

# **Proposed Standard Practice for Surveys on Science, Engineering, Technology and Innovation (SETI) Policy Instruments, SETI Governing Bodies, SETI Legal Framework and Policies**

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## THE GLOBAL OBSERVATORY OF STI POLICY INSTRUMENTS (GO→SPIN)

The aim of UNESCO's Global Observatory of Science, Technology and Innovation Policy Instruments, known as GO→SPIN, is to generate reliable, relevant information about the different landscapes of science, engineering, technology and innovation (SETI) policies around the world. The generated information is based on replies to the national GO→SPIN surveys, combined with government reports and statistical data from the UNESCO Institute for Statistics and other international sources.

Each country profile represents a comprehensive study of all the SETI policies, which include:

- a long-term description of the political, economic, social, cultural and educational contextual factors;
- a standard content analysis of the explicit SETI policies, including those research and innovation policies implemented in other sectors, such as the agricultural, energy, health, industrial and mining sectors;
- a study of R&D and innovation indicators;
- a long-term scientometric analysis of scientific publications, patents, trademarks and utility models;
- a description of the SETI policy cycle;
- a complete analysis of the SETI organizational chart at five different levels (policy-making level; promotion level; research and innovation execution level; scientific and technological services level and evaluation level);
- an inventory of all the SETI government bodies and organizations related both to research and innovation and to science and technology services;
- an inventory of the SETI legal framework, including acts, bills, regulations and international agreements on SETI issues;
- a standard inventory with 18 different analytic dimensions of all the SETI operational policy instruments in place;
- a analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT) of the country's research and innovation landscape.

## THE GO→SPIN APPROACH

The strategy of the GO→SPIN programme is four-fold:

**Capacity building:** training high-ranking national officials in the design, implementation and evaluation of a variety of SETI policy instruments at national and regional levels;

**Standard-setter:** providing a standard practice for surveys on SETI policies and operational policy instruments through the *Paris Manual*<sup>1</sup>.

**Data collection:** worldwide distribution of the GO→SPIN surveys, prioritizing Africa, Arab States, Asia-Pacific and Latin American and the Caribbean.

**GO→SPIN platform:** creation of an online, open access platform for decision-makers, knowledge-brokers, specialists and general-public, with a complete set of various information on SETI policies.

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<sup>1</sup> The Paris Manual is being drafted by an international committee of experts put together by UNESCO in 2011. Once completed, the manual will define the ontological and epistemological bases of a common paradigm for evaluating STI policies and policy instruments worldwide.

The online platform will provide an innovative cluster of databases equipped with powerful graphic and analytical tools. The platform has been devised for political leaders, planners, directors and administrators of S&T in government, parliament, universities, research institutions, productive enterprises concerned with innovation, international organizations working for development; research personnel and specialists whose field of study embraces S&T policies.

The platform will also be a useful tool for the democratization of decision-making and public accountability of SETI policies.

The GO→SPIN survey and the information generated are primarily intended for the use of specialists and governmental bodies responsible for national SETI policies. It is their function to analyse the results of the survey and draw appropriate conclusions when they are required to prepare decisions by political bodies in the field of science, engineering, technology and innovation. The survey is also of interest to national bureaux of statistics and international organizations for promoting scientific and technological cooperation among their member states. Collectively, these users are:

- The national developing planning agencies, more particularly the government bodies responsible for formulating and co-ordinating national SETI policies and other national bodies involved in the application of science and technology (S&T) to sustainable development;
- Parliamentary groups especially concerned with STI policies;
- SETI information brokers, consulting groups and advisory bodies;
- Teaching and research departments engaged in SETI policy studies;
- The governing bodies of R&D institutes and S&T services;
- The boards of management of productive enterprises heavily reliant on R&D or engaged in the transfer of technology and innovation;
- International governmental and non-governmental organizations concerned with SETI and their application to sustainable development;
- Other more peripheral users, such as university departments of political science, economics and social sciences and national and international documentation and information services;
- The mass media.

At individual level, the main groupings are:

**Decision-makers:** i.e. those responsible for national SETI policies and the management of R&D (ministries of R&D or S&T, directors of bodies responsible for formulating national S&T policies, directors of R&D institutes, heads of productive enterprises heavily reliant on R&D, etc.)

**Intermediate users:** i.e. those who serve as the link between decision makers referred to above and researchers in S&T policy; their function is to prepare decisions by the former using theories and methods put forward by the latter, this category is made up of experts, consultants, advisers, liaison officers, the staff of ministerial offices and of parliamentary committees, etc., and they usually require rapid access to factual data.

**Researchers in SETI policies:** i.e. those who develop the theories and methods on which S&T policy is based (researchers in the philosophy, history, sociology and economics of science, engineering and innovation, in the transfer of technology and in the management of R&D).

**The general public:** by making SETI information more accessible, the GO→SPIN approach introduces a new dimension to the democratization of SETI.

## THE METHODOLOGICAL FRAMEWORK

Science, engineering, technology and innovation (SETI) are becoming increasingly important for socio-economic and sustainable development. During the past 60 years, both developed and developing countries have recognized this fact by increasing the number of SETI government bodies, establishing new SETI legal frameworks and implementing a diverse set of new SETI policy instruments. This has driven investment in scientific research, technological development and innovation (STI), led to an increase in the number of scientists and engineers and fostered exponential growth in the number of new scientific articles and patents worldwide (UNESCO, 2010a).

The information economy is one of the key concepts invented to explain structural changes to the modern economy (Godin, 2008). The infrastructure to manage SETI information has been largely considered the core resource of national competitiveness in research and innovation (Neelameghan and Tocatlian, 1985). With the globalization of SETI information infrastructure has come a need to implement comprehensive strategies to connect, share and trade both domestic and foreign information at the national level (Lee and Kim, 2009).

The formulation of adequate SETI policies is critical to tackling contemporary challenges that include mitigating the consequences of global climate change; exploring new energy sources; generating innovation to foster social inclusion; promoting the sustainable management and conservation of freshwater, terrestrial resources and biodiversity; disaster resilience; and fostering the eradication of extreme poverty and hunger. These policies also need to be designed to achieve the UN Millennium Development Goals.

Over the past five decades, operational definitions have been elaborated within the framework of multilateral organizations to measure R&D and the broader concept of S&T. Statistical techniques have been developed to estimate private and public resources invested in these areas. For the former the OECD has laid down a methodological framework in the *Frascati Manual*, the sixth edition of which was published in 2002 (OECD, 2002). For the latter, the Member States of UNESCO have adopted the Recommendations concerning the International Standardisation of Statistics on Science and Technology (UNESCO, 1978; 1982; 1984a; 1984b). Methodologies for generating data about R&D investment and human resources have been constantly upgraded and extended.

During the first African Ministerial Conference on Science and Technology<sup>2</sup> (AMCOST I), in 2003, countries committed themselves to developing and adopting a common sets of STI indicators. The New Partnership for African Development (NEPAD) established the African Science, Technology and Innovation Indicators Initiative (ASTII) with the objective of building Africa's capacity to develop and use STI indicators. More specifically, NEPAD aims to: (a) develop and promote the adoption of internationally compatible STI indicators; (b) build human and institutional capacities for STI indicators and related surveys; (c) enable African countries to participate in international programmes on STI indicators; and (d) Inform African countries on the state of STI in Africa. The first African Innovation Outlook was published in 2011, while the second volume is being published in 2013. The methodology employed - that suggested by ASTII officials - follows the recommendations of the Frascati Manual for R&D indicators and the Oslo Manual (OECD, 2005) for innovation indicators.

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<sup>2</sup> The final declaration of the AMCOST meeting in 2012 recommended coordination between the African Observatory on STI (AOSTI), ASTII and UNESCO's GO→SPIN. An agreement between UNESCO and AOSTI in February 2013 assigned AOSTI with responsibility for following up GO→SPIN surveys with a group of West African countries.

## BOX A - MEASURING R&D: CHALLENGES FACED BY DEVELOPING COUNTRIES

The methodology for measuring R&D is detailed in the *Frascati Manual* (OECD, 2002), which has been in use for more than 50 years. A revised edition is due out in 2015. Despite the manual's longevity, developing countries still face problems when trying to apply its standards to measuring the situation in their particular country.

The UNESCO Institute for Statistics conducts a biennial data collection of R&D statistics and produces a methodology tailored to the needs of developing countries; it also holds training workshops and builds capacity through other means in developing countries.

In 2014, the UNESCO Institute for Statistics published a Guide to Conducting an R&D Survey: for Countries starting to Measure R&D. This guide presents the relevant R&D indicators, discusses the main issues facing each of the major sectors of performance, provides a simple project management template and proposes generic model questionnaires for the government, higher education, business and private non-profit sectors, which countries can use and adapt to suit their needs.

In 2010, the UNESCO Institute for Statistics produced a technical paper on Measuring R&D: Challenges faced by Developing Countries. The OECD Working Party of National Experts on Science and Technology Indicators (NESTI) subsequently suggested that the paper serve as the basis for an annex to the *Frascati Manual: Proposed Standard Practice for Surveys of Research and Experimental Development* (6th edition). This annex was adopted as an online adjunct to the *Frascati Manual* in March 2012 (OECD, 2012).

Measuring R&D: Challenges faced by Developing Countries provides guidance on a number of challenges that are relevant to developing countries and which may not be elaborated on clearly enough in the *Frascati Manual*. The following situations are addressed in the document, among others:

- Despite the increasing presence of developing countries in global R&D, there is still a marked lack of demand for science, technology and innovation (STI) indicators from policy-makers in developing countries. Even if the demand does exist, there are often significant problems with compiling the data due to a lack of coordination at the national level, a lack of cooperation by research institutions, universities and businesses, and a generally weak statistical system in the country.
- R&D used to be largely funded by the government but new sources of funds are emerging. Foundations, scientific associations, NGOs and particularly foreign organizations already play an important role. In addition, the contribution of private business is becoming more important and gaining more recognition in a wider range of developing countries. Many of these new sources of funding go directly to individuals and groups rather than to institutions and therefore remain unaccounted for, including for statistical purposes.
- Although the *Frascati Manual* recommends the collection of primary data through direct surveys, the use of secondary data from national budgets and budgetary records of public R&D performing units has been a widely adopted practice to obtain a rough estimate of gross expenditure on R&D (GERD). However, there is often a discrepancy between voted and allocated budgets. Furthermore, national research systems have a limited absorption capacity, which may leave funds unused in central accounts instead of being transferred to institutions performing R&D. Moreover, care needs to be taken to ensure that such transfers are not 'double counted' as expenditure of both the funding body and the institution performing R&D.
- The definitions used by finance ministries and other government institutions to establish S&T budgets may be ad hoc and fail to distinguish between broad S&T and narrower R&D activities. Furthermore, many institutions (universities in particular) do not compile a separate R&D budget, especially where research is a low institutional priority.
- R&D components in the national budget, especially capital expenditure, can be difficult to identify and may be aggregated under different headings. In addition, when R&D activities stretch over more than one financial year, it may not be easy to estimate the amount of resources used each year. For example, work done to develop land and buildings used for research in a given year should be clearly earmarked and not recorded in subsequent years.
- A concentration of innovation activities by sector or in a small set of institutes may lead to volatility and inconsistencies in statistics. There is generally lower emphasis on R&D in the business sector, in part due to reduced competitive pressure in local markets.
- In the higher education sector, the increasing number of private universities makes it useful to distinguish between public and private higher education and to further break up private higher education into government-dependent and independent private institutions. Further disaggregation into private-for-profit and private-not-for-profit higher education institutions should also be considered to track where most research is carried out.
- Surveys that cover all R&D performers should in principle all report for the same period. This is difficult to achieve since, in many countries, higher education institutions and businesses do not necessarily report on the same period - the business sector's calendar tends to be the most problematic. Also, not all countries follow the same calendar. As a solution, the recommendation that R&D performers report on the financial year closest to the survey period may have to suffice.
- Information systems in government and higher education are often not set up to enable the extraction of data on R&D personnel and expenditure. Thus, accurate information on financial expenditure only becomes available a long time after completion of an activity. Unfortunately, ad hoc IT solutions to address these issues may also lead to errors and inconsistencies.
- The collection of data in full-time equivalents (FTE) for researchers provides useful information on the true volume of human resources devoted to R&D. This information is also essential for estimating R&D labour costs. Tallying the number of researchers in a given country presents further challenges. In some developing countries, salaried researchers may not have research budgets or unpaid researchers may undertake research. In other scenarios, academic staff may hold part-time contracts at more than one university. Even if academic staff have contracts that specify the amount of time to be spent on conducting research, it is difficult to enforce especially where there is a lack of resources. Estimating the time spent on research and hence the calculation of the FTE for research staff - particularly in the higher education sector - is fraught with difficulties. This directly impacts the calculation of R&D expenditure.

A number of special types of activity warrant attention when measuring R&D, as they are rest on the border of what is considered R&D. Three examples follow from the technical paper:

- In the case of traditional knowledge, it is important to set boundaries. Activities which establish an interface between traditional knowledge and R&D are considered R&D. However, the storage and communication of traditional knowledge in traditional ways is excluded.
- Clinical trials are an area of growth in some developing countries. Identifying research personnel in the extended clinical trials value chain may be difficult, as their involvement is occasional and harbours a risk of double counting (i.e. as personnel in the trial and as academic staff).
- Reverse engineering is important in many developing countries. However, this generally falls outside the scope of R&D. Only if reverse engineering is carried out within the framework of an R&D project to develop a new (and different) product, should it be considered R&D.

STI statistical systems are often weak in developing countries. To help strengthen these systems, the paper recommends that countries institutionalise R&D statistics, establish registers of R&D performers and document survey procedures and estimations.

*Countries interested in embarking on R&D measurement are encouraged to contact the UNESCO Institute for Statistics.*

In 2009, the UNESCO Institute for Statistics organized an Expert Meeting on Measuring R&D in Developing Countries, in Windhoek (Namibia). During the meeting, the experts identified the difficulties and challenges faced by the majority of developing countries, which were not explicitly addressed in the *Frascati Manual* (UNESCO Institute for Statistics, 2010; see Box A). The UNESCO Institute for Statistics is working towards a global standardization of STI statistics, including those items which are not taken into account in the *Frascati Manual*.

The availability of input and output R&D indicators alone does not suffice to evaluate SETI policies. Much more important than the particular value of one specific indicator at a given time is the long-term rate of change that long temporal series of indicators show (Lemarchand, 2010: 27-28). For that reason, long-term temporal series of indicators are necessary to analyse the impact of specific public policies. Improving the reliability of this analysis requires new ways of standardizing information about public policies and the policy instruments designed to implement them. Owing to the complexity of these issues, the 'science of science policy' has emerged in recent years as a new discipline where new analytic paradigms can be tested.

## BETTER WAYS OF MEASURING EVIDENCE-BASED POLICIES

SETI policy debates are not yet dominated by a thoughtful, evidence-based analysis of the likely merits of different investment options and policy decisions. The latter are strongly influenced by past practice or data trends that may be out of date (Husbands Fealing *et al.*, 2011). The evolution of new policies has been accompanied by more difficult challenges related to planning and evaluating these policies; this indicates a need to improve the theoretical frameworks for policy formulation (Steinmueller, 2010).

Unfortunately, a number of factors prevent countries from reaching most of the objectives established by their own development plans: the lack of reliable information on SETI national potentialities; difficulties in coordinating the various SETI stakeholders; an absence of mechanisms for promoting a strong interaction between the supply and demand sectors in SETI, and; the absence of any explicit industrialization policy promoting endogenous innovation.

These difficulties mostly appear in small economies. For example, Flanagan *et al.* (2011) have explored the ways in which innovation policy studies treat actors, instruments, institutions and interactions, in



order to arrive at a more useful conceptualization of the policy mix for innovation. They stress the need for a genuinely dynamic view of policy formulation and policy interaction. They conclude that 'despite the importance attached to "strategic policy intelligence" in recent innovation policy analysis, little empirical attention has been devoted to actual processes of policy learning.' In developing and exploiting technological opportunities, institutional competencies – namely, the governance of SETI decision-making bodies – are just as important as the SETI incentive instruments they promote (Pavitt, 1996). Path dependency emerges, as the cost of institutional changes to SETI is often higher than that of accommodating new instruments and policies in existing structures (Van der Meulen, 1998). For this reason, the design, analysis and monitoring of any national SETI policy will strongly depend on the adequate mapping of: the structure of the SETI governing bodies; the SETI national legal framework and; of the implicit and explicit operational SETI policy instruments which are implemented (Herrera, 1971; 1972; Sagasti and Aráoz, 1976).

## THE POLICY-MAKING CYCLE

The term policy cycle refers to the recurrent pattern shown by procedures that ultimately lead to the creation of a public policy. The greatest advantage of the analytical model of the SETI policy cycle is that it facilitates an understanding of public policy-making by breaking down the complexity of the process into a limited number of stages and sub-stages, each of which can be investigated alone, or in terms of its relationship to any or all of the other stages of the cycle. This also allows for an examination of the role played by all actors and institutions dealing with SETI policies, rather than solely those governmental agencies formally charged with the task. The GO→SPIN methodological approach divides the SETI policy cycle into five different stages. Here are the working definitions provided for the survey:

**Agenda setting:** refers to the process by which problems involving SETI and its relation to society and the economy come to the attention of the government. Agenda setting is also a socially constructed process, in which actors and institutions, influenced by their respective ideologies, play a fundamental role in determining which problems or issues require government action (Howlett and Ramesh, 2003).

**Policy formulation:** refers to the process by which SETI policy options are formulated by the government. Policy formulation involves identifying and assessing possible solutions to policy problems, weighing the pros and cons, and deciding which should be accepted and which rejected. The relationship between the government and social actors thus exerts a significant influence on the formulation of public policies.

**Decision-making:** refers to the process by which governments adopt a particular course of action or non-action.

**Policy implementation:** refers to the process by which governments put SETI policies into effect. This is when a decision is carried out through the application of government directives and is confronted with reality.

**Policy evaluation:** refers to the process by which the impact of SETI policies are monitored by both state and societal actors, the result of which may be a re-conceptualisation of policy problems and solutions.



## WHY TALK ABOUT SETI POLICIES?

The term 'science policy' was coined following publication in 1945 of Vannevar Bush's seminal article *Science - the Endless Frontier*, which laid the foundations for the first social contract for science. By 1950, UNESCO had initiated the first systematic studies on science policies in a dozen developed countries. Originally, this term referred to public policies related to scientific and technological research, experimental development, scientific and technological services and innovation. Science policy as a discipline evolved over the coming decades. Today, it is possible to distinguish specific operational policy instruments according to the different needs established by science policies, engineering policies, technology policies and innovation policies. As these four distinct types of public policy require different skills, major universities around the world have recently introduced specific postgraduate programmes targeting each of the four types of policy:

**Science policy:** relates to those policies needed to: promote scientific research, determine and select scientific objectives and goals consistent with national plans or strategies, exercise judgment in fixing norms to govern the ways and means by which science is developed, transferred and applied; gather, organize and deploy resources required to pursue the selective objectives and; monitor and evaluate the results obtained from applying the policy. The following are therefore among the most important questions dealt with by policy-makers in the field of science policy: (a) establishing and strengthening government structures and mechanisms for planning, budgeting, co-ordinating, managing and promoting scientific research; (b) gathering, processing and analysing basic data concerning the national scientific potential, including data on ongoing research, monitoring national scientific development and ensuring the smooth growth of the institutional infrastructure for scientific research; (c) maintaining a proper balance between the various types of research (fundamental, applied, experimental development), supporting the development of a creative national scientific community and setting standards for the status of scientific researchers in conformity with their responsibilities and rights; (d) optimizing human, financial, institutional and informational resources to achieve the objectives established by the national SETI policy; (e) assessing and promoting productivity, relevance, quality effectiveness of national research and scientific and technological services in various sectors of performance (higher education, government institutions, business enterprise, private non-profit) and removing organizational and managerial difficulties encountered in the execution of scientific research; (f) initiating appropriate legislative action in relation to the impact on the individual, society as a whole or the natural environment of the application of discoveries and inventions; evaluating the economic profitability and social utility (or harmful effects) of the said discoveries and inventions. Although the aforementioned list is not exhaustive, it indicates the key areas for which government policy-makers are primarily responsible. Each individual issue requires the design of a particular operational policy instrument.

**Engineering policy:** the role of engineers in public policy can be seen as a two-fold endeavour: (1) to help create public policy related to the utilization of technology to solve public problems as well as monitor and ensure compliance with such policies; and (2) to use engineering knowledge to assist in the construction of policy directives to help solve social problems. In many cases, the development and implementation of such regulations and laws requires both a technical understanding of the functioning of these artefacts and an understanding of how this technology interacts with social and natural systems and would benefit from the involvement of a technical expert. The issues addressed by engineering policies are vast and global in nature and include water conservation, energy, transportation, communication, food production, habitat protection, disaster risk reduction, technology assessment and the deterioration of infrastructure systems. These issues need to be

addressed while respecting the rights and meeting the needs and desires of a growing world population [for a detailed list of issues and challenges addressed by engineering policies, see UNESCO (2010c)].

**Technology policy:** the fundamental premise of technological policies is that it is possible for governments to implement public policies to improve social welfare by influencing the rate and direction of technological change. The conventional entry point for economic analysis is to identify the conditions needed for such influence to be superior to the outcome of ordinary market competition. These conditions, in turn, direct further examination of the feasibility and methods for such intervention, including the question of whether government intervention is necessary to improve social welfare. Succinctly stated, government intervention would be necessary if profit-seeking actors underperformed or performed poorly in producing or exchanging technological knowledge from the perspective of social welfare.

**Innovation policy:** innovation policy can be characterized in various ways, such as by distinguishing between 'supply-side' and 'demand-side' policy, or between 'mission-oriented' and 'diffusion oriented' policy. Policy instruments include financial instruments (e.g. R&D tax credits, export incentives, soft loans, etc.) and regulatory instruments such as laws and binding regulations (e.g. the use of safety equipment for children in cars). Innovation policy encompasses many types of innovation. Innovation may be characterized, inter alia, by: the type of innovation - technological (product and process) or non-technological (organizational and marketing); the mode of innovation - novel innovator (strategic and intermittent), technology modifier and technology adopters and; the socio-economic impact - incremental, disruptive or radical. The effectiveness of innovation policies requires a sufficiently stable framework, institutions and policies. Stability and predictability are particularly important for risky activities with a long time horizon such as R&D and innovation. Excessive instability may inhibit innovation by increasing uncertainty for innovators. It may lessen the effectiveness of policy instruments by weakening the incentives they provide. In addition, it reduces opportunities for learning and developing evidence-based policy practices. Whereas there are manifold sources of unwarranted discontinuities, political instability and fiscal problems - often related to policy cycles - are a common cause. In an increasingly complex innovation landscape, developing effective governance requires better co-ordination at, and among, the local, regional, national and international levels.

SETI projects normally occur within a larger temporal framework administered by an organization or a government policy-making body. The early stages of a new SETI policy usually appear as successive expansions of the group of agents and stakeholders whose endorsement is needed to launch the initiative, whereas the latter stages focus on programme management, with feedback as to its success or failure at the policy level (Marburger III, 2011). Consequently, in order to provide an accurate landscape of the SETI policies and policy instruments in a specific national context, it is imperative to understand the long-term evolution of the SETI organizational chart, SETI infrastructure and legal framework (i.e. explicit policies), as well as the type of funding mechanisms implemented. The latter dimensions must be contrasted with detailed analyses of the long-term behaviour of political, educational, economic, productive and social macrovariables (i.e. implicit policies).

It is impossible to describe the current status of SETI without accurate data. Moreover, these data should be presented in such a way as to allow decision-makers and experts to estimate whether the status of SETI meets societal needs or expectations. Policy-makers benefit from additional policy tools to assist them in deciding about budget allocations or in the design of new SETI policy instruments, especially if these are real-time tools or new innovative prospective methodologies. Recent empirical studies show the relevance and long-term impact of appropriate SETI information services on SETI policies designed to improve national competitiveness (Lee and Kim, 2009).

It is also important to note the availability of a large group of public and private databases. These can be most useful tools for evaluating the performance of the SETI policies and providing adequate technology intelligence studies. There are robust, accessible systems designed to make rapid analyses and apply mathematical models to identify critical points or levers triggered by policy changes that can directly affect the performance of innovation activities. For example, Zucker and Darby (2011) present a comprehensive survey of all available databases that may be used to analyse the impact of SETI policies.

## **POLICY INSTRUMENTS: LEVERS FOR IMPLEMENTING DECISIONS**

A policy may remain a mere rhetorical statement if no means are provided for its implementation or to realize its potential effect. To do this, a number of things may be needed, which we will incorporate under the term of policy instrument. A policy instrument constitutes the set of ways and means used when putting a given policy into practice. It can be considered as the vehicle through which those in charge of formulating and implementing policies actualize their capability to influence decisions taken by others.

The study of public policy instruments in national settings has contributed significantly to the understanding of policy, political systems and relations between State and citizen. Research on policy implementation usually focuses principally on the effects of a specific instrument, within a wider reflection on whether the correct instrument has been chosen for the purpose. As far as new governance models is concerned, the search for suitable instruments is above all governed by pragmatism (Kassim and Le Gales, 2010).

SETI operational policy instruments are the levers by which the organizational structure ultimately implements the decisions on a day-to-day basis and attempts to produce the desired effect on the variables the policy has set out to influence. Throughout the analysis of an instrument's effectiveness, it is important to bear in mind the 'actors' or key decision-makers who are directly involved in the design and use of a policy instrument. An instrument does not act on its own accord. Rather, it responds to the will of the policy-makers and decision-makers using it.

A related concept can be found in the problem of *Ordnungspolitik* stressed by the German Freiburg School in the 1930s. Here, the focus was how to devise a framework or set of rules (*Ordnungsrahmen*) for an economy that would define the operating space for individual and private activities. The challenge for SETI policy instruments can be interpreted as a problem of transformation, namely the question of choosing the best policy instrument in order to reach the set target.

A policy instrument attempts to make individuals and institutions take decisions following the rationality dictated by the collective objectives established by those in power. It is the connecting link between the purpose expressed in a policy and the effect that is sought in practice. An SETI policy instrument includes, as a significant component, the manipulation of SETI variables.

One of the first and more relevant studies on SETI policy instruments was conducted in the 1970s by the International Development Research Centre. The principal objective of the study was to devise ways and means of understanding how a country's investment in S&T could be most effectively related to its objectives for industrial development. Sagasti and Aráoz (1976) developed an interesting methodological framework for making a survey and analysing the policy instruments of ten countries in Latin America, the Middle East, Southern Europe and Asia.



Figure A: Instruments for ensuring a policy obtains the desired effect. Adapted from Sagasti and Aráoz (1976)

UNESCO's Global Observatory of Science, Technology and Innovation Policy Instruments<sup>3</sup> (GO→SPIN) has adapted and expanded the theoretical framework of Sagasti and Aráoz (1976), in order to implement a systematic survey in Africa, Arab States, Asia and the Pacific and in Latin America and the Caribbean. The information in the present country profile has been organized according to this methodological approach. Figure A presents the basic analytical units around which the present report is organized.

All national SETI policies, be they implicit or explicit (Herrera, 1971; 1972), attempt to harness a country's creative potential to its socio-economic, environmental and cultural objectives. An explicit SETI policy is a statement by a high-level government official or institution, such as a ministry or the planning secretariat, that deals with activities related to STI. The policy expresses a purpose (effects according to SETI variables) and may set objectives, define desired outcomes and establish quantitative goals. Policies also contain criteria for choosing from among several alternatives to guide decision-makers as to how SETI works. SETI policies might also be formulated by representatives of the private sector. A number of factors impinge on the efficiency of SETI governance, namely, the extent to which policy processes have the greatest effect with a given use of resources. It must be acknowledged that overall efficiency is not easily defined and measured in a multi-objective, multi-actor world.

## THE KEY ROLE OF THE SETI ORGANIZATIONAL STRUCTURE IN POLICY IMPLEMENTATION

The SETI organizational structure or chart usually shows the distribution of responsibility for implementing a given policy. Under the term 'organizational structure,' it is possible to distinguish at least five different levels: (1) policy planning level (policy design); (2) promotional level (i.e. funding and co-ordination of R&D, innovation and scientific and technological services); (3) implementation level (execution of R&D and innovation); (4) scientific and technological services and; (5) assessment or evaluation level.

**Policy planning level:** includes policy planning, budgeting, decision-making, interministerial co-ordination. The responsibility for the formulation of SETI policies generally rests with a special government department, ministry or statutory body, in some cases assisted by national councils of research and innovation. SETI policy formulation normally includes the preparation of the national development plan or strategy relating to SETI; it also includes the annual preparation of the functional state budget for SETI activities (mainly research, innovation and scientific and technological services). The decision-making function usually falls to the government, or to a committee of ministers more specifically concerned with SETI; it mainly involves the approval of the national SETI plan (or strategy), as well as the assignment of funding mechanisms. The interministerial co-ordination takes place during the formulation of policies and preparation of plans and budgets then at the various stages of the implementation of these policy documents, once approved by the government.

**Promotional level:** the promotion, financing and co-ordination of research, innovation and scientific and technological services in the various sectors of the economy and in society. The functions performed at this level begin with the policy decisions taken by the government and continue with the various government departments or ministries through traditional budgetary procedures along

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<sup>3</sup> See [www.unesco.org/new/en/natural-sciences/science-technology/sti-policy/global-observatory-on-policy-instruments](http://www.unesco.org/new/en/natural-sciences/science-technology/sti-policy/global-observatory-on-policy-instruments)

administrative budget lines or through programme budget procedures, as applied to the so-called management by objectives. Several funding mechanisms and SETI operational policy instruments of various kinds have been implemented over the years (i.e. research funds, innovation funds, sectorial funds, tax-incentives; competitive grants, scholarships, etc.). Most countries apply a combination of operational policy instruments to handle the financing of research, innovation and scientific and technological services according to well-defined programmes. The latter can be achieved either by responding to requests for the funding of specific projects submitted by external institutions, laboratories, research units, individual research scientists and high-tech enterprises, or by providing incentives for innovation, or by selectively entrusting the external bodies mentioned above with the execution of specific projects called for by certain development objectives according to the national SETI plan or strategy (normative method). At this particular level, several countries have special institutions (i.e. national research councils) which promote the advancement of scientific research and technological development with a view to improving the quantity and quality of new scientific knowledge to expand the country's potentialities, particularly through support for post-graduate education and research at universities and polytechnics.

**Implementation level:** this operational level concerns the actual performance of scientific research, technological development and innovation.

**Scientific and technological services (STS) level:** this represents a mixed group, including the institutions in charge of: (a) SETI information and documentation, (b) museums of science and technology, botanical and zoological parks and other SETI collections (anthropological, archaeological, geological, etc.), (c) general purpose data collections: all the activities comprising the routine systematic collection of data in all fields of SETI, such as topographical, geological and hydrological surveys, routine astronomical, meteorological and seismological observations, surveying of soils and plants, fish and wildlife resources, atmosphere and water testing, monitoring of radioactivity, UV and CO<sub>2</sub> levels, prospecting and related activities designed to locate and identify oil and mineral resources, gathering of information on human, social, economic and cultural phenomena, usually for the purpose of compiling routine statistics; testing, standardization, metrology and quality control, activities related to patents and licenses, as well as the production of scientific publications.

**Assessment or evaluation level:** this consists in government sectors and institutions monitoring the implementation of policy goals and measuring the societal impact of those policies. Their function also encompasses the conduct of an ongoing survey of a country's SETI potential at the level of research, innovation and scientific and technological service units, including ongoing research results and their practical application.

The GO→SPIN methodological approach introduced a normalized way of encoding the different types of organization and their functions. By representing each national SETI organizational chart and by using the same set of coding tools (Lemarchand, 2010: 310), it will be possible in future to associate these charts and tools with specific topological metrics to identify patterns in performance. The latter will be very useful for defining a new set of SETI policy indicators able to reveal the level of complexity and functionality of each STI organizational chart. Table A shows a typical example on how different countries structure SETI policy design.

Since its purpose is to guide decisions about the future that must be taken now, a SETI watch cannot seek to identify future developments in S&T independently of past and current developments, or independently of the material and human resources devoted to research and innovation. The prerequisites for any future is: knowledge of the present, knowledge of the current trends observed in a real world composed of different nations and institutions and knowledge of the strength and



weaknesses of the national SETI system in which the decisions informed by the GO→SPIN survey methodological approach have to be taken.

**Table A:** Models of governing bodies heading SETI policy design

Argentina	Scientific and Technological Cabinet (GACTEC) Ministry of Science, Technology and Productive Innovation
Australia	Prime Minister's Science Engineering and Innovation Council Commonwealth State and Territory Advisory Council on Innovation Coordination Committee on Innovation
Chile	Inter-ministerial Committee for Innovation National Corporation for the Promotion of Production (Ministry of Economy) National Commission for Scientific and Technological Research (Ministry of Education)
Croatia	Ministry of Science, Education and Sports National Council for Science National Council for Higher Education
Czech Republic	Ministry of Industry and Trade Council for Research, Development and Innovation Ministry of Education, Youth and Sports
Finland	Research and Innovation Council Ministry of Employment and the Economy Ministry of Education and Culture
Ireland	Inter-Departmental Committee on STI Department of Jobs, Enterprise and Innovation
Malaysia	Ministry of International Trade and Industry Ministry of Science, Technology and Innovation Economic Planning Unit
Republic of Korea	National Science and Technology Council Ministry of Science and Technology
Singapore	Economic Development Board Research, Innovation and Enterprise Council National Research Foundation
South Africa	Department of Science and Technology Department of Trade and Industry Department of Higher Education and Training

Source: UNESCO

The diversity of institutions at the promotion level (funding) in a given country seems to be one of the most fundamental indicators of good practices. The GO→SPIN global database will provide empirical evidence to confirm or refute this and other hypotheses.



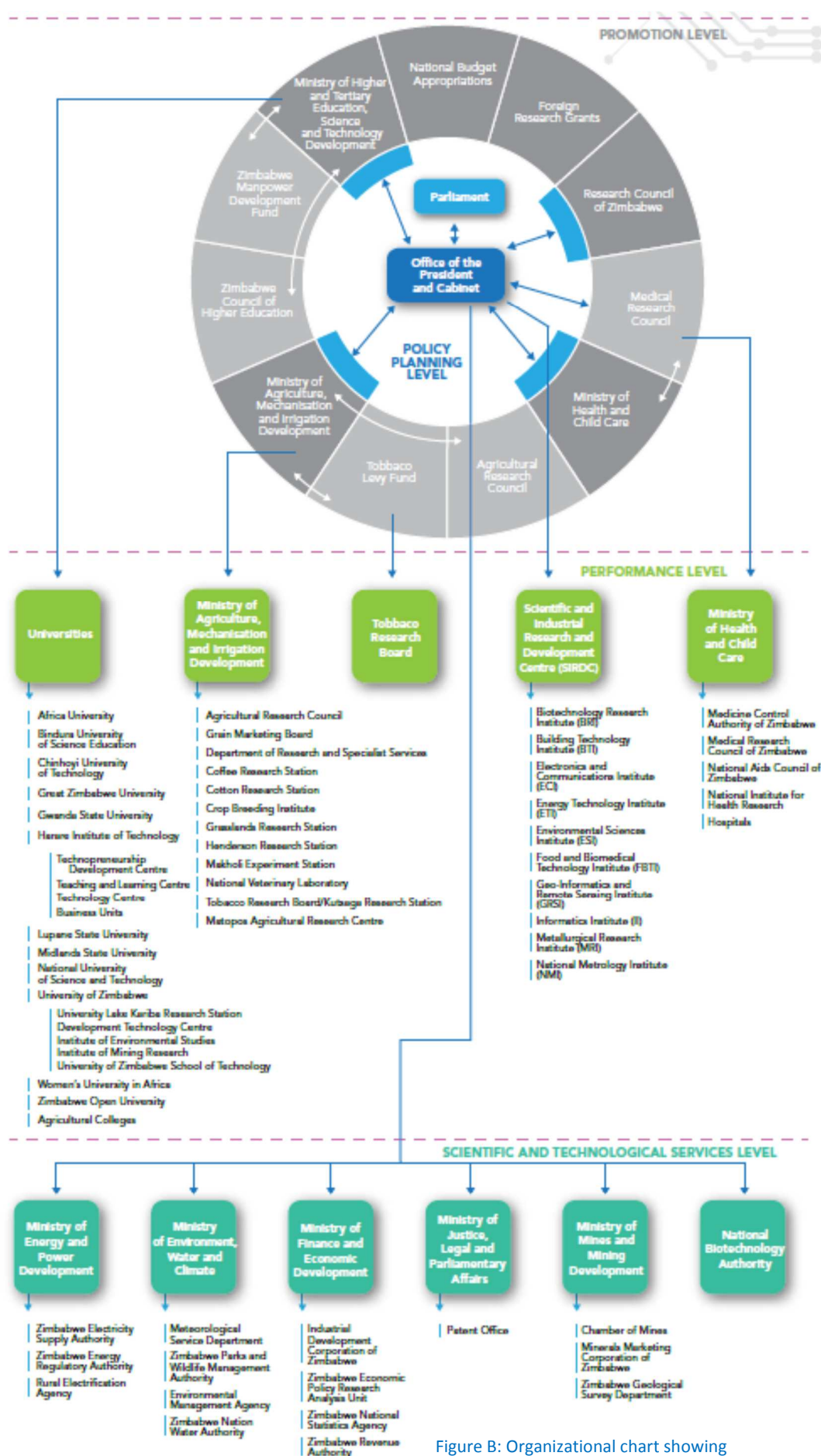


Figure B: Organizational chart showing Zimbabwe's research and innovation system

## THE LEGAL FRAMEWORK

The so-called legal framework can also be considered as a legal instrument. This embodies the policy, or parts thereof, in the form of a law, decree or regulation. Formal agreements, contracts and international STI cooperation treaties may also be included in this category. A legal instrument goes one step beyond a policy by stipulating obligations, rights, rewards and penalties. The GO→SPIN systemic approach has developed a friendly platform offering direct access to the entire SETI legal framework, description and the full text of laws, acts, decrees and agreements adopted by each country. Table B shows different examples of the most important types of legal instrument.

**Table B:** Examples of SETI legal instruments

A law for the creation of national research labs, universities, national research councils, ministry of S&T, R&D Funds, etc., or a legal framework to regulate the organization of the national innovation system.
A law to regulate the imports/exports of high-tech products.
A law to regulate tax incentives to promote innovation within the private sector.
A law to regulate foreign direct investments promoting the establishment of new high-tech enterprises.
A law to regulate the protection of the national biodiversity and to establish norms on how foreign companies exploit the active substances available within each national territory (new rules for the protection of indigenous knowledge).
Laws to foster R&D activities within the private sector and the creation of technological funds associated with the most strategic sectors of the economy (energy, mining, agriculture, industry, communication, fishing, tourism, etc.).
National regulations and decrees to establish new national policies, creation of new funding mechanisms, import/export tariffs, etc.
Bilateral, regional and international agreements on SETI activities.
Contracts on technology transfer.

Source: UNESCO

A law to regulate the protection of the national biodiversity and to establish norms on how foreign companies exploit the active substances available within each national territory (new rules for the protection of indigenous knowledge).

Laws to foster R&D activities within the private sector and the creation of technological funds associated with the most strategic sectors of the economy (energy, mining, agriculture, industry, communication, fishing, tourism, etc.).

National regulations and decrees to establish new national policies, creation of new funding mechanisms, import/export tariffs, etc.

## SETI OPERATIONAL POLICY INSTRUMENTS

GO→SPIN also includes a complete description of SETI operational policy instruments; these are the levers, or actual means, through which the organizational structure ultimately implements the decisions on a day to day basis and attempts to influence the behaviour of the various stakeholders targeted by the policy. Throughout the analysis of an instrument, it is important to keep in mind the actors or key decision-makers who are directly involved in the design and use of a policy instrument. An instrument does not act on its own accord. Rather, it responds to the will of the policy-makers and decision-makers using it. Table C shows different types of operational policy instrument, whereas Figure C shows various instruments that can be employed to effect at the different stages leading to market penetration of an innovation.

**Table C:** Examples of operational SETI policy instruments

Programmes and objectives	Policy instrument	Strategic objectives	Beneficiaries	Mechanisms for allocating funding
Scientific research and technological development	Competitive grants	Promote the endogenous production of new scientific knowledge in the exact and natural sciences. Promote regional networking.	Research groups at national universities and national research centres associated with similar research groups from other countries in the region, within formal partnership agreements	Competitive grants selected on a peer review basis; national research groups must be associated with similar groups from countries in the region which provide matching funding
Promotion of science education	Public subsidies for projects establishing science laboratories at public secondary schools	Improve scientific knowledge; methodological approach and critical thinking for secondary school pupils	Public secondary schools in less developed parts of the country	Public subsidies to mount new science cabinets and laboratories and new posts for science professors
Promotion of gender equality in research and innovation	Scholarships	Promote the participation of women in high-tech research and innovation	Young women enrolled in a PhD programme in basic and engineering sciences	Scholarships of up to four years and small grants for participation in international conferences
Protection of indigenous knowledge	Intellectual property rights, public law–national legislation and public subsidies	Protection of traditional knowledge to confer exclusive ownership and rights on local communities when the object of protection is a product or domesticated animal, cultivated plant or any micro-organism, or a design or an object of a functional or aesthetic nature, including any element of handicrafts, the act prohibits third parties from making, using, stocking, offering for sale, selling, commercializing, importing, exporting or identifying the active substances for commercialization, without consent	A local traditional practitioner, a local community or its representative may apply to register traditional knowledge	Public subsidies and tax exemptions to defend the Intellectual property rights of holders of indigenous and traditional knowledge
Attraction and reinvestment of foreign direct investment	Public financing Tax incentives	Strategies vary from country to country, examples being: (a) an Industrial policy based on attracting export-oriented industries; (b) promotion of structural change; (c) capacity-building to improve competitiveness, focusing on sectors or market niches; (d) internationalization of enterprises, and promotion of innovation; (e) prioritizing the generation of higher-tech goods and services (f) attracting selective FDI oriented towards ICTs, biotechnology, nanotechnology and financial services; (g) improving the business climate by refining legislation and simplifying formalities to facilitate corporate operations.	National Infrastructure (buildings, technology corridors, technological cities) and training of labour and professionals for the industry in question SMEs with export capacity	Soft-loans, tax incentives, grants For specific periods: tax discounts, exemptions, preferential rates, rebates on machinery and equipment
	Attracting R&D firms		Endogenous entrepreneurs High-tech emerging sectors: biotechnology, nanotechnology, new materials, ICTs.	The same tax incentives plus special competitive funding
	Other services	Structural change within a large country offers more opportunities for the domestic market, small and medium-sized countries generally focus on schemes conducive to the development of exports	Strengthening exports of industries and services considered to have strong potential in the country	Creation of a “one-stop shop” with representatives from different ministries/agencies to deal with problems concerning programmes, public regulations and post-investment services



Programmes and objectives	Policy instrument	Strategic objectives	Beneficiaries	Mechanisms for allocating funding
Technological development	Non-repayable contributions	Increased competitiveness through innovation in products, services and processes	Micro-, small and medium-sized enterprises and broader enterprises certified as having attained international standards	By public competition; up to 50% of project cost
	Loans for technological development projects	Finance for middle-income technology production projects	Micro-, small and medium-sized enterprises with R&D departments or teams, collaborating groups and technical linkage units underwritten by the enterprise	Compulsorily repayable loans; up to 80% of the total cost, allocated on an open window basis, with a maximum of \$... for three years
Technological modernization (improvement of products and processes, training)	Fiscal credit programme	Assistance in executing R&D	Physical or juridical persons who own enterprises producing goods and services	Subsidies through fiscal credit certificates obtained via public competition; up to 50% of the total cost of the project
	Loans for modernization Projects	Technological adaptation and improvements to products and processes with a low level of technical and economic risk	Enterprises with R&D department or groups; collaboration groups, and technical linkage units underwritten by the enterprise	Special compulsorily repayable loans allocated on an open window basis. Up to 80% of the total cost of the project, with a maximum of \$...in three years
	Loans to enterprises	To finance projects for the development of new production processes, products and modifications thereto	Enterprises, without any restriction on size or sector; no finance provided for projects with a rate of return of less than 12%	Compulsorily repayable loans allocated on an open window basis. Up to 80% of the total cost of the project, with a maximum of \$...
Promotion of the technological services market (research institutes and business research centres)	Subsidies for projects to develop business plans	Finance for business development projects based on R&D	Micro-, small and medium-sized enterprises whose projects are executed by technical linkage units	Subsidies allocated on an open window basis. Up to 50% of the total project cost, with a maximum of \$..., for up to one year
	Loans to institutions	To promote the establishment and strengthening of structures for the provision of technological services to R&D enterprises and institutions	Public or private institutions providing services to the private productive sector; projects may be presented on an individual or associated basis	Obligatorily repayable subsidies allocated on an open window basis, up to a maximum of \$...
Training and technical assistance	Subsidies for training and retraining projects	Subsidies to support activities for training and retraining human resources in new technologies	Micro-, small and medium-sized enterprises whose projects are executed by technical linkage units	Subsidies allocated on an open window basis. Up to a maximum of 50% of the total cost of the project, or \$... for up to six months
	Subsidies for project Formulation	Support for the formulation of R&D projects, technology transfer or technical assistance	Micro-, small and medium-sized enterprises whose projects are executed by technical linkage units	Subsidies allocated on an open window basis. Up to a maximum of 50% of the total cost of the project, or \$... for up to six months
Technological advisory assistance programmes and those strengthening the performance of technical small and medium-sized enterprises	Technological advisory assistance programme	Support for the formulation of R&D projects, technology transfer or technical assistance	Micro-, small and medium-sized enterprises producing goods and services which incorporate technological added value	Subsidies allocated on an open window basis to individuals or groups, with a maximum of 50% of the total cost of the project, or \$... and a maximum of \$... per participating enterprise
Popularization and social appropriation of science	Competitive grants	Support for the organization of national exhibitions and science fairs	Science museums, educational institutions at primary, secondary and tertiary levels	Subsidies allocated on a competitive basis

Source: UNESCO, UN ECLAC, FONTAR (Argentina)

Figure C: policy instruments for different stages of the innovation process and market penetration

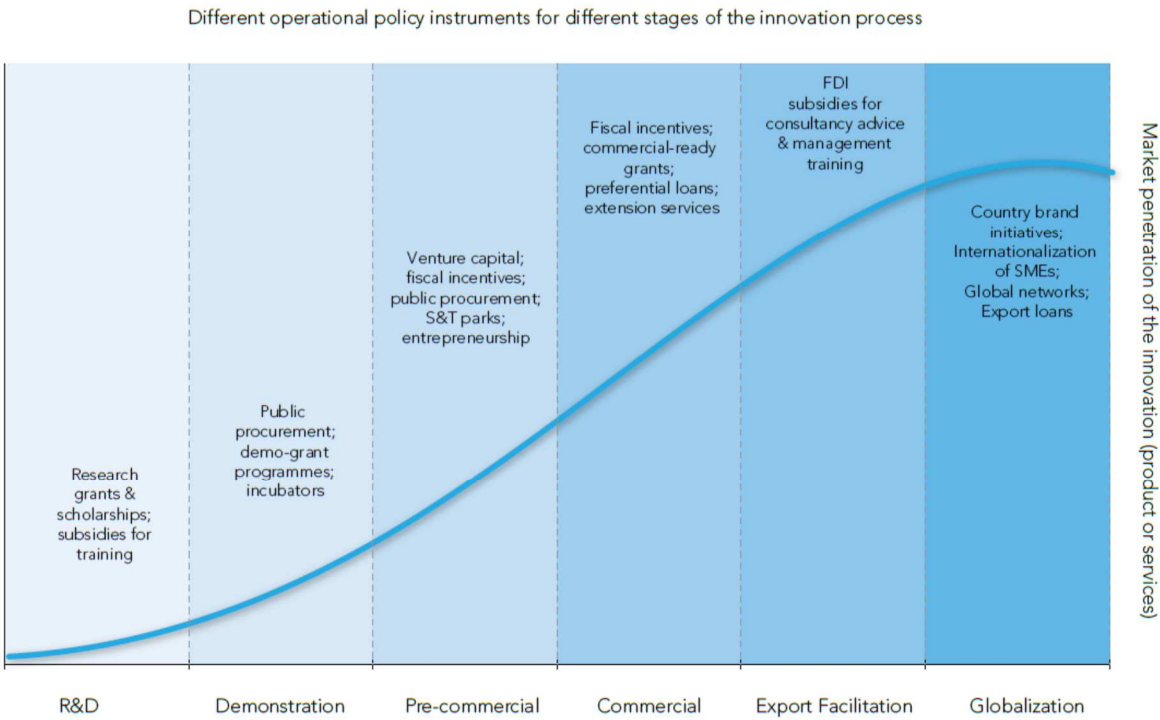


Table D presents the taxonomic classification of SETI operational policy instruments employed by GO→SPIN according to its methodological approach, by objective and goal; the type of mechanism/mode of support and target groups/beneficiaries. By analysing the aggregated information for groups of countries employing these classification schemes, it is possible to detect development patterns.

**Table D:** Taxonomic classification of SETI operational policy instruments employed by GO→SPIN

Objectives and goals	Type of mechanism/ Mode of support	Target groups/Beneficiaries
Strengthen the production of new endogenous scientific knowledge	Grants (grant funds)	Technical and support staff at SETI
Strengthen the infrastructure of research laboratories in the public and private sectors	Donations (individuals/ companies)	Students
Human resources for research, innovation and strategic planning; capacity building, education and training of specialized human capital for (1) the production of new scientific knowledge, (2) development of new technologies, (3) promotion of innovation within the productive and services systems and (4) management of the knowledge society	Loans	Individual professionals / PhD holders
Strengthen gender equality for research and innovation	Creation of, and support for, technological poles and centres of excellence	Teachers/ Researchers
Strengthen the social appropriation of scientific knowledge and new technologies	Tax incentives	Universities
Development of strategic technological areas and new niche products and services with high added value; promotion and development of innovation in the production of goods and services; promotion of start-ups in areas of high technology	Technical assistance	Research centres
Strengthen science education programmes at all levels (from primary school to postgraduate)	Scholarships	Technical training centres
Promotion of the development of green technologies and social-inclusion technologies	Credit incentives and venture capital	Schools/ Colleges/ Institutes
Promotion of indigenous knowledge systems	Trust funds	Corporations/ Foundations
Research and innovation eco-system: strengthening co-ordination, networking and integration processes which promote synergies among the different actors of the national scientific, technological and productive innovation system (i.e. government, university and productive sectors)	Information services	Professional Institutes
Strengthen the quality of technology foresight studies to: assess the potential of high-value markets; develop business plans for high-tech companies; construct and analyse long-term scenarios and; provide consulting services and strategic intelligence	Others	SETI local groups (e.g. a group of independent researchers)
Strengthen regional and international co-operation, networking and promotion of SETI activities		Private companies
		Science and technology public or private non-profit organizations
		Ad hoc associations
		Individuals
		Small and medium-sized enterprises
		Public institutions
		Co-operatives
		Other

Source: UNESCO

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