facilitated production through the project, Development of a Strategic Framework for UNIDO's Approach to Science, Technology and Innovation for the Achievement of Sustainable Development Goal 9.

Development of this booklet was led by Fernando Santiago, from UNIDO, with assistance of Jennifer Taborda, UNIDO consultant, and benefited from contributions and comments from UN expert staff from different entities that participate in the WS6, including Guillermo Anllo, Kornelia Tzinova, Despoina Sousoni and Zengmei Wang, UNESCO; Dimo Calovski and Clovis Freire, UNCTAD; Ludovico Alcorta, UNU-MERIT; Tamara Nanayakkara, WIPO; Pierre Henri Boileau and Francesco Gaetani, UNEP; Victor Konde, UNECA; Sebastian Rovira and Nicolo Gligo, UNECLAC; Ralph Heinrich and Lars Anders Joensson, UNECE; and Marco Kamiya, UNIDO. Support and contributions were also received from IATT partner EC-JRC, represented by Monika Matusiak and Angela Sarcina.

Camelia Soare, UNIDO, provided administrative and logistics support; Mike Fisher, proof-reading, and Santiago Palazzesi, design and layout.

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Abbreviations

COVID-19	Coronavirus disease 2019
EC-JRC	European Commission's Joint Research Centre
GO-SPIN	Global Observatory of STI Policy Instruments
GDP	Gross domestic product
IATT	United Nations Inter-Agency Task Team on Science, Technology and Innovation for the Sustainable Development Goals
IP	Intellectual property
IPR	Intellectual property rights
FDI	Foreign direct investment
IS	Innovation systems
LAC	Latin America and the Caribbean
LDCs	Least developed countries
MBA	Master of Business Administration
R&D	Research and development
SDGs	Sustainable Development Goals
SMEs	Small and medium enterprises
STI	Science, technology and innovation
STI Forum	UN Multi-stakeholder Forum on Science, Technology, and Innovation for the SDGs
TURF	Territorial use rights for fishing
UIS	UNESCO Institute of Statistics
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNIDO	United Nations Industrial Development Organization
UNECA	United Nations Economic Commission for Africa
UNECE	United Nations Economic Commission for Europe
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCWA	United Nations Economic and Social Commission for West Asia
UNU-MERIT	United Nations University – Maastricht Economic and Social Research Institute on Innovation and Technology
USD	United States Dollar
UN-TFM	United Nations - Technology Facilitation Mechanism
WIPO	World Intellectual Property Organization
WS6	The IATT Work Stream 6
WTO	World Trade Organization

1. INTRODUCTION

The 2030 Agenda for Sustainable Development, unanimously adopted at the United Nations Sustainable Development Summit in September 2015, positioned science, technology and innovation (STI) as one of seven key action areas for achieving the Sustainable Development Goals (SDGs).

Developed in reaction to the 2030 Agenda, the UN Inter-Agency Task Team on STI for the SDGs (IATT) was established as the operational body under the Technology Facilitation Mechanism (UN-TFM) to secure implementation of the STI mandate. The IATT promotes "coordination, coherence, and cooperation within the UN System on STI-related matters, enhancing synergy and efficiency, in particular, to enhance capacity-building initiatives."

IATT Workstream 6 on Capacity Building in STI for SDGs (WS6), formed in 2017, is mandated to foster capacity-building and to design and deliver training courses and workshops on STI Policy for SDGs, targeting primarily developing countries. Its main goal is to assist policymakers, public-service experts and key STI stakeholders in keeping abreast of the most current approaches to STI policy formulation, and to enhance their ability to mobilize STI as part of their strategy to achieve the SDGs.

Following the successful delivery of several training workshops—two in-person meetings in Amman, Jordan (April 2018) and Panama (May 2019), and a series of four online sessions in November and December 2020 (global), April and May 2021 (Latin America and the Caribbean) and December 2021 (Southern Africa)—WS6 decided to produce this booklet for use as background material for those interested in the design and implementation of STI-oriented policies in the member states, with the SDGs as the basis to inform SDG targets. The content is derived directly from the discussions at the training sessions, with further detailed elaboration based on direct interaction with participants. The following sections discuss the UN SDGs and the role that STI plays in a country's efforts to achieve them and define STI policy and present various conceptual and methodological approaches to STI policy formulation. These are followed by sections devoted to the STI policy cycle and best practices to use in each stage of the cycle. Finally, each stage of the STI policy cycle is discussed in greater detail, providing key information and examples to illustrate policymaking processes to leverage STI to achieve the SDGs.

2. SUSTAINABLE DEVELOPMENT GOALS (SDGs)

2.1. SDGS: AN INTERNATIONAL SUSTAINABLE DEVELOPMENT AGENDA

The Agenda 2030 for Sustainable Development provides a blueprint for a sustainable, prosperous and peaceful global future. At its heart are the 17 SDGs to help achieve this mission, covering core economic, social and environmental needs for a sustainable future.

FIGURE 1. The Sustainable Development Goals

Source: United Nations

The SDGs have been accepted by all developed and developing country UN member states and many subnational authorities and international organizations. In practice, the SDGs represent a commitment, at the country level, to establish national policies and actions to achievement the goals as well as systems to monitor and review their progress. All actors play a role in working toward SDGs, and everyone must do their part: governments, the private sector and civil society (United Nations 2015, 55).

The SDGs are made up of a complex system of 169 targets that interact with one another and integrate a set of priorities and objectives that are fundamentally interdependent (LeBlanc 2015). Hence, there are positive and negative interactions—which means that achieving progress in one SDG can leverage or create tensions with progress towards achieving other goals. For instance, striving towards success on Decent Work and Economic Growth (SDG 8) might delay progress on Responsible Consumption and Production (SDG 12), while at the same time help to achieve Zero Hunger (SDG 2). Therefore, it is important to understand the interlinkages across multiple SDGs to manage trade-offs and create synergies for their achievement. Such understanding requires a systemic view of the SDGs plus an interdisciplinary approach to tackling them. Since it is difficult to imagine finding a solution to these trade-offs without STI, it is necessary to know how to devise and implement STI policies.

2.2. ROLE OF STI IN ACHIEVING THE SDGS

STI plays a key role in achieving the SDGs, particularly in targets that concern human well-being, such as health, clean water and sanitation, climate change, clean energy, decent work, and responsible production, among others. As STI is comprised of the production, dissemination and use of knowledge, it has the potential to expand the evidence available to appraise the challenges associated with each SDG. Moreover, STI can inform the set of possible solutions to address the trade-offs that the systemic nature of the SDGs present.

STI includes three distinct but strongly related domains. Science is devoted to the pursuit of knowledge using the systematic study of the structure and behaviour of the physical, natural and social world; Technology involves the application of knowledge for a given end; and Innovation involves a new way of producing, delivering or using goods and services based on new technology, new business models or new ways of economic or social organization. There is a close and non-linear relationship between these three domains. Innovations, for instance, can be based on new technologies, and the emergence of innovations in a society can fundamentally change the dynamic of the social, physical or natural system, opening new questions for science. Thus, new opportunities to produce knowledge are driven by new technologies, and so forth. Each of the three STI domains features a set of actors that have specific linkages with each other and that interact with other domains. For instance, scientists or researchers are key actors for science, organized in public and private research centres, universities, academies of sciences, professional societies or other research institutions. Governments usually have a ministry responsible for science policy

and funding agencies in charge of research programmes. Regarding technology, scientists conduct applied research, and engineers and product/ service developers develop and apply new technologies. Meanwhile, entrepreneurs, farmers, industry leaders and individuals develop better ways of producing or using goods and services, which fuels a surge in innovations (UN IATT on STI for the SDGs 2020).

Actors in each domain benefit from their interaction with other domains. Scientists draw new ideas and information from private companies, consumers and product developers to feed their process of knowledge production. Innovators are inspired by new scientific and technological developments to create new products, services and processes. Engineers and applied scientists can adapt and apply new scientific discoveries by understanding the science behind them, but also by "having a feel" for what the market needs. In that sense, STI is systemic—meaning that a well-organized STI system is composed of a series of actors, organized into domains or components, with important relationships among them. The particular logic of each domain should be understood on its own in order to approach all three domains in an integrated and systemic way (UN IATT on STI for the SDGs 2020).

Achieving the SDGs by 2030 demands new strategies and solutions to tackle the complex problems that they highlight and to increase the current pace of progress in all of them. For that reason, as part of the Agenda 2030, member states adopted STI as an integral element in their national sustainable development strategies. This entails building robust STI systems based on the understanding of the linkages between actors and the dynamic of exchanges that characterize them. STI systems with good governance, well-established organizational structures, and a legal framework that articulates a variety of policies should be the goal of any STI policy for the SDGs. The challenge is adopting and rethinking new approaches to STI policy that consider the specific problems inherent in achieving the SDGs.

3. STI POLICY

3.1. RATIONALE AND APPROACHES

STI policy seeks to foster the production, dissemination and use of knowledge. To that end, STI policy usually comprises a set of strategies and actions designed to improve the performance of the STI system. STI policy has the potential to set the pace and direction of scientific production, technological learning and innovation. Today, the function of STI policy is particularly relevant, due to the accelerated development of science and technology and the pervasive use of new technologies in all human activities. We are living in what has been called a "knowledge economy" or "knowledge society", which requires new skills, new types of knowledge, higher levels of education and greater flexibility in the governance system to adapt to a constantly changing environment.

Designing public policies involves shaping management tools and instruments to address problems that impact the public agenda. STI systems have different elements that can contribute to public policy to address these problems. It is critical to understand the particularities of each of the STI domains and areas to articulate the actions required for each of them and approach the solution systemically.

The traditional rationale for STI policy is to provide solutions for *market failures* in the production, dissemination and use of knowledge (Joseph and Johnston 1985). Classical market failures in STI include: (1) information asymmetries related to high uncertainty in the production of STI outputs and short-time horizon of private investors, which lead to underinvestment in R&D; and (2) non-rivalry in the use of basic knowledge that makes it difficult to appropriate the returns of investment in R&D, undermining the incentives to fund basic research. The traditional market failures approach to STI policy analyses the incentive structures in each STI domain—science, technology and innovation—as a separate market and provides targeted solutions for each domain to solve these problems—such as subsidies, insurance, cost

mitigation, intellectual property rights, etc.—with a bias towards the R&D and invention-related aspect of STI. However, market failures are not the only cause of under-performance in STI. Other mechanisms can also contribute to a weak performance of the STI system.

Modern approaches to STI build on the popular notion of *innovation systems* (IS) (Freeman 1995; Lundvall 1992). In the IS perspective, the systemic character of STI has a central role, meaning, the interaction between different domains and actors involved in the process of producing and applying new knowledge (Edquist 2004). The main goal of STI policy under this view is to tackle *system failures*, mechanisms that impede learning and innovation by slowing down the performance of the IS. To identify system failures, it is necessary to understand the key STI actors or stakeholders of the IS and how they interact with each other to produce, disseminate and use knowledge. Woolthuis (2005) identifies four types of system failures: (1) infrastructural failures, the lack of appropriate physical and science and technology infrastructure (IT, telecom, roads) that actors need to function; (2) institutional failures, related to the absence or excess of problems related to the regulation and the legal system (hard institutional failures), and the existence of informal institutions (social norms and values, entrepreneurial culture, trust, risk-taking attitude, etc.) that hinder innovation (soft institutional failures); (3) network failures—the existence of strong links and intensive cooperation in closed networks can lead to a myopia that does not allow the infusion of new ideas (strong network failure); on the other hand, if interaction between actors and domains is weak, and there is weak knowledge exchange, learning cannot take place in an optimal way (weak network failure); and (4) capabilities failures, the lack of competences and resources to learn rapidly and effectively at the firm or actor level, impeding the possibility to use, adapt and create new knowledge and technology.

The identification of a system failure calls for policy action to address structural deficits in any given IS. This kind of analysis can be applied to any type of IS level, namely sectoral, regional or national. However, there are other kinds of problems that justify policy action apart from fixing market failures and solving structural problems of the IS.

Beyond the goal of maintaining a structure that generates innovations as effectively and efficiently as possible, there is a need to direct those efforts to solving challenges. The existence of *directionality failure*—the lack of a shared vision on the goal toward which STI efforts should be directed—can hinder the potential of STI to solve grand challenges. In this sense, directionality failure includes the lack of other abilities and resources—such as insufficient regulation to guide the direction of change, lack of targeted funding and inability to coordinate multiple actor's agendas around a common objective—to direct the effort of the STI system towards a shared vision. Identifying a directionality failure calls for STI policymaking under a *mission-oriented* approach, in which policy actions redirect technological change to achieve grand social challenges. To be able to redirect current trajectories of progress, policymakers need to work with all stakeholders involved and encourage them to work towards the same direction. SDGs are an example of big goals that can lead to STI policy direction with a mission-oriented approach. In this sense, a combination of the mission-oriented and the IS approach with the SDGs as big targets gives directionality to STI policy and narrows down the boundaries of the IS to the key actors required to reach the chosen goals.

Another requirement of STI policymaking is to align interests and objectives between different policy levels (regional, sectoral, etc.). In this realm, the lack of multi-level policy coordination is identified as a *policy coordination failure* and may involve coordination problems across systemic levels (regional, national, international), between technological and sectoral systems, between STI policy and sectoral policies, between ministries and implementing agencies, between public policies and private-sector institutions, and stemming from the lack of temporal coordination resulting in mismatches related to the timing of interventions (Weber and Rohracher 2012). Policy coordination failures can be tackled by applying the *smart specialization* approach (Foray, et al. 2009, 2011), a widely used method for innovation strategies in the European Union. This place-based approach to STI proposes to prioritize domains, areas and economic activities where regions or countries have a competitive advantage, or where they have the potential to generate growth based on knowledge creation. It is place-based in that the approach builds on the resources and assets of regions or countries and considers their specific challenges to identify unique opportunities for development and growth (Foray 2015). The set of priorities evolves as new developments or new information becomes available and are materialized in specialized options for investment, which take advantage of the competitive strengths of the region and represent a real growth potential. In recent years, this approach is being modified to better address social and environmental challenges embodied in the SDGs and initiatives such as the European Green Deal, and to embrace more transformative actions and agendas beyond simply economic growth.

In the spirit of thinking STI as a driving force of change with the power to transform society towards a more sustainable and inclusive future, there are two additional types of failures that justify policy action. Demand *articulation failure* is the incapacity to enable the uptake of innovations by users and consumers (OECD 2011). This failure reflects lack of spaces to anticipate and learn about user needs as well as the absence of stimulating and orienting signals from the public sector towards the adoption of innovations. A classic example is the development of eco-products that are not geared to consumer requirements. The adoption of innovations with the power to transform the existent social and economic relationships very often require solving the demand articulation failure by creating spaces for learning and experimentation to integrate consumers and producers into the innovation process.

Second, *reflexivity failure* is the inability to monitor, anticipate and involve actors in processes of self-governance; in other words, it is the absence of a monitoring, anticipation, evaluation and impact-assessment system to provide an analytical and forward-looking basis for adaptative policies (Weber and Rohracher 2012). To use innovation as a transformative tool to achieve grand social challenges such as the SDGs, a long-term and adaptative view is needed. In this sense, a society needs to be able to periodically reflect on the progress made and future course of action. However, policy action is needed to guarantee that such a system is in place and works as a space for reflection and learning.

From an STI policymaking perspective, the *transformative innovation* policy approach answers these two additional failures (Schot and Steinmueller 2018), by having a goal of achieving a combination of social, behavioural and technological change. Such transitions entail changes in skills, infrastructures, production, regulations and cultural predilections (socio-technical system transitions). Promoters of the transformative approach argue that only by achieving such profound transitions is it possible to overcome the social and environmental challenges that the SDGs pose. Transformative changes require innovative paths to achieve them. Thus, it is necessary to consider all possible proposals from different interest groups as well as alternative visions that call for inclusive deliberation processes to choose STI priorities and possible transformative pathways. Experimentation, then, is the main principle to move forward to test alternative paths. This involves pilots, collecting data on the test, analysing results and improving pilots via trial and error. Experimentation should add to the learning policy process by monitoring, anticipating possible results and involving multiple stakeholders for action (Schot and Steinmueller 2018).

3.2. STI POLICY FOR SDGS

The adoption of SDGs as a beacon for STI activities introduces the notion of directionality to traditional STI policymaking. STI policy for SDGs requires articulating existing national and regional policy frameworks. For instance, national development plans that set broad policy goals and key sectoral priorities should relate such policy objectives to the achievement of the SDGs. Similarly, national STI strategies with clear actions, resources, principles for governance, policy instruments and funding mechanisms would, ideally, reflect a vertical logic with the achievement of the broader national development goals, which should include attaining the SDGs (UN IATT on STI for the SDGs 2020). In addition, STI policy for SDGs might require adapting and reforming legal frameworks, the organizational structure of institutions involved in STI activities, and the coordination mechanisms among them. This guarantees that the knowledge needed to tackle the SDGs can be effectively created, diffused and put into use towards concrete solutions to achieve them.

There are additional strategic policy issues that emerge in the context of the SDGs. There is a need to complement national with international perspectives on cooperation. The SDGs are a global challenge and, as such, countries will benefit enormously from leveraging other countries' experiences. The role of multistakeholder partnerships for investment in STI for SDGs is therefore crucial. By the same token, the practice of open access to data and knowledge, open infrastructure and citizen science will increase transparency, accountability and openness for society. Science diplomacy as a channel to share and access knowledge is key. The SDGs call for global inclusiveness because the size of the task requires the use of a diversity of talents, world views and knowledge, as well as a better understanding of the needs and ways to profit from the contributions of every gender, age group and race.

An effective design and implementation of STI policy require the involvement of all actors. Certainly, the government oversees the coordination and drafting of the STI policy and is the key actor to ensure implementation. However, a government cannot do it all. There are unintended consequences of well-intentioned policies that can produce results that may contradict initial objectives. Sometimes, too, the interest of policymakers is misaligned with the long-term interests of society. And even a well-trained and committed body of public servants can fail to understand the underlying causes of systemic failure that underpin knowledge production, diffusion and use. To prevent and mitigate all possible sources of government failure, the action of multiple stakeholders is needed along every step of the policy cycle.

Beginning with STI policy design, the following sections offer some guidelines that can help the policymaking process to ensure transparency, efficiency and effectiveness in the long run.

4. STI POLICY: KEY STEPS AND GUIDELINES

4.1. KEY STEPS OF THE STI POLICY CYCLE

The STI policy cycle is made up of a series of stages beginning with preparation (see Figure 2. STI policy cycle: Participatory processes), followed by design; implementation; and monitoring, evaluation and learning. The results of monitoring and evaluation feed the learning policy process to improve the preparation of new interventions. In theory, this is a cycle that follows a defined order. In practice, however, many of the stages of the policy cycle can take place simultaneously. Implementation of SDG-oriented STI policy can be supported by dedicated STI for SDGs Roadmaps (Box 1)[1].

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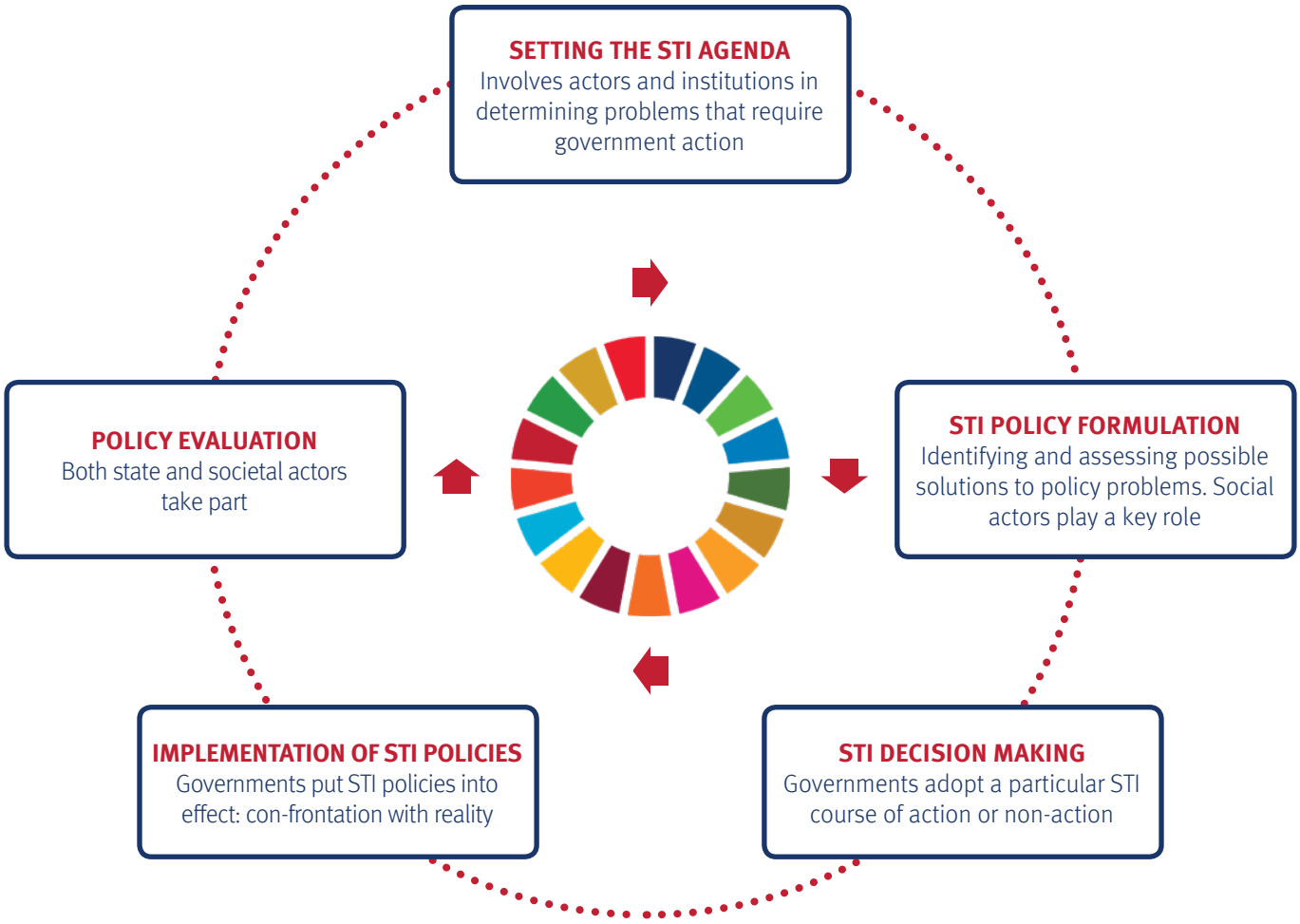
1. For detailed guidance on using STI for SDGs Roadmaps see: United Nations Inter-Agency Task Team on Science, Technology and Innovation for the SDGs and European Commission, Joint Research Centre (2021).

FIGURE 2.

STI policy cycle: Participatory processes



Source: WS6 based on UNESCO.

BOX 1.

UN-IATT Guidebook: Framework for developing STI for SDG roadmaps.

To guide STI policy efforts to achieve SDGs, the UN Multi-stakeholder Forum on Science, Technology, and Innovation for the SDGs (STI Forum[2]) identified STI roadmaps for SDGs as a key tool. The STI for SDGs roadmaps can be used to envision, plan, communicate and facilitate actions; track progress; and foster a learning environment to harness STI to achieve the SDGs. The STI roadmaps follow a multistakeholder approach and provide a clear blueprint to guide policymakers throughout the STI policy cycle, aiming at fulfilling the SDGs objectives. STI roadmaps can be developed by following six steps that cover all the STI policy stages and should be tackled with the participation of a broad number of stakeholders: (1) define objective and the scope of the roadmap; (2) assess the current situation, including diagnostics, assessments and policy reviews of STI needs and gaps; (3) develop the vision, goals and targets of the STI policy; (4) assess alternative pathways to reach the policy goals; (5) develop a detailed roadmap integrating the work developed in previous steps into a coherent action plan; and (6) execute, monitor, evaluate and update the roadmap.

Throughout the entire process of building an STI for SDGs roadmap, three core inputs are key for success. The first is stakeholder consultations, which should be performed with different interest groups at each stage of the policy cycle. Stakeholders should be partners and co-creators of the roadmaps to build an action plan that guarantees legitimacy and engagement. The second key input is technical and managerial expertise. The consultations, analysis, scenario evaluations, calculations, planning, monitoring, etc. that are necessary to build an effective STI roadmap require trained and experienced hands and minds. However, is possible to use the expertise of international experts, researchers, organizations and networks to bridge the gap if the required capabilities are not in place in the country. Finally, the process should use the best and most complete data and evidence available to inform every step of the STI roadmap. Data and evidence include databases and scientific evidence as well as qualitative information on the progress of the process, the level of engagement of stakeholders, feedback, etc.

Source: United Nations Inter-Agency Task Team on Science, Technology and Innovation for the SDGs and European Commission, Joint Research Centre (2021)

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2. The Annual Multi-Stakeholder Forum for Science, Technology, and Innovation (STI Forum) has been the platform for TFM to discuss topics of common interests of Member States and STI stakeholders in the context of the 2030 Agenda.

- **Stage 1: Preparing or setting the policy agenda** involves developing a vision, goals and central problems. To advance in this task, this stage focuses on forecasting and foresight exercises and diagnostic analysis at different levels. Forecasting is a tool to take advantage of existing data and analysis to understand where current trends might lead in the future. It uses historical data to identify stable trends to predict future situations under current as well as past conditions. These exercises are useful to build baseline scenarios in which current conditions prevail and there are few expected big changes that could affect long-term trends. Forecasting and monitoring of the STI system help to identify and quantify existing constraints and the ultimate sources of system failures. Foresight can help to build a common vision by thinking about the impact of current trends on future trends. It allows for the identification of alternative futures and the creation of new strategies to reduce risks and develop resilience. Foresight requires a broad participatory dialogue, which helps to expand existing perspectives about the future and how to build a common vision around it[3]. Finally, initial diagnostic analysis at the national, regional and sectoral level can help to clarify immediate causes and effects of key problems and bottlenecks.

  To decide whether or not a policy intervention is needed requires a conscious analysis of the nature of the problem and identifying plausible causes and multiple alternatives for a solution. Every possible solution—including no policy intervention at all—should be balanced against the existing resources and capacity to implement it. Once the feasible alternatives have been identified, it is useful to reflect and measure, if possible, the impact of the proposed alternative. What is the potential social return? What difference could the intervention make? In addition, the potential complementarities and interactions with other policies should be considered. This task cannot be performed in isolation. To understand the relevance, impact and costs of all possible alternatives, the private sector and other key stakeholders are useful sources of information and feedback. As in any other participatory process, the interest of each group plays a role in their participation.

- **Stage 2: Policy design** involves the choice of shared vision, goals, objectives, strategic directions and the better alternatives for policy intervention; the instruments to materialize them; the combination of policies or policy mix; the means and resources to implement them; and the tools and systems to monitor and evaluate them. To support policy design, it is useful to perform a cost-benefit analysis for policy instruments, reviewing possible trade-offs that might emerge in the choice of policy instruments.

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3. For more details on foresight methods and techniques see UNCTAD (2017), UNESCO (2018) and UNDP (2018).

- **Stage 3: Policy implementation** involves putting in motion the different policy instruments. In this phase, it is essential to develop a detailed action plan with resources, roles, a timetable and mechanisms to monitor the pace of policy implementation. Implementation entails the mobilization of resources (physical, financial, human, technical) as well as promoting and gathering participation from all stakeholders to guarantee the success of the STI policy. Successful implementation requires flexibility to tweak support and to adapt to new and unforeseen circumstances, including specific needs that were not expected in the design phase.

- **Stage 4: Monitoring,** evaluation and learning requires establishing and measuring appropriate performance criteria at the product, results and impact level. Complemented by a system to change or drop an intervention should it not be working, and scale and replicate those that do work well. Monitoring needs to be performed at two levels: STI system level and the level of programmes and policies. It implies putting in place a system of indicators to follow up the capacity to create, diffuse and use knowledge in the STI system, and to measure progress in the implementation of STI policy. Evaluation requires designing rigorous mechanisms and studies to understand the effectiveness and additionality of STI policy. Here, the collection of relevant data and statistics to fuel such systems is an especially urgent task of STI policy. Evaluation is key to understanding what works and what does not work. Monitoring ensures that accumulated knowledge, by trying out diverse policy actions, is shared. Everybody is empowered to follow the advance of policy implementation and act to ensure that it progresses in the intended direction. Furthermore, monitoring of the STI system is a crucial tool to detect failures in the specific context in which STI policy is intended to act. Thus, monitoring and evaluation increase the transparency and accountability of STI policy, while enhancing credibility and allowing learning.

4.2. GUIDELINES FOR POLICYMAKING

Some basic guidelines can help greatly increase the efficiency of the STI policy cycle. First, *directionality* refers to the need to set clear policy goals. Directionality in the context of STI policy for the SDGs requires an ambitious and clearly defined goal, capable to mobilize to action a broad set of actors, researchers, entrepreneurs, government officials, civil society, etc. The SDGs are an example of clearly defined goals to direct STI policy. Directionality puts a true north to the policymaking process; facilitates monitoring, evaluation and learning against clearly defined targets; and makes more transparent the utter motivations and expectations of STI policy. Ethiopia offers an illustrative case of how to implement the principles of directionality and coordination in STI policy design and implementation (see Box 2).

BOX 2.

***Case:* Ethiopia directionality and multistakeholder approach to STI policy for the SDGs**

In the early 2000s, Ethiopia had one of the highest growth rates in Africa thanks to a good flow of foreign investment and improvements in infrastructure and access to education. However, the country was still highly dependent on agriculture (70% of GDP), with some value-added services and construction activities gaining space, but minimal participation in manufacturing activities. The STI policy in place at the time focused on technological transfer, which helped to stimulate economic growth and foreign direct investment (FDI) but had no effect on technological learning and innovation. Focusing on SDG 8, Economic Growth and Decent Work, and SDG 9, Industry Innovation and Infrastructure, helped to guide Ethiopia's new approach to STI policy.

A second step involved a detailed assessment of the causes for poor performance in terms of technological learning and innovation. Three main problems were detected. The first was a lack of interest in technology and innovation in the private sector. According to different surveys, less than 1% of firms in the country introduced new technology to develop products and services. The second referred to low levels of cooperation between firms and R&D institutions, like universities, research institutions and others. And the third was the absence of many key actors in the design and implementation process of STI policy. This assessment called for the need to apply the principles of directionality and coordination in the STI policy cycle in Ethiopia.

In terms of directionality, having SDGs 8 and 9 and improving technological learning and innovation as goals helped Ethiopia alter the aim of its STI policy from technological transfer to innovation. In Ethiopia, innovation is strongly related to productive diversification, which does not necessarily involve the production of goods and services that are new to the world. In this case, the objective was to stimulate the production of goods and services that the country was not producing but could replace or compete with imported products or create new consumer markets. This change in directionality places the private sector in the centre of the policy and calls for a new set of STI policy instruments. After revaluating the STI policy mix, the government decided to create industrial parks, such as Hawassa, that have created thousands of jobs and attracted foreign investment.

Regarding this multistakeholder approach, the experience of Ethiopia shows that the main goal of an STI policy must be agreed upon and interiorized by the government, universities, knowledge centres and firms so that they all direct their efforts towards the main objective, enabling a successful outcome. In this sense, a key change in the STI policy

process in Ethiopia entailed involving different actors in the design and implementation of STI policy, starting with the participation of different government agencies. The country's experience demonstrates that it is crucial to coordinate the policy mix with all the possible governmental actors, not only in the design but also in the implementation and follow-up phases, engaging as much as possible with the private sector, to have better overall management and coordination.

Source: Author elaboration based on UNCTAD (2020).

A second guideline is the *use of evidence, experience and foresight* in the STI policy cycle. This can lead to designing policies that take advantage of the accumulated knowledge at the national and international levels. It ensures rigor and helps minimize the risk of government failure by avoiding conflicting interests in STI policy design. Evidence-based policymaking is a good way to follow this guideline, primarily in the name of exercising governance principles. However, it is not always easy to find evidence on specific problems in local contexts. In that case, any kind of previous knowledge or qualitative assessments is very useful to start gathering information on a particular problem. The idea is to build robust policies that are based on a sound understanding of what the problem is. To do so, a body of evidence-based scientific and policy research is needed. This body of evidence will improve over time, resulting in successes and challenges as the information is gathered.

The saliency, legitimacy and credibility paradigm should inform the collection and use of evidence. For scientific evidence to be considered legitimate by the user community, it must be presented in a language and format that policymakers feel comfortable with. Ideally, policymakers will have an active role in the production of scientific evidence through interaction with researchers. In this way, the saliency of information will be guaranteed. On the other hand, scientific evidence for policymaking must be credible for the scientific community. It should be the result of a research process that respects basic empirical and social science principles based on authoritative and convincing information and analysis.

Policymakers and scientists typically have different needs and speak different languages. However, policymakers need science-based evidence to build better policies, and researchers can benefit from the use of their research results in applied policymaking by validating the usefulness of their research efforts—collecting data, gathering new information and improving their predictions.

UNEP has developed a guide to help in the process of using existing scientific evidence and producing new evidence to tackle environmental problems for policymaking (see Box 3). The guide contains basic steps to produce an integrated environmental assessment related to a specific and pressing environmental issue. The goal is to provide a solid base scientific base to develop an STI policy that considers the complexity and variety of actors involved in any environmental problem.

BOX 3.

***Case:* UNEP environmental assessment of Abalone Fishery, Chile**

Environmental challenges are systemic problems that affect human and planetary health, with multiple impacts on society. Therefore, collective action is needed to produce an environmental assessment that includes the scientific and the policy perspective. A key aspect for a successful environmental assessment is finding a common language between scientists, policymakers and the public at large to guide discussions, reach common agreements and produce reports and communication pieces.

The making of an environmental assessment is a dynamic activity that takes at least one year to complete. The first step is to assess the existing literature on the topic at hand. This involves surveying and summarizing existent knowledge coming from published scientific articles and books, as well as opinions of experts in the field, to reconcile in an ordered way a set of multiple opinions around the same topic. The result of assessing the literature must be a compelling narrative that policymakers can use to enlighten their search for policy actions. In that sense, the results must be compiled in summaries for policymakers using communication resources such as images, graphs, videos and real-world examples.

The next step is to define clear policy questions and goals related to them. The policy questions help to clarify the field of action: What is the central problem? When does it need to be solved? Who is involved in the process of solving the problem? Who can be affected by the solution? These answers provide a guide to designing policy solutions to the problem. This step requires the joint action of policymakers and scientists from different areas and is derived from the literature assessment.

The process of using scientific evidence to find policy answers to the problem at hand must involve all stakeholders, including the scientific community that took part in the literature assessment. One successful example of this type of process is the case of the Abalone Fishery in

Chile. In this example, the Chilean environment ministry (MMA) wanted to protect fish stocks from overfishing and, at the same time, allow traditional fisheries to flourish. After following the process of an environmental assessment, they decided to implement a method that combines common property theory and local scale governance to create territorial use rights for fishing (TURF). In this strategy, the fishing communities involved in the process of policymaking assume the responsibility of preserving TURFS and sanctioning anybody who does not respect them. Apart from fishing communities, the fish industry and other agents on the value chain were supportive of the process. The TURF policy managed to reduce the pressure on vulnerable species, mitigate poaching and develop sustainable management of the fisheries over time. Further, the policy is low-cost, fulfills all the expectations and involves the whole community.

Source: Author elaboration based on UNEP.

A third guideline is *multi-stakeholder participation* in STI. Due to the systemic nature of STI, many ministries, government agencies and members of civil society would need to be involved in the design and implementation of STI policy. A broad as possible participation process guarantees the inclusion of all possible points of view, available knowledge and external validity needed to implement a successful STI policy. Moreover, this approach to policymaking prevents and mitigates possible government failures and guarantees engagement from key stakeholders from the start. The design of a bottom-up STI policy is only possible by ensuring multistakeholder participation. However, it is challenging to coordinate and engage such a variety of actors inside and outside the government to ensure resources and to maintain accountability on implementation. For that reason, groups of actors outside the government should have an active role as leaders of STI policy initiatives, aiding and overseeing the work of government officials.

A fourth guideline involves *learning and experimentation*. STI policymaking is not a linear process. Instead, it is a continuous effort of experimentation and learning to improve over time. To that end, it requires constantly assessing a changing environment in which there are new actors, interests and relationships evolving continuously. As knowledge increases and new technologies change society, the STI system changes accordingly and the policymakers should be prepared to respond to new challenges and different sources of systemic failure. At the same time, emerging technologies are already changing the way governments work and interact with other stakeholders. For example, greater interconnectivity has changed the boundaries of public and private domains.

Hence, STI policy should focus on learning how knowledge is created, distributed and used, and how that process impacts the existing organizational structures and relationships in the STI system. This implies a change of perspective towards STI policy, a long-term process in which policymakers build on their past knowledge and competencies to constantly adapt their actions to a changing environment and new challenges. It demands organized experimentation—trying possible solutions based on assessments of the STI system and the information at hand that should be as comprehensive as needed to act. There is a core, fundamental need to recognize that evidence, information and mapping will always be incomplete, but that trying creative solutions and deciding what works, what does not and why is the key to improved effectiveness.

Learning and experimentation as guidelines for STI policymaking apply not only to the policy process but also to all activities in the STI system. Better performance of the STI system is impossible without learning through experimentation. In that sense, enabling and promoting systematic experimentation and mechanisms for learning, by all actors in the system, should be top of mind for policymakers. This principle demands a high tolerance for risk and a willingness to abandon outdated or ineffective approaches.

Policy learning requires the capacity to monitor own performance and learn from past successes and failures, adapting to ongoing changes in the environment. It also demands a change of attitude towards failure. Policymakers need to frame failure as a learning opportunity and not a point of exacerbating institutional or personal accountability. Not doing so, through extreme risk aversion and investment in policy programmes that play it safe and do not strive to deliver value for STI stakeholders, undermines all STI policy efforts.

5. STI POLICY INSTRUMENTS

STI policy instruments are the tools used to shape public- and private-sector activities to reach the goals set by the STI policy. The way that these tools shape economic activities is through promoting innovation, technology transfer or research and development. In general, more than one tool is needed to achieve intended results, hence the need to form a policy mix or a policy portfolio. Ideally, the policy mix will tackle both the creative side and the destructive side of innovation. For example: a green growth policy mix should include policy instruments to promote renewable energy, but also instruments to phase out carbon-based activities. Furthermore, new scientific knowledge is needed to understand how to promote green development, foster the use of new technologies, and set up the right incentives to influence human behaviour towards green innovations.

To define a policy instrument means to determine the objective it pursues, the type of instrument to use, expected outputs, strategy to achieve the results, beneficiary or target group, rules for access (competitive or accessible to all beneficiaries), source and amount of funding, and time frame. In addition, if an instrument is part of an STI policy framework for SDGs, it must be analysed according to its link to the SDGs and potential synergies and trade-offs with other instruments. This is meant to guarantee coherence between the policy instrument and the goal of achieving the SDGs.

There are many ways to classify STI policy instruments. One is the sectoral or horizontal character of the instrument. A sectoral instrument targets specific sectors like garments, textiles, software or green innovation. A horizontal instrument, however, is cross-cutting, such as, for example, a human resource development fund for scientific capacity in general or a programme for small and medium enterprise (SME) innovation. Sectoral STI policy instruments can deliver bigger returns on investment. For example, designing an STI policy instrument to promote green growth may reveal that just three sectors account for most carbon emissions in the country. Deploying green technologies in these three sectors, then, may be more effective than a horizontal policy instrument aiming to promote sustainable production in general.

Another way to classify policy instruments is by their focus on supply or demand. Supply-side policy instruments are intended to promote the supply of information, knowledge, inventions, technology and innovation. They include direct incentives and support, such as tax incentives, direct subsidies, training and skills development, provision of infrastructure, technical assistance and creation of government-sponsored firms in new sectors. By contrast, demand-side instruments stimulate innovation through “pull” factors. Their focus is to influence the behaviour of users or consumers. They include tax rebates for consumption, public procurement, financing consumption, awareness campaigns, standards, certificates, etc.

Finally, policy instruments can be classified according to the target area of the policy intervention. Market-based incentives impact prices and taxes operating through pricing links. They include tax incentives and vouchers, subsidies, interest rate subsidies and catalytic financial incentives like seed capital funds, venture capital funds, angel investors networks, FDI incentives, etc. Public inputs, on the other hand, reflect the provision of goods and services, which firms cannot supply adequately. These types of instruments include the financing of R&D centres, universities, I+D funds, public procurement, guarantee funds, technology transfer services, business intelligence services, networking services, technical assistance, the intellectual property rights system, competition, metrology, and normalization rules and standards (Weiss 2015).

5.1. STI POLICY MIX

A policy mix is a set of policy instruments that deliver the intended goals and objectives of the STI policy via an *intervention logic*. An intervention logic explains how to move from goals and objectives to the planned outcomes and results. Building the right policy mix is a continuous process of learning and improvement. It requires constantly evaluating the impact of the policy mix to influence the behaviour of agents and improve the functioning of the STI system. This in turn requires understanding the interactions and complementarities between policy instruments in the policy mix.

The comprehensiveness and complexity of deciding on a policy mix is illustrated in Figure 3, building on the example of the Smart Specialization Strategies. In this case, the definition of policy instruments is linked to the rationale for intervention and the intervention logic; hence, the policy mix, or combination of instruments, is expected to help achieve intended objectives. The rationale for intervention in the figure is to foster growth and job creation in a territory. This rationale is transformed into concrete objectives in terms of innovative entrepreneurship, innovation capabilities in the territory and so on. The next step is to decide on the activities that would help operationalize those objectives. In practice, multiple activities can serve one objective. Similarly, a given activity may address one or more objectives. Finally, each activity relates to a set of expected outcomes. In summary, Figure 3 illustrates a policymaking process that links what a certain policy intervention is intended to achieve, and the means required to do so.

FIGURE 3. Intervention logic in Smart Specialization Strategies

Source: WS6 based on Doussineau et al. (2021).

In many cases, the questions driving the choice of policy instruments seeks to answer include: What is the goal we want to achieve and what are the goals of the policy instruments? What is the current situation of the STI system? Which are the main systemic failures? Which STI policy instruments are in place and how effective are they individually and as a policy mix? Which economic sectors and institutions need to be shaped to reach the objectives? What are the key actors of the national innovation systems involved in these sectors and activities? What are the supply and demand factors that need to be changed? Who is responsible for the policy instruments?

A quick assessment conducted by UNECLAC on the Latin America and the Caribbean (LAC) experience responding to the COVID-19 outbreak can help illustrate many of these possible questions (see Box 4). The first lesson is the usefulness of directionality in policy design. Among the many challenges posed by COVID-19, LAC countries decided to tackle both narrow, short-term objectives like supplying essential goods to manage the epidemic in a short time, as well as broader objectives like scouting for all types of ideas to contribute to the understanding and control of the pandemic. Further research is needed to determine which kind of approach resulted in the best return on investment.

BOX 4.

***Case:* Innovation calls, the case of Latin America during the COVID-19 pandemic**

In April 2020, UNECLAC reviewed the strategies implemented by 13 countries in the LAC region. The review covered the first wave of policy instruments to tackle the COVID-19 pandemic.

The challenges imposed by COVID-19 required innovative solutions. In this context, LAC countries wanted to solve the shortage of essential goods to manage the pandemic and to produce new knowledge about the disease to support the development of vaccines and treatments. All 13 countries directed at least part of their efforts toward the first objective, which required quickly scalable solutions that were comparatively easy to implement. Ten countries tackled the second objective by providing funds to R&D projects on COVID-19.

Many of the LAC countries were able to launch innovation calls to face the pandemic. Institutions, companies and researchers presented innovation projects to the local STI institution to be evaluated and compete for financing. All countries capitalized on their previous experience with this kind of instrument to launch a quick response to the pandemic.

However, there were differences among LAC countries in the design of the policy instrument. Some countries (10) launched general scope calls that welcomed all kinds of projects providing solutions for diagnosis,

control, prevention, treatment and monitoring of the disease. This was the case in Colombia, where the Ministry of STI issued a call to present projects around five thematic lines: public health, diagnostic systems, prevention and treatment strategies, equipment and devices, and monitoring systems. Five countries launched calls directed to specific solutions. This was the case of CORFO in Chile, which opened a COVID-19 innovation challenge aimed at stimulating the supply of protection elements like masks, face shields and biosecurity suits. As input for participants, the Intellectual property Institute of Chile released a report with all patents available related to these products. The challenge was directed to accelerate and scale the production of essential products for personal protection based on existing knowledge.

On average the average application time available was 12.4 days. With such a short window, the calls most likely mobilized teams that had already worked together on topics closely related to the objectives of the instrument. Additionally, the value per project was very modest (approx. $30 million).

An open question is whether or not project competition is the best instrument to solve problems at hand. This type of instrument may lead research teams and firms to work in isolation instead of sharing knowledge that can be valuable to find a better solution overall. UNECLAC suggested that joining efforts, both financially and intellectually, and generating policy instruments that could combine projects associated with different teams' proposals could be a better strategy to face a challenge like COVID-19. In the same vein, regional collaboration rather than country-specific solutions might work best in the context of an emerging pandemic with regional consequences.

Source: Author elaboration based on ECLAC.

5.2. POLICY INSTRUMENTS TO FOSTER INNOVATIVE ENTRE PRENEURSHIP

Ordinarily, innovation and entrepreneurship are understood as separate activities. Innovation implies generating improved or significantly new goods and services. Entrepreneurship is a process of identifying and implementing business opportunities. However, these activities often go together. Innovative entrepreneurship is not just another way of generating innovation. Instead, it is an activity with the potential to create quality jobs and foster productivity and growth. Innovative entrepreneurship can create new growth opportunities, or a business model based on novel products or services with a strong base on cut-

ting-edge knowledge. It can also be the application of novel technologies and business approaches. Some types of SMEs (the so-called "gazelles" or "unicorns") are examples of innovative entrepreneurship. They are small, dynamic and young companies with huge growth potential and the power to create jobs, particularly skilled jobs. Innovative entrepreneurs are agents of change; their business activities have the power to change their environment and their business strategies are directed towards big objectives such as sustainability, the global market, market disruption, inclusion, etc. In this sense, an innovative entrepreneur is a dynamic entrepreneur.

There are three main differences between a traditional entrepreneur and an innovative entrepreneur. First is the motivation to start a new business. While an innovative entrepreneur identifies a business opportunity that implies the use of a novel technology or the application of new knowledge, a traditional entrepreneur, instead, follows a business opportunity that does not require the use of frontier knowledge. The second difference is related to the academic background and experience of entrepreneurs. Given the nature of innovative entrepreneurship, this kind of entrepreneur is more educated than the traditional entrepreneur and/or has accumulated experience in its field to understand the technology base behind the business. Finally, innovative entrepreneurs require a large and dynamic network of allies to facilitate technology transfer, access to knowledge, high-skilled workers, financial resources and institutional support. This kind of network can help traditional entrepreneurs succeed but is essential for innovative entrepreneurs that seek to exploit business opportunities that depend largely on knowledge and technology.

The SDGs open opportunities for new business in many areas, related to the process of overcoming the social and economic challenges that the SDGs highlight. In effect, the SDGs reinforce the idea that economic and technological development go hand in hand with social and distributive considerations.

In the context of SDGs, innovative entrepreneurship has a key role in exploiting those opportunities based on creative and new solutions that have growth potential. To take advantage of innovative entrepreneurship, however, considerable support is needed. STI policy with a view towards innovative entrepreneurship needs to combine instruments to facilitate access to finance, knowledge, technology, business and consumer networks; to provide technical assistance and training to navigate the market; to increase their managerial capabilities; and to find and engage the appropriate human resources.

5.2.1. INTELLECTUAL PROPERTY RIGHTS

Intellectual property rights (IPR) are a key element supporting innovative entrepreneurship. These rights are created by law to provide innovators, inventors and creators time-bound rights over their inventions and creations. The role of IPRs is to create a tradeable asset that can attract investment and entrepreneurial effort to transform it into a commercial product or service. The IP system also stimulates commercialization using trademarks and design rights, which allow firms to better differentiate and market their products and services.

IPR include patents, which protect technical solutions; trademarks, which protect business signs; and design rights that protect the visual elements of a product. Copyright protects authored works such as software, audio and video production, published written works, etc. Trade secrets—while technically not an IPR but a contract between consenting parties—protect confidential business information and can be used as an IP instrument. The scope of rights that the owner of an IP asset can designate may vary from "all rights reserved/no unauthorized use permitted" to explicit license statements that permit certain types of use under specific conditions, while prohibiting others. These IP licenses are frequently found in copyrights as "public licenses" and "creative commons licenses". Some entrepreneurs may choose to place their inventions in the public domain and "gift" their contribution to humankind. Such is the case of Tim Berners-Lee and html—the standard language of the internet. Certain IP, such as patents or trademarks, need to be registered with designated authorities. Others, such as copyrights, are created on the promotion of the authored work into public circulation.

Therefore, businesses can use a variety of IP rights to pursue their objectives. IP owners can exploit IP rights either by integrating them into a product or service, or by selling, licensing (including in franchising agreements) and even donating the IP. In licensing, the right to use IP is given to a third party in compensation for a royalty. The heart of a franchising agreement is the licensing of different IP rights. IP can also be used as leverage in partnerships and joint ventures, whereby a substantial IP portfolio is attractive for potential partners or important in putting in place cross-licensing agreement, whereby parties will grant a general license to each other's IP. A well-conceived firm-level or institutional IP policy can serve to attract top-tier experts and researchers. Additionally, IP is useful as collateral for accessing financial resources.

Among the main pillars of an innovation system are its knowledge base, technological ability and set of firms and industries. A well-regulated IP regime stimulates the production of knowledge and technology, i.e. *inventions*, by providing researchers and inventors the possibility to monetize their creations by interacting with firms and industries.

Thus, an effective IP system is a key to stimulating STI. At a national policy level, governments need to develop both an IP regime compatible with international standards as well as IP offices that can assist inventors, researchers, firms and industries in maximizing their objectives, whether they are commercial or altruistic. Universities and research institutions should develop institutional IP rules and guidelines that support their research and creative staff and enable them to engage with the firms and industries in monetizing their research and creative output. Firms and industries should benefit from a supportive IP regime that enables them to manage and exploit their IP wisely and maintain their competitive edge in the market.

5.2.2. INSTRUMENTS TO FOSTER INNOVATIVE ENTREPRENEURSHIP

Innovative entrepreneurship is key to stimulating innovation-based growth and the role of STI policy is crucial to ignite the process of innovative entrepreneurship (see Table 1). Innovative entrepreneurs need policy support to mitigate the risks and costs of their activity through holistic approaches that recognize the diversity of factors involved.

TABLE 1.

Policy problems and instruments that influence and foster innovative entrepreneurship

POLICY PROBLEM	POLICY INSTRUMENTS
FINANCE	• Debt • Angel investors • Risk capital • Impact investors (social) • Crowdfunding
ORGANIZATIONAL CULTURE AND BUSINESS SKILLS	• Business support programmes • Mentoring and coaching • Incubators • Contests
HUMAN CAPITAL	• Internships • Contracts • Migration
MARKETS	**Creation of demand through:** • Links with larger companies • Business accelerators • Public procurement (strategic)
KNOWLEDGE	• Networking / cooperation • Intellectual property rights (IPR)
REGULATION	• Creation/closure of companies • Tax regime

Source: Author elaboration based on UNIDO.

One of the primary needs of innovative entrepreneurship is suitable financing. Traditional loans offered by the financial system are frequently inadequate for this kind of business, particularly at an early stage when they lack a track record, collateral, proven business model and positive cash flow. Instead, financial instruments based on equity, such as angel and venture-capital investments, are better tailored to the high-risk environment around innovative entrepreneurship. However, the lack of a critical mass of innovative entrepreneurs in an economy may hinder incentives for specialized providers to offer this type of financing to the market; and without specialized finance available, it becomes very difficult for innovative entrepreneurs to emerge and thrive. There is an opportunity for governments to act as a catalyst of this process, establishing a venture capital industry and promoting innovative entrepreneurship.

The role of government is, in this case, to invest public money into innovative companies in ways such that it crowds in rather than crowds out private capital, providing an incentive for the venture capitalist to emerge. To that end, the government should try to lower the risk-adjusted costs of entering the market for private investors and venture and capital managers. The government may initially choose to take on a significant chunk of the risk itself to signal to potential private investors that the country is serious about developing a venture capital industry and promoting innovative entrepreneurship. Decisions over the selection of companies for investment and shutting down of investments because of lack of growth potential should, ideally, be left to the professional private fund managers, via partnerships with the government.

There are three models for public-private venture capital financing. One is *equity carry*, where the government accepts shares from a private capital fund as collateral for subsidized loans. The second is *co-investment*, where the government matches the investments made by a private venture capital fund into the projects the fund managers select. And third is the *fund of funds* model, where the government creates a fund used to invest in private venture capital funds. The first option is the easiest to implement, but probably has the least catalytic effect on the emergence of the venture capital industry. The fund of funds model requires a significant number of venture capital funds in the market. When the country has few experienced venture capital investors and fund managers in place, it is key to bring in experienced fund managers and investors to draw on their existing experience abroad. In addition, governments can also try to get money from international organizations to supplement the funds, adding credibility to the programme.

Apart from appropriate financing, an STI policy to foster innovative entrepreneurship should guarantee a dynamic flow of innovative projects to in which to invest. Therefore, it is key to direct policy instruments to create a culture of entrepreneurship that incentivizes the emergence of

new innovative business ideas and a critical mass of innovative entrepreneurs, from the country or abroad, that can invest time, energy and resources in trying their ideas in the market. This can be achieved by implementing specific programmes, as in the case of Startup Chile (see Box 5). When there is a sufficient critical mass of innovative entrepreneurs and a culture of entrepreneurship in place, it is important to keep fostering networking, demonstrative events to the public, and feeding the existing community to ensure growth over time.

BOX 5.

***Case:* Policies to promote innovative entrepreneurship, Startup Chile**

Startup Chile offers an interesting example of the design and implementation of policy instruments to foster innovation entrepreneurship. In 2010, Chile was at a breaking point in developing its STI strategy. Since the beginning of the 1990s, the country had been building an institutional structure around STI and was able to create a variety of funds to finance research and technology projects, as well as venture capital funds to finance innovation projects. Additionally, Chile had in place a comprehensive structure to support the transformation of new ideas into businesses, with a network of incubators around the country. However, there was a lack of projects and business ideas to take advantage of the institutional and financial support. Part of the problem was the lack of an entrepreneurship culture in the country.

To fill the gap, a Chilean fresh out of his MBA degree from the United States identified the subprime mortgage crisis in the United States as an opportunity to attract entrepreneurs to work in Chile. The plan was to offer a package of benefits for foreign entrepreneurs in exchange for their commitment to work on their business ideas in Chile for at least six months. In this way, an influx of people with an entrepreneurial spirit and new ideas could ignite an entrepreneurship culture in Chile. Startup Chile began with a benefits package that included a working visa for one year, equity money ($40,000) and co-working space for each entrepreneur.

Today, Startup Chile has a range of programmes focusing on different stages of the entrepreneurial process. However, the main factor in the programme's success continues to be the nurturing of an active community of entrepreneurs that keep alive Chile's entrepreneurial culture. This is done via network events, academic lessons, meetings, meetups, seminars, entrepreneur camps, etc. Active participation of entrepreneurs since the development of the first pilot is key and has helped to create a platform in which entrepreneurs support entrepreneurs, giving legitimacy and validation to the instrument. Furthermore, the public servants in charge of the programme are

young, very motivated people that want to foster change and speak the same language as the entrepreneurs, thus creating a special environment of trust with entrepreneurs.

There is a before-and-after Startup Chile in terms of entrepreneurship culture in Chile. About 2,000 startups with entrepreneurs from 85 countries have benefited from Startup Chile, with one-quarter of the participants coming from Chile. The survival rate of the startups is around 50%-54.5 %, and the formal valuation of one-fifth of the projects reaches $1,500 million.

The experience of Startup Chile should be analysed through the lens of three facts. First, the design of a policy instrument is a continuous learning process. Startup Chile began as a pilot and evolved over the last decade with trial and error, changing benefits, beneficiaries and scope. Second, the development of an entrepreneurial ecosystem is a systemic challenge. There is no one silver bullet: although Startup Chile was important to strengthening the entrepreneurship culture in Chile, other policy efforts complemented the job of the programme. Third, bringing together the right people for the right task is key for a successful programme. The public servants who manage the programme have been instrumental for Startup Chile and there is a noticeable difference with other programmes that have a more traditional approach.

Source: Author elaboration based on ECLAC.

In addition, STI policy for innovative entrepreneurship should strive to maintain a healthy business environment, with an appropriate balance between taxes for companies and incentives for innovative startups that have not reached their equilibrium point. How? By (1) offering a stable environment for businesses with a set of clear and transparent rules for all players and only the absolute necessary changes in the tax system; (2) maintaining an intellectual property system that provides incentives to produce new knowledge and their application on improved and new goods and services; and (3) improving production standards, competition regulations and metrology rules to guarantee a level field for innovative new companies and incumbents.

Finally, supporting innovative entrepreneurship requires engaging the right people for the right task inside the government. A successful strategy needs to be designed and developed with the needs, language and way of working of innovative entrepreneurs. This might necessitate engaging people outside the government to help tailor and execute programmes and work hand in hand with the final beneficiaries of the policy instruments.

6. STI POLICY IMPLEMENTATION

Implementation is the third stage in the policy cycle and is essentially about execution and operationalization. There are some key characteristics of the implementation process. Policy implementation is a proof of concept, the stage where policy instruments get tested. At this point in the cycle, policymakers validate in practice whether stakeholders agree with the policy instruments as they were designed and discover any practical obstacle that affects the implementation. The process of implementation is social and political, involving different beneficiaries, bureaucracies and social groups, all with diverse interests, that will try to exercise their power during implementation. Policy implementation aims in many cases to change behaviour. Therefore, it is important to turn resistance to change into support. Finally, implementation is a managerial process, requiring resources, management, investment of political capital and decision-making.

During implementation many challenges can emerge. Among the most important are the following:

1. Leadership. STI policy needs top government support and STI should be one of the government's main priorities, if not the most important one. In addition to priority from the prime minister, the president, the parliament, or similar, policy must have ministerial priority. The minister or head of the department responsible for implementation must be convinced that the STI policy is necessary and worthwhile.

2. Operational Planning. To be able to anticipate possible responses, it is key to have an operational plan. And medium-, short- and long-term operational plans are critical for implementing STI policy. An operational plan includes a map with all the actions required to implement the policy; a chronogram with dates, roles and responsibilities, targets and performance indicators; and detailed costing of the measures themselves and of the process of implementation.

3. Systemic view of the implementation process. Policymakers should consider key STI actors; the social, economic and political relationships between actors; and the possible effects of the STI policy on those relationships. In line with systems-of-innovation views of STI, a holistic and comprehensive view is needed, where all variables and issues are considered. Further, these variables are interdependent. If one changes, all others will be affected.

4. Governance. STI policy needs people that advocate, promote, push and sell the innovation policy initiatives. Ideally, these people would be in strategic places within the executing STI agencies,

other public agencies and the private sector. STI middle-level bureaucrats are key to secure leadership in the implementation process. They can influence their superiors and their peers and generate a coalition of interest around STI policy. As committed bureaucrats are also important to ensuring proper implementation, it is recommended to have an overarching, multistakeholder representative consulting or decision-making body at the top level of government to review policies and problems systemically and coordinate across sectors. Below that level, there must be a body that has the overall responsibility for implementation, following very clear objectives. Finally, there should be clear duties and responsible people to execute them, well-defined structures, and joint tasks teams. The organization of intra- and inter-organizational teams can help enormously to implement STI policy. They manage the day-to-day activities and keep up with the details of implementation. These processes must be transparent, fully informed and accessible to the public and large and to specific STI stakeholders.

5. Coordination of the many agencies involved in the implementation of STI policies is also a challenge. For that purpose, multistakeholder implementation committees, working groups and teams are instrumental tools, by ensuring that relevant organizations and people are part of them. Another useful tool is rotating managerial responsibilities among involved agencies. Focal points in all organizations are necessary because they are the repositories of knowledge of those organizations. Finally, it is critically important that central agencies follow up the delivery of tasks and ensure that they are finished on time and at the expected quality.

Managers are key actors during implementation. A successful implementation process needs a competent manager who can think holistically, solve problems and communicate effectively. This person should be well-connected, with the ability to give executive orders, implement administrative mechanisms and enact rules and regulations. Getting the right manager for STI policy implementation is key and securing the individual resources is crucial. To do so, financial resources are needed for consultants, interviews, studies, travel, etc. Finally, access to knowledge must be maintained, guaranteed by the epistemic community on policy research or with the help of international organizations.

6. Public support is needed to implement STI policies. It should come from interest groups and can be leveraged through social media, the press and multistakeholder consultation processes. Part of this strategy is to identify media outlets that are used by

key STI communities to disseminate information and launch a social media campaign, including through internet platforms, Facebook, Twitter, etc. The campaign should use information and language that is easy to understand, useful and comprehensive. The traditional press offers a second channel to disseminate key information, like the big objectives and strategies of the policy, to generate interest and expectative among the public. Another powerful tool is the multistakeholder consultation process, which involves rounds of exchanges with different interest groups to create consensus and feedback on the STI policy. These processes help to strengthen the commitment of different communities to the policy and guarantee the legitimacy of the STI policy.

Finally, the extent of the STI policy implementation challenge depends on the degree of institutional sophistication of the country. The more elaborate the policy instruments are, the more complex the implementation process will be. During the implementation stage, complexities tend to be of the social, political and managerial type rather than the technical kind.

The experience of African countries in the development of STI policy strategies to tackle SDGs demonstrates a variety of mechanisms that countries have implemented to facilitate alignment of their STI policy with other policies in place, in order to foster coordination between different agencies in the making of the policy and use evidence and data to inform policy decisions (see in Box 6).

BOX 6.

***Case:* STI policy implementation in the context of SDGs, Africa**

Ghana is one of the African countries that has been working together with UNESCO, as part of the UN IATT team, to implement STI policy. The process is co-led by the central government and ministries, which engage with the scientific community and innovation institutions. To facilitate coordination, Ghana implemented two coordination groups, each with different roles. The first group sits at a high political level and audits the political commitment of the governmental institutions that are in charge or have any responsibility for the policymaking process. The second group is technically focused and follows up on the commitment and engagement of the stakeholder groups involved in funding and financing the policies, as well as the commitment of the private sector. This structure helps to maintain the engagement of diverse actors with the process.

Other countries use different methodologies to find key areas for policy action. In Mozambique, a delegated team built a complete map of its STI system (UNESCO 2021). The mapping exercise turned out to be

extremely helpful for the country's next phase of designing the national STI policy and strategy because it allowed for the understanding roles and interactions between different actors of the STI system. Moreover, with the mapping analysis, the country has identified strategic areas for investment in STI with the participation of all the provinces in the design and monitoring of the STI policy. Ghana uses situational analysis to identify implementation gaps on current policies and to find ways to align STI policy objectives with the SDGs. Finally, Gambia uses policy assessments to identify gaps in instrument implementation that can inform policymakers to adjust their action plans.

Kenya offers another experience of policy planning and implementation. Its STI roadmap development process was built and improved thanks to a constant feedback process between ministries in charge of the STI policy, the State Department of Planning, and the African Center for Technology Studies. These institutions work together to find gaps in the synchronization between STI policy and the SDGs.

Source: Author elaboration based on UNESCO.

7. STI POLICY MONITORING, EVALUATION AND LEARNING

Monitoring, evaluation and learning is the last stage of the policy cycle. The main objective of this stage is to track progress on the implementation of policies and to gather evidence on what works and what does not work to reach the main goals of the STI policy in a country. It is a crucial step to learn from and improve STI policy, to adjust the existing instrument mix, and to inform the design of other policy instruments. It forms the basis of evidence-based policymaking, the practice of designing and adjusting policies based on evidence about the effectiveness of interventions (see Box 7). The use of quantitative and qualitative evidence to select the best policy alternatives helps to understand not only what kind of instrument can contribute to reaching policy goals, but also how those policies should be implemented in the country while considering possible unexpected outcomes or external variables that might affect the results.

BOX 7.

***Case:* UNEP qualitative method to assess policy effectiveness in South Africa**

As part of the sixth *Global Environment Outlook*, published in 2019, UNEP included an assessment of 25 environmental policies using a qualitative method that can be extended to STI policies. The method evaluates each case study using 12 criteria that range from robustness of policy design to goal achievement. It is a complete ex-post assessment that considers the policy cycle to determine not only if the policy was effective, but also to identify which criteria contributed to the effectiveness of the policy. It is an evidence-based method, using all available information, data and reports to make a compelling case for each policy.

One case that illustrates the utility and effectiveness of the assessment involves South Africa, where in 2002, despite the constitutional mandate to guarantee the right to water (Section 27 of the constitution) and two laws concerning the issue (1997 Water Services Act and the 1998 National Water Act), there was a serious water access problem. In 2002 out of a total population of 44.8 million, 5 million (11%) had no access to safe water supply and a further 6.5 million (15%) did not have a defined basic service level. A solution was needed for the proposal of a free basic water policy in the country.

We can apply some of the 12 criteria of the UNEP assessment to this specific South African case as follows: (1) Baseline, meaning the value of goal indicators before the intervention that justify the need for policy action. In South Africa, the baseline was that "out of 44.8 million, 5 million (11%) had no access to safe water supply, and a further 6.5 million (15%) did not have a defined basic service level"; (2) Coherence/convergence/synergy of the policy with other national and sectoral policies; (3) Co-benefits, meaning spillover to other variables or sectors. In South Africa, some co-benefits were expected in public health, welfare and gender equity; (4) Balance of winners and losers of the policy to understand the effect of the policy on different stakeholders; (5) Enabling/constraining factors, which result from consultations and analysis reflecting on the details of the policy design and implementation; (6) Cost/cost-effectiveness, to determine the balance in financial terms. It turned out that the cost of the free water policy in South Africa was high: urban water supply was $385 per capita and rural water supply $278 per capita; (7) Time frame in which the policy was developed; (8) Feasibility of the policy; (9) Acceptability of the policy; (10) Level of stakeholder involvement; (11) Unintended effects of the policy; and (12) Effectiveness in the sense of goal achievement.

For more details and cases see:
Global Environment Outlook 6 | UNEP - UN Environment Programme.
https://www.unep.org/resources/global-environment-outlook-6

Monitoring, evaluation and learning are different yet complementary processes. Monitoring provides information on the progress of a policy or programme at any given moment, based on the planned results and products of the policy and the number of resources devoted to achieving the results. Input indicators, output indicators, goals linked to indicators, and mechanism of reporting and monitoring, etc. should be defined in the design phase of the STI policy and must be aligned with the action plan for implementation. Input indicators measure how many resources are demanded by the policy or programme. They include financial, human, physical and intangible resources. Output indicators can be impact, result or product indicators and should be linked to the general and specific objectives of the policy or programme. Each indicator should be specific, measurable, achievable and relevant to the objectives of the policy. Finally, it is important to have a baseline and a measurable goal for each indicator, such that monitoring can be done by comparing the advancement or progress on each indicator vs goals.

Evaluation provides judgement on the effectiveness of the policy to achieve the results and allows for the identification of factors that contribute to the success or failure of the policy. Similar to learning, the results of evaluation exercises are valuable to facilitate accountability of the policy, to inform advocacy by providing support to successful policies, to aid communication strategies on the value of the policy, and to engage stakeholders by making them part of the evaluation exercises. However, a rigorous evaluation is not always possible to achieve, because it requires a large amount of data and financial and human resources to be performed. Moreover, in the case of STI policies, there is a tension between the linear causal model behind many of the evaluation methodologies and the complex nature of the effects of STI policy on the innovation system. Most quantitative evaluation methodologies—such as cost-benefit analysis, randomized trials, and instrument variables and differences—allow testing simple causal relationships between the policy actions and the expected effects. However, in STI policy multiple interactions affect the success of the policy and cannot be considered in the evaluation models. Therefore, it is key to interpret wisely the results of the quantitative evaluation exercises and use a range of qualitative methods—such as case studies, user surveys, interviews, peer reviews and focus groups—to complement the analysis.

Policy evaluation can be conducted at different levels. At the national level, it is possible to review the coherence and relevance of STI policy to the characteristics of its innovation system, the policy objectives and other policies in place. This is the role of STI Policy Reviews, conducted by UNCTAD at the request of a UN member state, which provide a comprehensive assessment of the innovation system of the country and are designed to strengthen their functioning (see Box 8). STI Policy Reviews provide a holistic perspective on the goal, performance and areas for improvement of the STI policy in the country, and they are a useful tool to assess the coherence of the STI policy mix and the alignment with other national and regional policies. STI Policy Reviews benefit largely from previous exercises of evaluation for programmes or groups of programmes in the country. However, UNCTAD performs STI Policy Reviews for countries in any stage of policy development. Even if the country has not completed the planning and design of the STI policy, the STI Policy Review can encourage a more rigorous approach to design and implementation.

BOX 8. *Case:* UNCTAD STI Policy Reviews and UNESCO's GO-SPIN

When a country is in the process of preparing a new STI policy and there is no monitoring, evaluation and learning system in place, a complete STI Policy Review contains four main sections. **Section 1** is a comprehensive assessment of both the previous STI policy and the operation of the innovation system. The assessment of the old STI policy involves analysing the coherence of the policy with other national strategies; the extent to which the STI policy influences other sectoral policies or domains; the extent to which it covers science, technology and innovation matters; and the interrelationships with other policies on its implementation. The assessment of the innovation system includes a mapping that identifies subsystems, information gatekeepers, key roles to facilitate the exchange of information and knowledge, and obstacles to this exchange. This assessment also covers information flows of the innovation system with external actors. Finally, UNCTAD performs many discussions with stakeholders to understand the consensus about the features of the innovation system, policies that work, and those that can be improved.

Section 2 includes a review of the innovation performance of the country. This section uses data on innovation outcomes from different sources such as the Global Innovation Index, the *World Competitiveness Report* and other national and international databases such as innovation surveys, enterprise data, etc. Additionally, it analyses the framework conditions for innovation, which range from macroeconomic indicators (GPD, productivity, trade, structure of the economy, cost of capital, physical infrastructure, human capital, etc.) to institutional and microeconomic factors like access to funding, R&D infrastructure, technology institutes, innovation centres, incubators, etc.

Section 3 is devoted to defining goals and outcomes for the new STI policy. To reach this goal a series of consultations should be performed with stakeholders to develop a consensus on common challenges. This is an opportunity to energize policy learning cycles and strengthen linkages and is an active stage of the STI Policy Review that prepares the field for policy design and provides opportunities for capacity-building among key institutions and STI stakeholders.

Finally, **Section 4** is a summary of recommendations to the country. It is useful not only for the process of STI policy design under consideration but also for improving the general functioning of the innovation system.

Another methodology for mapping STI policies and instruments that countries can apply for monitoring, evaluation and learning purposes is UNESCO's Global Observatory of STI Policy Instruments (GO-SPIN). It provides data and information on STI governance, legal frameworks, operational policy instruments and indicators that can underpin evidence-based policymaking and foresight studies. Data and evidence collection are based on online surveys and upload of information into UNESCO's online platform GO-SPIN, which prioritizes developing countries. These data and information are complemented with desktop research, government reports and statistical data from the UNESCO Institute of Statistics (UIS) and other international sources. The data serve to build comprehensive country profiles that contain attributes such as contextual factors and analyses of explicit STI policies (such as research and innovation policies for education, agriculture and health) as well as other indicators on STI governance bodies, legal frameworks, issues and operational policy instruments. The methodology places strong emphasis on the need for policy instruments and analyses of operational policy instruments in different countries.

Source: Authors elaboration based on UNCTAD and UNESCO.

8. KEY MESSAGES

- STI encompasses the production, dissemination and use of knowledge. It has the potential to expand the evidence to appraise the challenges associated with each SDG and inform possible solutions to address trade-offs inherent in achieving SDGs.

- Achieving SDGs by 2030 demands new strategies and solutions. That's why during Agenda 2030, member states adopted STI policy as an integral element of their national sustainable development strategies for the SDGs.

- Effective STI policy requires robust STI systems with good governance, well-established organizational structures and a legal framework that articulates a variety of policies.

- STI policy can set the pace and direction of scientific production, technological learning and innovation, and solve failures, allowing a transition towards radical social and economic transformation.

- The STI policy cycle is made up of five stages that cover preparation, design, implementation, and monitoring, evaluation and learning.

- Some basic guidelines can help make the STI policy cycle more efficient: directionality; use of evidence, experience, and foresight; multistakeholder participation and collaboration; and learning and experimentation.

- STI policy instruments shape public- and private-sector activities that help a country reach policy goals. In general, a policy mix or portfolio of multiple instruments is needed. A policy instrument requires a responsible entity, an objective, a logic of intervention or strategy to achieve results, expected outputs, beneficiary population, rules for access, funding source, and time frame. Instruments targeting the SDGs must be analysed according to SDG relevance and synergies and trade-offs with other instruments.

- Building the right policy mix requires continuously evaluating its impacts on the behaviour of agents and ability to improve the functioning of the STI system. Understanding the interactions and complementarities between instruments in the mix is important.

- During implementation, many challenges can emerge. Leadership, operational planning, keeping a systemic view, governance, coordination, and getting and maintaining public support are among the most important.

9. FREQUENTLY ASKED QUESTIONS

Q: Is there a body that could assist countries in updating their STI policy? How can some UN agencies contribute to aiding countries to develop the STI policy?

• UNCTAD's STI Policy Reviews programme assists countries in assessing and updating their STI policies.

• UNESCO supports member states in assessing the STI system, understanding the STI landscape, and providing technical for policy development, review and implementation. The Organization develops standard-setting instruments in the form of UNESCO Recommendations. An example is the 2021 Recommendations adopted on Open Science and Ethics in Artificial Intelligence.

• The IATT, which has more than 50 UN entities that are active in STI, provides combined and complementary cooperation with member states with different methodologies and competencies.

• UNEP contributes environmental data, statistics and indicators to help countries understand their environmental situation.

• United Nations Economic and Social Commission for Western Asia (UNESCWA) supports the Arab States in the development of their STI policies, providing technical assistance to review policy and helping in the formulation of STI policy, in collaboration with the country. It also offers a capacity-building workshop for decision-makers to develop policy strategies based on needs and objectives.

• ECLAC generates and disseminates analyses and policy proposals on the structure and dynamics of production and innovation systems at the microeconomic and sectoral levels. It also evaluates and generates public policy proposals, promotes the exchange of experiences, provides technical assistance and supports the development of capacities in the LAC countries.

• UNU-MERIT provides basic and applied research that shapes the policy cycle conceptual framework as well as the required diagnostic and policy formulation analysis, at global and national levels. It is involved in STI capacity-building, mainly in collaboration with other UN agencies.

• European Commission supports its member states, neighbours and associated countries in the design, implementation and monitoring of their STI policies, including Smart Specialization Strategies.

Q: How to best balance whether to support tech transfer or to foster local innovation?

• Innovation doesn't need to have new-to-the-world dimension. Least developed countries (LDCs) usually rely on very few commodities, agricultural commodities or low value-added manufacturing. They share the need to diversify their economy, and diversification can start with simple and traditional products that are produced in other countries, but not their own. By encouraging the production of new or improved goods or services inside the country, technology transfer might aid the production of innovative goods for the country. In that sense, by pursuing innovation, technology transfer might follow.

Q: How to guarantee stakeholders' coordination, intermediary coordination and private-sector participation in the STI policy cycle?

• Coordination should be at two levels: (1) a high political level, ensuring the commitment and the political driving force to the process, and (2), a more technical level, where key stakeholders from different horizons and different institutions, including in the private sector, are engaged. At the same time, working groups that include representatives from different stakeholders for specific topics are important.

Q: Given the importance of IP for innovation, what is the fundamental aspect that needs to be addressed to strengthen IP in the country?

• Each country should identify their industrial priorities, economic objectives and the IP system supporting them, within World Trade Organization (WTO) rules. Whether priorities are in agriculture or manufacturing, different IP rights become important and different IP regimes become relevant. Fine-tuning the country's STI policy objectives might be required to use the right IP system to advance those objectives.

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