Guidance Note

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Public Expenditure Reviews in Science, Technology, and Innovation

WORLD BANK GROUP
Trade & Competitiveness

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A Guidance Note

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FOREWORD

Developing countries have not fully tapped into their innovative and entrepreneurial potential. If properly mobilized, this potential can accelerate economic growth, diversify exports, and create job opportunities. In this way, innovation can play a major role in promoting the World Bank's twin goals of shared prosperity and eradication of poverty.

Policy makers in developing countries are increasingly aware of this untapped potential, as well as its power to mitigate potential risks imposed by several global challenges, including climate change and food scarcity. For instance, attention is increasingly been paid to the positive effect of public investment in agricultural research and development (R&D) and extension on agricultural productivity and the income of low-paid workers. In order to mobilize untapped innovation potential and address those challenges, developing countries are spending more on science, technology, and innovation (STI).

Despite this growing effort, few governments can answer with confidence basic questions such as how much is spent on STI, by whom, and to what end. Verifying the results of those investments is a major challenge, as is assessing the effects of the design and implementation of programs, the existing framework conditions, or the overall policy mix. To be able to tap into their innovation potential, developing countries will need to address all those questions and better understand the returns of public investments in STI.

The purpose of this Guidance Note is to help countries to assess the quality of public spending on STI. It adopts a results-oriented framework, combining the consolidation of STI expenditures with the analysis of their main outputs, intermediate outcomes, and developmental impact. The framework proposes the analysis of three main sources of deficiencies: (i) program design/implementation; (ii) institutional conditions; and the (iii) composition and level of public expenditure. The main product of this exercise is an integrated set of actionable measures combining institutional reforms with changes in the policy mix (the composition and level of public spending) and strategic investments.

This note is one of a larger set of products—including policy notes, firm-level surveys, and a joint global platform with the OECD (the Innovation Policy Platform)— developed by the World Bank Group to meet the demands of our client countries in this field of innovation policy. We hope you find them useful.

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ACRONYMS AND ABBREVIATIONS

ASTI	Agricultural Science and Technology Indicators
BERD	Business Enterprise R&D
BNDES	Brazilian Economic and Social Development Bank
BoP	Balance of payments
BTYK	Supreme Council of Science and Technology
CEM	Country Economic Memorandums
CGIAR	Consultative Group on International Agricultural Research
CIS	Community Innovation Survey
COFOG	Classification of Functions of Government
EA	Efficiency Assessment
EC	European Commission
EFA	Effectiveness Assessment
EFTA	European Free Trade Association
EU	European Union
FDI	Foreign direct investment
FINAME	Financing of Machinery and Equipment
FR	Functional Review
GBAORD	Government Budget Appropriation and Outlays for R&D
GCI	Global Competitiveness Index
GERD	Government-financed gross domestic expenditure on R&D
GDP	Gross domestic product
GFS	Government Finance Statistics
GII	Global Innovation Index
GMP	Good Manufacturing Practice
GUF	General university funds
HACCP	Hazard Analysis Critical Control Point
ICA	Investment Climate Assessments
ICTSD	International Centre for Trade and Sustainable Development
IDB	Inter-American Development Bank

IMF	International Monetary Fund
INSEAD	Institut privé d'enseignement supérieur
IOOI	Input-output-outcome-impact
IP	Intellectual property
IPR	Intellectual property rights
IUS	Innovation Union Scoreboard
KAM	Knowledge Assessment Methodology
KE	Knowledge Economy
KEI	Knowledge Economy Index
KI	Knowledge Index
KOSGEB	Small and Medium Enterprises Development Organization
LEA	Leader
LCU	Local currency unit
M&E	Monitoring and evaluation
MoD	Ministry of Development
MoE	Ministry of Economy
MoIT	Ministry of Industry and Trade
MoNE	Ministry of National Education
MoSIT	Ministry of Science, Industry, and Technology
MRA	Mutual Recognition Agreement
MSES	Ministry of Science, Education, and Sports
MSTI	Main Science and Technology Indicators
MSTQ	Metrology, standards, testing, and quality
NABS	Nomenclature for the Analysis and Comparison of Scientific Programs and Budgets
NCBIR	National Center for Research and Development
NESTI	National Experts on Science and Technology Indicators
NIS	National innovation system
NSI	National Survey of Innovation
NSO	National statistical office
OECD	Organisation for Economic Co-operation and Development
PAR	Partner
PBS	Applied Research Program
PER	Public expenditure review
PRO	Public research organization
RAS	Reimbursable Advisory Service
RAZUM	Development of the Knowledge-Based Companies
R&D	Research and development
STI	Research, development, and innovation
SAR	Special Autonomous Region
SI	International System of Units
SME	Small and medium-sized enterprises
S&T	Science and technology
STEM	Science, technology, science, engineering, and mathematics
STI	Science, technology, and innovation
STIDATA	Science and Technology Indicators database

STIP	Science, technology, and innovation programs
TFP	Total factor productivity
TPE	Turkish Patent Institute
TTGV	Technology Development Foundation of Turkey
TTO	Technology transfer offices
TUBA	Turkish Academy of Sciences
TUBITAK	Scientific and Technological Research Council of Turkey
TURKAK	Turkish Accreditation Agency
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNIDO	United Nations Industrial Development Organization
VAT	Value-added tax
WEF	World Economic Forum
WDI	World Development Indicators
WIPO	World Intellectual Property Organization
WTO	World Trade Organization
YOK	Council of Higher Education
YPK	High Planning Council

EXECUTIVE SUMMARY

This Guidance Note lays out a framework for the assessment of science, technology, and innovation (STI) expenditures in developing countries, with an emphasis on their contribution to economic development.

INNOVATION MATTERS

The importance of innovation for economic development is uncontested. It contributes to the twin goals of shared prosperity and poverty reduction by generating productivity gains that increase employment, raise wages, and improve access of the poor to products and services. Investing in innovation increases firm capabilities and facilitates the adoption of new technologies to improve labor productivity.

Innovation is commonly seen as the work of highly educated labor in research and development (R&D) departments, laboratories, or research institutes—and therefore a "first world" activity. However, innovation is better characterized as the attempt to try out new or improved products, processes, or ways to do things. For this reason, innovation is intrinsically linked to the 'catching up' of firms and countries, the engine of economic development.

WHY CONDUCT A PUBLIC EXPENDITURE REVIEW ON STI?

Governments can improve a country's STI performance by correcting for the externalities and uncertainty inherent to the process of innovation. For this reason, there has been a renewed emphasis on STI policies in developing countries in recent decades. However, few governments can answer with confidence basic questions of how much is being spent, by whom, for what purpose, and with what results.

For starters, governments tend to intervene on the assumption that providing policy inputs (that is, money) will automatically lead to the production of the results they desire. They therefore ignore the fact that the high-level developmental impacts that they aim to achieve, such as economic growth and job creation, are often "third order effects": the indirect consequences of outputs and outcomes that will only occur under specific circumstances.

Governments also underestimate the complexity of the interactions and decision-making dynamics that underpin the development of policy. Many factors—both internal and external—influence the capacity of policy to lead to desired results and impacts. After all, innovation is a systemic process in that it depends on a variety of interactions among organizations, markets, and individuals.

MAIN ISSUE

This note addresses how to assess whether resources reallocated from the market towards STI improve society's economic welfare. In other words, are taxpayers better off because money was spent on STI?

While "economic efficiency" is the ultimate test for welfare-enhancing public policies, this Guidance Note addresses a more modest objective—namely, how to improve the impact of public spending in STI on economic and social development. In other words, it focuses on the quality of public spending in STI.

HOW TO ADDRESS IT

This note proposes a results-based framework to logically link inputs, outputs, outcomes, and impacts. The development and application of such an instrument is the essence of the proposed public expenditure review (PER). A PER helps focus analysis on (i) the fact that development goals are second- and third- order effects of public spending, and (ii) that the impact of public spending depends on a number of conditions that are not affected by public spending per se.

DEFINING OUTPUTS, OUTCOMES, AND IMPACT

The note proposes that "increasing productivity" (including labor productivity and total factor productivity or TFP) is the ultimate developmental goal to be achieved. Three corresponding default intermediate outcomes are identified based on the evidence provided by the academic literature: (i) research excellence; (ii) collaboration of science and industry, including research commercialization; and (iii) business innovation, including STI and technology adoption and diffusion.

The definition of those intermediate outcomes enables the analysis to focus on the specific conditions necessary for the achievement of identified outcomes. Intermediate outcomes also work as intermediate "links" between the public spending and their direct output, the ultimate development goal.

This approach could also be applied to a different system of development goals and intermediate outcomes. In this case, adjustments to this framework will be necessary to reflect the new issues at hand, starting with the corresponding adjustments to the inputs, outputs, outcomes, and development goals to be considered.

ASSESSMENT QUESTIONS

The assessment of public expenditures on STI is based on four main sets of questions:

1. How much is spent by the government on STI, by whom, with what objectives?
    - How much is spent in each of the intermediate outcomes? In particular, what is the consolidated STI budget? This includes the expenditure that is outside of pure R&D spending.
2. Are STI expenditures generating the expected outputs? Are they doing it efficiently? Do programs and funded activities generate the expected output with a reasonably level of inputs?
    - What design and implementation issues are affecting the performance of programs and other STI expenditures?
3. Are public expenditures effective? Are outputs translating into intermediate outcomes?
    - Which factors beyond the reach of the existing interventions are affecting the emergence of the expected outcomes?
4. How does the composition and level of public expenditures in STI (the policy mix) affect its impact? Is the composition of public expenditures relevant

to the country's development stage, consistent with existing higher-level goals, and coherent in terms of the funded measures?

- How does the governance of the national innovation system impact this allocation of resources?

THE NATURE OF PROPOSED SOLUTIONS

By improving the quality of public expenditures in STI, policy makers could increase economic efficiency. To achieve that result, recommendations in the PER combine program and policy reforms—that aim to increase the operational efficiency and effectiveness of public spending on STI—with budgetary adjustments that reflect changes in the policy mix to increase its relevance, consistency, and coherence. In sum, the PER exercise provides recommendations related to the following actions:

- Improvement of the design and implementation of selected programs—based on the Efficiency Assessment
- Adoption of policy reforms and investments in new programs to improve the systemic, institutional, or market conditions for effectiveness—based on the Effectiveness Assessment
- Changes in the policy mix, including recommendations about changes in the composition and level of public investments—based on the Policy Mix Assessment
- Enhancement of organizations and processes (the governance structure), through which research and innovation policies are managed—based on the Governance Analysis

The main output of the PER is an actionable plan that combines institutional (policy and program) reforms, changes in the policy mix (composition and level in public spending), and other strategic investments.

COMPARISON WITH SIMILAR EXERCISES

The proposed PER builds on a large body of PERs implemented by the World Bank Group and other organizations, as well as several other exercises to analyze national innovation systems and national innovation policies. However, the exercise proposed by this Guidance Note has two main differences with existing exercises. First, it seeks to go beyond R&D expenditures to encompass public investments in innovation—which is especially relevant for developing countries. Second, it aims to go beyond the description of the composition and level of public spending to shed some light on its impact (or how to improve its impact).

HOW TO USE THE GUIDANCE NOTE

This guidance note is composed of nine chapters, starting with an introduction. The second chapter provides two practical examples of public interventions in STI that were motivated by good intentions but ended up generating bad outcomes. Chapter 3 describes the proposed analytical framework and the remainder of the note is dedicated to the implementation of that framework (the "how to"). Chapter 4 describes the Inception Report, and chapter 5 provides for the analysis of a STI budget. The core of the analytical work is described in chapter 6 on the operational efficiency analysis, chapter 7 on the effectiveness analysis, and chapter 8 on the final report and policy mix analysis. Chapter 9 concludes.

CHAPTER 1

INTRODUCTION

This Guidance Note lays out a framework for the assessment of public expenditures in science, technology, and innovation (STI) in developing countries. Developing economies have been paying more attention to the contribution of STI policies to their development strategies. Consequently, investments in research and innovation by developing nations have increased substantially in the past decade. However, governments often lack the tools to properly allocate resources, ensure adequate returns on the spending, or even account for its use.

Innovation, when seen as the work of highly educated labor in research and development (R&D) laboratories of large companies or world-class academic institutions, is inevitably seen as a "first world" activity. However, as described in the World Bank's 2010 report on "Innovation Policy for Developing Countries," the term "innovation" also encompasses off-the-frontier innovations, that is, the adoption by firms of knowledge and its adaptation for local contexts or new uses. Similarly, in this note the term "research and development" is employed in a broad sense, comprising creative work undertaken on a systematic basis in order to increase the stock of knowledge and the use of this stock of knowledge to devise new applications. Box 1.1 provides the definitions adopted by the OECD's 2002 *Frascati Manual* (OECD 2002).

- Off-the-frontier innovations include incremental improvements and innovations in process, product, organization, and marketing that may or may not be technology driven.
- At the firm level, R&D activities may or may not generate innovations but are often the way firms

Box 1.1: Definition of R&D Activities

Basic Research	Experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.
Applied Research	Original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily toward a specific practical aim or objective.
Experimental Development	Systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

Source: OECD 2002.

turn innovation into a routine in their business model, rather than a random event.

- R&D does not need to be the source of the new idea or new knowledge: knowledge will often be embedded in internationally available capital and intermediate goods.

The framework proposed in this note aims to help countries to improve the quality of public expenditures in STI. Conceptually, the problem is to assess whether government's reallocation of resources from the market toward STI, through taxation and public expenditures, improves economic welfare as compared to the market allocation. The focus of the framework is, therefore, on maximizing the social and economic returns of public expenditures on STI.

The approach in this note represents a middle ground between two kinds of innovation policy assessments: (i) program-based evaluations, which by design do not take into account the systemic nature of the innovation process, and (ii) assessments of innovation systems, which often struggle to establish priorities and conditions for impact. Our approach builds on lessons learned from a variety of World Bank studies, policy dialogues, and projects in the area of innovation policy and public expenditure reviews (PERs).

Helping countries improve the quality of public expenditures in STI is closely linked to the World Bank's twin priorities of promoting shared prosperity and eradicating extreme poverty. Innovation has long been recognized as a critical source of economic growth and an important activity for addressing major development challenges, such as food scarcity; access to services, and climate change (IEG 2013).

The note is organized in nine chapters including this introduction. The next two chapters are mainly conceptual, aimed at explaining to the reader the analytical framework proposed for the assessment of the quality of public expenditures on STI. Chapter 2 presents the motivation for the work. Chapter 3 follows with a brief methodological discussion and the reasoning behind the structure of a PER on STI. Readers interested only in the implementation of the PER can perhaps skip most of that discussion and focus on the remaining five chapters.

Chapters 4–8 address in more detail how to implement the proposed framework. Each chapter corresponds to one of the five modules constitutive of the PER for STI. Chapter 4 describes the preparation of the Inception Report, chapter 5 address the challenges of building and analyzing an STI budget, chapters 6 and 7 describe assessments of the operational efficiency and efficacy of those expenditures, respectively. Chapter 8 focuses the relevance, coherence, and consistency of the policy mix and, building on the previous sections, assesses the likely impact of public spending. Chapter 9 concludes the note.

CHAPTER 2

WHY PUBLIC EXPENDITURES ON STI

Imperfect appropriability, information asymmetries, risk, and uncertainty inhibit private investments in science, technology, and innovation (STI). Addressing the conditions leading to this underinvestment by the private sector would likely raise long-term growth. This in turn provides an overarching rationale for public investments. Nevertheless, investment remains at low levels. For example, the average Organisation for Economic Co-operation and Development (OECD) country's budgetary allocation for research and development (R&D) corresponded to about 0.7 percent of average gross domestic product (GDP) in 2011.

Developing countries have been investing more in STI in recent years. However, few governments can answer with confidence the basic questions of how much is being spent, by whom, for what purpose, and with what results. In this context, government spending on STI often translates into poor results and modest impact, if any, on economic development. The point is illustrated briefly with two case studies (the cases are real—country names are omitted).

2.1. CASE STUDY 1: INCREASING PUBLIC EXPENDITURES ON R&D

Like other European Union (EU) member states, country "Alfa" committed to significantly increase its expenditures on R&D to boost competitiveness and growth. Those expectations were, in principle, well-grounded on evidence. For example, one study had estimated that reaching the 3 percent target as defined by the Lisbon Agenda in the early 2000s[1] would increase exports by 13 percent and income by 12 percent above projected levels by 2025. In five years, government expenditures on R&D doubled, raising the country's total R&D levels from 0.5 to more than 1 percent of GDP.

Would those investments generate the intended outcomes in terms of competitiveness and growth? Hardly so. In the same period, basic research in country Alfa increased from 22 to 44 percent as a share of total investments in R&D. For comparison, basic research corresponded to 17 percent of total investments in R&D in the United States and less than 15 percent in Japan and Israel. While relevant, investments in basic research are less likely to generate innovation in the near term.

Moreover, the impact of public investments in R&D on economic development depends on how efficiently technology is transferred from public research organizations to the market. This transfer is not an automatic process; it depends on a number of institutional and market factors that may or may not be in place.

Given the objective of raising export competitiveness, country Alfa would probably be better off by allocating a larger share of public resources to subsidize business R&D, as opposed to basic research.

1. http://www.euractiv.com/future-eu/lisbon-agenda/article-117510.

2.2. CASE STUDY 2: PROMOTING COLLABORATION BETWEEN RESEARCH INSTITUTIONS AND INDUSTRY

In the early 2000s, "country Beta" aimed to increase collaboration between research institutions and industry by favoring the location of companies on university campuses. To encourage that type of decision, the government conditioned access to tax breaks on R&D expenditures to the firm location in those technology development zones. As physical space became scarce and rent value increased, the government decided to subsidize the construction and expansion of such zones.

A survey of tenants implemented years after the start of the program showed, however, that only 4 percent of tenants started collaborating with researchers after locating in the technology development zones. Moreover, the combination of those measures resulted in a supply of science parks the country (when normalized by the number of researchers or R&D investments) about 6 times larger than the United States—indicating that the supply of technology zones in the country was probably excessive. These results are hardly close to the intended goal of policy makers. What went wrong?

Probably the conditions leading to collaboration between universities and industry were misinterpreted. The implicit understanding was that firms' physical proximity to universities would increase research collaboration. Studies have shown, however, that firms prefer to be located close to university when collaboration already exists, and when that collaboration demands physical proximity. Policy makers possibly got the direction of the causality wrong and thus ignored the factors affecting universities' decisions to collaborate with firms.

2.3. WHAT CAN GO WRONG?

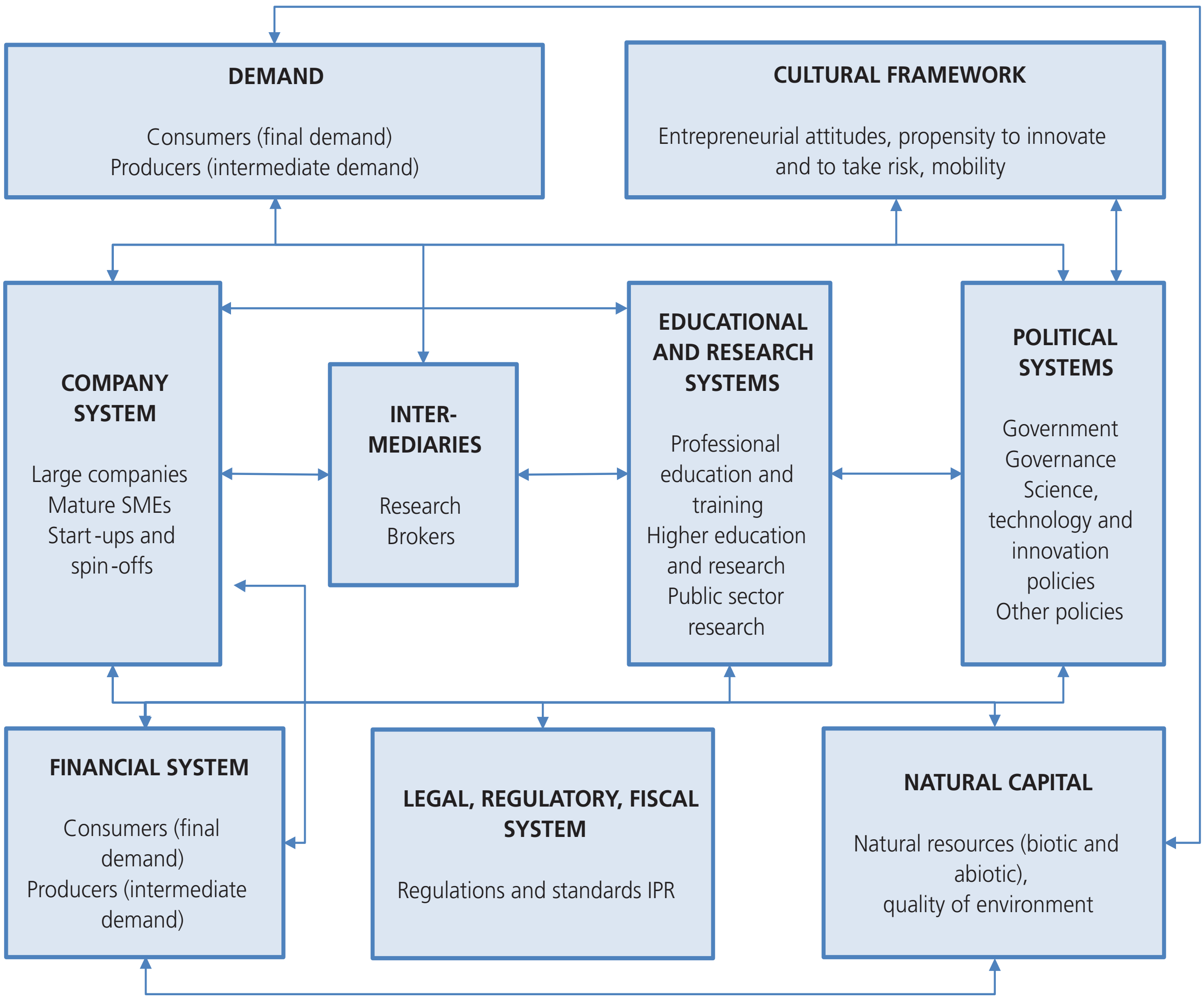
The examples above illustrate how public spending on STI, even when based on a sound economic rationale, may fail to generate the expected outputs or may lead to outcomes which are very different from those that policy makers are aiming for. How do good intentions, often based on solid evidence and implemented through well-known measures, generate poor, unintended consequences?

One general reason is that decision making about public policies often assumes that outputs and results will be automatically achieved once the policy input (public funds) is made available. High-level developmental impacts (such as competitiveness) are, however, "third-order effects": they are the indirect consequence of outputs (first-order effects) and outcomes generated by the intervention under specific circumstances. Assuming that those first-order effects will generate second-order effects and that those will be transformed into the desired high-level impact is a common mistake in policy making. Similarly, omitting the conditions under which public expenditures will reach a desired outcome is a major cause of the misuse of public funds.

Another reason why public spending in STI may fail to reach the desired impact relates to the fact that innovation is a systemic process. Innovation's success depends on a variety of interactions among organizations, markets, and individuals, comprising a "system" (see figure 2.1) (Patel and Pavitt 1994). For example:

- High-quality educational and research institutions are less effective in generating economic growth if firms are not capable of making use of either the research outputs or the graduates they generate. In such a context, investing in public research—even if it succeeds in generating academic excellence—will not contribute to the competitiveness of firms or to economic growth.
- Similarly, entrepreneurs may be unable to put good ideas into practice due to the lack of venture capital or angels investors willing to risk financing and nurturing the endeavor. Again, under these circumstances, public spending on pre-seed financing is unlikely to generate innovation and the desired economic impacts.

Figure 2.1: A Simplified View of Innovation Systems



Source: Technopolis Group & MIOIR 2012.

Policy makers also struggle to establish effective coordination of STI policies and public expenditures. Policy design and public spending involve different governmental organizations—ministries of science, economy, energy, defense, and so forth—often at the same hierarchical levels. The frequent outcome is some sort of "negative" coordination between organizations, whereby each respects the others' commitments but does nothing to integrate its actions. This result is hardly consistent with good principles of policy making.

2.4. WHAT IS THE BASIC OBJECTIVE?

The objective is to assess whether government's reallocation of resources from the market toward STI, through taxation and public expenditures, improves economic welfare as compared to the steady-state situation. In other words, are taxpayers are better off after the intervention, as compared to their welfare without the intervention.

In practice, the objective is to help countries improve the quality of their public expenditures. This includes building governments' capacity to identify how much is spent, by whom, and for what objectives. Another practical goal is to improve the government's capacity to assess the likely contribution of public expenditures to the country's economic development.

2.5. HOW THIS GUIDANCE NOTE HELPS

None of the existing methodologies for assessing innovation policies focus on the impact of public expenditures on STI. Program-based evaluations have a narrower approach by design and are not expected to capture the issues related to the systemic nature of innovation. On the other hand, most country-level analyses of innovation systems often struggle in establishing priorities and conditions for impact, due to the mostly descriptive nature of the approach used.

An approach that combines both program and country elements is far from straightforward, for a number of reasons. The expansion of the range of objectives of innovation policy and of the bundles of instruments deployed has made for an increasingly complex policy landscape. This widening of the "frame" of innovation policy has led to new rationales for policy intervention and has opened up a larger toolbox of policy instruments. Beyond core innovation policies, such as those targeting science and technology (S&T) and education, the impacts of other policies must be taken into account. Taxation policy, competition laws and regulations, and so forth constitute the framework conditions for innovation (OECD 2012).

Referring to figure 2.1, the boxes represent areas of the economic, institutional, and political conditions of a country (demand, cultural framework, political system) as well as groups of stakeholders (company system, educational and research system) and certain types of organizations (intermediaries). The figure outlines the factors constitutive of a national innovation system but does not provide any guidance on how to identify the impact of existing policies or the conditions that are missing.[2]

Let's see an example of how the lack of an assessment framework affects policy planning. An adequate supply of human capital (scientists, engineers, technicians) is a requisite for well-functioning innovation systems. In fact, it turns out that the country has fewer engineers than expected given its development level. But this does not necessarily imply that access to human capital is a constraint for the impact of public expenditures on STI. Rather if the demand for engineers has been systematically low (as evidenced for instance by the evolution of wages in that segment of the labor market), then the effectiveness of public expenditures supporting innovation would not be affected by the supply of engineers.

A framework for the assessment of public expenditures on STI should guide the analyst like a map through the landscape of the innovation system. Landmarks in that system include stakeholders, organizations, programs, and policies; economic, institutional, and political environments; and the complex interactions between these entities. Developing this assessment framework and providing guidance on how to implement it is the main goal of this note.

2. An important exception to the lack of impact evaluation is the recent OECD studies focusing on the mapping of countries' policy mixes. OECD is developing a database with quantified information about selected policy instruments. The information is obtained by means of a policy questionnaire and the study has been implemented to a few developing countries. See http://stats.oecd.org/Index.aspx?DataSetCode=REG_INNO_TL.

CHAPTER 3

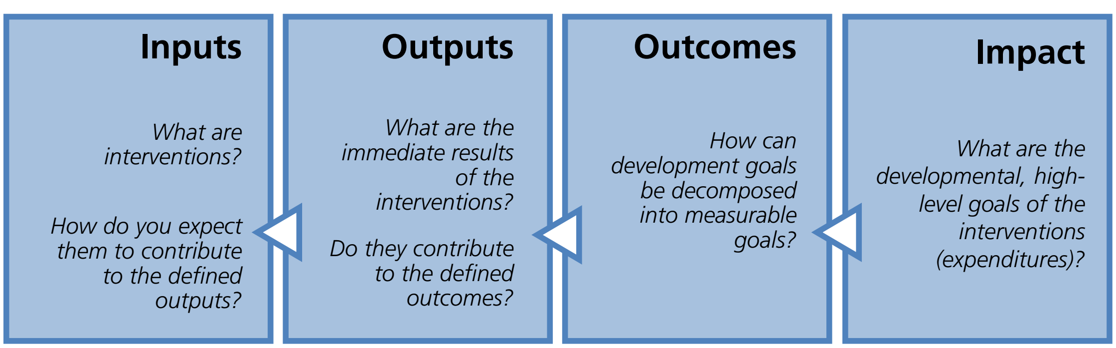
FRAMEWORK

The framework proposed in this note will help correct the usual misconception that the impacts of policy inputs are the direct, immediate result of the intervention. This approach is illustrated in figure 3.1, which depicts the structure of a generic logical framework for the assessment of public policies in general, using the input-output-outcome-impact (IOOI) model.

Figure 3.1 shows that the process starts with identification of the desired development impact. The arrows indicate the backward-induction process adopted to help identify the causal links between the intervention and the high-level goals. Intermediate outcomes (events that are immediate prerequisites for impact—second-order effects) and outputs (results derived directly from the intervention that may or may not contribute to the intermediate outcome—first-order effects), consistent with the defined development impact are identified. This establishes the causal links between the intervention and the overall impact—the logic of the intervention.

The model can be decomposed into additional steps if useful. For instance, the "Inputs" box could be separated into three separate issues: what are the interventions, why they are chosen (economic rationale), and what is the expected benefit. Or one could include an "Activities" box between the "Inputs" and "Outputs" boxes if there is an interest in identifying the actions to be taken through which the inputs are mobilized to generate specific outputs. As a rule, however, there is no benefit in describing all possible points. A map that exhaustively describes the environment is not always useful for navigation.

Figure 3.1: The IOOI Approach to Assessment of Public Policies



The main advantage of this approach, as will be discussed later, is to provide an analytical framework that is results oriented—a perspective that is missing in most assessments of innovation systems. How can the IOOI approach be applied to the case of public spending in science, technology, and innovation (STI)? The development and application of these instruments to assess the impact of a given set of public expenditures in STI is the essence of the proposed framework.

3.1. A RESULTS-ORIENTATED APPROACH

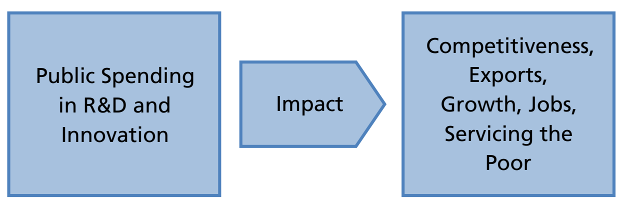
Development Impact

As a general methodology, the IOOI model can be applied to any developmental impact or high-level goal, from export diversification to shared prosperity or eradication of poverty. Each high-level goal will generate one specific logical framework with different inputs and outputs to be considered, setting up the scope as well as the structure of the assessment to be undertaken. Figure 3.2 and 3.3 describe a step-by-step application of the IOOI methodology.

Figure 3.2 depicts the initial situation in which a given amount of public expenditure on STI is expected to generate broad, often generic developmental goals. Figure 3.3 depicts the initial decompositions of the problem. First, public expenditures are divided according to the beneficiary, namely, expenditures benefiting the public sector and expenditures benefiting the private sector. In addition, the development objective is turned into innovation (new, better, less expensive goods and services) and productivity growth.

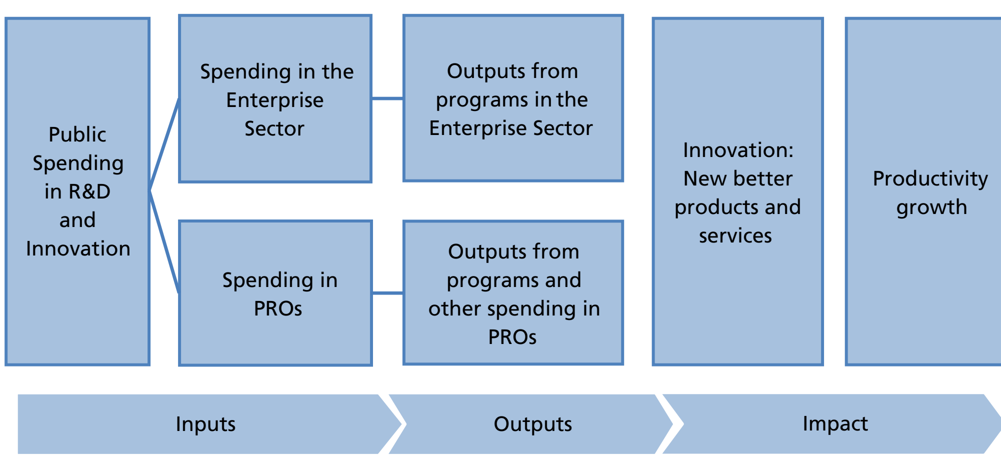
Productivity growth is proposed as the "default" developmental goal. Box 3.1 discusses the rationale

Figure 3.2: Spending and Goals



Note: ES = enterprise sector; PROs = public research organizations

Figure 3.3: Spending, Outputs, and Goals



Box 3.1: Productivity as the Default Development Goal

As Nobel laureate Paul Krugman said once, "productivity isn't everything, but in the long run it is almost everything." In simple terms, productivity is efficiency in production: how much output is obtained from a set of inputs. Generally speaking, the higher the productivity of a country—the more a country produces for a given set of inputs—the higher the living standards that it can afford and the more options it has to choose from to improve well-being.

Labor productivity is the most common measure of productivity. Economists have found that labor productivity growth depends on two major factors: the accumulation of capital (human, physical, and so forth) and the growth of an unexplained (or residual) portion that arguably reflects advances in production technologies and processes, referred to as total factor productivity (TFP) growth (for a review see Shackleton 2013). In fact, because capital is known to have decreasing returns, sustained growth in the long run depends primarily on TFP growth.

In this sense, productivity growth is closely associated with innovation—with the invention of new products, tools, and technical processes that not only reduce the cost of extracting or producing raw materials and energy but also reduce the cost of transforming those inputs into finished products. In this sense, by promoting innovation, policies may also contribute to TFP and labor productivity growth.

- Private-sector nonfarm TFP in the United States, which could be considered the technological frontier, has grown at an average annual rate of 1.6–1.8 percent.
- The link between R&D, innovation, and productivity for developed economies has been established in a number of studies as described in Hall and Rosenberg (2010).
- In Latin America, it has been shown that product innovation has a positive impact on employment growth, compensating for the neutral or negative effects of process innovation (Crespi and Tacsir 2010).

STI policies often involve multiple development goals such as improving international competitiveness, increasing exports, raising per capita income, and increasing productivity. Public investment in STI may also have noneconomic objectives, such as those related to the environment and social sectors (health, education, basic services, and so forth).

As the ultimate factor driving economic growth and rising living standards, **productivity growth** (labor productivity or TFP growth) seems a good candidate for the default impact or high-level goal of inputs—against which public expenditures on STI can be evaluated. While a relatively straightforward concept, a host of measurement issues emerge when constructing productivity indicators from actual production data. For a review of the concept, metrics and determinants, see Syverson (2011).

Using micro-level data from manufacturing industries, Saliola and Seker (2011) estimate TFP levels for 80 developing countries from Eastern Europe, Central Asia, Latin America, Africa, and Asia. The study also estimates separate TFP values obtained at the industry level. These industry-level estimates are the most useful for policy makers in that they reveal comparative advantages of specific industries within countries.

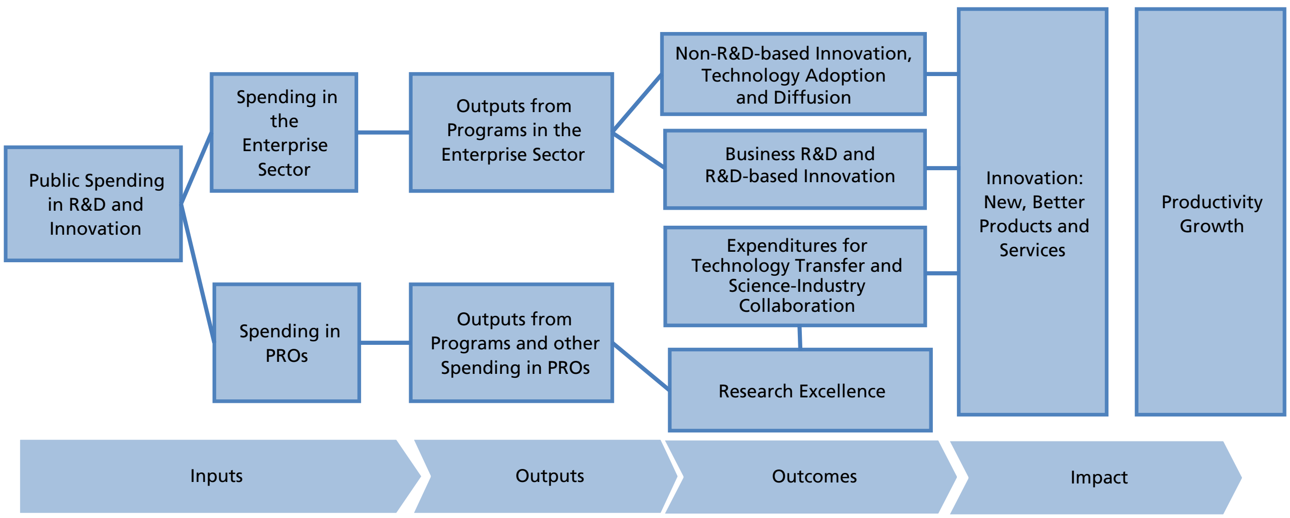
Source: OECD 2002.

of choosing productivity as the default development goal. Other goals may be preferred depending on the circumstances of this exercise.

Intermediate Outcomes

Figure 3.4 completes the logical framework linking public expenditures to immediate outputs and intermediate outcomes. Taking productivity as the highest development objective, the three intermediate outcomes to be taken into account are (i) research excellence, (ii) science-industry collaboration and technology transfer, and (iii) business innovation. The analyst can further decompose intermediate outcomes if useful. Business innovation is decomposed into R&D and non-R&D innovation (but other intermediate outcomes may probably be collapsed to one of these three intermediate outcomes). Box 3.2 discusses the rationale for choosing these three intermediate outcomes.

Figure 3.4: The IOOI Model—Proposed Results Framework



Box 3.2: Three Default Intermediate Outcomes

Research Excellence. In developing countries, innovation depends to a large extent on the ability to recognize, assimilate, and apply the value of new, external information to commercial ends (absorptive capacity).[a] Given that "knowledge" is a public good, public research can play an important role in building the country's learning and innovative capacity by raising the level of extra-industry knowledge. In this sense, public research can have a direct influence on firm productivity.

- Consider the impact of public agricultural research, especially when combined with effective agricultural extension services. Recent simulations illustrate substantial gains in agricultural productivity to be achieved by higher R&D investments over the next 20 years in East Africa (Nin-Pratt 2011).
- Agricultural research is particularly needed to help developing countries to address the challenges of climate change Research plays an important role creating the necessary technologies, and enabling developing countries to adapt them to their agricultural systems (Lybbett and Sumner 2010).
- In addition, government investments in research provide training to graduates and scientists, some of whom join the private sector, raising its capacity to use new tools and knowledge to solve complex problems.[b]
- Evidence suggests that university research has a significant effect on corporate patents, innovation, and productivity (the latter with a 20-year delay) (Adams 1990; Jaffe 1989).

Science-Industry Collaboration and Technology Transfer. A second intermediate output through which public research can contribute to firm productivity is through efficient commercialization of research outputs and collaboration with the business sector—that is, efficient technology transfer from public research organizations (PROs). Sustainable impact of public R&D expenditures on economic development depends on the way the research results of public investment are transferred to the market through patents, licenses, joint ventures, or spin-off companies. The problem is not so much the existence or nonexistence of commercialization activity but whether the conditions for a massive and systemic (as oppose to rare and occasional) process of research commercialization are in place (Audretsch et al. 2010).

Science-industry collaboration, from joint and contract research to training and technical consultancy, is a way to commercialize research capacity or, more broadly, knowledge that is available in PROs. For example, science collaboration in R&D activities can leverage technological spillovers through the stimulation of additional private R&D investment (Rosenberg and Nelson 1994). Small firms also use research alliances to gain access to research inputs, which would have been otherwise unavailable (Audretsch and Feldman 1996).

(continued next page)

Box 3.2 (continued)

- Scott (2003) finds that research alliances with universities are a way through which firms improve their absorptive capacity. This is particularly true for firms that have downsized their R&D facilities.
- Mueller (2006) uses a cross-sectional time series to find that regions with high levels of entrepreneurship and university-industry relationships experience a greater level of economic productivity (and growth).

Business Innovation: R&D, Startup Creation and Technology Adoption. Most productivity gains emerge from day-to-day introduction of technological solutions and incremental improvements to products and processes of production (as opposed to new discoveries and patenting) (Trajtenberg 2006). Those improvements can occur routinely, in a structured way, or randomly. Business investments in R&D are a way to turn innovation into a routine activity for firms. Naturally, firms can innovative without R&D activities.

- Studies have also shown that business investments in research and innovation have a positive and non-negligible impact on labor productivity growth in Latin America (Crespi and Zuniga (2010) and Crépon et al. (1998))

Investments in R&D are fundamental to enhancing a country's "absorptive capacity." Prior knowledge gives one the ability to acquire new information. But firms that have their own R&D are better able to use external information. Moreover, a firm's absorptive capacity may be a byproduct of R&D investments; that includes the ability to adapt and adopt foreign technology, to benefit from spillover effects from foreign direct investment (FDI), and to gain from other sources of knowledge transfer.

Start-ups, which very often do not result from R&D, are at the forefront of innovation. They introduce breakthrough technologies, have taken risks in nascent sectors such as the Internet and biotechnology in the past, and are active in areas such as nanotechnology today. They also play an important role in job creation. Kane (2010) finds that for the period 1977 to 2005, start-ups on average created 3 million jobs annually while existing firms lost around 1 million (Kane 2010).

The adoption of modern technology is a way of introducing new products or services to the market. Increasing the amount of capital per worker (capital accumulation) is known to be a primary source of labor productivity growth. Differences in technology adoption have been shown to be an important determinant of the gaps in growth and per capita income across countries (Hall and Jones, 1999; Prescott, 1998). In fact, recent studies have shown that:

- Differences in the rate of technology diffusion over the past two centuries can account for at least a quarter of the differences in per capita income across countries (Comin and Hobijn 2010).
- About 45 percent of cross-country variation in income per capita can be explained by technology adoption at the intensive margin.[c.]
- Countries that have caught up with the United States have been those that saw an acceleration in adoption of new technologies (Comin and Hobijn 2010).
- Technology adoption is also an easy way for firms in a developing country to absorb technology that is being developed and used in economically advanced countries. This has become particularly true during the era of globalization as there is broader availability of technology and new machinery (Eaton and Kortum 2001; Keller 2004).

Notes:

a. The term refers to "the ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal 1990). See also Griffith, Redding, and Van Reenen (2003).

b. For instance, the biotechnology industry has seen a sharp increase in the number of firms from the 1970s. Zucker et. al. (1998) show that that this was due to the diffusion of trained human capital made available through basic research investments in this field.

c. Comin and Mestieri (2010) describe the intensive margin as follows: "Once a technology has been introduced, the intensive margin of adoption captures how many units of the good embodying it are demanded relative to aggregate demand. The intensive margin is determined by the productivity and price of goods that embody the technology and the cost that individual producers face in learning how to use it. Other things equal, these variables produce vertical shifts in the evolution of observable measures of technology adoption."

While some marginal overlap is inevitable, these are fairly distinctive intermediate outcomes. Their respective contributions to productivity growth are well documented in the academic literature, which makes one confident about the causal links. For example:

- Public research organizations (PROs) that are supported by public spending need first to focus on research excellence. Then, knowledge accumulated in PROs needs to be transferred to the private sector (through technology transfer or science-industry collaboration). Without the intermediate outcomes of research excellence, PROs are unlikely to reach higher development impacts.

With this framework in mind, it is straightforward to recognize that the transition from output to outcomes depends on a number of conditions outside the reach of the public spending (the original intervention). This may refer to framework conditions (such as a legal framework and regulation of intellectual property), market functioning (for example, for early-stage financing), or institutions (such as management of public research organizations). Furthermore, these conditions are often specific to the different intermediate outcomes. The point echoes the lessons described in chapter 2. For example:

- Investments in technology transfer offices may not lead to more efficient technology if the rules for development of researcher's career favor pure academic achievements (such as publications) to the detriment of collaboration with companies or commercialization of research. More recently, universities have started to explore ways to include achievements in science-industry collaboration (such as patenting) as part of the promotion criteria.

In Economic Terms

The underlying hypothesis of this Guidance Note is that to be welfare enhancing (that is, able to improve economic efficiency), public spending in STI should achieve the following objectives:

(i) Fund research and innovation activities in public research organizations or in the business sector which generate outputs efficiently (programs and funded activities are operationally efficient)

(ii) Effectively generate the expected intermediate outcomes from these outputs (as conditions for effectiveness beyond the public spending itself are presented)

In addition, STI policies should be relevant, coherent, and consistent. As discussed before, the performance of a national innovation system (NIS) is recognizably related to its systemic nature. Consequently, the impact of a given policy instrument frequently depends upon its interaction with other instruments that may or may not exist. Moreover, policy measures, designed at different occasions and somewhat different goals, are introduced into settings that already contain an array of instruments, often with the same or overlapping targets (OECD 2012: 156).

In such a context, policy design and implementation may or may not result in a *coherent* body of measures *consistent* with an intended public goal (common good). Rather, policy measures may contradict each other, be redundant, too numerous, and operating at an excessively small scale. Also, there is no reason to assume, a priori, that policies will target economic and social goals that are *relevant* given the country development context. Conflicting interests and visions about the role of research and innovation, the compartmentalization of policies, and the piling up of instruments over time are some of the factors hindering STI policies from being relevant.

3.2. STRUCTURING QUESTIONS

This PER on STI is primarily interested in understanding how governments can spend better in STI—in other words, how governments could improve the "impact" (contribution) of STI expenditures on economic development. From the IOOI model, the proposed core questions (in bold) and sub-questions to be asked in assessing ways to improve the quality of public spending in STI become straightforward. They are summarized below:

- How much is spent by the government in STI, by whom, and for which expected objectives?

- – How much is spent in each of the intermediate outcomes? In particular, what is the consolidated STI budget (going beyond pure R&D spending)?
- Are STI expenditures generating the expected outputs? Are they doing it efficiently, with a reasonably level of inputs?
  - – What design and implementation issues are affecting the performance of programs and other STI expenditures?
- Are public expenditures effective? Are the outputs translating into intermediate outcomes?
  - – Which factors beyond the reach of the existing interventions are affecting the emergence of the expected outcomes?
- How is the composition and level of public expenditures (policy mix) affecting its impact? Is the composition of public expenditures *relevant* to the country's development stage, *consistent* with the existing higher-level goals, and *coherent* in terms of the funded measures?
  - – How does the governance of the NIS impact this allocation of resources?

The last question summarizes the core objective of the PER exercise. It addresses the fact that public spending in the STI sector needs to be analyzed from a systemic point of view, reflecting the interdependence of policy measures. Each of the four questions is addressed in chapters 5–8 of this note.

The Governance Structure

The governance structure of STI policies—the organizations, institutionalized rules, and procedures for designing STI policies—is an underlying determinant of the allocation of public spending and its corresponding results. Governance matters because policies are not the result of rational choices from a single policy maker (government) acting to maximize the common good.

Public policies in general, and economic policy in particular, are very often the outcome of bargaining processes involving multiple stakeholders who possess different access to resources and power, and whose actions reflect their private interests in a context of asymmetric information.[1] The issue is particularly relevant given the multiplicity of actors designing and implementing research and innovation policies. By affecting the behavior of stakeholders, different governance structures induce the development of different "policy mixes" and therefore the quality of public expenditures in STI (box 3.3).

1. A broadened concept, encompassing the way that the government manages public research organizations (that is, "exercises control"), arguably would link governance issues to the effectiveness of public spending on STI (this point is returned to later in the Guidance Note).

Box 3.3: The "Policy Mix" Concept

The "policy mix" concept, borrowed from other economic policy discussions, is defined as the combination of policy instruments that interact to influence the quantity and quality of STI investments in the public and private sectors. The term implies a focus on interactions and interdependencies between different policies as they affect the extent to which intended outcomes are realized. The assumption is that policy makers are underutilizing the full portfolio of instruments theoretically available to them.

The policy mix concept, as intuitive as it may be, lacks clear normative implications. Often the term is associated with notions such as "balanced," "appropriate," or "effective," qualities that are hard to define. An abstract "optimum" policy mix toward which the composition of public expenditures could be benchmarked probably does not exist. Rather, the optimum policy—the one that maximizes the impact of public expenditure—must be specific to each country context. This understanding is captured with the notion of "relevance." "Consistency" between public expenditures and the high-level goals and "coherence" (for example, avoiding redundancy of programs) complete the attributes that this Guidance Note suggests to be used to characterize a balanced police mix.

Source: Based on Flanagan, Uyarra, and Laranja (2010).

3.3. THE TYPE OF RECOMMENDATIONS

By improving the quality of public expenditures in STI, policy makers could increase economic efficiency. To achieve that result, recommendations on the PER will combine program and policy reforms—aiming at increasing the operational efficiency and the effectiveness of public spending in STI—with budgetary adjustments that reflect changes in the policy mix to increase its relevance, consistency, and coherence. In sum, the PER exercise provides recommendations for the following actions:

(i) The improvement of the design and implementation of selected programs—based on the Efficiency Assessment

(ii) The adoption of policy reforms and investments in new programs to improve the systemic, institutional, or market conditions for effectiveness—based on the Effectiveness Assessment

(iii) Changes in the policy mix, that is, recommendations about changes in the composition and level of public investments—based on the Policy Mix Assessment;

(iv) The enhancement of the organizations and processes (governance structure)—through which research and innovation policies are managed—based on the Governance Analysis.

Table 3.1 provides the suggested structure for the summary matrix. It combines the four proposed intermediate outcomes (rows) and the four analytical dimensions (columns). The matrix is supposed to be filled based on the assessment carried out through each of the three modules—efficiency, effectiveness, and policy mix assessment (the latter including the governance analysis). Note that the last column is not a necessary element of the regular matrix. Rather, it simply indicates the possibility of consolidating the results of the analysis by "intermediate outcome." Table 3.1 also describes some of the expected inputs for its cells:

- Cell (A) brings the broad recommendations from the policy mix assessment. An example is the need to rebalance the policy mix toward more investments in innovation, particularly non-R&D innovation, in order to improve the *relevance* of the policy mix for the country's development needs.

Table 3.1: Expenditure Review—Summary Table

Intermediate outcomes	Program operational efficiency	Effectiveness conditions	Policy mix	Governance structure	(Sector analysis)
Research excellence			(C)		Analysis of the research sector (G)
Science-technology collaboration transfer		(F)			
Business R&D and knowledge-based startups			(B)		
Non-R&D business innovation and technology adoption	(E)				
Overall			Overall policy mix analysis (A)	Overall governance analysis (D)	

- Cells (B) and (C) address other policy mix issues (which happen at the level of intermediate outcomes). Examples are the balance between direct and indirect subsidy for the business sector (B) and the balance between basic and nonbasic research (C).
- Cell (D) presents the recommendations related to the overall procedures and organizations involved in policy design and implementation in the NIS. An example is the revitalization of the NSI council and the inclusion of a larger number of participants from the private sector with voting power.
- Cell (E) brings the recommendations for the improvement of operational efficiency of programs for non-R&D based innovation (E). An example is the need to adjust technology support programs to emphasize labor training and informational issues (in addition to access to finance).
- Cell (F) shows the recommendations for the improvement of conditions for effectiveness for science-industry collaboration. An example is to reform how researchers' career development is regulated to incentivize them to develop joint projects with the business sector.

Tables 3.2 and 3.3 are possible developments of table 3.1. Table 3.2 helps organize the PER recommendations according to the nature of the measure to be undertaken, namely, program and policy reforms and strategic investments. One advantage is to be able to identify an overall cost of the strategic investments by intervention (program, policy reform—represented by the vertical arrow) or by intermediate outcome (horizontal arrow). Strategic investments involve, for instance, programs to support managerial training by small firms, investments in the country's metrology system, or investments in the modernization of the agricultural research and extension services.

Table 3.3 helps with the prioritization and ranking of measures. It provides a simple example of a "dashboard" that could be used in order to identify priority

Table 3.2: Expenditure Review by Type of Measure

Intermediate outcomes	Program operational efficiency		Conditions for effectiveness		Policy mix	Governance structure		(Sector analysis)	
	Program reform	Strategic investments ($)	Policy reform	Strategic investments ($)		Policy reform	Strategic investments ($)	Reforms (Program and policy)	Strategic investments ($)
Research excellence									Total costs, Research sector
Science-technology collaboration transfer									
Business R&D and knowledge-based startups									
Non-R&D business innovation and technology adoption									
Overall		Total costs							Overall costs

Table 3.3: Expenditure Review—Prioritization

Intermediate outcomes	Program operational efficiency	Effectiveness conditions	Policy mix	Governance structure	Overall prority
Research excellence	+	++	+++	++	
Science-technology collaboration transfer	++	+++	+		
Business R&D and knowledge-based startups	++	+	+++		
Non-R&D business innovation and technology adoption	+++	++	+		
Overall priority	+	++	+++	+++	

areas of intervention and/or adjustment. Based on the assessment carried out through each of the three modules, each individual box is to be filled out through the use of a simple rating system. For example, if the analysis led to the conclusion that the overall governance issues are a main problem, this could be indicated by using a rating system (i.e. +++ = very high, ++ = average, + = below average).

The final deliverable consists of an Action Plan of policy and institutional reforms as well strategic investments (for instance, resulting from shifting resources from one STI component to another). The Action Plan aims to enhance the impact of public spending on STI on economic development.

In discussing the main results of the PER exercise and considering its effective impact, the team may consider including two additional deliverables: (1) an action plan for the development of STI statistics, and (2) a monitoring and evaluation (M&E) system for the STI spending (which enables the country to continue collecting program data and advance issues that were not covered during the PER exercises for data, funding, or related limitations).

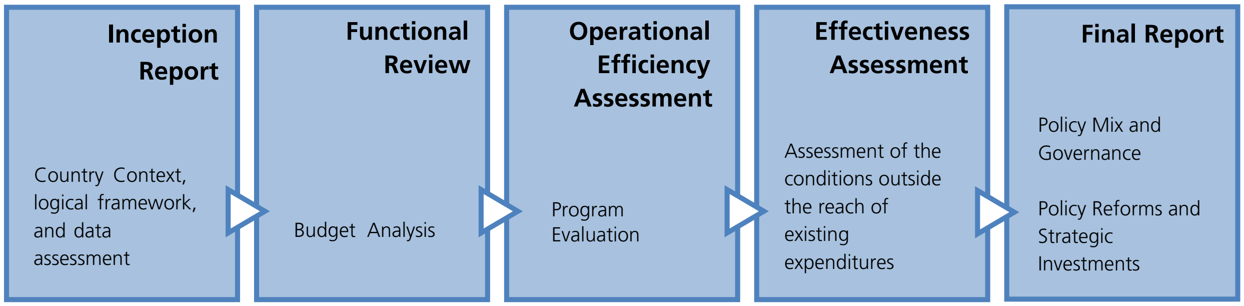
3.4. IMPLEMENTATION ISSUES: A SUMMARY

Five Stages of Implementation

This note proposes that the PER on STI is implemented in five stages. The proposed stages are: (1) Inception Report; (2) Functional Review; (3) (Operational) Efficiency Assessment; (4) Effectiveness Assessment; and (5) Final Report (see figure 3.5). The Functional Review and the Operational Efficiency and Effectiveness Assessments correspond to three out of the four structuring questions discussed in section 3.2. The Final Report stage addresses the issues of coherence, consistency, and relevance of policies and consolidates the results from the previous sections. Each stage builds on the information/analysis obtained in the previous stage.

The Inception Report stage corresponds broadly to the preparation of a concept note. In essence it should

Figure 3.5: The Structure of the Public Expenditure Review on STI



contain a clear definition of the objectives and scope of the work, a thorough assessment of data requirements and availability, and an implementation agreement.

Data Requirements

Access to general STI statistics and data statistics and on public spending—is the central challenge for the implementation of the PER on STI. Table 3.4 summarizes the main data issues by stage of PER. Most of the challenges are related to the availability and quality of budgetary data and data related to the performance of the programs. Statistics on STI for developing countries, at aggregate or firm level, are only partially available—very often with a significant time lag, and with quality and comparability issues. Potentially available data on public spending on R&D are limited by design (categorized at 4-digit levels as a government function by the IMF's 2001 *Government Finance Statistics Manual*) (IMF

Table 3.4: PER Data Requirements—Potential Challenge and Proposed Instrument

Data collection Instrument	***Data required***	***Potential challenge***	***Proposed instrument***
Inception Report	Data on country's economic development and aggregate indicators on NIS	The World Bank WDI database has broad coverage. Aggregate indicators on NIS also have a global coverage	No instrument proposed
Functional Review	Data on government STI spending (public sector budget)	Government Budget Appropriation and Outlays for R&D (GBAORD), the standard indicator, is available for a limited number of countries. GBAORD does not cover non-R&D expenditures related to research or innovation expenditures	Data to be generated through a **policy questionnaire**
Operational Efficiency Assessment	Data on program results from program management	Data may not be available or quality may be poor	Data to be generated through a **survey of beneficiaries**
Effectiveness Assessment	Data on outcomes (scientific excellence; science-industry collaboration and technology transfer; business investments in R&D; non-R&D innovation; technology adoption	Science, technology, and innovation (STI) statistics and innovation surveys (IS)—as defined by UNESCO, OECD, and Eurostat—and national statistical office data will suffice. R&D statistics are sometimes unavailable or of poor quality Data on science performance may be very expensive	Data can be partially generated by a **survey of PROs** World Bank Enterprise Surveys (innovation module) are broadly compatible to the Innovation Surveys

2001). Most expenditure data for non-R&D innovation-related programs are buried in the expenditures of other agencies.[2]

- A thorough review of what data is *available* and *accessible* is therefore essential. Accessibility matters because different parts of the administration not necessarily engaged in the exercise may have more or less willingness to generate (or gather) and provide the required information.
- Three main instruments for data collection are: (i) the policy questionnaire, (ii) a PRO questionnaire, and (iii) a survey of beneficiaries.

Implementation Arrangements

In terms of implementation arrangements, beyond standard planning issues, adequate distribution of responsibilities between the team and the government counterpart is essential. Ideally, the government counterpart should be responsible for providing information available in the public administration but not publicly available (such as information about program budgets, beneficiaries, and outputs), or, at a minimum, facilitating access to it. While data collecting and processing may be time consuming, access to the original registry of information is commonly the biggest bottleneck.

- In this sense, the choice of the counterpart is critical. While ministries in the fields of science, innovation, and technology are natural candidates, one may consider the involvement of ministries of economy or finance.
- The team may also want to consider forming a consultative group or steering committee with key stakeholders. This not only could facilitate access to information but also serve as a sounding board for the exercise. In addition, the mechanism could facilitate consensus-building around the proposed measures and facilitate the future implementation of its recommendations.

The extension of the PER is also adjustable to data availability and access. In countries where STI statistics are well advanced and public expenditures are categorized according to international best practices, it may be convenient to avoid the burdensome process of information collection and limit the analysis to the available information. Countries covered by Eurostat, ERAWACHT, and OECD—where part of the relevant information is generated (see chapter 5 or appendix B on data sources)—are primary candidates to adopt this approach.

The PER can be implemented in a gradual way without necessarily aiming to reach the final phase of the full report. For example, governments can decide to carry out the first stages of analysis (Inception Report and Functional Review) and draw enough conclusions for policy making. It is evident, however, that the strength of the proposed approach comes from the implementation of the five stages of analysis of public expenditures in STI.

2. Indeed, very few, if any, of the public expenditure reviews implemented in the past decades reached a level of disaggregation in which R&D activities are covered.

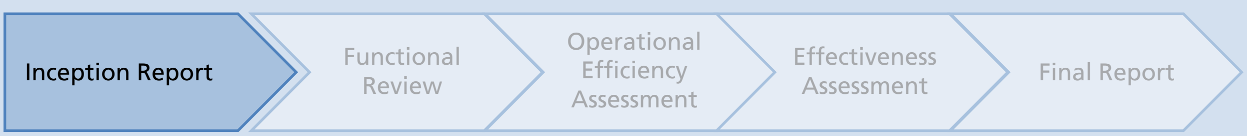
CHAPTER 4

INCEPTION REPORT

The Inception Report (IR) is the first stage in the implementation of the Public Expenditure Review (PER) and provides important background for the rest of the exercise. The information collected for the Inception Report facilitates planning, and provides a foundation for reaching an agreement with the counterpart(s) on the approach for implementing the PER (see figure 4.1).

The chapter starts with a description of the Country Paper in section 4.1. This includes a discussion of the strategic context and benchmarking. This is followed by a discussion of the data assessment in section 4.2, including data sources, data sets, and reports. The chapter concludes with a proposed structure for the Inception Report as well as useful readings.

Figure 4.1: The Inception Report



Summary

The Inception Report includes:

1. A Country Paper that
   (a) Describes the country's economic performance and its main challenges
   (b) Benchmarks the country's national innovation system (NIS)
   (c) Describes the main organizations, policies, and programs
2. A Review of Data Availability and Accessibility
3. A draft Analytical Framework
4. An Implementation Plan

The Inception Report provides the factual basis that can be used to plan the rest of the PER. This includes coming to an agreement with counterpart(s) on:

- The scope of analysis, including, to the extent possible, the expenditures to be addressed, the programs to be reviewed, the outcomes to be covered, and corresponding indicators—which may be expressed as an agreement on the *logical framework* to be adopted by the PER. The scope of analysis will be jointly decided by the counterpart and the team based on the discussion of the logical framework to be adopted, information (data) constraints, the budget and time available for the exercise, as well as the counterpart's level of engagement.
- A conclusion on how to meet the corresponding informational requirements, which may be expressed in a *Data Gathering Plan.*
- The implementation arrangements to be followed by the implementing team and the government counterparts.

The main data sources for the Inception Report are publicly available data sets and reports. These may be complemented with field interviews and focus groups.

4.1. COUNTRY PAPER

The Country Paper aims to (i) generate analysis about the country development priorities; (ii) benchmark the country's NIS; and (iii) describe the key organizations, policies, programs, and regulations of the country's NIS that are relevant to the subsequent stages of the exercise. The strategic context section is useful background information for the discussion of the logical framework. The overview of key institutions, programs, and policies will serve as the basis for the governance and budget analysis in the second stage of the preparation of the PER (the functional review).

The Strategic Context

In this section of the Country Paper, the analyst is advised to report on the main challenges faced by the country in its current stage of social and economic development in order to have a preliminary understanding of the country's demand for innovation and technology.

For example, the productive structure that emerged in some Western Balkan countries after transition toward a market economy—with lower participation of R&D-intensive sectors such as the pharmaceutical industry—reduced the demand for science-industry collaboration and for research commercialization. On the social side, one emerging challenge in some countries is the increasing costs in health care associated with an aging population. Such a context is rare in low-income countries in Sub-Saharan Africa, where the population is young and agricultural productivity and the income of impoverished agricultural workers can be increased by adequate agriculture research and extension services. Demands for research and innovation policy emerging from those two contexts are likely to be substantively different, as will be the trade-offs faced by each country in addressing social and economic goals.

Another important issue to be taken into account is export competitiveness.[1] Recent research suggests that the developing countries which have been more successful in terms of growth of both exports and output have tended to increase the diversity and sophistication of the products they produce and export (UNIDO 2009). In most cases, when diversification and sophistication are coupled, they are an outcome of "moving up the production ladder" from relatively simple mass manufacturing activities, such as textiles or footwear, to increasingly complex production processes, such as metal-mechanical, chemical, or electronics industries (World Bank 2013). Hence the interest of policy makers on addressing competitiveness as a high-level objective.

The technological and innovative capabilities that a country needs to move up the production ladder[2] change significantly according to trade specialization and the level of country development. Some researchers argue that a country's requirements for technological capabilities become more stringent, particularly with respect to innovation capabilities, as countries climb up the development ladder (Fagerberg et al. 2010). On the other hand, less-developed countries would need more basic capabilities such as managerial training.

Following, World Bank (2013a) and Fagerberg et al. (2010), table 4.1 provides a broad taxonomy articulating the type of industrial specialization, the corresponding knowledge sources, and the associated technological capability. For instance, traditional manufacturing technological capabilities are more linked to access to trained labor and modern machinery at affordable prices rather than to direct support for business R&D. Agricultural-intensive industries still rely upon access to machinery and intermediate inputs as the main source of innovation. However, they may also benefit from public support for agricultural research and extension services as well as better enforcement of phytosanitary measures.

The taxonomy is expected to help the analyst start identifying the country's needs in terms of innovation and technology at a given moment in time. But during

1. The remaining of the section is based on the World Bank (2013a): "Trade and Competitiveness Toolkit."

2. That is, "the ability to make effective use of technological knowledge in efforts to assimilate, use, adapt, and change existing technologies" (Kim 1997).

Table 4.1: Industrial Specialization, Knowledge Source, and Technological Capability

Industrial specialization	*Modes of innovation*	*Main source of knowledge*	*Technological capabilities*
Traditional manufacturing (Textiles and apparel, footwear, furniture, tiles, etc.)	Product innovation (including design, logistics, distribution, and marketing) Incremental process innovation (cost reduction) New designs and branding (product differentiation)	Most new techniques originate from machinery and chemical industries Most technology is transferred internationally, embodied in capital goods Product characteristics and quality consistent with international standards	Firm access to internationally competitive machinery, equipment, and intermediate goods. Access to global value chains Managerial and labor skills compatible with adoption of modern technologies and business practices Access to information for product compliance (standards/technical regulations, including packaging and labeling) Certification capacity and internationally recognized certifiers Trademarks regime to enable firms' appropriate innovation efforts
Natural resource-based (Sugar, tobacco, wine, fruit, milk, mining industry)	Process innovation (cost reduction) Main emphasis on health (food safety) and environmental issues Certification of origin or production technique (organic products)	Most new techniques originate from machinery, chemical, and biotechnology industries Knowledge is transferred internationally, embodied in capital goods and intermediate goods (such as fertilizers, pesticides, seeds, etc.) Knowledge specific to an industry/region/country may need to be generated	Firm access to internationally competitive machinery, equipment, and intermediate goods. Access to global value chains Testing laboratory and internationally recognized accreditation Patent regulation and an efficient system of intellectual property rights Public research system and public investments in R&D
Complex products (Automobile and auto components, consumer electronics, pharmaceuticals, machinery, equipment, and precision instruments)	Incremental product and process innovation Radical innovations based on scientific discoveries Provision of customized goods and services (e.g. software, precision equipment)	Technological accumulation is generated by the design, building, and operation of complex production systems or products Important user-producer interactions. Learning from advanced users High in-house R&D for development of cutting edge technologies	Firm access to internationally competitive machinery, equipment, and intermediate goods. Access to global value chains Labor skill (specialized workers, technicians, engineers, and researchers) Metrology laboratory upgrading toward internationally recognized accreditation, inter-calibration schemes Public support to business R&D Public research system and public investments in R&D. Emphasis on research commercialization and science-industry collaboration

Sources: World Bank 2013; Fagerberg et al. 2010.

a catching-up process, the appropriate level of technological capability is a moving target in constant need of improvement (Bell and Pavitt 1993). Assessing the country's trade opportunities would help one understand the capabilities needed by the country in the future in order to move up the production ladder. Three main sources of trade opportunities may be considered: (i) diversifying geographic markets, (ii) improving product sophistication, or (iii) exporting newly created products (innovation). Each type of opportunity will generate a

Box 4.1: Thailand's Cassava Exports

Until 2012, Thailand's exports of dried cassava to China were not subject to any quality or food safety regulation. Only a minimum level of starch content was required. By contrast, Thailand's exports of cassava pellets to the EU are required to meet two demanding sets of standards: the Good Manufacturing Practice (GMP) code, covering sanitary and processing procedures, and the Hazard Analysis Critical Control Point (HACCP), as cassava pellets are an input into animal feeds. Thailand's successful entry into EC cassava markets required its domestic exporters to develop greater technological capabilities than needed for exporting to China.

Source: World Bank 2013.

specific set of technological capabilities, as in the case of geographic diversification of Thailand's cassava exports (box 4.1).

Data on trade performance and industrial structure available from sources such as the World Bank's World Development Indicators are a preliminary source of information. In addition, the "Trade and Competitiveness Toolkit" (World Bank 2013) provides a comprehensive list of possible indicators, as well as qualitative and quantitative methodologies on how to develop a broader competitiveness assessment. As a starting point, we suggest that the analyst focus on the following issues:

- What is the country's current trade specialization? What are the innovation and technological capabilities required for sustaining existing export performance?
- What are the country's trade opportunities in terms of diversifying geographic markets, increasing product sophistication, and introducing new products (non-R&D or R&D-based?)
- What are the innovation and technological capabilities needed by the country to explore each of the opportunities identified?

In developing the Country Strategic Context, a number of World Bank reports on competitiveness, productivity, trade, and innovation are potentially a useful starting point. Those topics are often covered by Country Economic Memorandums (CEMs), Investment Climate Assessments (ICAs), Trade Outcome Notes, and others. They provide a first glance at the competitiveness challenged faced by the country.

Benchmarking the Country's NIS

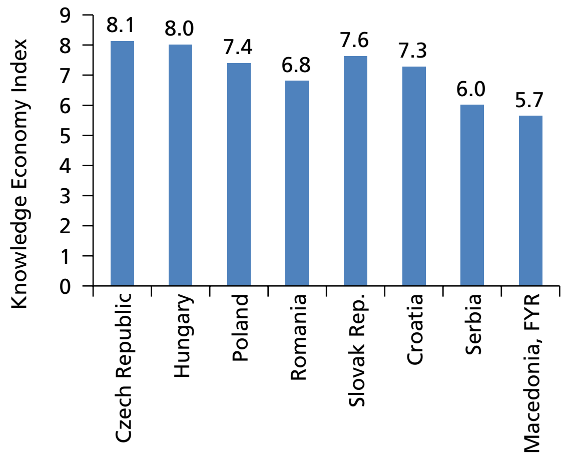
This section aims to give the PER team a sense of the strengths and weaknesses of the country's NIS. There is no standard methodology to do such work. Different organizations present different but largely interchangeable methodologies, often based on aggregate indicators. The indicators try to cover the different aspects of a national innovation system (including science-industry collaboration, overall investments in R&D, innovation performance, and so forth). Four indicators are illustrated in figure 4.2 for countries in Central and Eastern Europe. Indicators shown are the Knowledge Economy Index from the World Bank's Knowledge Assessment Methodology, the Global Innovation Index, the Global Competitiveness Index, and European Union's Innovation Union Scorecard (UIS). The methodologies for these indices are described in appendix C.

Overview of Key Institutions, Programs, and Policies

Identify the key research and innovation stakeholders, including policy makers, implementing bodies, and beneficiaries (including public research institutes, higher education institutions, and the largest beneficiaries in private sector).

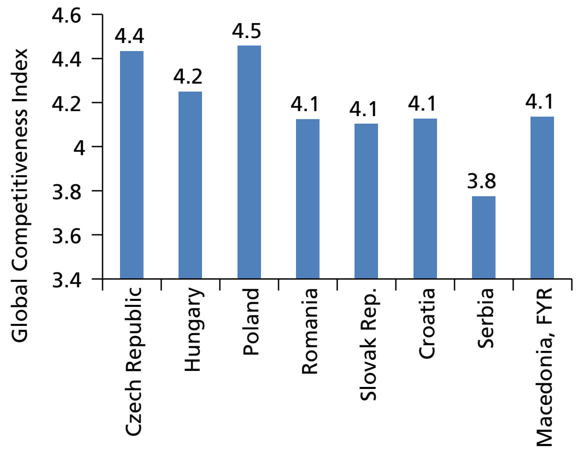
Figure 4.2: Illustration of Different Measures of Countries' NIS

(a) Knowledge Economy Index



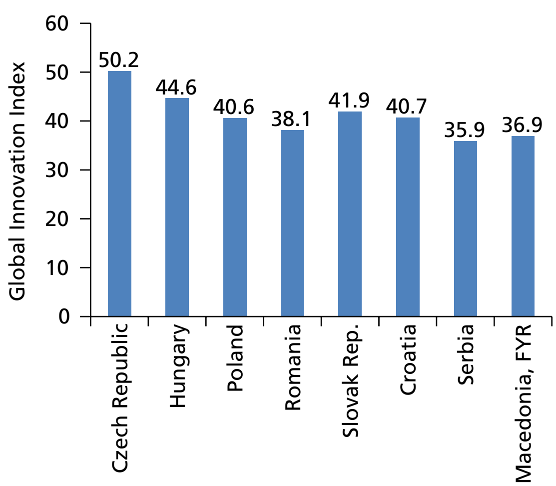
Source: Knowledge Assessment Methodology 2012 (www.worldbank.org/KAM)

(b) GCI's Global Competitiveness Index 1–7 (best)



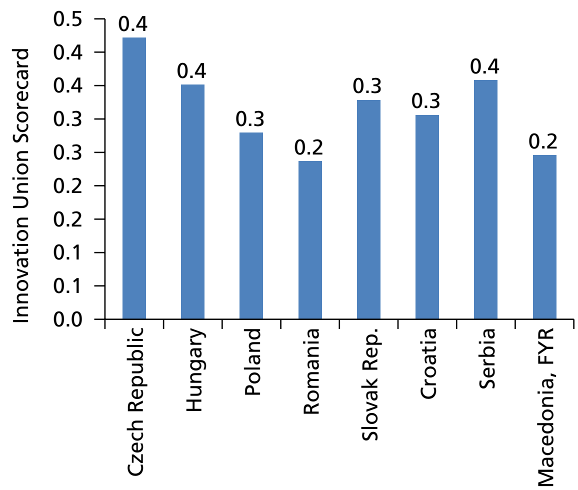
Source: Global Competitiveness Index (http://www.weforum.org/issues/competitiveness-0/gci2012-data-platform/)

(c) Global Innovation Index



Source: The Global Innovation Index (http://www.globalinnovationindex.org/content.aspx?page=data-analysis)

(d) Innovation Union Scorecard



Source: Innovation Union Scorecard (http://ec.europa.eu/enterprise/policies/innovation/policy/innovation-scoreboard/index_en.htm)

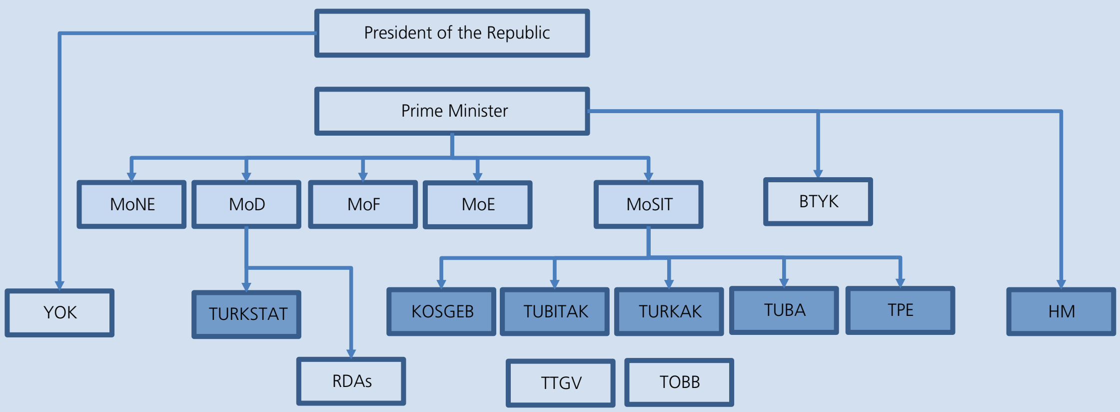
Collect the key strategic documents (those establishing long-term vision, priorities, and so forth); the main legal documents (related to key stakeholders, mandate of policy making bodies, and so forth); the list of main policies, programs, and their respective regulations; and documentation of the composition of policy-making bodies, regulations, and mandates.

- What is the overall governance structure for managing research and innovation policies in the country?
- Who are the key innovation policy stakeholders? Organize them using a hierarchical map that outlines the governance structure and provides detailed descriptions of roles and mandates (as illustrated for the case of Turkey in box 4.2).

Box 4.2: Structure of the Research and Innovation System in Turkey

At the political level, the Turkish research system is led by the Supreme Council of Science and Technology (BTYK), a legally formalized body chaired by the prime minister. The BTYK determines, directs, and coordinates research and innovation policies, and is composed of relevant ministers, heads of public and private bodies, universities, and nongovernmental organizations. The Scientific and Technological Research Council of Turkey (TUBITAK) is affiliated to the Ministry of Science, Industry, and Technology (MoSIT) and acts as the secretariat of the BTYK. The Ministry of Development (MoD) and the High Planning Council (YPK) are two other important actors in the design and implementation of STI policies. The Ministry of National Education (MoNE) and the Council of Higher Education (YOK) design and implement education policies, and integrate them with research policies. The Turkish Academy of Sciences (TUBA) determines and recommends scientific priority areas and proposes legislation to the government on issues related to scientists and researchers.

Figure B4.2.1: Overview of Turkey's Research and Innovation System Governance Structure



BTYK:	Supreme Council of Science of Technology
MoF:	Ministry of Finance
MoSIT:	Ministry of Science, Industry and Technology
MoNE:	Ministry of National Education
MoD:	Ministry of Development
MoE:	Ministry of Economy
TUBITAK:	Scientific and Technological Research Council of Turkey
KOSGEB:	SME Development and Support Organization
HM:	Undersecretariat of Treasury
YOK:	Higher Education Council
TUBA:	Turkish Academy of Sciences
TSE:	Turkish Standards Institute
TURKSTAT:	Turkish Statistical Institute
RDAs:	Regional Development Agencies
TTGV:	Technology Development Foundation of Turkey
TURKAK:	Turkish Accreditation Agency
TPE:	Turkish Patent Institute
TOBB:	Union of Chambers and Commodity Exchange of Turkey

At the operational level, the leading actor in the system is TUBITAK. It designs and implements programs to increase R&D activities of the public and private sectors and universities. The Small and Medium Enterprises Development Organization (KOSGEB) and the Technology Development Foundation of Turkey (TTGV) are the other main bodies implementing industrial R&D support measures. The Turkish Patent Institute (TPE) carries out the procedures related to industrial and intellectual property rights. The Turkish Accreditation Agency (TURKAK) deals with the accreditation of organizations and laboratories. The primary research performer in the public sector is the Marmara Research Center of TUBITAK. It provides contractual research, testing, training, consultancy, analysis, and certification services in its research centers, and operates a technopark. TUBITAK's institutes are the most active research organizations conducting research in their fields of specialization. For nuclear research activities, the Turkish Atomic Energy Authority is the main body both for strategy preparation and for carrying out research activities. There are also the R&D centers operating under universities and various ministries, such as the ministries of Energy and Natural Resources, and Food, Agriculture and Livestock.

Apart from public research agencies, the private sector established R&D centers in the context of Law No. 5746, which concerns the support of research and development activities. Moreover, the gains acquired from application of Technology Developing Zones Law No. 4691 create potential for private sector R&D.

Source: Erdil and Çetin 2014.

4.2. DATA ASSESSMENT

Data quality, access, and the possibility of gathering unavailable data affect the scope and depth of the application of any given logical framework. Besides helping establish the final scope and depth of the overall PER, the data assessment framework will help the team to decide if and when to start surveys and questionnaires.

STI data is normally generated by the national statistical offices through surveys of beneficiaries (at the "point of use"), following the methodology established by the OECD (2002) *Frascati Manual*.

The *Frascati Manual* describes how to divide R&D expenditure and employment into different categories. This includes the types of R&D, basic research. applied research and experimental development, and the institution conducting it namely business enterprises, government (as is done with GBAORD), private non-profit, higher education, and expenditure on institutions outside the country or abroad. A number of definitions from the *Frascati Manual* are reproduced in appendix A. The main indicators from the *Frascati Manual* are as follows:

- Indicators for expenditure include:
  - Gross domestic expenditure on R&D (GERD) is the total intramural expenditure on R&D where intramural expenditures are all those performed within the economy during a specific period
  - Gross national expenditure on R&D (GNERD) comprises total expenditure on R&D financed by a country's institutions and so includes expenditure on R&D performed outside the country
  - Government budget appropriations or outlays for R&D (GBAORD) this aggregates expenditure by government
- Employment on R&D, including those workers employed directly on R&D as well as those providing direct services such as R&D managers, administrators, and clerical staff.

STI data in developing countries have limitations in terms of quality and availability. Data quality varies among countries because, despite the widespread use of the *Frascati Manual*, significant usage gaps remain, especially in Africa, Central and South Asia, and Latin America and the Caribbean (OECD 2002). Data availability varies because the surveys of beneficiaries (at the point of use) are costly to implement. Countries with more fragile statistical systems, therefore, will likely lack the resources to develop this information. When available, data provision will inevitably occur with significant time lags (of two or more years sometimes, even for developed countries). Yet data coverage has improved recently: for instance, by the mid-2000s, UNESCO estimated that some R&D data was available for more than half of African countries (Ellis 2008).

The feasibility of data collection (time, cost, and quality) needs to be carefully considered. Relevant considerations include the likelihood of local collaboration and willingness to bare the primary responsibility for forging the collaboration with third parties within the public administration**.**

For each of the following types of data—R&D statistics; innovation survey; budgetary information; program reporting; beneficiary's data; agreed outputs; and agreed outcomes—assess:

- What data is publicly available and the quality of the data (STI statistics)
- Data availability and accessibility of data not directly available (budgetary information)

STI Statistics

STI data is generated by the national statistical offices through surveys of beneficiaries (at the point of use), following the methodology established by the *Frascati Manual*. The manual, originally written for the national experts in OECD member countries who collect and issue national R&D data, became the standard for conducting R&D surveys and data collection in other UN member states, for example through the science and technology (S&T) surveys of the UNESCO Institute for Statistics (UIS) (NESTI 2011).

Box 4.3: The World Bank Science, Technology, and Innovation Database

A useful source of data is the World Bank Science, Technology and Innovation (STI) Database—a "one-stop shop" for macro- and micro-level datasets on STI and entrepreneurship indicators. It aggregates 15 data sources, including some with world-wide coverage. The database comprises more than 500,000 records covering 180 countries and providing insight into almost 600 indicators. The indicators organized by source and categories and user-friendly devices allow the generation of country-level summaries. The website is:

http://fpdweb.worldbank.org/units/fpdvp/fiedr/sti/Pages/Home.aspx.c.

- UIS collects S&T data from more than 200 countries around the work through biennial R&D surveys and through partnerships with other statistical organizations. Data cover a number of variables related to STI, including those related to human resources.
- OECD's Main Science and Technology Indicators (MSTI) database compiles a similar range of data generated by country's statistical offices with a focus on its member economies.

Innovation Statistics

In addition to the standard R&D statistics, a number of firm-level innovation surveys have been implemented in recent years. Firm-level data on innovation are available in most EU member countries in the format of Community Innovation Surveys (CIS), available online at the Eurostat website.[3] Innovation surveys are less frequent in developing countries: for instance, in the African continent, only Morocco, South Africa, and Tunisia had developed that instrument by 2008 (Ellis 2008).

- The 2013–14 round of the World Bank's Enterprise Survey has a new module on innovation performance, which is to a large extent compatible with the standard innovation surveys. Combined with a variety of other data sources, firm-level data has given a richer picture of innovative activity at the firm level and of the ways in which knowledge is generated and transmitted within and between firms (Hall and Mairesse 2006).

Table 4.2 presents a summary of the most recent national innovation survey that was carried out by a list of non-OECD and non-Eurostat countries. The information was obtained through a metadata collection implemented by UNESCO-UIS from September 2012 to April 2013. It shows that most of the surveys were conducted in 2012 and 2010. Although there is no harmony in the years covered by these surveys, in 16 out of 24 countries the observation period had a length of three years. It is noteworthy that in 8 countries the national statistical office (NSO) was the agency in charge of the survey.

Information on Institutions, Policies, and Programs

A useful source of information is the existing reports on innovation policy. Several organizations perform, with some regularity, analyses of national innovation systems, benchmark exercises, reviews of policy trends, and so forth. Some of those reports concentrate on gathering factual information about the recent developments at the organizational, policy, or program levels.

The appendix to this chapter summarizes the coverage of some of those reports—namely, the OECD Reviews of Innovation Policy, United Nations Conference on Trade and Development (UNCTAD), STIP Reviews, the ERAWATCH Country Reports, and INNOTREND Mini-Country reports—in terms of the following issues: governance and policy assessment, policy measures, innovation budget data, STI systems, economic performance and framework conditions, as well as main policies and programs. While frequency also varies, they are useful sources of background information.

3. http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/.

Table 4.2: Most Recent Innovation Surveys (as of 2013)

Country	*Survey name and year*	*Observation period*	*Institution in charge*
Azerbaijan	On innovation activity of enterprises 2012	2011 (calendar year)	The State Statistical Committee
Belarus	Innovation activity of organisation 2012	2011 (calendar year)	National Statistical Committee of the Republic of Belarus
China	Industrial Enterprises Innovation Survey 2007	2004–2006	National Bureau of Statistics of China
Hong Kong SAR, China	Survey of Innovation Activities 2010	2010 (calendar year)	Census and Statistics Department
Colombia	Quinta encuesta de desarrollo e innovación tecnológica en la industria colombiana 2011	2009–2010 (calendar year)	Departamento Administrativo Nacional de Estadísitica (DANE)
Costa Rica	Encuesta Nacional de Indicadores de Ciencia, Tecnología e Innovación 2012	2010–2011	Ministerio de Ciencia y Tecnología
Cuba	Encuesta Nacional de Innovación 2006	2003–2005 (calendar year)	Ministerio de Ciencia, Tecnología y Medio Ambiente (CITMA)
Dominican Republic	Encuesta Nacional de Innovación 2010	2007–2009 (calendar year)	Ministerio de Educación Superior, Ciencia y Tecnología
Ecuador	Encuesta de Actividades de Innovación 2013	2009–2011 (calendar year)	Secretaría Nacional de Educación Superior, Ciencia, Tecnología e Innovación (SENESCYT)/ Instituto Nacional de Estadística y Censos (INEC)
Ethiopia	Ethiopian National Innovation Survey 2011	2011 (fiscal year)	Ministry of Science and Technology
Indonesia	Innovation survey in manufacturing industry 2011	2009–2010	Indonesian Institute of Sciences (LIPI)
Lesotho	Lesotho Innovation Survey 2012	2009/10–2011/12	Department of Science and Technology
Malaysia	National Survey of Innovation (NSI-6) 2012	2009–2011	Ministry of Science, Technology and Innovation
Palestine	Palestinian Community Innovation Survey 2010	2006–2008	Palestine Academy for Science and Technology (PALAST)
Panama	Encuesta de Investigación, desarrollo e innovación en el sector privado de Panamá 2008	2006–2008 (calendar year)	Secretaria Nacional de Ciencia y Tecnología
Paraguay	Encuesta para la determinación de la línea de base de innovación tecnológica en empresas paraguayas 2007	2004–2006	Consejo Nacional de Ciencia y Tecnología (CONACYT)
Peru	Encuesta Nacional de Innovación el la Industria Manufacturera 2012	2009–2011	Instituto Nacional de Estadística e Informática
Philippines	Survey of Innovation Activities by Establishments 2010	2009–2010	Department of Science and Technology
Serbia	Community Innovation Survey 2010	2008–2010	Statistical Office of the Republic of Serbia
Tunisia	Enquête R&D et Innovation 2008	2005–2007	Bureau des Etudes et de la planification, Ministère de l'Enseignement supérieur et de la Recherche Scientifique
Uganda	National Innovation Survey 2012	2008–2010 (calendar year)	Uganda National Council for Science and Technology (UNCST)
Ukraine	The innovative activity of enterprise survey 2010	2008–2010 (calendar year)	State Statistics Service of Ukraine
Uruguay	IV Encuesta de Actividades de Innovación en Industria/II Encuesta de Actividades de Innovación en Servicios 2010	2007–2009	Agencia Nacional de Investigación e Innovación (ANII)
Zambia	National Survey on Innovation 2012	2008–2010	Department of Planning and Development, Ministry of Science, Technology and Vocational Training

Source: UNESCO-UIS 2013.
Note: For Ecuador and Malaysia, the surveys were still ongoing when metadata were submitted.

As discussed in table 4A.1 in annex A of this chapter, the reports on institutions, policies, and programs have different levels of coverage, with some specializing in some areas and not others:

The OECD reports are the most comprehensive with theoretical background, detailed analysis of a country's economic performance, innovation framework conditions, STI system including SWOT analysis and broad scope of data. In the majority of cases, each element is carefully introduced, assessed with suggestions for improvement built on international best practices suitable to the examined country. Since these are not annual report, their structure differs among the country cases. The OECD framework offers the most detailed analysis of responsibilities of each institution in the STI management system with recommendations on improvements, including suggestions for creation of new agencies based on other countries' experience.

UNCTAD's STIP reviews are similar to the OECD studies. The studies present careful analyses of selected sectoral innovation systems.

ERAWATCH Annual Country Reports (started in 2009) characterize and assess the performance of national research systems and related policies. Since these are annual reports, each report builds on a previous one, therefore focusing on recent policy changes rather than repeating what has been already said. Thus every year's report focuses on specific barriers in reaching the Lisbon goal, and provides analysis on the country policy mix routes and instruments to address the barriers. Also the studies investigate contribution of national policy mixes to the realization of the European Research Area. The reports offer policy assessment rather than recommendations on the approaches in enhancing the policy.

The 2011 INNO-Policy TrendChart mini country reports comprise the most detailed information on innovation financing, containing STI budget by ministry/instrument/financing source; broad composition of available national budgets by main categories of research and innovation measures (with budget and programs under each category); as well as description on future challenges for funding of innovation policy. INNO-Policy TrendChart mini reports (2011) primarily focus on recent changes in STI policy, existing innovation policy instruments, and RD&I budgets.

The UNESCO STI studies' structure and content varies among countries, and therefore, it is difficult to compare with other frameworks. The title of each of the UNESCO's study indicates the analysis area related either to formulation of STI strategy or a review.

4.3. CONCLUSION

This chapter described how to implement the Inception Report. The chapter began by describing the Country Paper. This included a discussion of the strategic context; benchmarking the country's NIS; and an overview of key institutions, programs, and policies. This provides a sense of the strengths and weaknesses in the NIS. This was followed by a data assessment, which discussed STI statistics; innovation statistics; and information on institutions, policies, and programs. The availability, ease of accessing, and quality of data is a major constraint on the rest of the PER exercise and so this section provides important inputs into planning the rest of the PER exercise. Box 4.4 provides a possible structure for the Inception Report as well as useful readings. The next chapter describes the Functional Review, which provides guidance on reviewing STI expenditures.

Box 4.4: The Inception Report—Possible Structure and Useful Readings

A proposed structure for the Inception Report as a standalone document

Executive Summary

1. Introduction
2. Country Paper
   a. Economic performance and main challenges
   b. Organizations, policies, and programs in the national innovation system
   c. Benchmarking the national innovation system
3. Data Availability and Accessibility
4. Analytical Framework
5. Implementation Plan
   a. Scope of analysis
   b. Data collection requirements
   c. Implementation arrangements
   d. Timeline
6. Conclusion

Useful readings

Organisation for Economic Co-operation and Development (OECD). 2008a "OECD Reviews of Innovation Policy, Norway." OECD, Paris. Available at: www.oecd.org/sti/innovation/reviews.

United Nations Conference on Trade and Development (UNCTAD). 2012. "Science, Technology & Innovation Policy Review Dominican Republic." UNCTAD/DTL/STICT/2012/1. United Nations, New York, NY.

World Bank. 2009. "Turkey National Innovation and Technology System: Recent Progress and Ongoing Challenges." Europe and Central Asia Region. Report No. 48755-TR. World Bank, Washington, DC.

ANNEX A: COMPARISON OF INNOVATION FRAMEWORKS ACCORDING TO MAIN CONTENT CATEGORIES

Table 4A.1: Comparison of Innovation Frameworks According to Main Content Categories

	OECD Reviews of Innovation Policy	UNCTAD's STIP Reviews	ERAWATCH Country Reports (annual)	EU INNO Policy Trendchart (2011 mini reports)
Objective	**A comprehensive assessment of an innovation system**	**Diagnostic analysis of STI effectiveness**	**Characteristics and assessment of the performance of national research systems and related policies/focus on recent policy changes**	**Assessment of innovation policy trends**
Reports that the table is based on	*Norway and partly Peru*	*El Salvador and Peru reports*	*All reports*	*All reports*
I. GOVERNANCE, INNOVATION POLICY ASSESSMENT				
Main current innovation policy priorities and challenges	√	√	√	√
Innovation system governance—description	√ (analyzed and assessed in great detail)	√	√	√ + the regional level
Assessment of each ministerial bodies in innovation policy	√	—	—	—
Innovation governance assessment	√	√	√ (refers to national research system)	√ (with SWOT analysis) +governance at the regional level
Governance recommendations	√ (recommendation built on experiences from other countries)	—	—	—
Summary of existing innovation evaluations (if any)	√	√	—	√ (mentioned)
Benchmarking innovation performance	√	√	—	—
Overall assessment of innovation/research policy	√ (with SWOT analysis)	√	√ (with strengths and weaknesses)	√

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Table 4A.1 (continued)

	OECD Reviews of Innovation Policy	UNCTAD's STIP Reviews	ERAWATCH Country Reports (annual)	EU INNO Policy Trendchart (2011 mini reports)
Objective	**A comprehensive assessment of an innovation system**	**Diagnostic analysis of STI effectiveness**	**Characteristics and assessment of the performance of national research systems and related policies/focus on recent policy changes**	**Assessment of innovation policy trends**
Reports that the table is based on	*Norway and partly Peru*	*El Salvador and Peru reports*	*All reports*	*All reports*
II. POLICY MIX MEASURES				
Policy mix issues—theoretical background	√	—	—	—
Direct policy mix measures—description	√	√	√	√
Examples of data used in direct policy mix measures	S&T and innovation funds/programs—their budget over time, expenditures according to, loans, budget support, other resources; committed and executed budget.	Types of instruments, some data on budget and distribution for some programs. Contains good practices in the use of STI policy instruments.	Depends on a report, e,g. 2009 reports incl. programs with criteria and overall budget listed along policy mix routes	-
Indirect policy mix measures	√ (detailed, with details and comparison of practices in OECD countries; Estimated revenue losses due to R&D tax incentives as a % of GBAORD; Generosity of fiscal support to R&D in OECD countries)	√ (briefly described incl. Intellectual property, Quality system; no data)	√ Depends on a report, e,g. in 2009 public funding trends for knowledge demand, including networks, cluster, TTOs, etc. (new initiatives with budgets)	√ (recent changes in the innovation policy mix, no data)
Assessment of policy mix issues/barriers	√ (with trends in financing + international comparison; detailed budgets of instrument)	√ (plus recommendation and case studies for other instruments)	√ Main policy opportunities and risks, Main barriers to R&D investments and respective policy opportunities and risks	—
Contribution of national policy mixes to the realization of the European Research Area	— (briefly on international links)	—	√ Very comprehensive	—

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Table 4A.1 (continued)

	OECD Reviews of Innovation Policy	UNCTAD's STIP Reviews	ERAWATCH Country Reports (annual)	EU INNO Policy Trendchart (2011 mini reports)
Objective	**A comprehensive assessment of an innovation system**	**Diagnostic analysis of STI effectiveness**	**Characteristics and assessment of the performance of national research systems and related policies/focus on recent policy changes**	**Assessment of innovation policy trends**
Reports that the table is based on	*Norway and partly Peru*	*El Salvador and Peru reports*	*All reports*	*All reports*
III. INNOVATION BUDGET DATA				
Level of detail	Detailed estimates	Basic	Basic	Very detailed and recent estimates (2010-2011)
Data example	• Estimates of **total expenditures on STI activities by source of funds** (i.e. direct budgetary resources and to which institution' Multilateral financing institutions' loans, Private universities, business sector, other sources) • Estimated **R&D appropriations by ministry** • Selected STI programs' budget and spending categories (i.e. financing HR, innovation, basic/ applied R&D, scholarships, etc.) • Returns from the Norway's research fund • Bottom-up funding of free basic research	GERD/BERD, selected programs budgets with results	GERD/BERD, selected programs budgets with results	• **Innovation budgets of the main government departments and agencies** • Broad composition of available **national budgets by main categories of research and innovation measures** (i.e. categories: Governance & horizontal research and innovation policies; R&T; HR; Enterprise innovation; market and innovation culture) with budget and programs under each category) • Future challenges for funding of innovation policy • Research and innovation policy measures with start and end date, budget and commentary
Data analysis	Trends in R&D expenditures, their reasons, comparison with other developing and the OECD countries	Deeper analyses regarding biometric analysis; and patent analysis	Data analysis from the perspective of the reasons, main barriers to R&D investments and respective policy opportunities and risks	Description of trends in spending, with major reasons without deeper data analysis

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Table 4A.1 (continued)

	OECD Reviews of Innovation Policy	UNCTAD's STIP Reviews	ERAWATCH Country Reports (annual)	EU INNO Policy Trendchart (2011 mini reports)
Objective	**A comprehensive assessment of an innovation system**	**Diagnostic analysis of STI effectiveness**	**Characteristics and assessment of the performance of national research systems and related policies/focus on recent policy changes**	**Assessment of innovation policy trends**
Reports that the table is based on	*Norway and partly Peru*	*El Salvador and Peru reports*	*All reports*	*All reports*
IV. ECONOMIC PERFORMANCE AND FRAMEWORK CONDITIONS FOR INNOVATION				
Macro-economic performance review	√	√	—	—
Labor force issues—education, training, mobility and flexibility Division among main R&D performers	√	√	√	—
ICT infrastructure	√	√	—	—
Innovation inputs indicators review	√ (detailed)	√ (detailed)	√ (brief)	—
V. SCIENCE, TECHNOLOGY AND INNOVATION SYSTEM				
STI system and governance theory	√	—	—	—
Institutional and legislative framework of science, technology and innovation (STI)	√	√	√	√
STI institutional structure	√	√	√	—
Governance at the regional level	√	√	√ (trends on RIS policy)	—
Innovation at sectoral level	√ (brief)	√ (detailed analysis of inn sys. in selected sectors)	—	√ (brief sectoral specificities of recent policy initiatives)

(continued next page)

Table 4A.1 (continued)

	OECD Reviews of Innovation Policy	UNCTAD's STIP Reviews	ERAWATCH Country Reports (annual)	EU INNO Policy Trendchart (2011 mini reports)
Objective	**A comprehensive assessment of an innovation system**	**Diagnostic analysis of STI effectiveness**	**Characteristics and assessment of the performance of national research systems and related policies/focus on recent policy changes**	**Assessment of innovation policy trends**
Reports that the table is based on	*Norway and partly Peru*	*El Salvador and Peru reports*	*All reports*	*All reports*
VI. STI MAIN ACTORS				
a. Innovation in business sector/ entrepreneurship review	√ (detailed)	√ (brief)	√ (brief)	—
Financing through market (e.g. Venture capital, business angels)	√	√	— (only mentioned)	—
Assessment of the barriers for innovation in the business sector	√	√	√ (brief)	—
b. Public research institutes (PRIs)				—
Description of current situation + legal documents	√	√	√	—
Details on PRIs	√ Details under which ministry, budget with share of institutional funding, main focus areas, number of personnel.	√ Information on some institutes and under which ministry they are, no budget data.	√ 2009 reports: General information on RIs number with names of the main ones, no data on budgets. 2010 : very basic inf.	—
STIs challenges	√	√	√ (summary assessment of strengths and weaknesses of the national research system)	—
Strategic vision with recommendation and STIs case studies from other countries	√	—	—	—

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Table 4A.1 (continued)

	OECD Reviews of Innovation Policy	UNCTAD's STIP Reviews	ERAWATCH Country Reports (annual)	EU INNO Policy Trendchart (2011 mini reports)
Objective	**A comprehensive assessment of an innovation system**	**Diagnostic analysis of STI effectiveness**	**Characteristics and assessment of the performance of national research systems and related policies/focus on recent policy changes**	**Assessment of innovation policy trends**
Reports that the table is based on	*Norway and partly Peru*	*El Salvador and Peru reports*	*All reports*	*All reports*
PRIs Trends in policy reforms	√ (based on the OECD countries)	—	√ (assessment)	—
Vision for PRI development strategy	√ (rec. based on the OECD experience)	—	—	—
Governance of PRIs	√	√	√	—
PRIs financing issues	√	√	—	—
Collaboration with the productive sector	√ (with rec. based on the OECD experience)	√	√ Knowledge transfer/knowledge circulation (policy programs targeting this issue as policy mix—knowledge circulation)	—
Examples of public-private partnerships for science, techonology, and innovation for consideration	√	—	—	—
Issue of monitoring and evaluation of institutes' performance	√ (with performance evaluation practices in other countries)	√	√	—

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Table 4A.1 (continued)

	OECD Reviews of Innovation Policy	UNCTAD's STIP Reviews	ERAWATCH Country Reports (annual)	EU INNO Policy Trendchart (2011 mini reports)
Objective	**A comprehensive assessment of an innovation system**	**Diagnostic analysis of STI effectiveness**	**Characteristics and assessment of the performance of national research systems and related policies/focus on recent policy changes**	**Assessment of innovation policy trends**
Reports that the table is based on	*Norway and partly Peru*	*El Salvador and Peru reports*	*All reports*	*All reports*
Policy framework for patenting by PRIs and universities	√ (with review of existing laws in other countries)	— (general info on patent data)	—	—
Universities in research	√	√	√	—
c. The higher education sector—focus on R&D cooperation and innovation plus assessment and recommendations	√ (detailed)	√ (brief, without indicators, trends, comparisons)	√ (recent changes in education policies having impact on innovation)	—
Education indicators	√	√	√	—
Challenges and bottlenecks	√	√	√	—
R&D activities, university funding and programs	√ (many indicators and data)	—	—	—
HE governance and regulatory issues	√	√	√ (also assessment of the educational reforms)	—
Research at universities	√	√	√	—

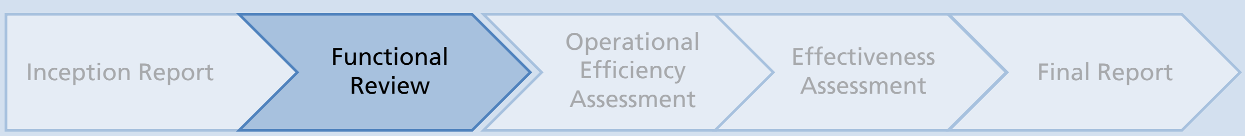
CHAPTER 5

FUNCTIONAL REVIEW

The Functional Review (FR) is the second stage in the preparation of the Public Expenditure Review (PER). The FR addresses questions related to how much is spent by the government on science, technology, and innovation (STI); by whom; and to achieve what objectives (see figure 5.1).

The chapter starts with a discussion in section 5.1 of how to prepare the STI budget, including an outline of its structure and an explanation of how to create it. Section 5.2 continues with a practical example. Section 5.3 concludes with a comparison between the proposed STI budget and other similar indicators.

Figure 5.1: The Functional Review



Summary

The objective of the Functional Review (FR) is to describe the flow of funds in the research and innovation sector. It describes how much is being spent, by whom, and for what objectives. This includes identifying the intermediate outcomes that the spending aims to achieve. Four intermediate outcomes are proposed: (i) research excellence, (ii) science-industry collaboration and technology transfer, (iii) business R&D and startups, and (iv) technology adoption.

Important challenges must be overcome to implement the FR. These include accessing budget and expenditure data, overcoming quality issues in the data, and identifying spending on innovation, when innovation is not among the categories typically used to categorize government spending.

The **Inception Report** provides information on the programs and organizations operating as well as publicly available RDI spending data. Additional data comes from:

- Government, including proposed, approved, and actual disbursements
- Policy questionnaires (examples of which can be found on data collection on tax incentive support for R&D expenditures (OECD 2013b), and STI policies for nanotechnology (OECD 2008b)
- Interviews with selected organizations, including ministries of finance, economic growth, and other sectors

The chapter starts with a brief description of the expected content of the mapping of STI spending in section 5.1, followed by discussion of some assessment questions for the governance analysis in section 5.2. The remainder of the chapter is dedicated to the preparation of the STI Budget with a proposed STI budget structure and how to implement it. Section 5.3 continues with a practical example and section 5.4 concludes with a comparison between the proposed STI budget and other similar indicators.

The work can be complemented by a governance analysis—when, for example, the exercise is restricted to this stage**.** The governance analysis focuses on how the existing governance structure leads to the current allocation of resources. The information for this analysis is generated in the Inception Report discussed in chapter 4 (main organizations, policies, and programs). The assessment questions for the governance analysis are presented in chapter 8.

Box 5.1: Government STI Spending in Turkey According to Implementing Agency and Programs, 2005–08

The Turkish Government's investments in public innovation and technology support programs have risen substantially in recent years and are projected to continue to increase. During the 2005–08 period, the government allocated a significant amount of additional resources (over US$1.5 billion) from its budget, primarily to the Scientific and Technological Research Council of Turkey (TUBITAK). Public resources allocated to innovation and technology support programs have more than tripled in the last 10 years with public R&D expenditures as a share of GDP rising from 0.67 percent in 2002 to 0.8 percent in 2006. Over the same period, the number of full time equivalent researchers grew from 23,995 to 28,000. The main public agencies in the Turkish NIS that implement STI support programs are TUBITAK, the Technology Development Foundation of Turkey (TTGV), the Small and Medium Enterprises Development Organization (KOSGEB), the Ministry of Industry and Trade (MoIT), and universities. A summary of the main allocation of funds within Turkey's NIS from 2005 to 2008 is provided in table B5.2.1.

Table B5.1.1: Public Expenditures on Innovation and Technology Programs

Implementing Agency	***2005***	***2006***	***2007***	***2008***
Universities	*274.2*	*278.7*	*256.3*	*253.5*
TUBITAK (TUBITAK Research Centers)	*108.8*	*155.0*	*141.8*	*183.3*
TUBITAK (Turkey Research Area Programs)*	*346.0*	*415.0*	*425.0*	*450.0*
Academic Research Projects	90.0	80.0	85.0	105.0
Industrial Research Projects (of companies)	116.0	215.0	215.0	175.0
Research Projects of Public Institutions	50.0	50.0	50.0	65.0
Defense and Space Research Projects	50.0	60.0	65.0	80.0
Researcher Development	25.0	5.0	5.0	15.0
Science & Technology Awareness	15.0	5.0	5.0	10.0
Public Institutions (outside TUBITAK)	*36.2*	*49.3*	*80.2*	*78.2*
Nuclear Energy Council (TAEK)	6.3	13.1	20	18.9
Ministry of Industry and Trade**		11	16.9	17.6
Ministry of Agriculture and Rural Affairs	2.2	2.5	4	3.6
Ministry of Health	0.1	6.2	5.2	4.9
National Boron Research Institute***	0.1	3	6	6.3
Ministry of Energy***				1
KOSGEB	*12.5*	*5.4*	*4.6*	*6.5*
TTGV	*8.9*	*35.6*	*35.4*	*35.5*
State Planning Organization	***1.1***	***10.0***	***18***	***18***
Undersecretary of Foreign Trade	**40.0**	**42.0**	**63.5**	**n.a.**

Notes: *TUBITAK funds the projects of other institutions' R&D projects. **Includes SAN-TEZ program that supports PhD students' theses that aim to solve company specific problems, and the support for the physical infrastructure of Technoparks. ***Includes programs in which the projects of other institutions are supported. n.a. = Not applicable

Source: World Bank 2009.

5.1. STI BUDGET STRUCTURE

The FR will provide a comprehensive review of the spending of main organizations and programs of the research and innovation sector. The objective is to be able to describe the basic flow of funds in the system: how much is spent, on what, by whom, and for what objective—that is, how the innovation system "functions." Box 5.1 provides a brief illustration of this exercise for the case of Turkey from 2005 to 2009. The exercise is essentially descriptive but provides a first look at Turkey's spending on STI.

Table 5.1 presents a possible simplified structure for an STI budget. Note that the proposed categories correspond essentially to the logical framework established in chapter 3. In the table, budget category Research Excellence and Technology Transfer Budget (C), and category Business Innovation Budget (G), reflect the two basic distributions of public funds described in figure 3.4 (see chapter 3). The four additional budget categories (Research Excellence (A), Expenditures for Technology Transfer and Science-Industry Collaboration (B), Business R&D and R&D-based Innovation (E), and Non-R&D-based Innovation, Technology Adoption and Diffusion (F) are exactly the four intermediate outcomes in figure 3.4. The last category, Other Expenditures (I), is introduced to capture expenditures that implement other objectives or have unclear objectives but are nominally related to research or innovation.

Table 5.1 can be further disaggregated as needed. For example, Business R&D and R&D-Based Innovation can be further disaggregated into Tax Breaks (D) and Direct Subsidies (E) as indicated. It can also be adjusted to fit different objectives established in the logical framework. For example, it can include a specific category to capture investments in social innovation and the category's corresponding intermediate outcomes and development goal.

National Budget and Budgetary Records

Government budget documents (such as central government consolidated accounts, line ministry information, medium-term expenditure framework documents) are a primary source of information for the preparation of the proposed consolidated STI budget. Public sector budgets are presented according to (i) Classification of Functions of Government (COFOG) or (ii) the Economic Classification. The majority of developing countries today follow the guidelines of the IMF's *Government*

Table 5.1: Consolidated STI Sector Budget—Simplified Structure

Budget item	***Value (US$ 000's current)***
Research Excellence (A)	
Expenditures for Technology Transfer and Science-Industry Collaboration (B)	
Research Excellence and Technology Transfer Budget (C)= (A+B)	
Business R&D and R&D based Innovation: Tax Breaks for Business R&D (D) and Direct Support to Business R&D and R&D-based Innovation (E)	
Non-R&D-based Innovation, Technology Adoption and Diffusion (F)	
Business Innovation Budget (G)= (D+E+F)	
R&D and Innovation Sector Budget (H) = (C+G)	
Other Expenditures (I)	
Consolidated R&D Budget (J)= H+I	

Finance Statistics Manual (IMF 2001), which includes an initial version of the COFOG.[1] The classifications are summarized in table 5.2.

Categories can be combined to provide, potentially, interesting analyses, as described in table 5.3. For example, spending on "R&D Defense" can, in principle, be combined with, among others, expenditures on "Compensation to employees," "Subsidies," and "Grants" (IMF 2001: 78, para. 6.104). In addition, the categories shown in table 5.3 can be further disaggregated. For example, data on subsidies can be decomposed by type of beneficiary, including nonfinancial public corporations and nonfinancial private enterprises (which could be a first good indicator for the priority given to the public and private sectors in governments' R&D policy).

Main Challenges

Budgetary data can help create an understanding of the patterns of public spending in STI for the country but its use involves important challenges worth keeping in mind. Apart from access to budgetary information as well as the data quality, issues discussed in chapter 4, the following are some of the main challenges.

One limitation refers to the identification of public measures to promote innovation. R&D spending is a functional category under the COFOG classification but "innovation" is not among those categories of government functions normally used. Therefore, most of the innovation-related expenditures may not be directly identifiable in budgetary documents. This is illustrated by Brazil's FINAME (Financing of Machinery and Equipment)—a program implemented by the Brazilian Economic and Social Development Bank (BNDES) that provides subsidized loans for the acquisition of machinery and equipment by the private sector.[2] As part of BNDES, the program as such does not appear in the national budget. Rather, it is "buried" in the BNDES budget line in the central budget.

Another limitation refers to coverage of expenditures under the R&D category of COFOG. This reports government expenditures under this category follow the definition of R&D of the *Frascati Manual* (OECD 2002): the category covers basic and applied research and ex-

1. The Classification of Functions of Government (COFOG) was developed by the OECD and adopted by the United Nations in 1986. It was adopted by IMF as the *Government Finance Statistics Manual.* For more information see IMF (2011).

2. The program funds a major part of the investments of the manufacturing industry, about 20 percent of total aggregate gross fixed capital formation in the country in the 2011–12 period.

Table 5.2: R&D Expenditures by COFOG Classification

7	**Total outlays**		
701	**General public services**	**706**	**Housing and community amenities**
7014	Basic research	7065	R&D Housing and community amenities
7015	R&D General public services	**707**	**Health**
702	**Defense**	7075	R&D Health
7024	R&D Defense	**708**	**Recreation, culture, and religion**
703	**Public order and safety**	7085	R&D Recreation, culture, and religion
7035	R&D Public order and safety	**709**	**Education**
704	**Economic affairs**	7097	R&D Education
7048	R&D Economic Affairs **Environmental protection**	**710**	**Social protection**
705	R&D Environmental protection	7108	R&D Social protection
7055			

Source: Elaboration of data from IMF (2001).

Table 5.3: COGOF and Economic Classification—Illustration (in US$ 100,000)

	Economic classification						
COGOF classification	***Compensation to employees (21)***	***Use of goods and services (22)***	***Consumption of fixed capital (23)***	***Subsidies (25)***	***Grants (26)***	***Social benefits (27)***	***Other expenses (28)***
7014 Basic research	1	71	5	61	75	73	54
7015 R&D General public services	34	37	8	34	33	47	24
7024 R&D Defense	21	71	23	55	14	75	70
7035 R&D Public order and safety	70	1	75	74	48	19	28
7048 R&D Economic affairs	13	62	14	69	23	28	13
7055 R&D Environmental protection	28	58	27	43	68	69	18
7065 R&D Housing and community	27	3	21	42	12	56	51
7075 R&D Health	26	29	64	2	27	30	46
7085 R&D Recreation, culture, religion	34	65	33	13	41	53	11
7097 R&D Education	45	42	62	37	55	45	6
7108 R&D Social protection	32	4	46	68	25	5	24

Source: Elaboration of data from IMF (2001).
Note: COGOF = Classification of Functions of Government.

perimental development. But it excludes, for example, other related scientific and technological activities (such as feasibility studies) and innovation activities other than R&D, including all those technical, commercial, and financial steps necessary for the implementation of the results of R&D activity.[3] This is particularly relevant for the collection of data on public spending related to two categories of the proposed STI budget: (i) technology transfer and science-industry collaboration and (ii) non-R&D innovation categories of the proposed STI budget.

- For instance, prototypes are counted as R&D activities as long as the primary objective is to make further improvements. Pilot plans should be included as long as the primary purpose is R&D. Trial production should be included if production implies full-scale testing and subsequent design and engendering. Patenting and licensing work should be excluded.

A third issue refers to the scope of measures to be included in the proposed STI budget. For example, some more developed countries may prefer to exclude a program like BNDES' FINAME from the calculation of their STI budget and classify the subsidy to the acquisition of machinery and equipment among more general "competitiveness" policies. Other public spending may be innovation related or not depending on its effective application.

- For example, the provision of labor training may be directly related to innovation if targeted to improve the technical skills of the workforce in the production process, improving quality, reducing re-work, and improving firm productivity. In those cases, the primary purpose of the public support seems to be innovation (in the broad sense applied by this note).
- On the other hand, several lifelong learning programs may involve the provision of "general skills." While those skills are vital for the employability of the labor force and efficient adjustments of the economy to changes in global demand, the programs' primary objective is not innovation and therefore they should not be included in the budget.

A fourth issue to be kept in mind refers to how expenditures are appropriated in the STI budget. Challenges include: (i) how to address spending by public research organizations (PROs) that are not funded by taxation (the gross versus net principle—see table 5.4b for more details), (ii) how to appropriate indirect support and loans, (iii) how to appropriate multi-year projects, (iv) whether to include taxes involved in the expenditures or not, and (v) estimating the share of specific expenditures not originally available. For example, the value of the subsidy incurred by the BNDES' FINAME may not be readily available from the source and may need to be calculated (that is, monetized) as part of the overall exercise.

A final challenge involves the classification of the measure according to the different intermediate outcomes. This step corresponds to the core of the work of the FR.

Table 5.4a summarizes a proposal for addressing the challenges discussed before. The problem of identification and coverage of R&D spending may be circumvented by close collaboration with the counterparts, field interviews with key stakeholders, review of policy documents, and review of third-party analyses of a country's research and innovation policy. The two classification issues (boundaries of STI programs and classification in terms of the intermediate outcomes) can be addressed by adopting the "primary purpose of the intervention" concept based on a review of the corresponding policy and program documents (see the *Frascatti Manual* (OECD 2002), Chapter 8, § 499–500). Table 5.4b addresses appropriation issues.

5.2. A PRACTICAL EXAMPLE

In this section the exercise is illustrated with a practical example. The STI budget is prepared in four main steps: identification of support measure; budgeting of support measures; classification of support measures according to the intermediate outcomes; and budget consolidation.

3. For detailed discussions about the boundaries of R&D activities see OECD (2002), especially Chapter 2.

Table 5.4a: Preparing the STI Budget: Challenges and Proposed Solutions

Challenge	***Proposed solution***	***Comment***
Identification of STI measures and coverage of R&D spending	Field visits and close collaboration with counterpart	Public spending on STI not always directly visible in government budgets
Inclusion of measures in the STI budget	Agree with the counterpart on the list of programs to be covered. A list of STI measures is presented in appendix B Consult program-specific documents. Decide whether to include the expenditure in the STI budget or not based on the **primary purpose** of the spending (if STI or not)	Budgetary information on public R&D spending does not cover the full spectrum of policies necessary to transform R&D result into innovation Boundaries of STI measures not always clear from simple examination of the budget items
Appropriation of spending in STI budget	See table 5.4b	How much of the budgeted spending to include in the STI budget?
Classification according to intermediate outcomes	Consult program-specific documents. Decide whether to include the specific expenditure or not based on the **primary purpose** of the spending (if STI or not)	How to classify the budgeted measures according to the intermediate outcomes

Table 5.4b: Appropriation of Expenditures: Challenges and Proposed Solutions

Challenge	***Proposed solution***	***Comment***
Gross/Net approach, net principle	Appropriations for which corresponding revenue is expected either from other government sources or other sectors of the economy should be excluded according to the net principle. (§488-489).	For example, if an R&D institute has a local gross budget of US$10 million including US$3 million income from the provision of contract research, then only the difference (US$7 million) should be counted as net budgetary appropriations.
Indirect funding (tax breaks) and loans	Monetize the value of the subsidy based on the notion of "forgone revenue." Loans that may be forgiven should be included, but loans that are to be repaid and indirectly support industrial R&D via tax rebates, etc. should in principle be excluded. (§493)	The 2001 *GFS Manual* (IMF 2001) provides specific guidance on how to appropriate those costs. Nevertheless, when such indirect support programs are undertaken as part of an integrated R&D policy (for example, when the sources are documented and are included in inter-ministerial discussions of a science budget), they may be included.
Multiannual projects	Multi-annual projects budgeted in only one year or over several years should be allocated to the STI budget of the year(s) in which they are budgeted, not in the years of performance. (§495)	Multi-annual programs that are authorized at some stage but budgeted over several years should be allocated to the years in which they are budgeted, not the year of authorization.
Value-added tax (VAT)	Data on R&D expenditure should be reported at factor costs (i.e. VAT and other taxes should be excluded). (§371)	In Lithuania and in the Slovak Republic, VAT has been included in the calculation of government spending in R&D while in Bulgaria and the Czech Republic it was partially included (as of 2009).
Estimating the share of specific expenditures	Estimates may be used to value the share of a given intervention in the overall budget of an organization. Make the approach transparent and simple. Use available data to make inferences, when possible.	For example, coefficients are used to estimate the R&D share of budget item (Austria), to separate R&D from non-R&D (Germany), to calculate General University Funds (Sweden), etc.

Sources: Elaboration of data from of Eurostat (2012), IMF (2001), and OECD (2002).
Note: The numbers following the symbol (§) refer to the paragraph of the *Frascati Manual* (OECD 2002).

Identifying the Measures

In order to identify the programs to be used, a checklist of STI programs can be used. This illustration uses one of the many different typologies of STI programs available.[4]

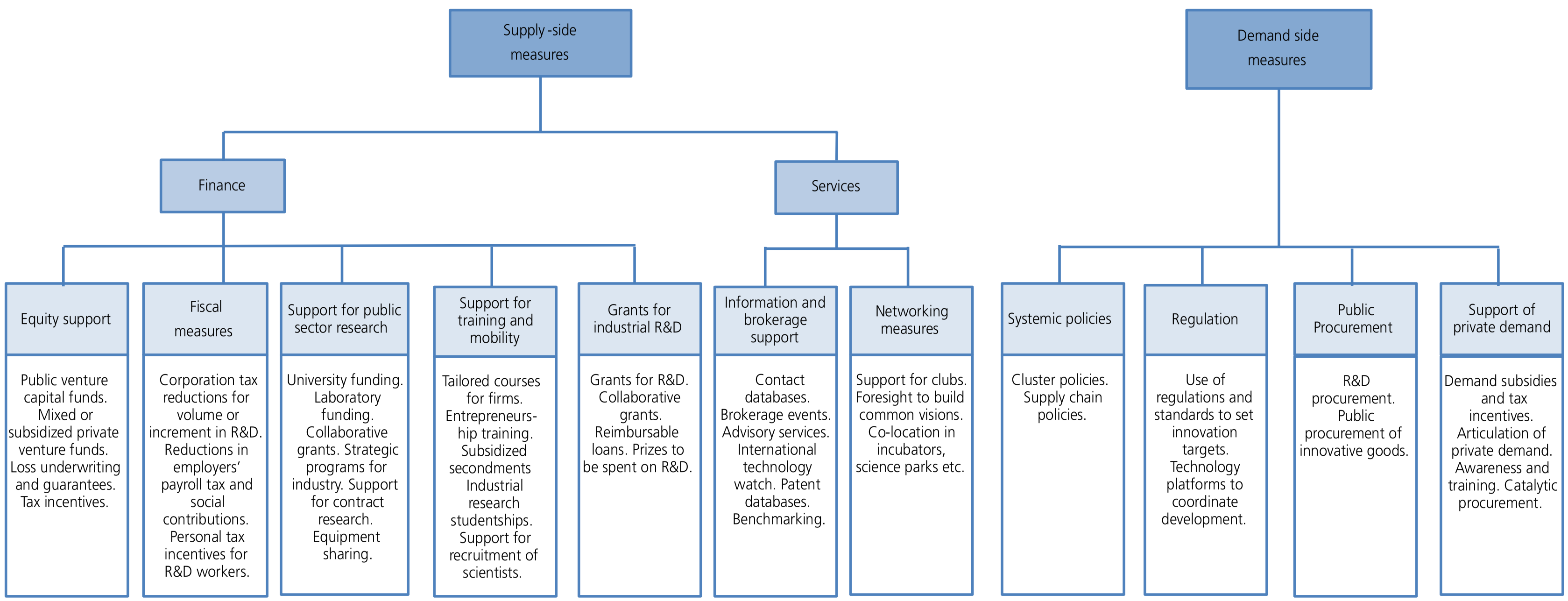
4. Public support for STI can be delivered through multiple channels, and through a variety of policy tools. An array of STI policy typologies have been developed for different purposes. Some of them are developed on the basis of their target groups (for example, SME support schemes, PhD grants, researcher grants), while others are developed on the basis of the policy challenge they are meant to address (for example, innovation financing schemes, skill development schemes).

Figure 5.2 presents a program taxonomy that primarily distinguishes between supply-side measures and demand-side measures. Within supply-side measures, it also makes a key distinction between financial measures and support services. It may be used as an initial check list for the scope of STI spending. In principle, any other taxonomy could be used.

Budgeting the Measures

Following the taxonomy presented before (or any similar list of measures), a consolidation of the number of pro-

Figure 5.2: An STI Policy Taxonomy



Source: Edler and Georghiou 2007.

Table 5.5: Example of Categorization of Programs Based on a Standard Taxonomy

Program/ organization	**Description of the program or expenditures**	**Public resources allocated** (appropriations, US$ '000)	**Public resources disbursed** (outlays)	**Appropriation issues**
Name the program and organization	*Present here the stated objective of the program and the nature of the instrument*	*Present here the total allocation of public funds for the program* *Consider reporting different levels of budget preparation*	*Present here the total amount of public funds disbursed at the end of the period*	*Describe the assumptions related to appropriation exercise (table 5.4b), as necessary*
Ministry of Science/ National Science Foundation	Research grants: promote scientific research	US$90,000	US$90,000	Obtained from budget codes (COFOG, 71040)
Ministry of Economy (MoE)	Center of Competence	US$5,000	US$5,000	Estimated as 50% of MoE Technological Platforms based on initiatives to promote centers of competence
Ministry of Finance	Subsidized loan for acquisition of machinery and equipment	n.a.	US$8,000	Estimate as 100% of forgone revenues in the past year

Note: n.a. = Not applicable.

grams and respective budgets can be carried out. This can be done by filling the information requested in table 5.5.[5] The description of the program/expenditures will generate the basic information for further classification according to the categories. At this stage, an estimation of the budget of each measure is also undertaken, as illustrated with three examples in table 5.5.

Classifying Measures by Intermediate Outcomes

In this step, the current expenditures are classified according to their potential contribution to the four intermediate outcomes defined previously. The effort consists of identifying all public programs and corresponding expenditures related to STI and classifying them according to each of the proposed four outcomes.

The proposed exercise is to some extent arbitrary. Programs are not easily classified in any of those four categories. In many cases multiple objectives will be declared, while in other cases the objective will not be stated clearly. It is proposed that the team/analyst accept the program's declared goal when it is sufficiently clear, or try to discern and follow the "principal purpose" otherwise. The exercise is illustrated by table 5.6. Note that the proposed classification is not exhaustive, that is, there may expenditures/programs that do not attempt to contribute to any of those four goals and should be classified under a fifth category (other goals/unclassified). These four objectives work therefore as a first filter for examining the quality of the public expenditures. Expenditures that cannot be classified by the team into any of the four categories are not linked to the four intermediate outcomes.

- Programs may be related to multiple goals (for example, both provision of training and support for technology development zones). Detailed analysis of project documents outlining proposed outputs, impacts, and goals would offer some understanding of the potential impact on different intermediate outcomes outlined in the framework.

5. The table only includes a limited number of program examples.

Table 5.6: Categories of Innovation Programs Based on Intended Outcomes

A	B	C		D		E		F	
		Research excellence		***Technology transfer and science-industry collaboration***		***Business innovation and start-up creation***		***Technology diffusion and adoption***	
Program/output type	***Program budget***	***Link to outcome (Y/N)***	***% of program resources linked to outcome***	***Link to outcome (Y/N)***	***% of program resources linked to outcome***	***Link to outcome (Y/N)***	***% of program resources linked to outcome***	***Link to outcome (Y/N)***	***% of program resources linked to outcome***
Center of excellence									
Principal investigator grants									
International research cooperation grants									
Research grants									
Science programs									
Strengthening national research performers									
Cluster initiatives									
Technology consortia (feasibility and R&D stages)									
Support for patenting and IPR protections									
Implanting scientists and engineers in industry									
Support for technology transfer offices									
Innovation project subsidies									
Tax credits for R&D projects done with registered technical centers									
Credits to fund innovation projects and investments									
Support to implement completed innovation projects									
Subsidy for technical consulting (innovation vouchers)									
Subsidized loans for acquisition of machinery and equipment									
Tax breaks for acquisition of machinery and equipment									
Technology management scheme									
Overseas technology missions									
Managerial training									
Labor training									
Strengthening MSTQ system									

Source: Elaboration based on data from Technopolis (2009)
Note: IPR = intellectual property rights; MSTQ = metrology, standards, testing, and quality; R&D = research and development.

Estimating the Budget by Intermediate Outcomes

Once programs have been classified according to the four proposed outcomes, an estimate can be established of the volume of funding allocated to each intermediate outcome. Table 5.7 illustrates a hypothetical STI budget for 2009. If budgets from a single measure can be allocated to more than one outcome, then the expenditure related to that measure should be further decomposed, and an estimate may need to be made. Otherwise, the previous estimate is fully appropriated in the STI budget. This is illustrated with the case of centers of excellence—note that the original US$5,000 is further divided into two different intermediate outcomes (collaboration science industry and business R&D).

5.3. OTHER EXISTING INDICATORS

Government Budget Appropriations or Outlays on R&D

The relationship between the STI budget and the Government Budget Appropriations or Outlays on R&D (GBAORD) is worth taking into consideration. GBAORD is the standard concept used for consolidating public expenditures on R&D using budgetary information. The characteristics and potential use of GBAORD are presented in box 5.2. Eurostat and the Organization for Economic Cooperation and Development (OECD) reports GBAORD statistics for 59 countries, including EU member states and candidate countries, European Free Trade Association (EFTA) countries, Japan, the Republic of Korea, the Russian Federation, and the United States. The statistics can be accessed online and used to create international comparisons.

The main limitation of GBAORD from the point of view of the exercise proposed by the PER is its coverage, which is focused on the R&D activity as defined by the *Frascati Manual* (OECD 2002). Thus, GBAORD essentially covers the research excellence component and the direct subsidy component (for example, matching grants to business enterprise R&D (BERD)). To complete the STI budget, the PER exercise needs to extend its coverage to the "innovation-related" activities not covered by GBAORD. Those activities are mainly related to science-

Table 5.7: Illustration—Country Alfa Classification of R&D Expenditures in 2009 (US$ '000s)

	Intermediate outcomes				
Government programs	***Research excellence***	***Science-industry collaboration and technology transfer***	***Business R&D and startup***	***Technology adoption***	***Other goals/ unclassified***
Research grants (general)	90,000				
Young research grants	10,000				
Matching grant for collaboration between PROs and business sector		1,000			
Tax breaks for business R&D			12,000		
Centers of competence		3,000[a]	2,000[a]		
Matching grants for proof of concept			1,000		
Conditional loan for prototype development			1,000		
Support to patenting by researchers		1,000			
Subsidized loan for acquisition of equipment				50,000	
Technology development zones program					80,000
Total STI budget	100,000	5,000	15,000	50,000	80,000

Note: a. US$2,000 of the resources for the development of centers of competence was used to fund a matching grant scheme to promote business investments in R&D.

Box 5.2: GBAORD—Concept, Statistical Description, and Use

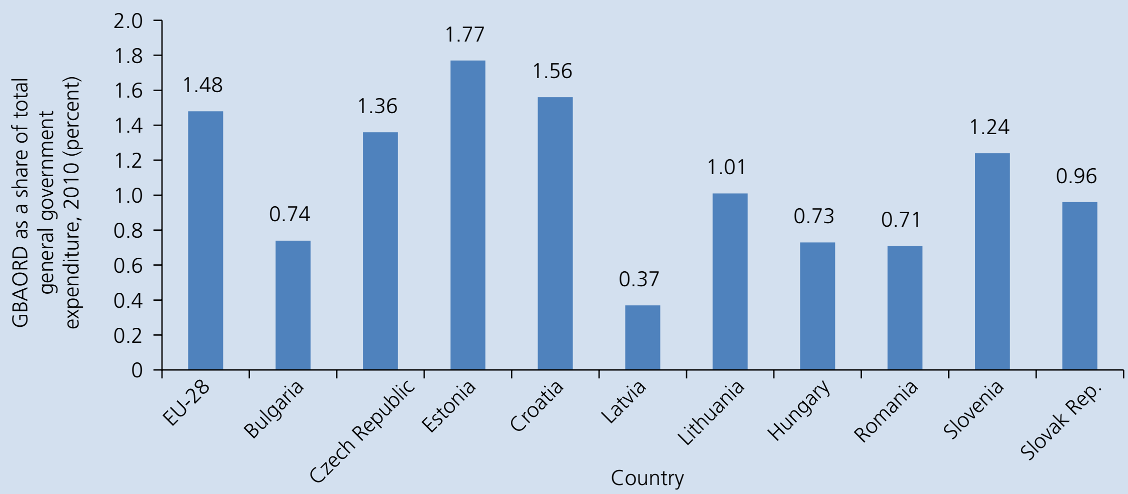
Unlike other statistical surveys carried out in the field of research and development, Government Budget Appropriations or Outlays for R&D (GBAORD) data are based on the analysis and identification of all appropriations spent on research and development (R&D) from public budgets. This means that the approach is based on the funder of research and development activities (here the state represented by administration), unlike the performance-based approach, which is adopted for example in the R&D survey.

Under definitions provided in the *Frascati Manual* (OECD 2002), GBAORD covers all appropriations or outlays allocated to R&D from public budgets to support research and development, including all contributions to international R&D programs or institutions abroad. The data are based on final budget appropriations (figures as voted by parliament for the coming year—provisional data) and actual outlays (money paid out during the year—final data).

Public budgets cover the central government budget and provincial budgets when its contribution is significant. GBAORD also covers general university funds, which are narrowly defined in line with the *Frascati Manual* as a sum of money given to universities by the ministry of education in support of their overall research activities. GBAORD includes both current costs and capital expenditure.

Figure B5.2.1 illustrates GBAORD's share of total general government expenditures. This indicator is commonly used to indicate the government's effective priorities. Data is also available in national currency, at 2000 prices, and per inhabitant, among others categories. GBAORD is also broken down in accordance to Nomenclature for the Analysis and Comparison of Scientific Programs and Budgets (NABS) at chapter and sub-chapter levels, corresponding to different socioeconomic objectives, as for example civil versus non-civil R&D. The goal is to help countries decide which R&D fields need more funding.

Figure B5.2.1: GBAORD as a Share of Total General Government Expenditure, 2010 (percent)



Source: Elaboration of data from the Eurostat website and OECD (2002).

industry collaboration, research commercialization, and non-R&D innovation, especially for technology adoption. Table 5.8 illustrates some cases at the borderline between R&D and other industrial activities.

If GBAORD data is not available, it is recommended that the team consider the possibility of calculating it to enable comparability of part of the STI expenditures. Table 5.9 shows the main recommendations from *Frascati Manual* on how to estimate GBAORD. Compilation of GBAORD statistics relies basically on administrative data and the accuracy of figures is considered appropriate. Most of the OECD and EU member states follow closely those recommendations from the *Frascati Manual*. Table 5.10 summarizes how some client countries are calculating the indicator.

Table 5.8: Some Cases at the Borderline between R&D and Other Industrial Activities

Cases	***Treatment***	***Remarks***
Prototype	Include in R&D	As long as the primary objective is to make further improvements
Pilot plant	Include in R&D	As long as the primary purpose is R&D
Industrial design and drawing	Divide	Include design required during R&D. Exclude design for production purposes.
Industrial engineering and tooling up	Divide	Include "feedback" R&D and tooling up industrial engineering associated with development of new products and new processes. Exclude for production processes.
Trial production	Divide	Include if production implies full-scale testing and subsequent further design and engineering. Exclude all other associated activities.
After-sales service and trouble-shooting	Exclude	Except "feedback" R&D.
Patent and license work	Exclude	All administrative and legal work connected with patents and licenses (except patent work directly connected with R&D projects).
Routine tests	Exclude	Even if undertaken by R&D staff.
Public inspection control, enforcement of standards, regulations	Exclude	

Source: Elaboration on UNESCO (2009)

Table 5.9: Summary of Recommendations from *Frascati Manual* on How to Estimate GBAORD

Category	***Principles***	***Detailed considerations and examples***
Type of expenditures covered	**All outlays on government expenditure on** R&D-related activities**.** **Follows the concept of R&D activities as defined in chapter 2 of the** *Frascati Manual* **(§481-485).**	Particular emphasis is given to **distinguishing** R&D from non-R&D activities. Covers both current costs and capital expenditures, including social security funds (§494 and 491). Contributions to international R&D programs and institutions should be included (§496). For example, GBAORD excludes the share of prototype development and development contracts not related to R&D, such as the manufacturing of a prototype itself. For example, appropriations to the Consultative Group on International Agricultural Research (CGIAR) should be included.
Level of government covered	Central government should always be included. State level governments should be included when spending is significant. Local governments should always be excluded	Includes public general university funds (GUFs).
Data classification and reporting	Spending should be reported by **purpose** of socioeconomic objective, and on the basis of the intended use of the funds at the time they are committed (**§497-499).** The actual reporting level chosen will depend on practical possibilities.	**For example**, a research project to develop fuel cells to provide power in remote areas financed by the Ministry of Agriculture should be classified as "agriculture, forestry, and fishing," but the project content is "energy."
Data collection	GBAORD data should be based on the **funder** rather than the performer. Data should be collected by national statistical institutes.	Data is basically obtained by means of text analysis, document reviews, and subsequent data validation process.
Sources	Budget proposals (figures presented to parliament). Initial budget appropriations (figures as voted by parliament).	Forecast (estimates of funding before beginning of budget discussion). Final budget appropriations (initial budget plus changes introduced during the year). Data drawn from ministries, universities, and other administrative sources.

Source: Elaboration of data from OECD (2002) and Eurostat (Reference Metadata Structure).
Note: Numbers in parentheses are section numbers from the *Frascati Manual* (OECD 2002).

Table 5.10: GBAORD—National Data Collection Schemes (as of 2009)			
Country	***Government coverage***	***Sources***	***Stages of data collection***[a]
Bulgaria	Central government	GBAORD survey[b] and budget	Final data: vii
Cyprus	Central government Local government	National data National budget data	Provisional data: iv Final data: v
Czech Republic	Central government Provincial government	STI Information System (STI state budget) Universities for Sector of Economic Activity	Provisional data: iv Final data: vii
Latvia	Central government	Ministry of Education and Science	Four stages (no detail available)
Lithuania	Central government	National budget account of Ministry of Finance	All stages (i–vii)
Hungary	Central government	Budget units (mainly ministries)	Final data: vii
Poland	Central government	*Annual Report on the Execution of the Budget for Science*—Ministry of Science and Higher Education	Final data (no detail available)
Romania	Central government	Ministry of Education and Research and the Romanian Academy of Science and other government levels managing funds	Final data: v
Slovenia	Central government	Ministries	Provisional data: iv Final data: vii
Slovak Republic	Central government	Ministry of Education	Provisional data: iv Final data: vii

Source: Eurostat (2012)
Note: a. The stages of data collection include: (i) forecasts (estimates of funding before beginning of budget discussion); (ii) budget forecasts (preliminary figures as requested by ministries, especially for inter-ministerial discussions); (iii) budget proposal (figures presented to the parliament for the coming year); (iv) initial budget appropriations (figures as voted by the parliament for the coming year, including changes introduced in the parliamentary debate); (v) final budget appropriations (figures as voted by the parliament for the coming year, including additional votes during the year); (vi) obligations (money actually committed during the year); and (vii) actual outlays (money paid out during the year).
b. Survey of expenditures.

Indicators from the OECD Policy Mix Database

In addition to the GBAORD indicators, the OECD Policy Mix Database produces information on a number of aspects of public spending in R&D based on the framework of the International Survey of Resources for R&D (OECD 2010b). Data availability varies by indicator but is mainly focused on OECD countries with some indicators available for Czech Republic, Estonia, Hungary, Mexico, Poland, the Slovak Republic, Slovenia, and Turkey. The following indicators are useful for the purpose of the PER exercise:

- GBAORD: Public spending to PROs versus the private sector.
- Private sector: direct support versus indirect support.
- PROs: Competitive versus institutional block grants, HEI versus public research institutes, basic versus non-basic research; socioeconomic objectives, and civil society versus non-civil society research.

Government-Financed Gross Domestic Expenditures on R&D

The sum of all the government expenses in R&D is commonly denominated "government financed." It is part of the R&D statistics generated by national statistical offices according to the "source of funds" for R&D activities. The information reported refers to government expenditures to finance R&D projects regardless the executing unit. Other sources of funding for which data are provided are higher education institutions, business, private nonprofit, and abroad. Overall, R&D expenditures are also classified by (i) sector of performance (government, higher education institutions, business, private nonprofit, and unspecified); (ii) field of science (natural science, engineering, and technology; health and medical science, agricultural sciences, social sciences, and humanities); and (iii) type of R&D activity (basic, development, and experimental research).

5.4. CONCLUSION

This chapter discussed the analysis of budgetary data. It described how to collect data on STI spending and provided a proposed budget structure for STI. The proposed budget structure links expenditure to the intermediate outcomes described in chapter 3. The chapter then provided a practical example, after which a number of a number of indicators where reviewed that complement the budgetary indicators. Box 5.3 describes a possible structure for the FR report, as well as a number of useful readings. The next chapter reviews the Operational Efficiency Assessment.

Box 5.3: The Functional Review—Structure and Useful Readings

Possible structure of the Functional Review as a standalone document:

1. Introduction: objectives and scope, as agreed in the Inception Report
2. Basic description of STI spending: Who spends, how much, and to achieve what objectives
3. Governance structure and the existing expenditures
4. Consolidated STI budget
5. Conclusions

Useful readings:

Fowler, Martin, Patrick Abbott, Stephen Akroyd, John Channon, and Samantha Dodd. 2011. "Forest Sector Public Expenditure Reviews: Review and Guidance Note." Program on Forests (PROFOR). World Bank, Washington, DC.

World Bank. 2007. "Spending for Development: Making the Most of Indonesia's New Opportunities. Indonesia Public Expenditure Review 2007." World Bank, Washington, DC.

World Bank. 2011 "Romania Functional Review: Research, Development, and Innovation Sector." World Bank, Washington, DC.

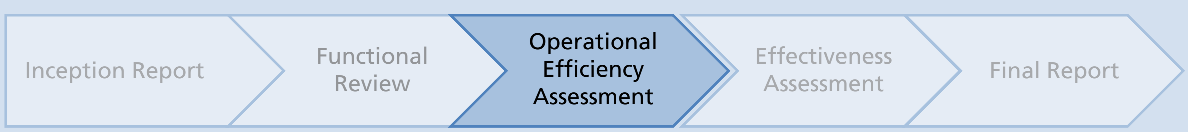
CHAPTER 6

OPERATIONAL EFFICIENCY ASSESSMENT

The Operational Efficiency Assessment (EA) is the third step in the implementation of the PER (see figure 6.1). The main objective of the EA is to provide an evaluation of the efficiency of the supported programs and therefore of the public expenditures.

The chapter begins with an overview of the EA in section 6.1. This section describes the challenges implementing an EA and approaches to overcome them. Section 6.2 describes how to evaluate the outputs produced by programs relative to their inputs. This is followed by section 6.3, which details how to evaluate the design and implementation issues that affect operational efficiency. Section 6.4 concludes by describing approaches to assess programs' efficiency.

Figure 6.1: The Operational Efficiency Assessment



Summary

The objective of the EA is to establish whether programs and funded activities are efficient. In other words, do they lead to the expected outputs given a reasonable level of inputs? The EA also aims to determine what design and implementation issues are affecting the efficiency of programs and funded activities.

The EA focuses on a selection of initiatives that are agreed in the Inception Report. These should represent a substantial proportion of public expenditures on each of the intermediate outcomes considered. There are a number of challenges in reviewing the selected programs, including measuring and valuing outputs. Another challenge is measuring the benefits from a program that spill over to institutions that did not participate in the programs.

The EA uses results from the Functional Review to select programs for more detailed analysis. Sources of data for the EA include (i) survey(s) of beneficiaries, (ii) peer and panel reviews, and (iii) focus groups and case studies. Microeconomic modelling may also be used.

6.1. OVERVIEW

Whereas the Functional Review (FR) is intended to provide a comprehensive overview of expenditures, implementation of the EA should focus on selected programs for feasibility reasons. An agreement achieved in the Inception Report stage should have defined these priority programs.

- To the greatest extent possible, however, these programs should represent a sufficiently large share of the public expenditure in each of the intermediate outcomes considered. The classification of public spending according to the intermediate outcome, performed in the FR phase, will help the analyst to check the balance of programs.
- Data for this work will be generated by survey of beneficiaries or collected from program managers (when available). The OECD has performed a number of these surveys and examples of the questionnaires used can be found in OECD (2003), OECD (2008b), OECD (2008c) and OECD (2013b).

Challenges

There are several challenges in assessing the operational efficiency of programs. They include the time horizon of the evaluation, measuring and valuing outputs, and addressing spillover effects (see box 6.1). Note that the concrete nature of those challenges as well as their importance will be program specific.

For instance, research programs often aim to improve the research capacity of young scientists. Research capacity is, however, an intangible output for which indictors such as hours of training and number of researchers trained are poor metrics. Agreeing on what to measure and which metrics to use is of crucial importance for program evaluation.

Another important challenge in assessing the efficiency of programs refers to the *attribution problem,* that is, connecting the intervention with the estimated effect. The issue is to estimate how much output would have been generated in the absence of intervention, everything else held constant.

Box 6.1: Challenges to Assessing the Efficiency of Programs

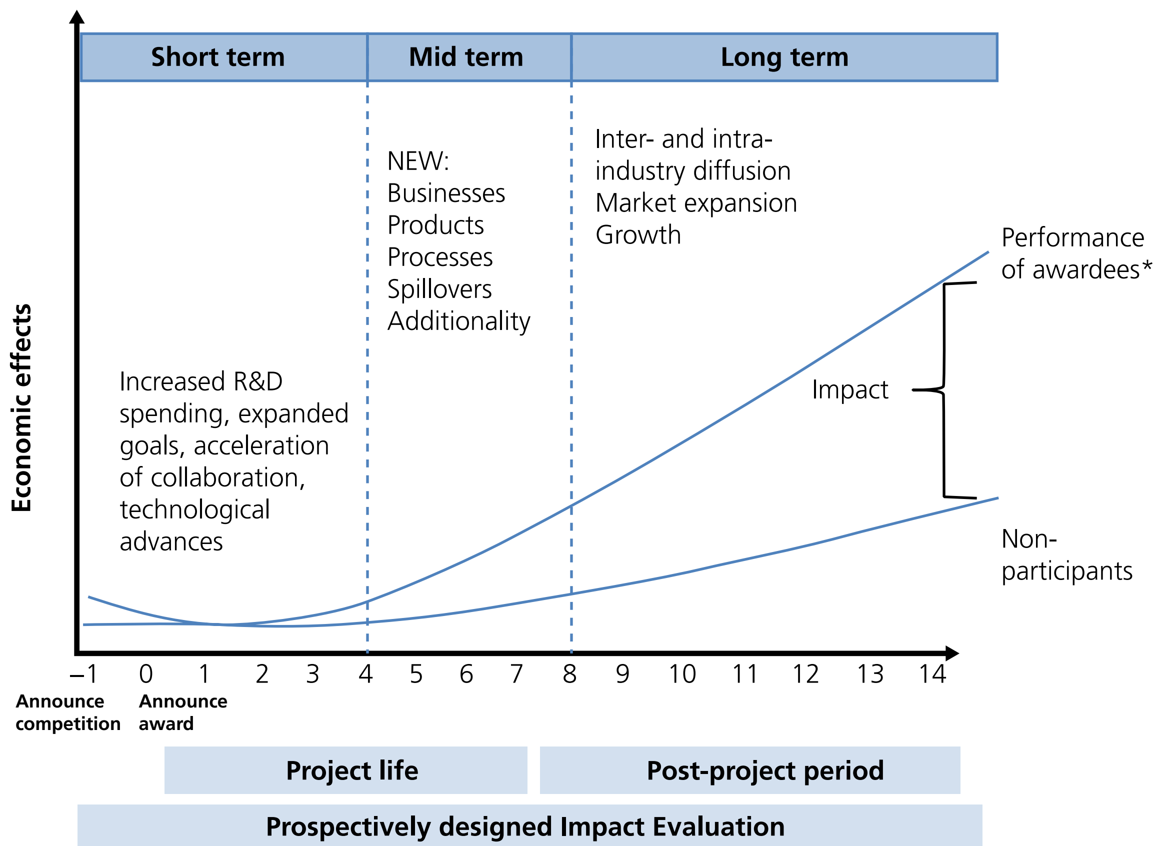
- *Nature of "success and failure" in research and innovation*. The metric of success in some policy domains is fairly straightforward. For example, children vaccinated versus children not vaccinated is a clear metric for success and failure of immunization programs. In other cases, the failure of a project—scientific or innovation experiment—funded by a government is not necessarily a metric that indicates failure of the investment program that funds the project.
- *Time horizon*. The time lag between the expenditure and the desired effect varies. For example, the impact of public support for additional firm R&D may be observable in the short term. Exports, on the other hand, are more likely observable over the longer term.
- *Measurement*. Tangible quantitative results, such as sales growth, are easier to measure than less tangible outputs, such as training received.
- *Valuing knowledge outputs*. Even quantifiable knowledge products may be hard to quantify and compare. For instance, the value of intellectual property (and thus of a patent or spinoff company) depends on a number of assumptions and subject to debate.
- *Addressing spillover effects*: Spillover effects are non-market effects on third parties (rather the direct beneficiary of intervention). For instance, a series of failed innovation attempts may generate enough information to enable the success of others. Accounting for such effects is not straightforward. For example, studies have argued that traditional output indicators—such as patents, sale of new products, and profit margins—fail to capture the full effects of R&D programs. Therefore, Buisseret et al. (1995) advocated that it was necessary to account for changes in the breadth of innovation activities and corporate business/technology strategies. These ideas became associated with the concept of "behavioral additionality."

For example, simply comparing the government spending of a matching grant to promote business R&D with the amount of R&D invested by the program beneficiaries may not give you a good estimate of the program impact. Some of that investment could have occurred in the absence of the program, a situation in which public funds would be "crowding out" private investments. Also, there is the possibility that events different from the measure itself (say for instance the location of a research department of a foreign company) increased the business sector's propensity to invest.

The challenges of evaluating STI programs are further illustrated in figure 6.2. The figure depicts the challenges in terms of timing (short-, mid-, or long-term results); type of results (for example, higher R&D in the firm versus innovation and productivity gains); what is to be measured (for example, spillovers); and the attribution problem. Note that the definition of impact is essentially the difference between the program results achieved for targeted beneficiaries discounted by program benefits obtained by non-targeted beneficiaries.

A related topic is to learn whether beneficiaries adjust strategically to the program and simply reduce their investments, replacing them with funding from the program (a substitution effect). This issue of "additionality" is a central topic in the evaluation of programs. Around half of the innovation policy evaluations in Europe (conducted between 2002 and 2007) investigated the issue of behavioral additionality implicitly or explicitly (Gök and Edler 2011). Three types of additionality impact are often considered in this literature:

Figure 6.2: Challenges in Program Evaluation



**Note:* As discussed in the main text the evaluation should consider the impact of spillovers—that is, benefits to firms that did not receive awards.

- *Input additionality* is the most widely used concept for measuring effectiveness of STI programs and deals with the extent to which a firm's inputs to the STI process (often firms' spending) have changed due to the intervention (Clarysse et al. 2009).
- *Output additionality* deals with the extent to which the firm's output has changed as a result of having received a subsidy. Apart from the standard output indicators, output additionality includes the following: (1) increments to the firm's stock of knowledge capital resulting from the R&D project; (2) development of the firm's capabilities, which might influence subsequent R&D productivity; and (3) benefits derived by the firm from commercial application of the R&D result (Roper et al. 2004).
- *Behavioral additionality* deals with changes in firm behavior that resulted from having received public support. Behavioral additionality includes the changes in the breadth of innovation activities, changes in technological and business strategies of the firm, and changes in the capacity of the firm to engage in innovative processes (Buisseret et al. 1995).

Need for a Tailor-Made Approach

The wide range of research and innovation measures implies the adoption of tailored evaluation approaches. A tailor-made evaluation requires detailed knowledge of the logic of the intervention. The rationale is similar to the one described in Chapter 3 except for the level of details and for its focus (on one program rather than the whole of public spending). In this case, however, it may be useful to further break down the problem into several additional steps. This further detailing may help the analysis to address some of the challenges above.

- For example, a research grant program, typical a two-stage chain of events (funding → publication), could be divided into several more steps: available funding → call for proposals → project applied → project selected → project implemented → project completed → paper submitted for application → paper accepted for publication → paper published.
- The description above can help the analyst choose the appropriate metric for the time of evaluation. For instance, project completion can be chosen as the evaluation metric if it is considered too early to publish results. Alternatively, one could argue that papers submitted would be a more robust evaluation measure. The evaluation could be done in stages for which the "paper submission" and "paper acceptance" performances could be compared.[1]
- The description above also helps localize the main factors affecting the emergence of expected impacts within that chain of events. This in turn allows the EA to define the main bottlenecks for success. For example, the success of a well-defined and designed program may be hindered by poor implementation of calls (not enough coverage, or insufficient time between announcement and application deadline) or long delays in the disbursement of funds.

Key Assessment Issues

Once the program details are well understood, the evaluation can be planned. The core of the operational efficiency assessment consists of the following set of issues: (i) what is the rationale for the program, (ii) how the program is designed, and (iii) how the program is implemented (Stiglitz 2000). Consistency among those three elements of the intervention is essential for its success.

In terms of the rationale for the program, it is generally accepted that an intervention is more likely to be successful if it focuses on the market, institutional, or systemic failure that it aims to correct. While a widely known principle, very often programs will depart from it for different (mostly political economy) reasons. Failures that are addressed by STI investment include the following:

- *Market failures* are often associated with time-inconsistent preferences, information asymmetries,

1. This is an example of the importance of leaving, as the result of the work, a good monitoring mechanism. Without such an instrument in place, the additional information and analysis would be unfeasible.

Box 6.2: How the Call for Proposals and the Project Evaluation Stages May Affect Program Efficiency

Calls for proposals may be *open-ended* or have a *fixed deadline*; while selection may be done only by *national experts* or include *international experts*. In both cases the options involve important trade-offs with different implications for the efficiency of the program.

Open-ended calls impose, for example, less burden on the applicants (and perhaps on program management) but raise the risk of selecting projects that perhaps would not rank among the best options (and perhaps do not merit support). Close-ended calls improve the selection mechanism toward the best projects—at least among the applicants—and thus use public resources more efficiently. Yet, some argue that those administrative deadlines may not be consistent with scientific research. Not surprisingly, several top research organizations keep using open-call systems for some programs.

Selection processes limited to national experts may compromise the independence of evaluations—especially when the local scientific community is small. Program managers, however, sometimes argue that access to international experts is impractical, costly, and runs the risk of excluding scientists that do not master a foreign language.

non-competitive markets, principal-agent problems, externalities, or public goods.[2]

- *Institutional failures* encompass traditional "government failures," as for example poorly defining property rights or enforcing contracts. They also include the failure to establish a system of rules that encourages individual interactions according to the common interest (Hodgson 2006).
- *Systemic failures* refer to the risks imposed by interlinkages and interdependencies in a system, including a national innovation systems or financial system.

When designing a program, the eligibility criteria for selecting the target group need to be consistent with the rationale/objective of the program. While it is not possible to identify perfectly those truly deserving support, adherence to the original objective of the program is a way to minimize the two typical selection errors: denying support to those who deserve and need it, and helping those who do not deserve or need support.

Among several implementation issues, the selection process—the criteria by which beneficiaries of the intervention are selected—is very important. These criteria determine if the targeted group is actually helped and whether the "failure" originally identified is remedied. Two aspects are of particular interest: *open-ended versus closed-ended* call for projects, and *national versus international* evaluation of projects (see box 6.2).

6.2. OUTPUT ASSESSMENT

The primary objectives of the EA are to address the two questions: (i) do programs and funded activities generate the expected results with a reasonably amount of inputs, and (ii) what design and implementation issues are affecting those results? This section discusses how to address the first question. The second question is addressed in section 6.3.

Tables 6.1a and 6.1b summarize the first task of the EA: combining inputs and outputs for the subsequent analysis. Note that the first two columns are generated in the previous stage (FR)—as the STI budget has been completed. The third column (Outputs) is therefore the focus of attention. In order to fill the table, three sources of information are envisaged: surveys of beneficiaries, monitoring reports, and focus groups.

Box 6.3 illustrates the application of the survey of beneficiaries, combined with interviews with the program managers and focus groups with beneficiaries for an applied research program in Poland.

2. Those market failures are not mutually exclusive. Information problems often provide part of the explanation of missing markets. In turn, externalities are often thought to raise from missing markets. See Stiglitz (2000).

Table 6.1a: Input-Output Metrics—Illustration		
Intermediate outcome	***Policy/program (budget/disbursement)***	***Outputs***
Research excellence	National Science Foundation Research Grants	Research projects funded Research projects completed (number and value) *Note:* Government executed GERD would provide an aggregate figure
	Academy of Science's Program for the Advancement of Research	
Science-industry collaboration	Research Institute for Marine Biology Institute for Agricultural Research	Research projects with the private sector (number and value) *Note:* Distribution between basic and experimental research funded by the government is a first approximation (from budget)
	Research Institute for Marine Biology Institute for Agricultural Research	
	Innovation Vouchers Program (from Ministry of Economy)	Value of disbursements and number of firms covered
Business investments in R&D	Cost of Tax-breaks for business R&D (forgone revenue)	Value of business R&D
	Matching grants Program for or early stage funding from Ministry of Science	Number and value of knowledge-based startups created that received funding from the program
Technology adoption	Technology Extension Services and Matching grants from Min. of Ind.	Number of firms assisted Number of firms certified
	Number of individuals trained	Agricultural Extension Services from Ministry of Agriculture

Table 6.1b: Example of Input-Output Indicator			
Program/organization and budget	***Output type (example)***	***Indicator(s)***	***Estimate***
Program to fund scientific research/national science foundation Budget: US$25 million	Doctoral and post-graduate training delivered	Hours of training Courses created MA or PhD programs created	800 hours of classroom work 30 new courses created 4 new MA programs 10 new PhD programs
	Research projects funded	Number of projects	
	Papers published in top journals	H-level of publications	
	Modernization of infrastructure	Value of infrastructure investment	

6.3. ASSESSMENT QUESTIONS

Programs can deliver different levels of output with the same level of inputs depending on the way they are designed and implemented. The following questions help assess the how effectively programs are translating inputs into outputs.

General

- What is the stated objective of the program? Are sustainable, measureable, achievable goals defined? Is the target group well identified?
- How do observable outputs compare with expected results? Is the target group being adequately covered? Is the funding provided adequate and timely?

Box 6.3: Assessing the Outputs of STI Program with a Survey of Beneficiaries—Illustration from Poland Mid-term Evaluation

In October 2013, Poland's National Center for Research and Development (NCBIR) engaged the World Bank to undertake a mid-term review of the Applied Research Program. The analysis included an evaluation of program design and implementation and success in targeting of intended beneficiaries. It relies on the information obtained from interviews with program managers, a survey of beneficiaries and applicant non-beneficiaries, and focus group discussions.

Table B6.3.1 illustrates the results for the Applied Research Program (PBS) programs according to the respondent (leader [LEA] vs. partner [PAR]; sub-programs (Path A and Path B) and call for proposals (CF1 and CF2). PBS is a research grant program dedicated to promoting research collaboration. Publications are the main output of program beneficiaries, followed by master theses, and lastly new product prototypes. A small percentage of beneficiaries announce creation of a new product or upgrading an existing product. These results are in line with the fact that most beneficiaries are scientific units. They also demonstrate the program's poor performance in generating outputs with high economic impact.

- Publications appear as the most important output, followed by MA and PhD theses, and new product prototypes.
- Leaders published more and provided more MA theses than partners: 57 percent versus 40 percent, and 19 percent versus 9 percent, respectively.

Table B6.3.2 provides some quantitative indicators. It shows that publications are the most important output. The mean of publications is higher for leaders, 2.1, than for partners, 1.2**.** Results in Path A (2.0) are larger than in Path B (1.3). And since innovation takes time, the mean of publications in CFP1 is higher than that of CFP2 (2.1 versus 0.8). The mean for the rest of the outputs does not exceed 0.5.

Table B6.3.1: Outputs Generated by Beneficiaries

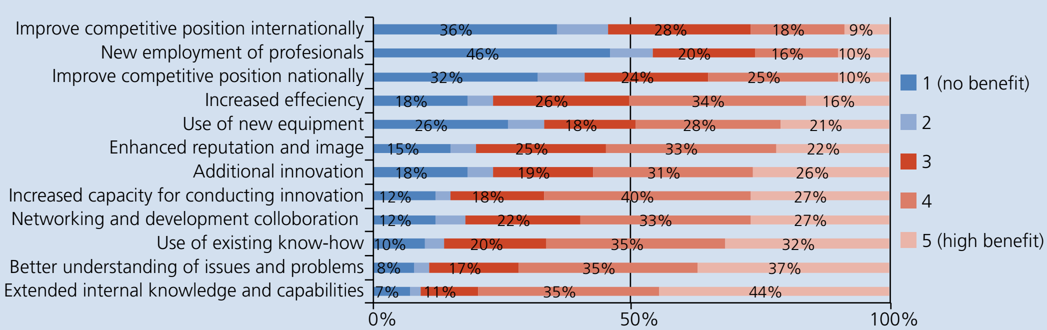
	LEA	PAR	PA	CFP1	CFP2
Patent	12%	9%	14%	12%	9%
Industrial design	1%	2%	2%	1%	2%
New product prototype	14%	15%	16%	16%	10%
New product	8%	9%	11%	9%	7%
Upgraded product	10%	5%	8%	9%	5%
New processes	13%	14%	13%	15%	10%
Upgraded processes	12%	8%	11%	12%	7%
Publications	57%	40%	55%	61%	22%
Master theses	19%	9%	18%	15%	10%
Ph.D theses	9%	5%	9%	7%	7%
Other	8%	7%	9%	10%	3%

Table B6.3.2: Mean of Produced Outputs

	LEA	PAR	PA	CFP1	CFP2
Patent	0.2	0.1	0.2	0.1	0.1
Industrial design	0	0	0	0	0
New product prototype	0.3	0.3	0.3	0.4	0.1
New product	0.1	0.1	0.2	0.1	0.1
Upgraded product	0.4	0.1	0.2	0.3	0.1
New processes	0.2	0.6	0.2	0.5	0.2
Upgraded processes	0.2	0.2	0.2	0.2	0.1
Publications	2.1	1.2	2	2.1	0.8
Master theses	0.5	0.1	0.4	0.3	0.2
Ph.D theses	0.1	0.1	0.1	0.1	0.1
Other	0.2	0	0.2	0.2	0

Other benefits. Yet, a large proportion of participants strongly agree that the program increased firms' innovative capacity. This includes increasing the internal knowledge and capabilities of employees, a better understanding of issues and problems, and better use of existing know-how. However, only 10 percent of beneficiaries strongly agree that the program improved companies' competitive position both nationally and internationally. A similar ranking is observed for expected benefits (see figure B6.3.1).

Figure B6.3.1: Other Benefits



Source: World Bank 2014.

- Are there reasons to suppose that the beneficiary would have adopted the expected change in behavior without the intervention? If so, to what extent?

Input-Output

- Could funding amounts be reduced without comprising the current performance? Could higher output levels be achieved with the existing funding level? Are there similar sources of funds to which potential beneficiaries do or could apply for?
- Is it possible to reduce administrative costs without affecting the quality of program management? Is it possible to reduce transaction (monetary and nonmonetary) costs for applicants?

The following aspects of program design and implementation have a direct effect on program performance: economic rationale, eligibility criteria, selection process, decision-making process, and management conditions.

Economic Rationale

- What specific market, institutional, or systemic failure justifies economically the intervention? How is the intervention supposed to correct the market failure (that is, what changes in the behavior of economic agents are expected to be generated)?
- How is the program or expenditure expected to contribute to the defined outcomes? How does the program complement other existing programs?

Program Design

- Do the eligibility criteria reach the right target group? Are there unnecessary criteria? Are there missing criteria?
- Which criteria were employed to determine the number of beneficiaries in each call? Is the selection too restrictive (excluding proposals of sufficient quality) or too loose, thus supporting a proposal of insufficient quality? Are proposals order?
- How is the decision-making process conducted? Who takes the final decision—panel or experts, investment committee, director-general?
- Which criteria were employed to determine the number of beneficiaries in each call? Is there a ranking of the application results?

Implementation Issues

- Are applications managed on an open-ended basis or in the format of closed calls? How many calls for proposals were conducted (if not open-ended call)?
- Is the application process clear and transparent? Does it take too long or is it too expensive to apply for the program? Is the timing of the call for proposals appropriate?
- Is the selection process transparent and fair? Who integrated the selection committee? Does it use international peer reviewers? Are evaluators' skills consistent with the project goals?

Implementation Conditions

- *Management*. How are funds disbursed? What are the reporting requirements to beneficiaries? What is the frequency of the field visits? What are the auditing requirements? How are programs monitored?
- *Staffing Issues.* Is the staff properly paid and well-trained? Are other material conditions (physical and financial infrastructure) commensurate with the workload? Are they sufficiently insulated from major political pressures? Are they incentivized to improve performance?

6.4. METHODOLOGICAL ISSUES

Different methodologies have been applied to evaluation of research and innovation programs. All methodologies show important trade-offs in terms of the quality of analysis and the resources requirements (see table 6.2). Moreover, the types of conclusions and analysis allowed by each of methodologies are often complementary to each other. For this reason, to the

Table 6.2: Summary of Program Evaluation Methodologies

Methods	***Description***	***Pros and cons***
Microeconomic modelling	From reduced-form models[a] to *randomized control experiments* using firm or individual level data	The most robust type of evaluation (with randomized control trials as the gold standard). Depends on high-quality data (often panel data) not always available. Scope of analysis may be narrow.
Survey of beneficiaries	Generate qualitative (soft) data from program's applicants (beneficiary and non-beneficiary.	Simple to implement and relative low cost. Effective in generating output information. Unable to credibly address the attribution problem. Subjectivity of responses.
Peer/panel reviews	Use of international experts to assess the quality of the program, often benchmarking the program against an assumed good practice	Simple to implement. Grants access to program specific expertise. Useful for the assessment of implementation and administrative aspects. Risk of persons/country biases and limited use of data-based evidence.
Focus groups/case studies	Structured interviews of program clients for the understanding of the strengths and weaknesses of the program.	Simple to implement. Good starting point for the understanding of the intervention logic. Does not allow generalized conclusions about the program.

Source: Adapted from Technopolis (2009).
Note: For an illustration see Ozcelik and Taymaz (2008).

extent possible, a combination of the four approaches is recommended.

- *Microeconomic modelling,* of which randomized control trials are the gold standard of impact evaluation but are also often difficult to implement due to data requirements, time limitations, and (sometimes) political sensitivities.
- *Focus groups and case studies* may provide a simple, cost-effective way to understand the logic of the intervention (including the different outputs and their timing).
- *Peer/panel reviews* may be the only effective option to evaluate science parks/incubators in the short term (as quantitative analysis—such as comparison of the survival rates of the incubated and nonincubated firms—may be only feasible at a later stage).
- *Surveys of beneficiaries* have a number of advantages over other approaches, but surveys come with some drawbacks. The data generated is more representative than that provided by focus groups, and peer/panel reviews. This comes at a higher cost as surveys are typically more expensive to design and implement.

To obtain information about program outputs, three sources of information are envisaged: interviews with managers (and monitoring reports); and focus groups through semi-structured interviews and surveys of beneficiaries. With the survey of beneficiaries it is also possible to obtain a first, tentative approximation to the attribution problem. As a rule, however, the team is advised to look exhaustively for opportunities to implement quantitative assessments, including exploring the different approach to more rigorous impact evaluations as discussed below.

Semi-Structured Interviews

Semi-structured interviews are the instruments for exploratory research that precede the implementation of the survey of beneficiaries (or any deeper quantitative analysis). Semi-structured interviews are conducted in order to explore in more detail the interviewees experience regarding the program. Prior to interviews, guides for interviews are developed for each type of program beneficiary. In the course of interview, questions are directed towards topics related to benefits and attitudes on particular program.

Researcher effects are one of the possible biases in qualitative research (Miles and Huberman 1994). Involvement of several researchers in case study development is important to avoid the researcher bias. In addition, triangulation by researcher (Denzin 1978) positively affects research validity. For example, more than one researcher is involved in the interview process; notes are returned to the interviewee before used and researchers that did not participate in the interview are used to the report the case studies.

The Survey of Beneficiaries

Surveys of beneficiaries belong to the category of highly structured questionnaires. Such questionnaires have a large core of common questions, but are often adjusted to the surveyed population (for example, beneficiary versus non-beneficiary, firm versus PRO, or leader versus participant) according to emphasis of the analysis. Responses are typically collected on five-point Likert scale (1 = lowest and 5 = highest) and sometimes use "yes-no" multiple choice questions. Response rates of 50–70 percent for beneficiaries (lower for non-beneficiaries) and follow-up interviews are often necessary. Questionnaires broadly follow the following sections: (1) general information, (2) performance prior to the grants project, (3) information about the project, (4) results and outputs of the project, (5) estimated impact without project, and (6) attitudes about the program

Survey of Beneficiaries and the Additionality Issue

Additionality is described in detail in section 6.1. Can one fully address the additionality issue without a standard impact evaluation? The simple answer is "no." Surveys of beneficiaries can, however, provide a first glance at the problem.

To assess the additionality issue, questions are asked involving a hypothetical "counterfactual scenario," that is, a hypothetical situation where respondents had to imagine what would had happened in the case of not being awarded the grant (Hsu et al. 2009). To gain additional insight into program additionality, applicants who were denied the benefit (non-beneficiary applicants) should also be surveyed.

Further insights are often possible when one focuses on incremental changes. For instance, a beneficiary company can be asked "would the company abandon the project were the grant not awarded?" If the answer is "no," then the beneficiary can be asked the following questions:[3]

- *Scale*. Would the project be performed on a smaller budget?
- *Scope*. Would the project be performed on a less-innovative level (lower risk/premium project)?
- *Acceleration*. Would the project be performed over a longer time period?
- Was there a change in the *non-persistent behavior* related to STI activities as a result of the intervention?
- Was there a change in the *persistent behavior* related to STI activities as a result of the intervention?

Mirroring a standard procedure in impact evaluation analysis, "before and after" questions are frequently used. For instance, beneficiaries of an innovation support program can be asked to agree/disagree with each of the following statements:

- "Prior to the support provided by the program, we had no formal process of new product development but now we have it."
- "Prior to the support provided by the program grant, we had a formal process of new product development and have now improved this process."

Box 6.4 illustrates the use of a survey of beneficiaries to assess the impact of Croatia's RAZUM Program.

Impact Evaluation

While useful, a survey of beneficiaries is not the instrument to be adopted if causality (attribution) is the

3. For a literature review see Hsu et al. (2009).

central issue for the evaluation. Teams are therefore encouraged to explore the data availability and consider the different options in terms of econometric strategy. Five main techniques are available (three related to impact evaluation and two statistical techniques often used for empirical micro-level work): randomization, regression discontinuity, matching, instrumental variable, and differences-in-differences. Table 6A.1 in annex A to this chapter presents some of the properties of those techniques. For a detailed review of the issues involved in the implementation of impact evaluation exercises in science and technology policies see Crespi et al. (2011).

- The guideline provides ideas and technical advice on how to measure the effectiveness of science, technology, and innovation programs (STIP). It addresses the specific challenges of evaluating STIP, from the assessment of the intervention logic to the choice of the most appropriate method to solve the attribution problem.
- Much attention is devoted to the topic of data, discussing pros and cons of different data sources, data quality issues, and strategies for data collection. The toolkit analyzes the potential application of experimental and quasi-experimental methods to

Box 6.4: Assessing the Impact of Croatia's RAZUM Program

RAZUM (Development of the Knowledge-Based Companies) was a conditional loan implemented by Croatia's Innovation Agency from 2007 to 2012 that supported investments in R&D by small and medium-sized enterprises (SMEs). Behavioral and output additionaility was measured by means of a survey of beneficiaries.

According to the survey's responses, the intervention enabled companies to increase their capacity for conducting innovation and R&D, and to extend knowledge and capability of the staff through hiring of highly educated professionals. In most cases these changes promise to be permanent. New product development process was positively affected in a large majority of the cases, promising better innovation capability. For most companies that received RAZUM support, work on the project generated additional ideas for innovations.

When asked what would have happened had they not received the RAZUM grant, 6 companies (30 percent) reported that they would have abandoned the project entirely. The majority (86 percent) of the remaining firms would have relied on their own resources, while some of them would have tried banks and venture capital funds. Three firms would have tried to find money through strategic partnerships and some other R&D subsidies. However, the absence of RAZUM money would not be without consequences. Most companies would have proceeded on a smaller budget, which would have affected the duration of the project (would have been longer), scope of the project (smaller), R&D capacity through additional employment of R&D staff (lower), and innovativeness level of the project (also lower) (figure B6.4.1).

A similar pattern is found in the case of non-beneficiaries. Those firms were either in the evaluation process (passed the pre-selection phase) or were approved and waiting for financing. In the hypothetical situation of not receiving RAZUM funding, 2 companies out of 14 would have abandoned this project and started another one, whereas all other companies would have proceeded with their projects (interestingly, no firm declared that it would not continue with that or any other project). However, the absence of th RAZUM grant would have had consequences for the duration, scope, R&D capacity, and overall quality of the projects (figure B6.4.2).

- In the absence of RAZUM grant, the vast majority of respondents said that they would have proceeded (i) with the project but over a longer timeframe (92.9 percent), (ii) on a smaller budget (85.7 percent), (iii) with a reduced scope (85.7 percent), and (iv) with inadequate equipment and/or machinery (71.4 percent).
- In terms of outcomes, many companies would have not hired additional employees (71.4 percent), and the innovativeness level of the output would have been lower (42.9 percent).

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Box 6.4 (continued)

Figure B6.4.1: Opinions of Consequences of Not Receiving RAZUM Grant: Beneficiaries (n=20)

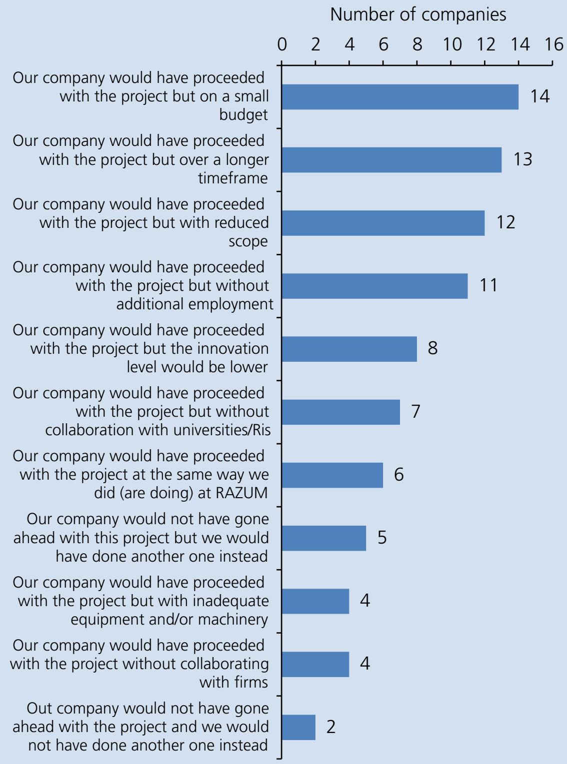
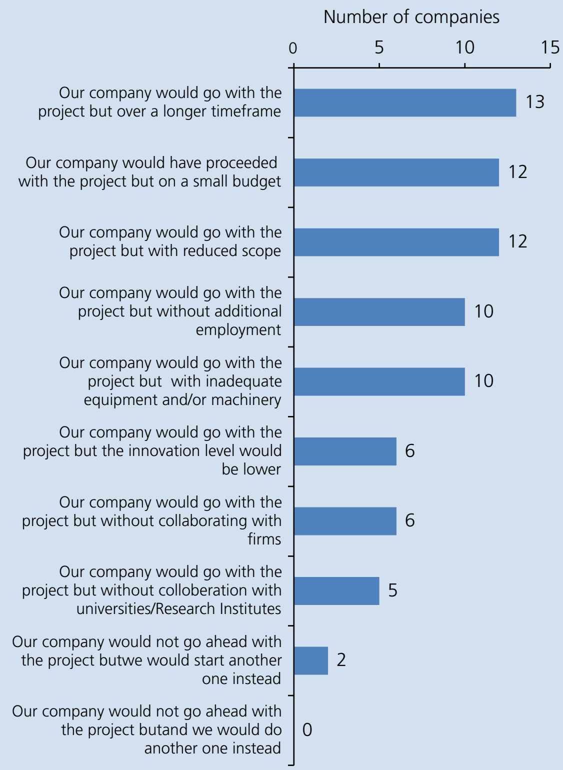


Figure B6.4.2: Opinions of Consequences of Not Receiving RAZUM Grant: Non-beneficiaries (n=14)



Source: Elaboration of data from Radas et al. (2011).

STIP. For each method, the paper highlights characteristics and assumptions, practical issues related to the implementation, and strengths and weakness specifically related to the application to STIP.

6.5. CONCLUSION

This chapter discussed how the EA is used to review the efficiency of STI programs. The first section in this chapter described how to how to assess outputs. It reviewed the need to evaluate whether the outputs generated by programs were additional. This was followed by discussion of a number of questions that can be used in outputs assessments. The chapter then reviewed methodologies that can be used in implementing program evaluations. Box 6.5 outlines a possible structure for the EA as well as a number of useful readings. The next chapter describes how to evaluate the effectiveness of STI programs.

Box 6.5: The Operational Efficiency Review—Structure and Useful Readings

Possible structure of the EA as a standalone document:

1. Introduction: Objectives and Scope, as agreed in the Inception Report
2. Overview of Programs and Funded Activities included in the Review
3. The Efficiency of Program and Funded Activities
    - 3.1 Program or funded activity A–Z (a section for each one reviewed):
        - 3.1.1 Description of the program
        - 3.1.2 Review of the program's outputs
        - 3.1.3 Evaluation of the program's efficiency
    - 3.2 Summary of findings
4. Design and Implementation Issues
    - 4.1 Review of governance issues affecting efficiency
    - 4.2 Proposals for interventions to improve efficiency
5. Conclusions

Useful readings

Edler, Jakob, Paul Cunningham, Abdullah Gok, and Philip Shapira. 2013 "Impacts of Innovation Policy: Synthesis and Conclusions Compendium of Evidence on the Effectiveness of Innovation Policy Intervention Project." Manchester Institute of Innovation Research, Manchester Business School, funded by NESTA

OECD. 1997. "Policy Evaluation in Innovation and Technology: Towards Best Practices." OECD, Paris.

Ruegg, Rosalie, and Irwin Feller. 2003 "A Toolkit for Evaluating Public R&D Investment Models, Methods and Findings from ATP's First Decade." Prepared for the Economic Assessment Office Advanced Technology Program, National Institute of Standards and Technology, Gaithersburg, MD.

ANNEX A. FIVE IMPACT EVALUATION TECHNIQUES

Table 6A.1: Empirical Approaches to Impact Evaluation and Other Statistical Techniques

Impact evaluation technique	***Definition***	***Main advantage***	***Feasibility challenges***
Randomization	Individuals/communities/firms are randomly assigned into participation Counterfactual: randomized-out group	Often addressed to as the "gold standard" By design: selection bias is zero on average and mean impact is revealed Perceived as a fair process of allocation with limited resources	Political constraints, especially for ongoing programs. Internal and external validity issues Difficult to extrapolate the results to a larger population
Regression discontinuity	Exploit the rule generating assignment into a program given to individuals only above a given threshold Counterfactual: individuals just below the cut-off who did not participate	Identification built in the program design Delivers marginal gains from the program around the eligibility cut-off point	Threshold has to be applied in practice, and individuals should not be able manipulate the score to become eligible
Matching	Match participants with non-participants from a larger survey Counterfactual: matched comparison group. Each program participant is paired with one or more non-participants that are similar based on observable characteristics	Does not require randomization, nor baseline (pre-intervention data)	Requires very good data: need to control for all factors that influence program placement Requires significantly large sample size to generate comparison group
Instrumental variables (IV)	Identify variables that affects participation in the program, but not outcomes conditional on participation (exclusion restriction) Counterfactual: The causal effect is identified out of the exogenous variation of the instrument	Does not require the heterogeneity assumption of matching Easier to implement (once the IV is identified) and less demanding in terms of data collection	The estimated effect is local: IV identifies the effect of the program only for the sub-population of those induced to take up the program by the instrument Therefore different instruments identify different parameters
Difference-in-difference	Observations over time: compare observed changes in the outcomes for a sample of participants and non-participants Counter-factual: changes over time for the non-participants	Can be in principle combined with matching to adjust for pre-treatment differences that affect the growth rate	Requires at least two cross-sections of data, pre-program and post-program on participants and non-participants Need to think about the evaluation ex-ante, before the program

Source: Elaboration from Goldstein (2010).

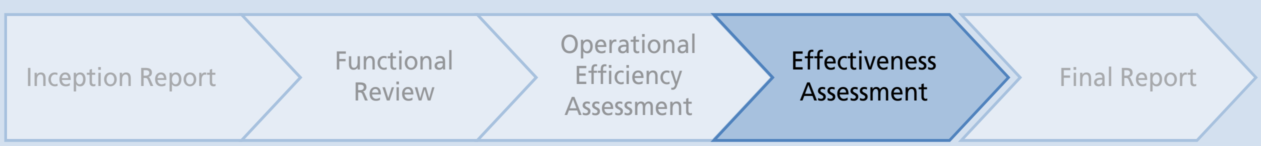
CHAPTER 7

EFFECTIVENESS ASSESSMENT

The Effectiveness Assessment (EFA) is the fourth component of the Public Expenditure Review (PER) (see figure 7.1). The EFA evaluates the extent to which policy outputs are being transformed into expected outcomes. This includes evaluating what factors beyond the reach of existing interventions affect the achievement of expected outcomes (the "conditions for effectiveness").

The chapter begins with an overview of the EFA in section 7.1. This section describes the main questions that are answered and the factors that inhibit the transformation of outputs into outcomes. A number of indicators for intermediate outcomes are described in section 7.2. This is followed by three sections that outline what questions need to be answered to understand

Figure 7.1: The Effectiveness Assessment



Summary

The objective of the EFA is to determine whether the expenditure and related outputs are leading to intermediate outcomes, such as an increase in the volume and quality of scientific papers, increased licensing by research institutions, and increased adoption of technologies in the business sector. The EFA then evaluates what conditions are facilitating or inhibiting the intermediate outcomes from being generated.

The EFA will typically analyze the national innovation system (NIS) by considering four sets of intermediate outcomes: (i) research excellence, (ii) science industry collaboration and technology transfer, (iii) business R&D and startups, and (iv) non-R&D innovation and technology adoption. These outcomes are measured by analyzing a number of indicators, which provides an indication of where the system is working effectively. These findings allow evaluation of the conditions for effectiveness, include issues such as the presence of appropriate research infrastructure or the presence of appropriate intellectual property regulation.

The starting point for the EFA is analysis of outputs from the Operational Efficiency Assessment. Additional data for the EFA will come from a combination of publicly available sources, surveys, interviews of program managers, R&D statistics, and budgetary information. Information on the conditions for effectiveness will largely come from a policy survey, interviews, and survey data on the enterprise sector.

whether the conditions for effectiveness are present. Section 7.3 addresses research excellence; section 7.4 addresses science-industry collaboration and technology transfer; and section 7.5 addresses business R&D, startup creation, and technology adoption.

7.1. OVERVIEW

The Effectiveness Assessment (EFA) aims to assess the extent to which each of the four outcomes defined in the intervention logic are being reached, as a result of the STI policy intervention. This implies moving up one level, from the analysis of first order effects—as described in the previous section—to the analysis of second order effects, or outcomes.

This is done with the objective of understanding if the policy intervention is leading the emergence of changes, and whether these changes are in line with the original objectives. Note that the production of outcomes is not in full control of those responsible for implementing programs. This is unlike outputs, which are a direct result of program implementation (for example, the number of projects financed).

Assuming the default intermediate outcomes (see chapter 3) are used, four intermediate outcomes are considered (note that business innovation is separated into two separate intermediate outcomes in order to facilitate the analysis):

- Are science, technology, and innovation (STI) expenditures promoting research excellence?
- Are STI expenditures stimulating better science-industry collaboration and more efficient technology transfer?
- Are STI expenditures enabling business research and development (R&D) and firm startups?
- Are STI expenditures stimulating non-R&D innovation and technology adoption?

As discussed in chapter 3, factors beyond the reach of public spending may affect the transformation of policy outputs into one of the identified intermediate outcomes. In broad terms, those are binding market, institutional, or systemic failures, that hinder the impact of public investments in STI. What market, institutional or systemic failures commonly hinder the impact of public spending on STI? What factors are affecting the impact of programs and public spending? Without the ambition of being exhaustive this section summarizes some central issues for each of the four intermediate goals established above.

- Research excellence may be affected by (i) the governance regime of public research organizations; (ii) access to research infrastructure; (iii) availability of well-trained researchers; and (iv) access to research funding.
- Science-industry collaboration and more efficient technology transfer may be affected by (i) the incentive regime under which researchers and public research organization (PROs) operate; (ii) the existence and quality of intermediaries, such as technology transfer organizations; (iii) mechanisms of collaboration such as voucher schemes, joint research projects, and centers of competence; and (iv) the availability of hard infrastructure such as techno- and science-parks.
- Business R&D and firm startup may be inhibited by (i) business environment factors (such as entry and exit regulations); (ii) support to business investments in R&D; (iii) access to mentorship, incubation services, and early stage finance; and (iv) public procurement.
- Non-R&D innovation and technology adoption may be stalled by (i) import costs of machinery, equipment, and intermediate goods; (ii) access and quality of manufacturing extension services; (iii) standard regulation and access to metrology and quality services (metrology, standards, testing, and quality [MSTQ] systems); and (iv) labor skills and access to credit.

The next section presents detailed discussions for each issue listed above. It provides a checklist of the main factors to be aware of, in order to be able to assess the extent to which each "condition for success" exists in a particular country. This checklist can be completed through the use of standard quantitative indicators (some of these indicators are provided in the following sections), or through qualitative assessment tools such as interviews. The issues suggested are by no means exhaustive, nor are they all relevant for all countries. They are meant to be used as a reference source for the implementation of this exercise.

To illustrate, an agency implementing a program can ensure that a research project by a PRO is selected and financed (output), the agency does not fully control whether the research project leads to the publication of a scientific article in an international peer-review journal (outcome).

7.2. LINKING INPUTS WITH OUTCOMES

Table 7.1a describes the types of outcomes that will be quantified and measured in order to establish to what extent the four proposed outcomes are being generated. Table 7.1b provides an example of how this table can be structured, again using the "research excellence" outcome as an example.

The first step is to define a streamlined list of outcome types that will be associated to each of the four proposed outcomes. Similar outcome types and indicators can be used for multiple programs implementing activities of the same nature. Once this is done, indicators and measurement units for each outcome type should be defined. Outcome types and their respective indica-

Table 7.1a: Intermediate Outcomes—Illustrative Metrics

Intermediate outcomes		***Possible indicator***
Research excellence and productivity	Volume and quality of scientific outputs	Citations per capita, publications per capita in top 10% of journals, and indicators such as the h-index that measure the quality of citations
	Outputs relative to expenditure	GERD divided by triadic patents, and GERD divide by papers published in top journals
	Internationalization of researchers and development of new research networks	Collaborations with foreign researchers/research organizations Collaboration across PROs
	Availability of research skills	Supported PhD students going to become researchers
	Improved use of research infrastructure	Occupation rate of new laboratories and research facilities
Research commercialization, science-industry collaboration		Revenues from services provided to the market as share of total revenues
		IP licensed and spinoff companies from PROs (number and value)
Technology adoption by manufacturing, agriculture, and service sectors		Imports of machinery and equipment; import of intermediate goods
		Quality certification (ISO 9,000; environmental standards)
		Computer use by firms; Internet use; intensity in the use of tractor, fertilizers (per hectare)
Business innovation, business R&D, and startups		Number of firms introduction new products or processes; share of firm revenues coming from innovation
		IP rights registered (trademarks, patents)
		Survival and capitalization of knowledge-based startups (number and value of knowledge-based startups five years old or more)

Table 7.1b: Example of Intermediate Outcomes Metrics		
Intermediate Outcome	***Outcome type***	***Indicator***
Research excellence (Volume and quality of scientific outputs)	Internationalization of researchers and development of new research networks	Collaborations with foreign researchers/research organizations Collaboration across public research organizations
	Availability of research skills	Supported PhD students going to become researchers
	Improved use of research infrastructure	Occupation rate of new laboratories/research facilities

tors are then organized according to the four proposed outcomes. This allows categorizing all STI outcome types into the four proposed outcomes, regardless of the program that is generating them.

Some of the proposed indicators for intermediate outcomes are available from standard data sources for STI data as reviewed in appendix B. An example would be government-financed gross domestic expenditure on R&D (GERD). Indicators may also be generated with simple manipulation of available indicators (for example, GERD per triadic patents). Information from surveys—like those proposed for business innovation—will be more difficult to find. Program outputs would be collected directly from program managers. In some cases, R&D statistics or budgetary information may be used as a first approximation at the aggregate level.

Analysis of intermediate outcomes metrics provides an indication of where the system is working effectively and where it is not. This provides a starting point for a more in-depth review of the conditions that are leading to the system working effectively or not. The next three sections explain how to conduct these in-depth reviews. They focus on the effectiveness conditions for three intermediate outcomes: (i) research excellence, (ii) science industry collaboration and technology transfer, and (iii) business innovation. The sections are structured around questions to facilitate use and should be seen as a non-exhaustive checklist. Also, the relevance of the sections and questions within each section will vary from country to country.

7.3. RESEARCH EXCELLENCE

Research excellence and productivity depend on the adequate supply (quantity and quality) of human resources, infrastructure, and funding, as well as the incentives under which the researchers and managers in PROs operate. Researchers and managers of PROs respond rationally to a system of rules and regulations that embed different payoffs to choices they face. Public investment in STI will be less effective if that system is not conducive to research quality and productivity.

Four sets of questions for assessing research excellence are presented below.

i. The presence of and the ability to attract highly motivated and well-trained human resources

Relevance to the outcome	An increase in public investments in R&D may not lead to an increase in research output and quality without adequate access to quality human resources. This requires the presence of a higher education system that is capable of producing academic talent, and incentives that can attract and retain this talent.
Assessment checklist	• Does the higher education system provide a steady supply of quality academic talent, compatible with the country's needs? • Are the PROs able to attract and maintain top academic talent? Is the share of local scientists abroad significant? Why? • Are the opportunities for young researchers fair, transparent, and effective? • Do employment regulations provide for the substantive reward of high performance and effective punishment of recurrent underperformers? • What is the degree of integration of local research with the international scientific community?

ii. Researchers have access to appropriate research infrastructure for research excellence

Relevance to the outcome	Quality human resources need access to modern infrastructure to conduct excellent research. This requires investment in research infrastructure that is in line with modern standards and research priorities of the country. In addition, collaboration with international labs and research facilities allow developing countries to leverage resources outside without costly investments.
Assessment checklist	• Are research facilities and infrastructure (in major fields of the country) up to international standards and compatible with the country's needs? • Is there a roadmap/strategy for investments in infrastructure research? Are actual investments in research infrastructure in line with the outlined research strategy? • Can researchers access research infrastructure anywhere in the country? How is research infrastructure regulated? • Can researchers access the relevant international research facilities?

iii. Research funds are administered appropriately

Relevance to the outcome	Access to funding in a predictable and stable way is another important factor contributing to research excellence. The way those resources are distributed (competitively or not) is also crucial. Finally, researchers funded by third parties (specially the business sector) are more likely to engage in results-driven work.
Assessment checklist	• Is the flow of public funding stable and predictable? Is there any source of earmarking for public spending in R&D? If so of what type? • Are allocations of funds to different PROs made in a competitive manner? What is the composition between block funding and competitive funding for public research institutes and universities? • Are researchers properly incentivized to look for third-party funds? Do researchers control funds mobilized from third parties?

iv. The governance of PROs is effective and geared toward research excellence

Relevance to the outcome	The rules and procedures governing how PROs operate also generate incentives that may or may not be consistent with reaching research excellence and research productivity. Rules governing the relationship between the government and PROs include those related to the selection and performance of senior managers. Therefore, of interest is the delegation of powers from the government to the PRO, the incentives under which managers operate, and the accountability to the public.
Assessment checklist	• Do PROs have clearly defined missions and research priorities? • Are public resources made available through a performance-based method? • How much managerial power has been delegated to managers compared to other decision-making bodies of the PRO (for example, scientific committees or governing bodies)? To what extent are the incentives of the different board members aligned with those of the PRO? • Do regulations of PROs effectively empower managers to achieve results? How adjustable are PROs' budgets (between activities and years)? How much autonomy do PROs have to manage human resources? • Are top management positions for PROs filled by a competitive meritocratic process? • Are there monitoring systems to measure management targets/goals? How does the government (owner) exercise control?

7.4. SCIENCE-INDUSTRY COLLABORATION AND TECHNOLOGY TRANSFER[1]

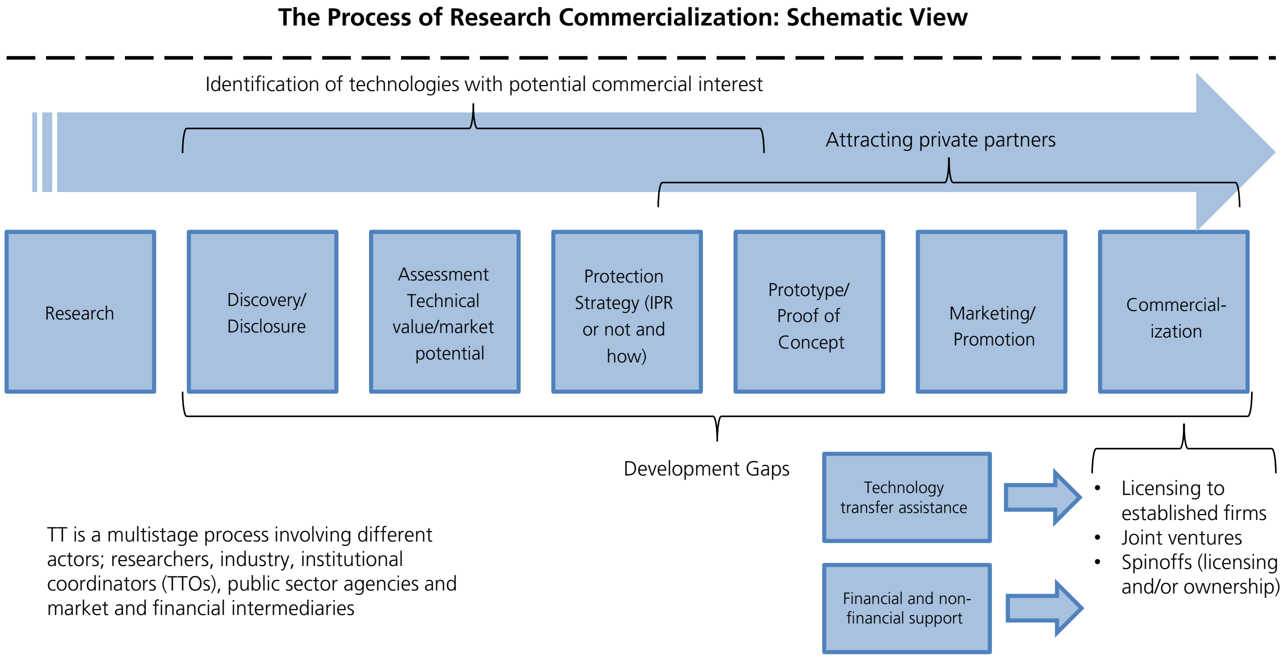
Universities and research institutes are large beneficiaries of public investments in R&D. The pace and effectiveness of the transformation of research outputs—or, more broadly, academic knowledge—into new or better products and processes has a substantial impact on the contribution of those public investments to economic development. By improving the process of knowledge transfer from PROs, countries can increase innovation in the economy, and raise productivity, and create better job opportunities.

Research commercialization does not evolve naturally and linearly from research and the discovery of scientific solutions. Rather, the process normally faces unfavorable economic incentives and an inadequate supply of complementary services to translate new ideas into technological and economically viable innovations. Technology commercialization is a multistage process involving different stakeholders—researchers, faculties, coordinating/managing organizations, private/public technology transfer intermediaries, and the enterprise sector. These stakeholders' objectives often differ from research commercialization (see figure 7.2).

In the remainder of this section, some issues are identified that need to be addressed when assessing the conditions for effective technology transfer, including an adequate incentive regime for researchers and PROs and the efficient provision of intermediation services. Factors facing the incentive regime here include the regulation of intellectual property (IP) rights and employment regulation, among other rules. Within a large set of intermediation services, the session concentrates on technology transfer offices, science and technology parks, the development of a pipeline of potentially investable projects, and financial support for science-industry collaboration.

1. Based on Correa and Zuniga (2013).

Figure 7.2: Research Commercialization



i. Intellectual Property Regulation

Relevance to the outcome

PROs are not necessarily interested in managing and actively seeking to commercialize research, as it is a very complex activity with high sunk and transaction costs as well as uncertain returns. Similarly, scientists are rarely interested in commercializing their research results, as investments in strictly academic or administrative tasks tend to yield higher net returns.[2] Therefore, without clearly defining rights and obligations of those key stakeholders, it is unlikely that an efficient commercialization process will emerge. How is the IP of publicly funded research performed by PROs regulated in the country?

Assessment checklist

- Who owns the IP—government (funding agency), university (or faculty/department), or researcher? If not the researcher, is there a minimum share of royalties assigned to researchers? Are regulations for ownership and royalties unambiguous?
- Is there an obligation for the PRO to manage its research base and actively pursue the development and commercialization of IP? Which organization is supposed to perform this task (faculty, department, university, PRO)? Are there penalties for nonenforcement?
- Do researchers have the obligation to disclosure their research activity and results to the PRO? If so, to whom and under which confidentiality rule? Are researchers obliged to engage in commercialization efforts? If so for how long? What are the penalties for noncompliance?

2. There are several reasons for this. One is that most scientific results are far from a stage in which they can be commercialized. Additional research, sometimes for a few years, is needed until a decision can be made about the commercial potential of a discovery. Another difficulty refers to the matching process, that is, finding an investor interested in nurturing a spinoff or a firm interested in buying the license. Therefore, except in the cases of breakthroughs with clear commercial potential, technology transfer from PROs will not follow naturally from research.

Box 7.1: IP Regulation in the United States and Denmark

As discussed above, altering the incentives of key stakeholders requires changing the expected payoffs of their alternatives. One way to do that is by creating a cost of noncompliance with the established rule. In this regard, developed countries have sometimes designated a series of legal responsibilities for PROs and researchers that benefit from public funds for research.

In the United States, the U.S. Bayh-Dole Act transferred to research universities the responsibility for managing IP rights related to publicly funded research (originally belonging to the funding agencies).

In Denmark, the 1999 Law on Inventions on Public Research Institutions established that researchers must disclose their inventions and assist in the commercialization process when needed. These regulations have the advantage of clarifying roles among stakeholders and are easy to monitor.

Source: Correa and Zuniga 2013.

ii. Employment Regulation

Relevance to the outcome

Human resources policies have an impact on the performance or researchers not only in terms of research excellence and productivity but also its commercialization. Criteria for career development of scientists may or may not reward commercialization efforts and collaboration with industry. Do employment regulations limit the participation of researchers in entrepreneurial activities or research activities with the private sector? More specifically:

Assessment checklist

- Is there a provision for sabbatical years for the researcher employment in the spinoff company through which her or his research will be commercialized?
- Is there any equivalence between academic achievement (such as publications) and technology transfer achievements (such as patenting, licensing, and volume of contract research with industry) for career promotion or in terms of financial compensation?
- Do regulations enable/encourage internships from and to companies?

iii. Other Regulations

Assessment checklist

Do PROs have the legal mandated and operational flexibility to efficiently manage IP rights (for example, managing a portfolio of spinoff companies)?

- Is the use of PRO resources (such as infrastructure facility, research material, and researchers' time) in collaborations with the private sector properly regulated? Does this regulation impose excessive financial and nonfinancial costs (red tape) for the private sector?

iv. Technology Transfer Offices

Relevance to the outcome

Technology transfer offices (TTOs) are a particular type of organizational arrangement that permits specialization and economies of scale. They emerged in the past three decades as one of the models used by developed countries to promote manage research and implement post-research commercialization efforts.[3]

3. Experience shows that the most successful institutions are the ones that devote sufficient resources that such coordinating entities can fully deploy their missions. See Debackere and Veugelers (2005) and Siegel et al. (2007).

Assessment checklist

- Are there TTOs? Do they cover most of the country's research base?
- Are there arrangements for long-term sustainability of the TTOs? Are they endowed with sufficient financial resources? Does the salary structure reward the performance of TTO staff? Are the right skills available in the market? Is the TTO staff appropriately prepared and connected to the PRO researchers and industry? Are PROs aware of the long-term and public nature of TTO activities (that is, that the TTO is not a short-term profit-making organization)? Are PROs committed to support their TTOs in the long term?

v. Science and Technology Parks

Relevance to the outcome

The primary role of science and technology (S&T) parks is to enable collaboration between firms and research institutions, facilitating the emergence of spin-off and start-up companies. The implicit assumption is that knowledge spillovers are location-specific (Link, Scott and Siegel, 2003). Are there S&T in the country? If so, is there evidence that firms installed in the park collaborate more or better with the respective PRO?

Assessment checklist

- Do the S&T parks cover most of the country's research base? Are S&T parks physically close to research institutions? What was the motivation for the creation of the park (discuss the feasibility study/demand assessment)? Is it privately or public managed? Are the parks involved in the commercialization effort? Do they provide incubation services?

vi. Science-Industry Collaboration

Relevance to the outcome

Science-industry collaboration in R&D is a major channel of technology transfer. There is ample evidence of the positive impact of joint research on business innovation in developed countries.[3] The positive impact of science-industry collaboration on firm innovation for developing countries is increasingly pointing to this direction (Crespi and Zuniga 2012).

There is limited understanding about market or institutional failures causing poor collaboration between science and industry. One hypothesis points to reputational issues, asymmetric information, and transaction costs (Audretsch, Bönte, and Krabel 2010). Policy instruments to foster science-industry joint research include research grants, matching grants, and tax-incentives.

Assessment checklist

- Are there voucher schemes to promote science-industry collaboration? Is there any evidence of sustained behavioral change from SMEs?
- Does the program target the private sector or PROs? Is there a focus on SMEs? What are the goals of the program, eligibility criteria, and selection process? Are there any other non-voucher programs?
- Are there centers of competence and centers of excellence?

4. For the United States, a study showed that firms taking part in Cooperative Research and Development Agreements (CRADAs) with federal laboratories were significantly superior in terms of technological performance when compared with other firms. According to Hall (2002), these consortia agreements, backed by real budgets and cost-sharing among parties, allowed internalization of spillovers and maximization of innovation possibilities and patenting.

7.5. BUSINESS R&D, STARTUP CREATION, AND TECHNOLOGY ADOPTION

Business Innovation: R&D, Startup Creation

Why do firms choose different techniques even when the "best practice" is available? Why do some firms introduce better products or reduce their costs while others don't? Unfortunately there is no simple explanation for these questions. As a general starting point, one may consider that profit-seeking entrepreneurs choose between productive (innovation, technology adoption), un-productive (rent seeking), or destructive strategies based on the different net pay-offs embedded in the governance/institutional regime of a given society. When economic incentives for productive strategies are dominant, entrepreneurs engage in a process of "creative destruction" and free markets become the "innovation machine" (Baumol 1990, 2002).

Frictions unlikely to support innovation and technology adoption include labor market rigidities, poor labor skills, limited access to credit, inadequate access to internationally available knowledge, weak rule of law, and excessive red tape (Parente and Prescott 1994). Consequently, countries reach higher levels of efficiency at different rates not because they have access to different stocks of knowledge, but rather because they differ in the amount of constraints placed on the technology choices of their citizenry (Parente and Prescott 2005).

Five sets of questions for assessing business innovation are presented below.

i. A business environment that encourages innovation

Relevance to the outcome	In assessing the impact of public expenditures in STI, it is important to take into account the business environment in which firms operate. The broad governance regime (including rule of law and contract enforcement), market entry and exit, labor regulation, red tape, and so forth play an important role in ensuring that research can be smoothly converted into innovative products.
Assessment checklist	• Is it easy for new businesses to enter the economy? • Can start-ups and businesses readily access financing for innovative products? • Do businesses have access to human resources with research capabilities? • Is the legal system effective in dealing with contract enforcement issues? • Does the government provide support for business R&D? • Are failing businesses allowed to exit easily?

ii. Investment Readiness

Relevance to the outcome	Timely access to mentors and networks can be critical in helping entrepreneurs who are seeking to market new products or penetrate new markets. These resources help entrepreneurs gain access to advice on strategic planning and marketing, financial resources, technological resources, and so forth. Connection to those networks and mentors is important to avoid the creation of graveyards of ideas, proof of concepts and prototypes.

Assessment checklist	• Are there funding schemes for the development of proof of concepts and prototypes? How much is the market test taken into account from the early stages of project development? • Are there mentoring services for the preparation of "investable" projects? Are there connections to potential users of the technology or possible investors? • Are seed financing schemes available (see the discussion of the Valley of Death in box 7.2)? Financing is often unavailable for the additional research that is needed to move beyond proof of concept, and prototypes. These activities are neither eligible for standard research grants nor attractive options for venture capitalists and so entrepreneurs, and researchers engaged in entrepreneurial activities struggle to finance ideas that would succeed were they to find the funds.

iii. The private sector has access to resources required to innovate

Relevance to the outcome	Innovation is not cheap. By its nature, it involves a higher degree of risk than business ventures that operate in established markets with tested products. Firms therefore require access to cheap capital, machinery, and associated assets to be encouraged to take the risks of innovation.
Assessment checklist	• Do innovating firms have access to cheap debt? • Do firms have access to equity financing? (see the discussion of the Valley of Death in box 7.2)? • Do firms have access to equipment and machinery as discuseed in the section of the "Affordability and availability of machines and equipment" in the Technology Adoption and Diffusion section?

iv. Government support for business R&D increases innovation [5]

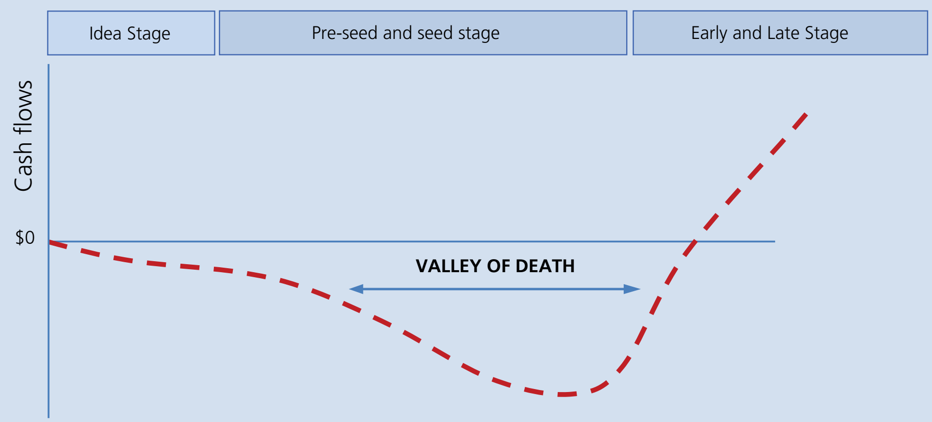
Relevance to the outcome	Fiscal support compensates firms for the externalities and risks involved in the R&D activity. It is designed to reduce the cost of private investments and increase the volume of R&D invested by the firm. The critical issue is to understand whether the incentive was generated by additional investments—that is, investments that would not have been made without the incentive. The number of OECD countries that implement an R&D tax incentive scheme rose from 18 in 2004 to 26 in 2011.
Assessment checklist	• Are government monetary support programs for business R&D appropriately targeted? • Are support programs designed to suit the needs of the economy? • Are the levels of direct and indirect support to private sector adequate? • Are the administrative requirements to access and use government support compatible with international good practices? • See the fifth question below for a list of questions on Tax Incentives.

5. Based on Correa and Guceri (2013).

Box 7.2: Knowledge-based Start-ups and the Valley of Death

Knowledge-based start-up firms often need substantial, externally provided funds to successfully grow. Their need for funding is often greater than the funding that friends or family can offer. At the same time, these firms are often too young and under-developed to receive funding from more formal sources of funding such as banks, venture capital, or private equity funds. Studies have shown that in developing countries, friends and family usually contribute up to US$50,000, enough for an entrepreneur to get started but not enough to generate sufficient revenues to scale the business. To grow, entrepreneurs may need an injection of capital, but banks have little appetite to lend to high-risk businesses with insufficient cash flows. Venture capital and private equity firms (which may not exist in some countries) usually do not invest less than US$1 million—too much for a seed-stage start-up. The resulting funding gap is called the "valley of death." It can be difficult to traverse, which leads to failure of start-ups. Firms can get through the valley of death with the help of pre-seed funding to achieve positive cash flows and so build successful and prosperous businesses.

Figure B7.2.1: Valley of Death



Source: World Bank (2014).

v. Tax Incentives for Research and Development[6]

Relevance to the outcome

Governments are increasingly relying on tax breaks to support to R&D efforts by firms. A number of studies have found that R&D tax credits increase R&D expenditure, and lead to an increase in innovation.[7] The economic rationale for tax breaks is that they increase R&D by lowering the cost of carrying out R&D in the private sector, and thus overcome the market failure that arises because the social returns from R&D are lower than the private returns.

Tax breaks can take a number of forms. These include tax credits (and enhanced deduction schemes) that allow firms to deduct R&D expenditures (or more) from their tax liabilities, depreciation allowances, and unconditional cash refunds which provide benefits to companies that are loss making and so don't pay taxes.

6. Based on Correa and Guceri (2013).

7. As discussed in Correa and Guceri (2013) some studies have found that some tax break schemes have not increased R&D expenditure.

Assessment checklist

- Is there a tax break scheme for R&D in place?
- What type of tax breaks are available? In other words do they come in the form of tax credits, depreciation allowances, unconditional cash refunds, or other?
- What types of firms are eligible for the R&D tax breaks?
- What types of expenditures are eligible for tax breaks?
- What is the red tape associated with access to tax incentives?
- Is there large-scale take up of the tax break scheme?
- Is the value of the tax incentives large enough to affect behavior?

Technology Adoption and Diffusion

Innovation in developing countries is based mostly on adoption, recombination, and adaptation of existing technologies rather than on the development of new technology. Innovation is therefore more "new to the market" or "new to the firm" than "new to the world." As a result, the capacity of developing countries to innovate depends, on the one hand, on foreign sources of knowledge and technology and, on the other, the country's capacity to absorb, adapt, and diffuse innovation.

Five sets of questions for assessing technology adoption and diffusion are presented below.

i. Existence of regulation framework

Relevance to the outcome

Building an enabling environment that is both attractive to foreign investment and locally supportive of innovation, adaptation of technology, and dissemination of knowledge requires an adequate institutional framework. Government policies to support innovation should embark on reforms that update the regulatory and institutional framework for innovation and remove bureaucratic, legislative, and regulatory obstacles to innovation—and particularly technology adoption and diffusion. These obstacles often affect competition laws, licenses to operate, government authorizations, technical norms and standards, and customs procedures. For instance, monopoly rights may represent a barrier to the adoption of technologies in the sense that industry insiders with monopoly rights to the current technology will resist the adoption of better production techniques. This suggests that more competitive economies are likely to be characterized by higher absorptive capacity.

Assessment checklist

- Is trade regulation and legislation acting as a driver for the influx of new knowledge and technology to the country (including embodied technology, contact with foreign suppliers, and FDI)?
- Are anti-competitive regulations and firm conduct acting as a barrier to the introduction and diffusion of technologies in certain sectors?
- Is the existing framework of technical regulations and standards acting as a driver for the influx and diffusion of technologies?
- Do national technical regulations and standards build on international standards?
- Does the domestic regulatory framework encourage attract foreign companies and FDI?

ii. Affordability and availability of machines and equipment

Relevance to the outcome

The acquisition of machinery and equipment represents a major source of knowledge for innovation in firms. The technological know-how embodied in machinery enables firms to employ more efficient production processes and thus raise the quality of their own products and processes. Embodied technology diffusion is about the introduction into production processes of machinery, equipment, and components that incorporate new technology developed in other firms either domestically or abroad (Papaconstantinou et al. 1996). The extent to which firms can acquire machinery is defined by the availability and affordability of machinery and equipment.

Assessment checklist

- Are firms able to acquire new technologies at competitive prices in local markets?
- Are there high tariffs or other restrictions on the importation of machinery, equipment, and intermediate goods?
- Are there restrictions or high tariffs on importation of used equipment and machinery?
- Is it difficult or costly to import machinery and equipment?
- Can firms rent machines?
- What is the depreciation policy embedded in the country's tax policy?
- Is there an adequate supply of financing instruments (at reasonable cost) for firms to purchase new machinery and equipment?
- Are there shared facilities enabling firms to access high-cost and modern technologies?
- Are there sufficient skills in the local labor market to operate cutting-edge machines and technologies?

iii. Technology extension services[8]

Relevance to the outcome

In many countries technology extension programs fall into the category of "innovation" policies and programs. However, the role of extension work within the spectrum of such programs is unique. Technology extension aims to improve the productivity and competitiveness of existing businesses through the adoption of the most appropriate technologies for their fields of activity. It aims to promote learning that is articulate, thoughtful, and repeatable by the companies so they are able to develop new skills for the future.

Several countries have programs to support manufacturing SMEs, of which comparative studies have been conducted. Most developing countries face special challenges in terms of the skill level of their workforce. The introduction of new technologies and processes requires more carefully designed assistance processes than those used in developed countries. The design and implementation of technology extension programs for these countries should keep this situation in mind.

Supplying technology extension services is not synonymous with offering financing. Support or advice on access to funding sources from other agencies may be a component of improvement projects, but they are not the main focus. Typical mechanisms by which technology extension services address SMEs information gap are assessed using the questions below (see box 7.3 for a summary of international good practices):

8. Based on Rogers (2013).

Box 7.3: International Good Practices for the Provision of Technology Extension Services

Demand driven/mission oriented. Technology extension programs should be geared to the needs of the industrial customers they serve and well informed about the nature of the demand for improvements as they feed a proactive vision for companies to solve their problems and make such improvements.

Practice-oriented technology applications. The applications of technology promoted by extension service programs should be primarily practical and of proven value among industry leaders. Providers must avoid recommending highly abstract projects or innovative but untested concepts that are more appropriate in research laboratories than in SMEs with challenging business problems.

Decentralization. Service centers must be distributed in regions where the demand for their assistance is documented and understood. Being near their customers helps providers understand regional variation in the needs of SMEs and makes their programs more visible and easily accessible to companies that are potential customers.

Target SMEs. When the pressure to become self-financing becomes too high, service providers tend to migrate to more capable, generally larger companies that have more resources and do not need subsidized consulting. The opposite mistake is focusing on micro-enterprises that do not have the capability of absorbing and leveraging the services received.

Critical role of human resources. Staffing the program with competent personnel who are familiar with SMEs and the delivery of industrial extension services is absolutely critical. The desirable profile of these providers, then, has three dimensions: they must have knowledge of technology, knowledge of the business environment of companies, and the ability to communicate in interpersonal relationships that grow out of improvement projects.

Source: Rogers 2013.

Assessment checklist

- Is there provision of information on opportunities for improvement in existing technologies, best practices, international trends, relevant regulations, business networks, opportunities to become government suppliers, and others?
- Is technical assistance and consulting in the context of improvement projects designed individually for interested companies?
- Is training of plant and administrative staff for the effective use of technologies more advanced than those previously used by the company?

iv. Standards and technical regulation[9]

Relevance to the outcome

Standards and technical regulations can play an important role facilitating innovation. They consist of rules and guidelines for products, processes or production methods. Compliance with standards is voluntary and they can be set by the state, private sector, or civil society. In contrast, technical regulations are mandatory and are typically set by the state. By codifying the technical characteristics of products and processes, standards and technical regulations embody technological knowledge and best practices. Because information in them is nonproprietary, they create a pool of technical knowledge that can be transferred across companies and countries, freely accessed by entrepreneurs, scientists, and engineers, and used to generate new ideas and technologies. Moreover, standardization stimulates innovation by helping to build focus, cohesion and critical mass in the emerging stages of technologies and markets. They also play an important role facilitating trade by reducing risks and transaction costs.

Governments play a leading role in designing and implementing certain standards and technical regulations. This includes ensuring that national standards and regulations are consistent with international ones, especially those in important export markets. Governments can also play an important role facilitating the adoption of standards by firms which may find standards to complex and demanding to implement by themselves. The state can promote awareness about standards and design appropriate capacity-building programs to ensure that standards do not exclude local companies from domestic and export markets. A number of services that are needed by the private sector to comply with technical regulations, standards, metrology, and quality requirements are described in table 7.2.

Assessment checklist

- Are local firms finding that their absence of compliance with local or international standards and regulations is restraining their ability to supply local or international markets?
- Are metrology facilities and testing laboratories able to supply the services needed by local firms?
- Do firms report a need for capacity building to satisfy the requirements of local or international markets?
- Are local regulations and standards consistent with those in major export markets?

7.6. CONCLUSION

This chapter discussed how to evaluate the effectiveness of STI programs. It first described how to link inputs with outcomes. There followed sections that evaluated conditions for effectiveness in research excellence, science-industry collaboration and technology transfer, business R&D, startup creation, and technology adoption. Box 7.4 outlines a possible structure for the EFA as well as a number of useful readings that go into more detail on the approaches described in this chapter, as well as illustrating their application. The next chapter discusses the final report.

9. Based on Swann (2010), Kaplinsky (2010), and Guimón (2014).

Table 7.2: Technical Regulations, Standards, Metrology, and Quality

Compliance area	***Business needs***	***Services needed***
Product standards/technical regulations, including packaging and labeling	Access to standards/technical regulations	Reference center in standards body or other
Product testing	Conformity assessment recognized by the (international) client	Testing laboratory upgrading toward internationally recognized accreditation, mutual recognition agreements (MRAs)
Accuracy of measurement	Internationally recognized equipment calibration, measurement traceability to the International System of Units (SI) standard	Metrology laboratory upgrading toward internationally recognized accreditation, inter-calibration schemes
Consistent product characteristics and quality	Enterprise Quality Management System Certification (ISO 9000)	Certification capacity and internationally recognized certifiers
Management of environmental impact	Enterprise Environmental Management System Certification (ISO 14000)	Certification capacity and internationally recognized certifiers

Box 7.4: The Effectiveness Assessment—Structure and Useful Readings

Possible structure of the EFA as a standalone document:

1. Introduction: Objectives and Scope, as agreed in the Inception Report
2. Research Excellence
3. Science-Industry Collaboration and Technology Transfer
4. Business R&D, Startup Creation, and Technology Adoption
5. Policy Recommendations and Conclusions

Useful reading:

European Parliamentary Research Service (EPRS). 2014. "Measuring Scientific Performance for Improved Policy Making." Science and Technology Options Assessment, EPRS, European Parliament, PE 527.383.

European Commission. 2012a. "Evaluation of Innovation Activities: Guidance on Methods and Practices." European Commission Directorate-General for Regional Policy.

Fahrenkrog, Gustavo, Wolfgang Polt, Jaime Rojo, Alexander Tubke, and Klaus Zinocker. 2002. "RTD Evaluation Toolbox—Assessing the Socio-Economic Impact of RTD-Policies." Strata Project HPV 1 CT 1999–00005.

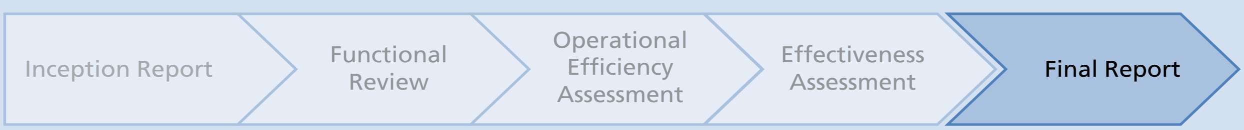
Indecon. 2008. "Value for Money Review of Science Foundation Ireland." Department of Enterprise Trade and Employment by Indecon International Economic Consultants.

CHAPTER 8

FINAL REPORT

The Final Report is the last stage of the Public Expenditure Review (PER) (see figure 8.1). The Final Report addresses the final analytical questions: (i) how is the policy mix affecting the impact of public spending in research, development, and innovation (RDI); and (ii) how is the national innovation system (NIS) governance structure contributing to shape that policy mix? In addition, it is envisaged that the Final Report will integrate the findings of the Efficiency Assessment (EA), the Effectiveness Assessment (EFA), and the Functional Review, as well governance analysis that may have been conducted for the Functional Review (as described in chapter 3 and chapter 5).

Figure 8.1: The Final Report



Summary

The ultimate objective of the Final Report is to provide a fact-based set of recommendations that describe how policy makers' strategic goals can be achieved through policy reforms and strategic investments. These recommendations can take the form of a plan that links the achievement of the strategic goals to the required inputs, outputs, and outcomes.

The Final Report recommendations arise from an analysis that complements and extends the work done in previous stages of the PER. The analysis begins with a review of the NIS policy mix, which considers whether policies maximize returns to public investment by considering their relevance, coherence, and consistency. There follows a review of the composition and level of spending, including issues such as the mix of direct versus indirect support to business R&D, operating versus capital investments, and basic versus experimental and applied research. Then, a governance analysis evaluates how policies are made and implemented, and how to improve this process.

The Final Report is largely based on data collected for the previous stages of the PER. This data may be complemented with additional material. In particular, interviews may be used to collect additional information for the governance section from policy makers and implementation agencies.

The chapter first presents in section 8.1 an analytical approach that can be used to assess the relevance, coherence, and consistency of public expenditures on RDI. Section 8.2 follows with a description of indicators that can be used to analyze the composition of public expenditures based on existing indicators. Section 8.3 contains a brief discussion about the level of R&D. Section 8.4 discusses assessment questions for the governance structure. Section 8.5 concludes.

8.1. POLICY RELEVANCE, COHERENCE, AND CONSISTENCY

As discussed before (see chapter 3) there is no reason to assume, a priori, that policies will target economic and social goals which are *relevant* for the country context. Nor is there reason to assume that that policy design and implementation will result in a *coherent* body of measures *consistent* with an intended public goal (common good). This analysis complements, therefore, the assessment of the operational efficiency of expenditures (chapter 6) and their effectiveness (chapter 7) with the analysis of the "policy mix." The underlying hypothesis is that the *more balanced* a policy mix is, the more it will serve to maximize returns to public investment. It follows that the interdependence of STI policies is a major determinant of their impact.

It is proposed that this issue is approached through three supplementary questions:

- **Policy relevance**: Do the composition and level of STI public expenditure reflect the development needs and priorities of the country?
- **Policy coherence:** Are the activities and programs being implemented and financed *complimentary*? Are the activities and programs being implemented and financed *redundant*?
- **Policy consistency:** Is the composition and level of public expenditures *consistent* across existing outputs, outcomes, and higher-level goals?

In order to address such questions, this section suggests the approach in table 8.1. It merges tables 6.1a and 7.1a and integrates inputs, outputs, outcomes, and impact information to enable a comprehensive, results-oriented review of public spending, following the input-output-outcome-impact (IOOI) framework (chapter 3). Table 8.1 is the core instrument for the proposed PER exercise. It reflects the intention to go beyond the pure review of public spending to involve a first assessment of their impact, linking disbursements/budgeting and the outputs and outcomes.

Table 8.1 can be complemented by table 8.2. Table 8.2 goes beyond R&D expenditures and links public spending to the results-oriented framework, thereby consolidating the STI budget. It follows a previous structure (described in table 5.1) and is filled with specific data to enable a subsequent practical exercise. Together with more disaggregated versions (see chapter 5), table 8.2 provides for a comprehensive, results-oriented approach of *public spending* in STI. It reflects the intention to go beyond R&D data and cover other government expenditures related to the innovation process.

Let's see a practical exercise starting with the data from table 8.2, which is expected to be available at this stage of the analysis. The analysis is not meant to be exhaustive but rather illustrate the potential of the proposed framework.

Policy Relevance

The ratio (H/J) in table 8.2 provides an approximation of the share of public expenditures with a potential impact on productivity growth—a possible indicator of the *relevance* of public spending on STI. In that case, more than one third of public spending on STI has a goal different from improving total factor productivity (TFP) or labor productivity. The reallocation of those resources toward the productivity objective could, in principle, represent a potential source of improvement in the quality of public spending in STI and thus a source of economic efficiency gains.

Table 8.1: Policy Input, Outputs, and Intermediate Outcomes			
Intermediate outcomes	***Possible indicator***	***Policy/program***	
		Output	***Budget/disbursement***
Development goal	Total factor productivity (TFP), labor productivity in manufacturing and service sectors; yield per hectare; export of new products		
Research excellence and research productivity	Citations per capita; publications per capita in top journals	Research projects funded Research projects completed (number and value) *Note:* Government-financed GERD would provide an aggregate figure	National Science Foundation Research Grants
	Gross domestic expenditure on R&D (GERD)/triadic patents, GERD/papers published in high impact factor journals		Academy of Science's Program for the Advancement of Research
Research commercialization, science-industry collaboration	Revenues from services provided to the market as share of total revenues	Research projects with the private sector (number and value) *Note:* Distribution between basic and experimental research funded by the government is a first approximation (from budget)	Research Institute for Marine Biology Institute for Agricultural Research
	IPs licensed and spinoff companies from PROs (number and value)		Research Institute for Marine Biology Institute for Agricultural Research
Business innovation, business R&D, and startups	Number of firms introduction new products or processes; share of firm revenues coming from innovation ;	Value of disbursements and number of firms covered	Innovation Vouchers Program (from Ministry of Economy)
	IP rights registered (trademarks, patents)	Value of business R&D or share of SMEs investing in R&D	Tax breaks for business R&D
	Survival and capitalization of knowledge-based startups (number and value of knowledge-based startups five years old or more)	Number and value of knowledge-based startups created that received funding from the program	Matching grants program for early-stage funding from Ministry of Science
Technology adoption by manufacturing, agriculture, and service sectors	Quality certification for computer use by firms using the Internet	Number of firms assisted; number of firms certified.	Technology extension services and matching grants from Mininistry of Industry
	Intensity in the use tractor, fertilizers (per hectare)	Number of individual trained	Agricultural Extension Services from Ministry of Agriculture

Table 8.2: Country Alfa Consolidated STI Sector Budget—Illustration (US$ '000s)	
Budget item	***Value (US$ '000s current)***
Expenditures on R&D (A)	100,000
Expenditures for Research Commercialization and Collaboration (B)	5,000
R&D and Technology Transfer Budget (C)= (A+B)	**105,000**
Tax Breaks for Business R&D (D)	15,000
Expenditures Supporting Business R&D and Startups (E)	3,000
Expenditures Supporting Technology Adoption by Firms (F)	50,000
Innovation Budget (G)= (D+E+F)	**68,000**
R&D and Innovation Sector Budget (H)=(C+G)	**173,000**
Other Expenditures (I)	87,000
Consolidated R&D Budget (J)= H+I	**260,000**

This is likely to be the case, for instance, if (i) the analysis from the Country Paper (chapter 4) indicates that low levels of agricultural productivity hinder poverty reduction given a large share of the population employed in subsistence agriculture; and (ii) the information generated using the sources referenced in table 8.1 indicates that very little public spending in STI is allocated to agricultural extension services.

Yet, the reallocation across categories should not be taken for granted. It is important to keep in mind that other objectives than economic efficiency may be driving the allocation of resources —for example, improving public health. Note that it is often difficult to too compare and trade off efficiency with non-efficiency goals.

Policy Coherence

It is also possible to analyze the *coherence* of public spending by comparing the allocation across the four intermediate outcomes. This *proportionality* check could demonstrate, for example, that the country Alfa is overinvesting in R&D (A) activities while neglecting to support technology transfer and science-industry collaboration (B).

In the hypothetical situation illustrated in table 8.2, too much seems to have been spent on R&D (US$100 million) compared to efforts to commercialize that research or foster science-industry collaboration (US$5 million). This is more likely to be the case if the indicators in table 8.1 suggest good performance in terms of research excellence and poor performance on science-industry collaboration and research commercialization.

The situation would be less clear were the results from the analysis described in table 8.1 to show poor indicators for both intermediate outcomes—research excellence and science-industry collaboration and research commercialization. If research outputs do not reach reasonable levels of academic excellence, the possibility of collaboration or commercialization is significantly reduced—and public investments in this area may not be warranted.

Table 8.1 also provides for the assessment of *policy coherence*. This includes the existence of *overlaps* in programs and activities, whether programs and activities *contradict* or *complement* each other, and whether program and activities may be *missing.* The identification of missing activities and programs is similar to the assessment of the effectiveness conditions (chapter 7).

The comparison between the innovation (G) and the research budgets (C) is an indicator of policy *consistency*—assuming that innovation is one of the development goals (as in the proposed structure in chapter 3). In the example of table 8.2, about 25 percent of the total spending in STI is allocated to innovation, of which less than 5 percent is invested in direct support to business expenditures in R&D. Table 8.1, which provides references for more detailed information on inputs (budget supporting business R&D), outputs (such as the value of firms' investments in R&D), and outcomes (innovation), complements the analysis with indicators (on the research and innovation performances), which may or may not corroborate the initial assessment.

Another approach to policy consistency is related to the *level of public spending*. Economic literature offers some empirical evidence on the level of public spending in R&D but not in terms of innovation investments. Moreover, calculating the social rates of return and comparing it with alternative allocation of public spending is often a tricky exercise (see next section). The analysis of consistency of the level of public spending across the different stages of the analysis—input-output and output-outcome—may be a useful approach. In more informal terms, one can think of the issue as "consistency between means and ends."

For example: resources invested in a quality certification program cover only a small number of exporting firms in the food industry sector. This in turn enables only a negligible increase in the food industry's exports which, in turn, is unlikely to lead to the diversification of exports (supposedly the developmental goal).

There are potentially other ways to use the notions of policy relevance, consistency, and coherence. The purpose of this Guidance Note is to identify some of them without the ambition of addressing all possible angles. Table 8.3 summarizes the exercise. The team implementing the PER exercise is encourage to consider other possible aspects according to the institutional specificities of the country being studied.

A final word of caution refers to benchmarking, which is implicit to some extent in the previous examples. For instance, in the case of policy relevance STI spending was lower than expected given the country's level of development. This conclusion rests on the analyst's ability to determine an optimal composition of public spending (even if roughly), and compare the country's spending to this. In some cases even a rough and ready

Table 8.3: Policy Relevance, Consistency, and Coherence

Assessment criteria	***Application***	***Example***
Policy relevance	Compare the information available in table 8.1 with the assessment of country needs prepared in the *Inception Report*. Use the main *budget categories* from table 8.2 to complement the analysis.	The *Country Paper* indicates that low levels of agricultural productivity hinder poverty reduction given a large share of the population employed in subsistence agriculture. Yet, very little of public spending in STI is allocated to agricultural extension services. Moreover, overall spending on STI is low compared to the country's development level.
Policy coherence	Identify possible *overlaps* in the programs and activities described in table 8.1. Consider to what extent programs and activities *contradict* or *complement* each other. Consider programs or activities that may be *missing* in table 8.1. Consider to what extent public spending among key categories in table 8.2 is *proportional*.	*Proportionality issue*. In the hypothetical situation illustrated in table 8.2, too much seems to have been spent on R&D (US$100 million) compared to efforts to commercialize that research or foster science-industry collaboration (US$5 million). This is more likely to be the case if table 8.1 indicates that research excellence indicators are comparatively high but indicators of research commercialization are comparatively low.
Policy consistency	Consider whether the *level* of public expenditures is consistent across existing outputs, outcomes, and higher-level goals	Resources invested in a quality certification program only cover a small number of exporting firms in the food industry sector. This small number of beneficiaries generates only a small increase in food industry's exports which, in turn, is unlikely to lead to the diversification of exports in the country.

version of this exercise may be impossible and the team will have to revert to the use of judgment calls. This is especially so in the case of inputs (public spending) and outputs (activities and programs) and less so in terms of outcomes (for which STI statistics is a starting point).

A better possibility of benchmarking public spending in STI refers to the use of the OECD data from the Policy Mix Database and other indicators that could be calculated using the 2001 *GFS Manual* (IMF 2001). The limitation, as discussed before, is that the OECD Policy Mix Database is restricted to R&D spending (see chapter 5). The next section describes some of those indicators and, when possible, how to generate them from the budgetary information. The next section also addresses issues related to the R&D level.

8.2. COMPOSITION AND LEVEL OF R&D SPENDING

Distribution of Public Spending to Public versus Private Sectors

STI policy in most countries has placed an emphasis on supporting business innovation. Yet policy makers often ignore the distribution of public spending between PROs and the business sector. As discussed before this is a critical first step for the proposed PER exercise. The analysis of the distribution by beneficiary can be generated by combining the Function of Government and Economic Classification of the *GFS Manual* (IMF 2001). Categories 2511 and 2521 of the Economic Classification correspond to subsidies provided to nonfinancial public corporations and nonfinancial private enterprises respectively. Data on R&D activity is available at the level of Government Functions. By combining both classifications it is possible to obtain the amount of subsidies resources allocated to the public and private sector (figure 8.2).

Direct versus Indirect Support to Business R&D

Another angle of possible interest is the distribution of expenditures between direct and indirect support. Direct support usually involves a transfer of public funds to the R&D performing firm, while indirect support applies some form of tax relief. Direct support is often directed toward particularly activities and sectors with perceived high social returns whereas indirect subsidies are more neutral in terms of sector preference (though this is not always the case). Direct support is often associated with the objective of supporting R&D projects in SMEs or startups (OECD 2010a). Budgetary data may be considered a possible source: the category 'transfer', as defined in the 2001 *GSF Manual*. Data on tax breaks, as mentioned before, need to be obtained separately. Figure 8.3 depicts the distribution between indirect and direct incentives for business R&D as a share of GDP for the 2008–09 period.

Basic versus Experimental Research

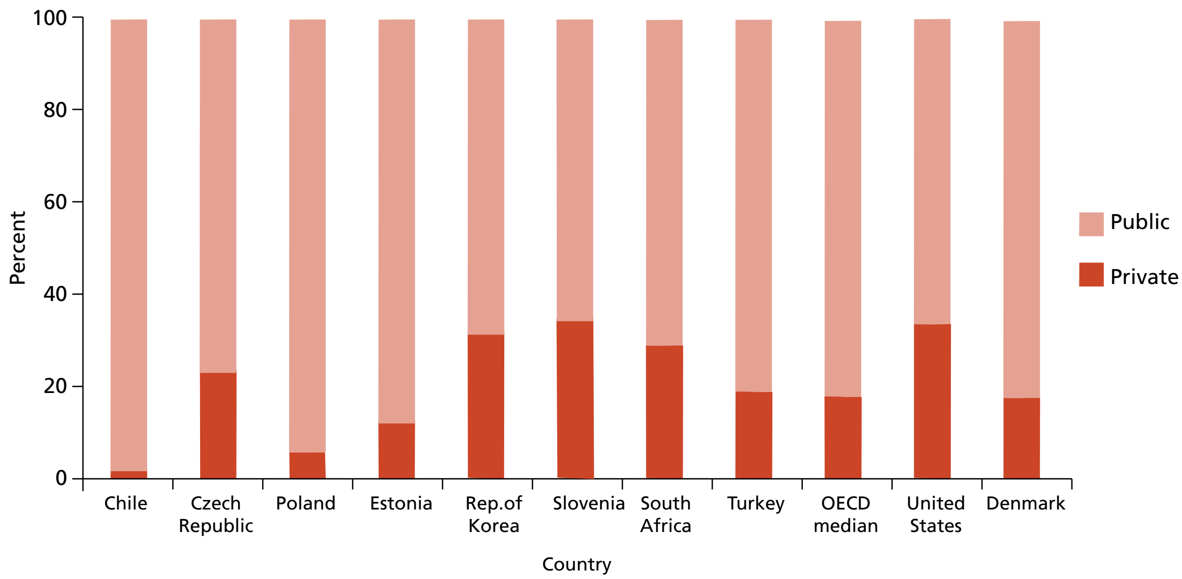
Basic research is often seen as relating to fundamental phenomena and linked to the idea of curiosity-driven research. Basic research is often riskier and involves potentially large positive externalities. In theory, the more fundamental research is, the less willing industry will be to fund it, because it is hard to appropriate and monopolize the results. Hence, governments tend to pay for most of the cost of basic research. Figure 8.4 shows the distribution of R&D at aggregate level by type of research. The result, which shows less developed countries investing a lower share of their budget in experimental research, is in principle questionable—even though the policy implication will not always be to recommend less investment in basic research. If not available, an approximation may be obtained by using the budget data and the Classification of Functions of Government (COGOF) classification following the definition adopted by the OECD in the Policy Mix Database.[1]

Operating Costs versus Capital Investments

While salaries of researchers are often a large share of R&D expenditures, the lack of a clear strategy to maintain and update research equipment has been an important bottleneck for the development of research excellence in developing economies. The allocation for fixed capital may be obtained by combining this classification with the COGOF. The codes related to

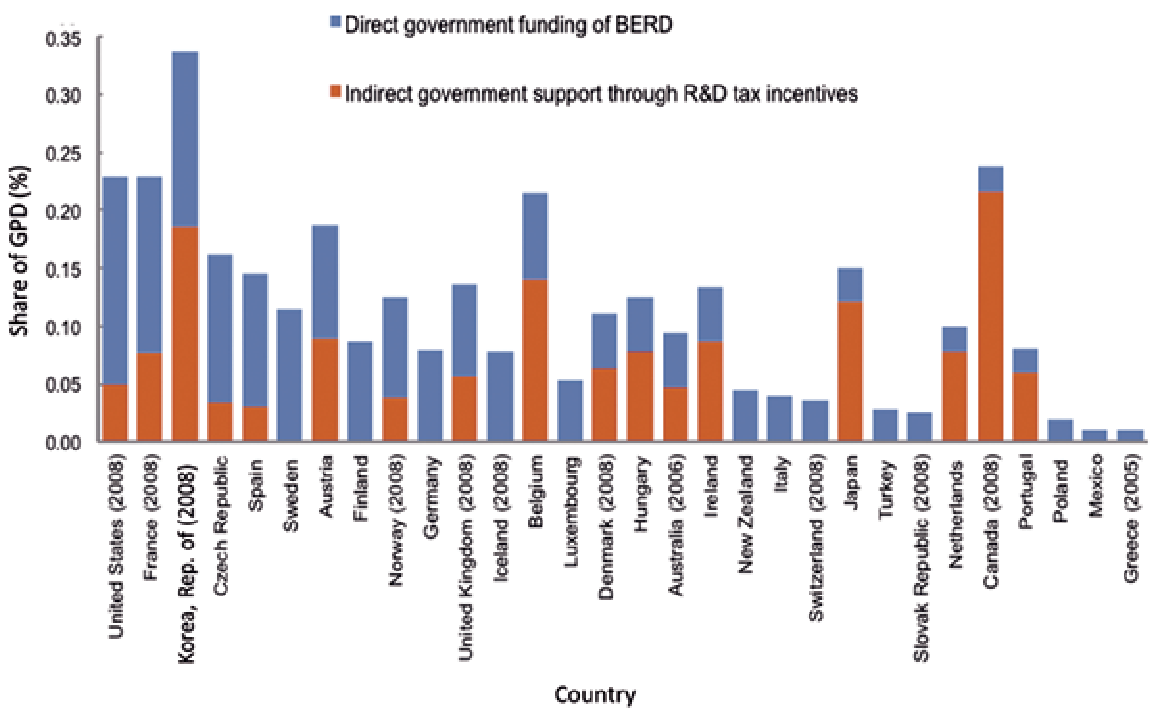
1. http://stats.oecd.org.

Figure 8.2: Distribution of Public Support between Public and Private Sectors (2010 or latest year)



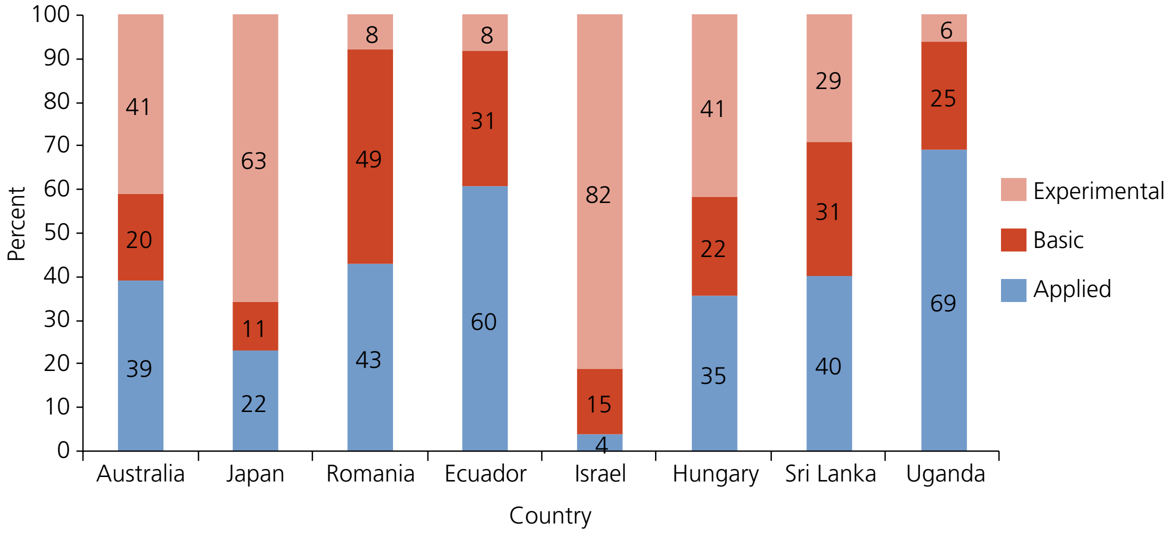
Source: OECD Policy Mix MetaData at http://stats.oecd.org.

Figure 8.3: Direct and Indirect Support to Business R&D (2008-09 OECD Countries)



Source: OECD, Main Science and Technology Indicators Database, March 2010.
Note: BERD = business enterprise R&D; R&D = research and development.

Figure 8.4: Share of Country's R&D Expenditure Based on Research Type (2008)



Source: Data from UNESCO.

investments in Fixed Capital according to the 2001 *GSF Manual* are (3111) Buildings and structures, (3112) Machinery and equipment, (3113) Other fixed assets, (31131) Cultivated assets, and (31132) Intangible fixed assets (23) consumption of fixed assets, for Depreciation). The challenges in balancing operational and capital expenditures are illustrated with the case of Croatia (figures 8.5a and 8.5b).

The Level of Public Expenditures on R&D

How much public investment in R&D is enough? To answer this question, it is necessary to calculate the social rates of return of public investment in R&D. Calculating social rates of return of public spending in general and R&D in particular is a complex task (see box 8.1). Yet social rates of return serve as parameters for the discussions about the optimal allocation of public ex-

Figure 8.5a: Operating Costs and Salaries in Croatia, 2006–14 (€ million)

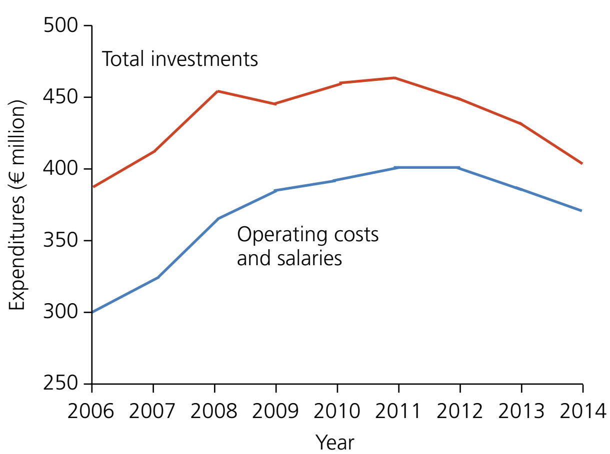
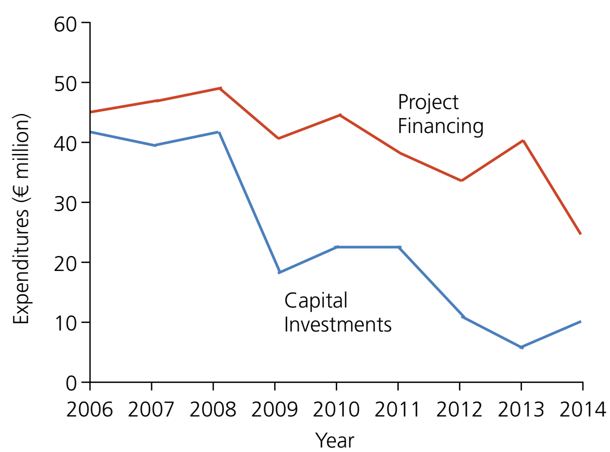


Figure 8.5b: Capital Investments and Project Financing in Croatia, 2006–14 (€ million)



Source: Elaboration of data provided by Croatia's Ministry of Science, Education, and Sports (MSES).

Box 8.1: Macro-Level Analysis on Social Returns to R&D, Infrastructure, and Human Capital

The **rate of return on gross R&D** investment is computed for Croatia using World Development Indicators macro-level data. Following the methodologies used in Coe and Helpman (1995), Jones and Williams (1998), and Lederman and Maloney (2003), the R&D capital stock is computed and then the elasticity of various output measures is found with respect to R&D capital and computed gross rate of return (see table B8.2.1 below). Rate of return on R&D investment for GDP measured in constant local currency unit (LCU) is 73 percent. Based on these findings, optimal amount of R&D investment can be estimated. In Croatia this amounts to 9.23 percent of GDP. The real interest rate in Croatia between 1997 and 2010 was around 7.3 percent. The current gross rate of return was 0.73 percent, which is close to 10 times less than real interest rate. As a result, optimal amount of R&D expenditure would be 0.92 * 10 = 9.2 percent, where 0.92 is the average R&D expenditure (as a percent of GDP).

Using macro-level data, there are several studies that estimate the rates of return to R&D. Among these studies, Lederman and Maloney (2003) use cross-country data for the 1975–2000 period and find that returns to R&D investment are around 78 percent. They group countries according to their income levels and find: 20–40 percent as OECD average, 60 percent for medium-income countries, and around 100 percent for poor countries. Returns to R&D in developing countries are higher than the values for industrialized countries. Coe and Helpman (1995) estimate rates of return to R&D for the period 1991–90 and find 123 percent for the G7 and 85 percent for the remaining 15 OECD countries. The result for rate of return obtained for Croatia is in accordance with the studies in the literature.

Table B8.1.1: Elasticity, Rate of Return, and Optimal Amount of R&D Investment

	Elasticity	*Gross rate of return (%)*
GDP (current LCU)	1.26	139
GDP (constant LCU)	0.66	73
GDP (constant 2000 US$)	0.66	73
GDP per capita (constant LCU)	0.66	73
GDP current LCU/labor force	1.34	147
GDP constant LCU/labor force	0.75	83

Optimal Amount of R&D Investment

Real interest rate (percent)	Lending interest rate (percent)
9.23	5.64

Canning and Bennathan (2000) compute the rate of **return to infrastructure** (electricity generation and paved roads) . They find that the average return to electricity generation capacity is 40 percent where the values vary significantly across countries. To give some examples, over their survey period, in Turkey, the rate of return was 32 percent, Portugal 7 percent, Mexico 51 percent, and Brazil 10 percent. They find the rate of return to paved roads was 30 percent over this period. In their study, elasticities of GDP per worker with respect to electricity services were 9 percent for a country at the median income level and 6 percent for a country in the lower quartile. Elasticity of GDP per worker with respect to paved roads was 9 percent for a median-income country and 5 percent for a lower-income country. In a recent study, Drezgic (2008) estimates the elasticity of GDP from 1996 to 2006 across Croatian counties with respect to transport and electricity sectors. The elasticity varied around 4.7 percent and 4.6 percent for transport and electricity sectors, respectively. In another specification where Drezgic combines transport, electricity, and construction sectors, elasticity of GDP with respect to this combined sector was 6 percent. Based on these estimates, rate of return on infrastructure in Croatia can be estimated using the methodology used in Canning and Bennathan (2000). Consider as the Cobb-Douglas production function where *K* is physical capital, *L* is labor, and *X* is infrastructure capital. Solving the aggregate production function, the following first order conditions are found:

$$\alpha = \frac{rK}{Y}, \ \gamma = \frac{p_x X}{Y}$$

(continued next page)

Box 8.1 (continued)

where p_x is rate of return to infrastructure capital and r is the rate of return to physical capital. Drezgic (2008) computes net capital stocks for each industry in Croatia from 1996 to 2006. He shows that electricity sector comprised around 19 percent of total private capital stock ($X = zK$ where z is a multiplier). The transportation sector comprised 21 percent of total private capital stock. Return to private capital stock which is the real interest rate, was around 7.3 percent. Using this information, the average rate of return on electricity and transportation sectors can be calibrated as follows:

$$p_x = \frac{\gamma Y}{X} = \frac{\gamma Y}{zK} = \frac{\gamma Y}{z\frac{\alpha Y}{r}} = \frac{\gamma r}{z\alpha}$$

According to this formula and using the estimates obtained from Drezgic (2008), the rate of return to infrastructure is 34 percent for electricity and 32 percent for transportation, and 24 percent when electricity, transport, and construction sectors are combined.

The literature on rates of **return to human capital** is much older. Psacharopoulos (1994) estimate the social returns to investment in education level for a large number of countries. An updated study (Psacharopoulos and Patrinos 2004) that presents results for the same countries finds that average rate of return to an additional year of schooling is 9.7 percent. Returns for low, middle, and high-income countries are 10.9 percent, 10.7 percent, and 7.4 percent in respective order. The value for Croatia is likely to be around 10.7 percent.

These findings on rates of returns on R&D, infrastructure, and human capital show that the returns to R&D (73 percent) are quite significant and higher than the returns of infrastructure (around 24-34 percent) or human capital (around 10 percent) in Croatia.

Sources: Seker (2011) and World Bank (2012).

penditures. Because those calculations are made under heroic assumptions, the robustness of results is to some extent debatable. In this sense, it is recommended to take them in as reference points. Among the authors who have recently estimated social rates of return for R&D in developing countries are Lederman and Maloney (2003), Böke (2009), and Seker (2011).

- *Lederman and Maloney (2003)* use cross-country data from the 1975–2000 period and find that returns to R&D investment were around 78 percent (60 percent for medium-income countries, and around 100 percent for poor countries).
- *Böke (2009)* used a calibration exercise and found a social rate of return to R&D in Turkey at around 62 percent, which, in turn, implies that the R&D levels in 2009 were between a tenth to a sixth of what they should be.
- *Seker (2011)* estimated the rate of return on R&D investment in Croatia at about 73 percent, significantly larger than the returns of investment in infrastructure (around 24–34 percent) or human capital (around 10 percent).
- *Goney and Maloney (2014)* show a more nuanced picture. They found that the rates of return of R&D expenditures follow an inverted U shape: they rise with distance to the frontier and then fall thereafter, potentially turning negative for the poorest countries.[2]

A related question refers to the amount of public investment in R&D necessary to generate a certain target of R&D expenditures (GERD) at aggregate level. For instance, new EU member countries and to some extent EU access countries have been asked to established R&D target levels for the 2014–20 period. Little attention has been given to how those targets would be generated and what would be the corresponding fiscal requirements. The answer depends essentially on the estimated elasticity of business R&D to public support (see box 8.2).

2. The findings are consistent with the importance of factors complementary to R&D, such as education, the quality of scientific infrastructure, the overall functioning of the national innovation system, and the quality of the private sector, which become increasingly weak with distance from the frontier.

8.3. GOVERNANCE ANALYSIS

This session focus on the institutionalized rules and procedures (governance) through which policies and programs were selected and implemented (governance structure). The main objectives are to understand how existing governance structure affects the existing allocation of public spending and more broadly, the management of the STI policies. Box 8.3 summarizes the vision of a well-governed national innovation system, as articulated in the EU 2020 Strategy document (European Commission, 2000).

Governance issues are also present in the design of programs and management of PROs. Three main set of issues are addressed that affect the impact of public spending: (i) Policy Making, (ii) Policy Implementation, and (iii) Policy Learning and Adaptation.

Horizontal and Vertical Coordination of Policy

By affecting the behavior of stakeholders, different governance structures induce the development of different "policy mixes" and therefore the quality of public expenditures in STI. The challenge is to set up

Box 8.2: The Cost of Reaching the Two Percent of GDP Target for R&D in Turkey in 2009

A back-of-the-envelope exercise can be done to calculate the necessary variation of public sector support to accomplish the goal of a total R&D to GDP ratio of 2 percent. In order to do this, one has first to consider the interactions between business enterprise R&D (BERD) and government R&D (GERD), and assume two different ways of public R&D spending. The first finances specifically BERD and the latter refers to total R&D spending by the government, without consideration of the sector where R&D takes place (whether BERD or GERD).

Accordingly, these two ways of public R&D spending define two kinds of business sector R&D elasticity to public sector R&D. The first is the elasticity of private sector financing of BERD to the government financing of BERD, which quantifies how much the business sector R&D performance financed by the government encourages the private sector to spend on its own R&D. The second is the elasticity of total R&D financed by business to the total R&D financing of the government; this elasticity informs how much the government financing of R&D activities in the country encourages business to invest in R&D.

The two elasticities are estimated in a background paper (Böke 2009), which was based on annual data between 1997 and 2007 from 36 countries. The majority of these countries are European, while others are large economies (including Russia, China, the United States, and Japan).[a] The first elasticity was inferred to be of the magnitude 2, which implies that an increase in government-financed BERD doubles the private financing of BERD. The second elasticity drops to a range 0.3 to 0.5, which means that when one takes into account the correlation of the two sources of financing without differentiating between the sectors in which R&D is performed, the effectiveness of government financing in crowding in business financing is reduced.

In order to finally calculate the necessary variation of government expenditure in R&D (as a percent of GDP), the report defines three elasticity scenarios: 2; 0.3; and 0.5. The first one focuses specifically on the public financing of BERD while the other two relate to the total R&D spending by the government. The nuance is important because it will inform the options on how further increases in public investment in R&D could be allocated (supporting more BERD, the first scenario; or keeping the current pattern of expenditures, the second or third scenarios). Solving the point elasticity equation for these three elasticity values, it is possible to construct three different scenarios, as summarized in table B8.2.1.[b.]

If all additional public investment is allocated to finance BERD (the first scenario), public support would have to increase by about half a percentage point of GDP (0.56 percent), which in turn would make business R&D account for the largest share of R&D in the country (58 percent of the total). If one assumes public expenditures increase regardless the supported sector of support (scenarios 2 and 3), then the variation of public support would be in the range of 0.98 percent of GDP (for a elasticity of 0.5) and 1.07 percent of GDP (for a elasticity of 0.3) and business R&D would account for 25–30 percent of total R&D. Concentrating further increases in public investments in R&D on the support of private R&D seems therefore the most effective way to reach a total R&D-to-GDP ratio of 2 percent.

(continued next page)

Box 8.2 (continued)

Table B8.2.1: Scenarios on Public R&D Expenditures

Scenario 1: Public Spending to Finance BERD			
Elasticity = 2			
	GERD expenditure	**BERD expenditure**	**Total**
Baseline	0.42% GDP	0.28% GDP	0.7% GDP
Share to total R&D expenditure	60%	40%	n.a.
Δ (variation)	0.56% GDP	0.74% GDP	1.3% GDP
Final	0.96% GDP	1.04% GDP	2.0% GDP
Share to total R&D expenditure	48%	52%	n.a.
Scenario 2: Public Expenditure to Finance Total R&D Activities			
Elasticity = 0.5			
	GERD expenditure	**BERD expenditure**	**Total**
Baseline	0.42% GDP	0.28% GDP	0.7% GDP
Share to total R&D expenditure	60%	40%	n.a.
Δ (variation)	0.98% GDP	0.32% GDP	1.3% GDP
Final	1.4% GDP	0.6% GDP	2.0% GDP
Share to total R&D expenditure	70%	30%	n.a.
Scenario 3: Public Expenditure to Finance Total R&D Activities			
Elasticity = 0.3			
	GERD expenditure	**BERD expenditure**	**Total**
Baseline	0.42% GDP	0.28% GDP	0.7% GDP
Share to total R&D expenditure	60%	40%	n.a.
Δ (variation)	1.07% GDP	0.23% GDP	1.3% GDP
Final	1.49% GDP	0.51% GDP	2.0% GDP
Share to total R&D expenditure	75%	25%	n.a.

Source: World Bank 2010.

Note: n.a. = Not applicable.

a. The data on R&D expenditure is obtained from the EuroStat while the data for control variables mostly come from the World Development Indicators. The R&D data includes the source of the financing as well as the target sector in which the R&D is undertaken.

b. The following point elasticity formula is assumed:

$$\text{Elasticity} = (\Delta BERDexp/\Delta GERDexp) \times (GERDexp_i/BERDEXP_i),$$

where *GERDexp* is the government R&D expenditure (as % of GDP), *BERDexp* is the same for private R&D expenditure, and $GERDexp_i$ ($BERDEXP_i$) is the baseline level of the government (private) R&D expenditure (as % of GDP). Accordingly, the elasticity can then assume three values: 2; 0.3; and 0.5, and once knowing the values of $GERDexp_i$ ($BERDEXP_i$), which are the same for all the three scenarios, it is possible to find Δ*BERDexp* and Δ*GERDexp*.

Box 8.3: Features of Well-Performing National Innovation Systems, as Outlined in the EU 2020

"… Design and implementation of research and innovation policies is steered at the highest political level and based on a multi-annual strategy. Policies and instruments are targeted at exploiting current or emerging national/regional strengths…

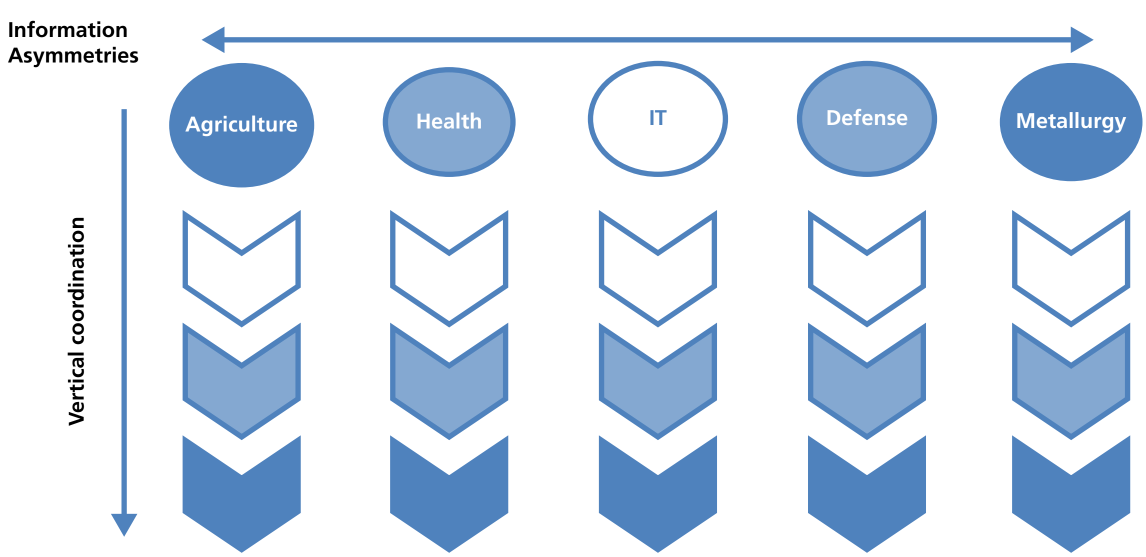
- An effective and stable center-of-government structure, typically steered by the top political level, defines broad policy orientations on a multi-annual basis and ensures sustained and properly coordinated implementation. This structure is backed up by networks involving all relevant stakeholders, such as industry, regional and local authorities, parliaments and citizens, thereby stimulating an innovation culture and building mutual trust between science and society.
- A multi-annual strategy defines a limited number of priorities, preceded by an international analysis of strengths and weaknesses at national and regional level and of emerging opportunities and market developments, and provides a predictable policy and budgetary framework. The strategy duly reflects (country) priorities, avoiding unnecessary duplication and fragmentation of efforts, and actively seeks to exploit opportunities for joint programming, cross-border co-operation and exploiting the leverage effects of EU instruments.
- An effective monitoring and review system is in place, which makes full use of output indicators, international benchmarking and ex-post evaluation tools.…"

Source: Innovation Union, Annex I: Self -assessment tool: Features of well performing national and regional research and innovation systems (European Commission, 2010)

a structure of incentives that that align the interest of the "principal" and the "agent" in both the process of policy making and policy implementation. Governance structure should align the incentives of the policy makers (such as different ministers) with that of the taxpayers in the policy-making phase. During implementation, a sequence of principal-agent interactions occurs throughout the command structure in an administration.

Figure 8.6 illustrates the point. The circles represent different organizations within a government (such as sector ministries) that are responsible for policies and programs affecting STI. These organizations are often at the same or a very similar hierarchical level. The vertical arrows indicate the number of stakeholders involved in the implementation process. Stakeholders may include, for example, a national innovation council,

Figure 8.6: Horizontal and Vertical Coordination Challenges



a ministry of higher education and science, the science department of that ministry, the agency responsible for funding research, and the internal departments up to the implementation unit.

In such governance structures, the level of information available decreases both horizontally and vertically, particularly in the absence of central coordinating agencies or mechanisms to reduce asymmetric access to information. The result of such an opaque governance structure is frequently a policy-making and implementation system that lacks cohesion. The system may create misdirected policies and programs that suit the needs of individual agencies or stakeholders and does not adequately improve the overall system. The challenge, therefore, is to set up a structure of incentives that aligns the interest of the principal and the agent in both the process of policy making and policy implementation. Box 8.4 summarizes recent lessons in addressing horizontal coordination issues.

The following are some proposed assessment questions for governance structure.

- How are the major decisions about policies, programs, and budget allocation taken—by a prime minister, council of ministries, national council, or other? Is the decision-making process considered transparent? Is there an institutionalized space for broad discussions about STI policies and consensus building?
- Does the government articulate a clear long-term STI strategy? Are there measurable goals and define corresponding means for their achievement? Is the strategy coherent, feasible, and adequately funded?
- Are there organizations in charge of coordinating STI policies across the government? If so, how are they composed? What is the legal basis for the operation of those organizations? What is the scope of their mandate? Are major stakeholders well represented? How does the government balance common tensions and contradiction in setting innovation policy agenda?

Policy Implementation

The implementation of STI policy involves a number of different actors and organizations. Without proper attention to those issues, the process policy implementation may lead to a final allocation or disbursement of public funds for purposes that are not in line with intended goals. These issues concern how the pro-

Box 8.4: Addressing Horizontal Bottlenecks in Innovation Policy

An important international experience in addressing horizontal coordination issues in innovation policy is the development of innovation councils. The development of such councils is part of a move toward more comprehensive, integrative, innovation policy making. Some countries that have moved toward such councils already had a history with organizations that were more narrowly focused on science and technology. For example, Finland and the Republic of Korea have had science and technology (S&T) councils established for decades. However, at present, no dominant structure seems to have emerged. Rather, the success of innovation councils depends largely on the council's composition, mandate, and functioning.

For example, all relevant stakeholders may be formally represented at the council, but the implementation structure of the council's recommendations is not clear. Or it may be the case that the horizontal dimension has identified the right goals and cross-ministerial planning works, but the ministries or other agencies assigned with policy implementation in the vertical dimension (such as S&T or the environment) are not implementing well. Stakeholders can also differ, or very little effort may be made to engage the relevant stakeholders in the design and implementation process. Finally, policy measures to achieve innovation policy goals may differ. The main innovation policy measure is resource allocation for R&D, but in many cases this may not be a sufficient measure to achieve the desired results. Therefore a number of other regulative and fiscal measures may be required. The composition of the innovation council can also be only a partial reflection of the relevant stakeholders, due to reasons of institutional tradition or otherwise. For example, S&T policies may monopolize the state budget's allocations for R&D.

Source: OECD 2005.

grams are designed and implemented. Poor planning can systematically jeopardize consistency between the objective at the decision-making stage and the implementation and impact of the policy.

- Are organizations that design, implement, and benefit from the programs legally distinct, acting independently according to their own missions? If not fully distinct, what is the overlap and how does it affect the incentives for and efficient and fair implementation of programs (if it does at all)?
- Are human resources in public administration properly trained to manage research and innovation programs? Is there a specific career for public servants working on innovation policy? Is it capable of attracting and retaining the most qualified professionals? What is the predominant field and level of education among public servants managing innovation policies? Do they participate in existing networks of research and innovation policy?
- Are material conditions (physical and financial) commensurate with existing workload? Is staff encouraged to improve performance? If so, how? Is staff insulated from day-to-day political influence? If so how?

Stability and predictability of public funds to STI are also aspects of implementation to be considered for a number of reasons. First, STI activities are often implemented over a period of few years. Interruptions in the flow of funds may have very negative effects on the achievement of research results. Maintenance of research infrastructure is another activity that requires recurrent expenditures. Finally, returns from public R&D investments will only be realized in the long run.

- Does the current governance structure provide for the stability and predictability of public expenditures on STI? Are there mechanisms for the implementation of multi-year planning and multi-year budgets?
- Are STI expenditures earmarked? If so, how does it affect the quality of public spending in STI?

Monitoring and Evaluation, Policy Learning, and Adaptability

Innovation policy is context specific and is particularly prone to conflicts of interest. Therefore, creating mechanisms for systematic evaluation of programs, policy learning, and policy adaptation is of crucial importance. Such mechanisms can built around two key elements: (i) quality information about programs and policies; and (ii) sound accountability rules for officials and organizations at the core of the policy making and implementation process, in addition to transparency and participation from stakeholders and beneficiaries. Transparency in this case is closely related to access to information and quality of data available.

- Have evaluations been done? If so, of what type (survey of beneficiaries, randomized control trials, peer reviews, or others)? Is monitoring and evaluation (M&E) mandatory for the main programs? Is there an organization responsible for M&E innovation programs? If so, is it properly staffed and equipped? Is routine monitoring occurring in the majority of programs (that is, are officials able to track the flow of funds and their corresponding results?) (see Gorgens and Kusek 2009).
- Are government officials obliged to communicate to the public and facilitate access to the results of evaluations of programs and policies? Is information accessible to the public in general (within the boundaries of standards regulations of individual rights to privacy or commercial/scientific secrecy)? Are stakeholders 'heard"? Is the government somehow obliged to act upon the findings of an evaluation or funded and generalized complains of stakeholder?
- What is the quality of STI statistics? Does the country have regulation firm-level innovation surveys? How comparable they are with existing surveys? Is there any explicit strategy to improve the STI statistics in the country? Does the statistical office have the capacity to gather and process STI information according to international standards? What is the quality of the available data on public finance?

8.4. INSTITUTIONAL REFORMS, POLICY RECOMMENDATIONS, AND STRATEGIC INVESTMENTS

The analysis in the PER concludes with recommendations for improved public expenditures on STI. It provides recommendations in terms of institutional and policy reforms and strategic investments, as described in chapter 3. The starting point for developing the "draft plan" is clarifying the strategic goals for the NIS. These goals inform what interventions will be needed, what outcomes will be generated by these interventions, and what outputs are needed to produce these outcomes. This informs what resources are required for the plan in terms of funding and institutional capacity. If the resources or institutional capacity needed to achieve the "draft plan" exceed what is available, then the "plan" will need to be adjusted. This may require changes in one rung in the process or perhaps all along the chain.

Tables 8A.4.1 and 8A.4.2 in annex A to this chapter show the results from a process similar to figure 8.6. The tables show the action plan from the Western Balkans Regional R&D Strategy for Innovation. The strategy was designed to strengthen the region's research capacity, enhance intra-regional cooperation, promote collaboration with business sectors, explore possibilities for financing R&D from EU funding schemes and other external sources, and help integrate the region with the European Research Area (ERA) and Innovation Union.

8.5. CONCLUSION

This chapter discussed the Final Report. It started by reviewing the analysis of the relevance, coherence, and consistency of NIS policies. This was followed by a discussion of the composition and level of R&D spending. An analysis of governance concluded the chapter. Box 8.5 provides a number of useful readings. The next chapter concludes this guidance note.

Box 8.5: The Final Report—Useful Readings

A proposed structure for the final PER is provided in table 9.1.

Useful reading:

Flanagan, Uyarra and Laranja. 2010. "The 'Policy Mix' for Innovation: Rethinking Innovation Policy in a Multi-Level, Multi-Actor Context." Manchester Business School. Working Paper, Number 599. Available at: http://www.mbs.ac.uk/research/workingpapers.

OECD. 2005. "Synthesis Report, Governance of Innovation Systems." OECD, Paris.

World Bank. 2008. "Chile: Toward a Cohesive and Well Governed National Innovation System." World Bank, Washington, DC.

ANNEX A: ACTION PLAN ILLUSTRATION FROM THE WESTERN BALKANS REGIONAL R&D STRATEGY FOR INNOVATION

Table 8A.1: Example: Excerpts from the Action Plan for the Western Balkans Regional R&D Strategy for Innovation

Overall Strategic Goal	***Metrics***	***Example of a Strategic Sub-Goal***	***Example of a short term intervention***	***Example of a long term intervention***
1. Improve the research base and conditions for research excellence	Citations and citation impact; co-publications within the region and with external partners; share of young researchers employed; participation in Horizon 2020.	1.1. Slowing down brain-drain supporting 'brain-gain'; and investing in human capital	Promote the collaboration of local scientists and the scientific Diaspora	Eliminate any bias against young researchers
2. Promote Research-Industry Collaboration and Technology Transfer	Patenting and co-patenting activity locally and internationally; licensing and spinoff companies (number and value); volume of joint-research projects; share of services provided to the business sector in total revenues; share of innovative firms collaborating with public research organizations (as measured by the Community Innovation Survey.)	2.1. Improving the incentive regime for collaboration between research institutes and the private sector	Simplify the legal requirements for collaboration between public universities, research centers, and the enterprise sector.	Develop/Unify the regulation regarding ownership and management of IP from publicly funded research performed by PROs
3. Enable business investments in research and innovation and startup creation	Share of innovative companies (as measured by the 'CIS'), BERD (Eurostat); trade-marks and ISO-certifications; volume of venture capital markets.	3.1. Improving access to innovation finance (pre-seed capital) and mentoring services	Develop matching grant schemes for pre-seed financing and the provision of 'mentoring' services for new enterprises and SMEs.	Promote the development of seed and venture capital industry.
4. Strengthen the governance of national research and innovation policies	Volume of R&D (GERD); distribution between basic and applied research; distribution between mission-related and 'curiosity' driven; share of public research organization costs financed through competitive funding; indicators related to the productivity of the system (e.g. Patent/GERD).	4.1. Completing the institutional reforms of universities and research institutes	Consolidation of research institutes. Reform management of public research institutes towards increasing the use of performance-based contracts and more autonomy.	Further integrate local universities to the European Higher Education Area (EHEA) and advance the implementation of the Bologna Process.

Table 8A.2: Example: Action Plan for Regional Cooperation—Summary

	Expected Outputs	*Expected Outcomes*	*Total cost (€ million)*
Research Excellence Fund	80 international collaboration research projects funded 50 young researchers projects funded 200 PhDs in science from leading universities	Contributed to Improve the Research Base and conditions for research excellence (Strategic Objective 1) Slowed brain drain, supported brain gain and investing in human capital	55
Networks of Excellence Program	Larger number of joint publications in high impact journals Increased mobility of researchers Better use and supply of research infrastructure, Increased number of post graduate students in the field Increased collaboration with the business sector through join research, licensing, training and technical assistance	Improved research base and conditions for research excellence Investing in human capital Improving access to modern research facilities and availability of research funding	55
Technology Transfer Program	10 TT Organizations developed and 100 staff trained, 100 Joint projects between research and industry supported 3 technology parks restructured 3 new parks created	Research Industry Collaboration and Technology Transfer promoted Soft support for collaboration and technology transfer provided Access and performance of technology and science and technology-parks improved	40
Early Stage Startup Program	300 proof of concepts and prototypes tested 100 business plans/bankable projects prepared 20 consultations with foreign and local investors	Enable business investments in research and innovation and startup creation More knowledge-based startups created Investments in startup companies increased Investments in R&D by the business sector increased Number of 'innovative' SMEs increased (as described by the Community Innovation Surveys)	40
Regional Technical Assistance Facility (WISE)	Coordination of regional policy dialogue and promotion of reforms Technical advise for the R&D Pillar of the SEE2020 Capacity building activities (technical assistance and training) provided	Strengthening the Governance of Research and Innovation Policies in the Western Balkans Improved public expenditures in R&D	10
Total	—	Better research, more innovation for growth and job creation	200

CHAPTER 9

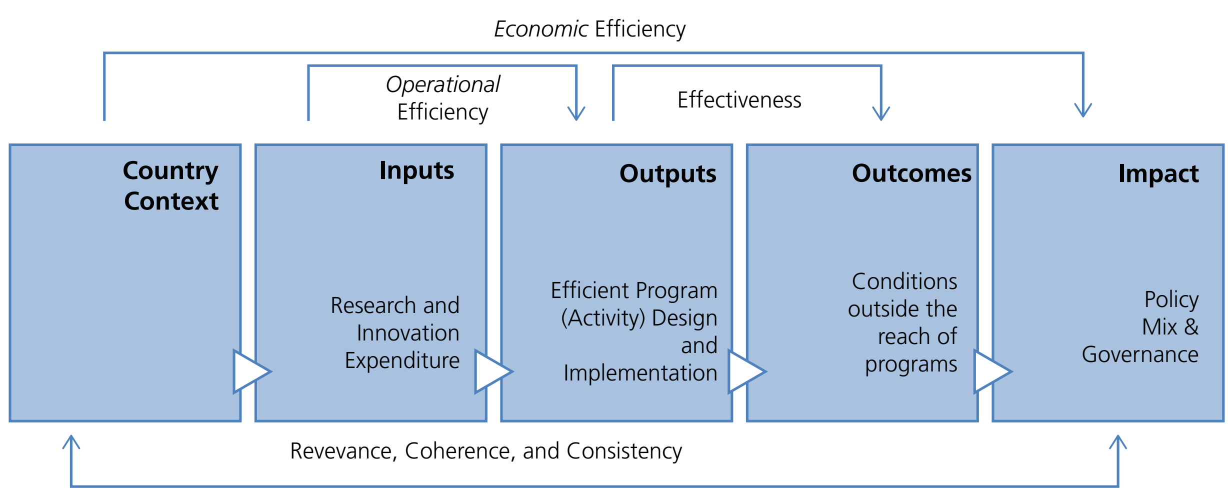
CONCLUSIONS

This Guidance Note proposes a framework for the analysis of public spending in science, technology, and innovation (STI) and discusses how to implement it in practice. Our goal is to make it flexible enough to be adjusted to the needs and government requests of different countries. The goal is to generate a set of actionable recommendations to improve the quality of public spending in STI—that is, to improve the contribution of public spending on STI to economic development.

The proposed PER exercise is structured around a results-oriented framework and a set of organizing questions, which correspond loosely to three assessment criteria (chapter 3): (i) operational efficiency; (ii) effectiveness; and (iii) relevance, coherence, and consistency of the policy mix (that is, composition and level of public spending). The logic of the proposed PER exercise is summarized in figure 9.1. The exercise starts with the consolidation of an STI budget that encompasses innovation expenditures, which are classified accordingly to that results-oriented framework (chapter 5).

The underlying idea is that public spending can be improved by (i) better design of programs and ac-

Figure 9.1: The Proposed PER Exercise



Source: Elaboration of Technopolis (2009).

tivities through which funds are disbursed; (ii) by improving conditions, beyond public spending, that affect the achievement of desired outcomes (effectiveness); (iii) through a more balanced policy mix; and (iv) reforms in the national innovation system (NIS) governance structure. Recommendations are provided on how to prioritize and design measures including reforms to policies and programs as well as strategic investments.

A major challenge for implementation of the PER is access to both data on public spending and standard STI statistics. For that reason, implementation requires close collaboration with the beneficiary government and a good dose of realism in defining the scope of the exercise—which must be congruent with the capacity to generate necessary information. The challenges are likely to be larger when addressing non-R&D innovation. This issue is discussed extensively in chapters 3 and 4. Chapter 4 also discusses other issues to be addressed at the inception stage.

While the analytical framework is presented in chapter 3, the "how to" is concentrated in chapters 5–8. Chapter 5 is dedicated to a comprehensive description of public spending in STI, chapter 6 discusses the implementation of the operational efficiency assessment, chapter 7 addresses the conditions for effectiveness, and chapter 8 analysis the policy mix and how the governance structure shapes it.

Each report builds on the previous one, with the goal of generating a unified report in the last stage of analysis. Yet, they may be seen as partial deliverables and, in some cases, new deliverables are conceivable. For example, chapter 5 can be combined with chapter 8 to generate an assessment of a policy mix based only on budgetary analysis. This may be useful especially when the emphasis of the country is on public spending on R&D and most of data is readily available (as illustrated in section 8.2). Table 9.1 illustrates a possible structure for the final report, linking each chapter of the PER to the chapter of this Guidance Note that would inform it.

Table 9.1: Final PER Report: Possible Structure

Section of PER	*Content of the PER*	*Guidance Note: Main Inputs*
Chapter 1: Country's Needs	Country's development level and associated developmental challenges (needs) related to the STI policies	Inception Report (chapter 4)–section 4.1, on Country Paper
Chapter 2: Functional Review	Review of public spending on STI: how much is spent, by whom, on what?	Inception Report and Functional Review (chapter 5)–**tables 5.1, 5.5–5.7**
Chapter 3:	Operational Efficiency of programs and activities funded by the government	Efficiency Assessment (Chapter 6)–section 6.3., **table 6.3a**.
Chapter 4	Economic Effectiveness of public spending: are public expenditures on STI generating the selected intermediate outcomes? Assessment of effectiveness conditions	Effectiveness Assessment (Chapter 7)—**table 7.1.** Each section discusses effectiveness conditions for each of the four intermediate outcomes
Chapter 5	Policy Mix	Final Report (chapter 8)—section 8.1, **table 8.1**
	Governance Analysis	Final Report (chapter 8)—section 8.3
Chapter 6	Conclusions and Main Recommendations	Analytical Framework (chapter 3)—see section 3.3 on Recommendations from PER; **tables 3.1–3.3**

APPENDIX A

DEFINITIONS

Table A.1 includes a number of key definitions from the Frascati Manual (OECD 2002).

Table A.1: Key Definitions

Term	***Definition***
Abroad	All institutions and individuals located outside the political borders of a country, except vehicles, ships, aircraft and space satellites operated by domestic entities and testing grounds acquired by such entities. All international organizations (except business enterprises), including facilities and operations within the country's borders.
Applied research	Applied research is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.
Basic research	Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.
Business enterprise sector	All firms, organizations and institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price. The private non-profit institutions mainly serving them.
Capital expenditures	Capital expenditures are the annual gross expenditures on fixed assets used in the R&D programmes of statistical units. They should be reported in full for the period when they took place and should not be registered as an element of depreciation.
Experimental development	Experimental development is systematic work, drawing on knowledge gained from research and practical experience, that is directed to producing new materials, products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed.
Extramural expenditures	Extramural expenditures are the sums a unit, organization or sector reports having paid or committed themselves to pay to another unit, organization or sector for the performance of R&D during a specific period. This includes acquisition of R&D performed by other munits and grants given to others for performing R&D.
Government (for purposes of GBAORD)	Central or federal government should always be included. Provincial or state government should be included when its contribution is significant. Local government funds (i.e. those raised by local taxes) should be excluded.

(continued next page)

Table A.1 (continued)

Government sector	All departments, offices and other bodies which furnish, but normally do not sell to the community, those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administer the state and the economic and social policy of the community. (Public enterprises are included in the business enterprise sector.) NPIs controlled and mainly financed by government, but not administered by the higher education sector.
Gross domestic expenditure on R&D (GERD)	GERD is total intramural expenditure on R&D performed on the national territory during a given period.
Higher education sector	All universities, colleges of technology and other institutions of post-secondary education, whatever their source of finance or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education institutions.
Intramural expenditures	Intramural expenditures are all expenditures for R&D performed within a statistical unit or sector of the economy during a specific period, whatever the source of funds.
Other supporting staff	Other supporting staff includes skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D projects or directly associated with such projects.
Private non-profit sector	Non-market, private non-profit institutions serving households (i.e., the general public). Private individuals or households.
R&D personnel (initial coverage)	All persons employed directly on R&D should be counted, as well as those providing direct services such as R&D managers, administrators, and clerical staff.
Research and experimental development (R&D)	Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.
Researchers	Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned.
Technicians and equivalent staff	Technicians and equivalent staff are persons whose main tasks require technical knowledge and experience in one or more fields of engineering, physical and life sciences or social sciences and humanities. They participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers. Equivalent staff perform the corresponding R&D tasks under the supervision of researchers in the social sciences and humanities.

APPENDIX B

DATA AND DATA SOURCES ON SCIENCE, TECHNOLOGY AND INNOVATION

REPORTS

This section summaries and compares the main innovation policy frameworks including (i) the OECD Reviews of Innovation Policy; (ii) ERAWATCH Country Policy Mix Reports; (iii) INNO-Policy TrendChart—Policy Trends and Appraisal Report; (iv) UNCTAD's Science, Technology and Innovation Policy Reviews (STIP Reviews); and (v) UNESCO's STI studies (Borowik 2012).

OECD Reviews of Innovation Policy

Objective: A comprehensive review and assessment of a country's innovation system.

- A comprehensive assessment of the innovation system of individual OECD member and non-member countries, focusing on the role of government
- Strong orientation towards concrete recommendations across a spectrum of innovation-related policies on how to improve policies to have an impact on innovation performance, including R&D policies. It does not attempt to conduct detailed policy design. Each review identifies good practices from other countries
- Builds on OECD work, especially on the links between innovation and economic performance, and on best practice policies to foster innovation

Content

The depth of analysis depends on *data availability*. For example, the review of Norway's innovation policy is much more detailed than the studies of Chile or Peru. Nonetheless all studies have similar structure and their content covers:

- Overall assessment and recommendations
- Economic performance and framework conditions for innovation (e.g. macroeconomic stability, financial markets and innovation, labor force, competition in the product market, innovation system's SWOT analysis (as in case of Norway); recommendations and identification of good practices for consideration
- STI main actors (business sector, public research institutes, the higher education sector, intermediary institutions)
- The role of government (STI governance and policy mix measures, Portfolio of instruments, innovation budget)
- International benchmarking in innovation performance

Data

OECD reviews include extensive data on innovation expenditure (this may vary among studies). Nonetheless, the reports do not contain comprehensive data analysis, but rather trends in R&D expenditures, their reasons, comparison with other developing and the OECD countries.

As in the comprehensive report on Norway, the review presents data on:

- *Policy mix: e.g.*: S&T and innovation funds and programs, their budget over time, expenditures according to loans, budget support, other resources; budget committed vs. executed; estimated revenue losses due to R&D tax incentives as a percent of GBAORD; assessment of policy mix issues and barriers (with trends in financing and international comparison; budget of an instrument)
- *Innovation budget*: Estimates of total expenditures on STI activities by source of funds i.e. direct budgetary resources and to which institution (i.e. Multilateral financing institutions' loans, private universities, business sector, other sources); estimated R&D appropriations by ministry, selected STI programs' budget and spending categories (i.e. financing HR, innovation , basic or applied R&D, scholarships, etc.); returns from the Norway's research fund bottom-up funding of free basic research; State vs. business-funded R&D as a proportion of GDP; Business sector science, technology, and innovation patterns
- *Data on PROs*: details under which ministry, budget with share of institutional funding, main focus areas, number of personnel
- *R&D expenditures in benchmarking:* R&D and overall innovation expenditures by sectors and main reasons for that; R&D intensity (GERD/GDP) and wealth (GDP per capita); Norwegian GERD/GDP compared with the largest OECD countries
- *Periodicity:* Not specified, every year different country review

The OECD reviews in this series so far include**:**

- Slovenia (2012)
- Peru (2011)
- Russian Federation (2011)
- Mexico (2009)
- Korea, Rep of (2009)
- Hungary (2008)
- China (2008)
- Norway (2008)
- Chile (2007)
- South Africa (2007)
- New Zealand (2007)
- Luxembourg (2007)
- Switzerland (2006)

ERAWATCH Annual Analytical Country Reports (since 2009)

Objective: Characterize and assess the performance of national innovation systems and related policies

- Focus on the national R&D investments targets, the efficiency and effectiveness of national policies and investments in R&D
- The articulation between research, education and innovation, and on the realization and better governance of ERA
- Focus on human resource mobilization, knowledge demand, knowledge production and science-industry knowledge circulation
- Reports cover the 'inter-linkage' between research and innovation, in terms of their wider governance and policy mix
- Reports across all countries have the same structure/ content
- As these are annual reports, each year reports build on the previous ones, therefore focusing on recent policy changes rather than repeating what has been already covered

Content

- Performance of the national research and innovation system and assessment of recent policy changes, also in relation to ERA

- Focus on Resource mobilization (provision for research activities; Evolution of national policy mix geared towards the national R&D investment targets, Providing qualified human resources), Knowledge demand, Knowledge production (quality of the knowledge production, the exploitability of the knowledge creation and policy measures aiming to improve the knowledge creation), Knowledge circulation (between the universities, PROs and business sectors, Cross-border knowledge circulation); Knowledge transfer; Interactions between national policies and ERA (Towards a European labor market for researchers; Research infrastructures; Knowledge transfer policies; Cooperation, coordination in ERA); Assessment of the policy mix.

Data and innovation expenditure analysis

- Data on GERD; GBAORD; BERD; GERD financed by abroad R&D performed by HEIs/ PROs/ businesses; GERD/GDP ratio;
- Data analysis from the perspective of the reasons, main barriers to R&D investments and respective policy opportunities and risks

Periodicity: Annually since 2009

Countries covered: EU 27 Member States, 11 Countries Associated to FP7 and selected third countries

Website: http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/reports/country_rep

INNO-Policy TrendChart "2011 Mini Country Reports"

Objective: Assess the innovation policy and identify examples of good practice, thus improving the basis for decision making in innovation policy.

- Serves the "open policy coordination approach" laid down by the Lisbon Council in March 2000
- Pursues collection, regular updating and analysis of information on innovation policies at national and European level
- Serves as benchmarking and the exchange of good practices
- INNO-Policy TrendChart produced "2011 mini country reports" for each of the 48 countries monitored by the network of country correspondents in the second half of 2011

Content of 2011 mini country reports

- Innovation policy trends containing key challenges, governance, changes in the innovation policy mix
- Innovation policy budget including innovation measures and evidence on effectiveness of innovation policy, future challenges for funding innovation; Departmental and implementing agency budgets for innovation policies
- Demand-side innovation policies (including sectoral specificities) and the governance challenges.

Data and innovation expenditure analysis

- Detailed data on departmental and implementing agency budgets for innovation policies
- Description of trends in spending, with major reasons without a deeper data analysis

Periodicity

- Mini country reports for 2011 only
- Since 2012, the INNO Policy TrendChart and ERAWATCH policy monitoring activities are run as a single fully integrated operation

The 2011 mini country reports include studies on:

- EU 27 Member States
- Albania
- Bosnia
- Brazil
- China
- Croatia
- Faroe Islands MCR

- Macedonia, FYR
- Iceland
- India
- Israel
- Japan
- Korea, Rep. of
- Liechtenstein
- Moldova
- Montenegro
- Norway
- Russian Federation
- Serbia
- Switzerland
- Turkey
- United States

Website: http://www.proinno-europe.eu/inno-policy-trendchart/repository/country-specific-trends

UNCTAD's Science, Technology and Innovation Policy Reviews (STIP Reviews)

Objective: Assist governments in developing national capacities in science, technology, and innovation.

- UNCTAD's reviews are intended to be an analytical tool that examine a series of proposals from a neutral external viewpoint tool for learning and reflection, not a rating mechanism
- The goal of the reviews is to provide the Governments with an up to date diagnostic analysis of the effectiveness of their STI -related policies and measures, and strengthen these policies and measures by integrating them in the national development process. It also seeks to improve technological capacity, encourage innovation, and incorporate greater added value into production processes.

Content (the level of detail vary among countries)

- Economic background, structural conditions and performance in STI
- Inputs, results and evaluation of the national innovation system (NIS)
- NIS institutional and legislative framework, policy mix instruments, financing measures, and governance
- Analysis of sectorial innovation systems—sector analyzed vary among country cases
- Conclusions and recommendations.

Data and innovation expenditure analysis

- Very extensive data. Presentation of trends in R&D expenditure and comparison to other countries. Based on the Salvador study data include R&D expenditure; comparative trends in R&D expenditure, investment in science and technology activities (STA), R&D expenditure by source of financing; staff employed in R&D, expenditure on STA by socioeconomic objective, patent data, expenditure on scientific and technological R&D area of knowledge; etc.
- Deeper analyses regard bibliometric analysis to identify the strongest areas of research, and patent analysis

Periodicity: not specified, each year different study

STIP Reviews comprise the following countries:

- El Salvador (2011)
- Ghana (2011)
- Peru (2011)
- Lesotho—An Implementation Strategy (2010)
- Mauritania (2009)
- Angola (2008)
- The Islamic Republic of Iran (2005)
- Colombia (1999)
- Jamaica (1999)

Website: http://archive.unctad.org/templates/Page.asp?intItemID=5463&lang=1

UNESCO STI Studies

Objective: Guide countries on national policy reforms.

- UNESCO assists countries in formulating or reformulating national STI policy;
- Reports adjusted to country's developing level and STI needs. In most cases the studies support creation of STI strategy from scratch or based on some first policy documents that serve as a STI plan.
- Include recommendations on how to approach setting up own strategy/modify it. In this context helps select an appropriate development module in order to develop an accurate policy.

Periodicity: no specified, studies based on demand

UNESCO STI studies series are shown in table B.1.

Table B.1: UNESCO STI Studies Series

Israel	(interview): The high level of basic research and innovation promotes Israeli science-based industries (2012)
Seychelles	(ongoing): Seychelles preparing its first science, technology and innovation policy (2011)
Botswana	(ongoing): Botswana instigates policy dialogue on revised STI policy in Gaborone (2011)
Azerbaijan	(ongoing): UNESCO assisting Azerbaijan in reviewing its STI strategy (2011)
Iraq	(ongoing): UNESCO helping Iraq to draw up science policy (2011)
Burundi	Bref état des lieux du système national de recherche scientifique et technique de la République du Burundi (2009)
Armenia	Towards a Science, Technology & Innovation Policy for the Republic of Armenia (2009)
Tanzania	(ongoing): UNESCO's work in Tanzania since 2008 within the One UN programme
Congo	(ongoing): Reform of the S&T system in Congo
Nigeria	(ongoing): Reform of the S&T system in Nigeria
Mongolia	Toward a Master Plan for Science and Technology Policy (2007)
Nepal	Science, Research and Technology in Nepal (2006)
Lesotho	Lesotho Science & Technology Policy (2006)
Bosnia & Herzegovina	Guidelines for a Science and Research Policy (2006)
Lebanon	Science, Technology and Innovation Policy for Lebanon (2006)
Namibia	New Directions for Namibia's Science and Technology Sector (2005)
Brunei Darussalam	Review Science and Technology Capacity and Policy Options (2005)
Albania	The Development of Albanian S&T Policy (1996)

INDICATORS

The section describes sources for a number of indicators. These describe scientific performance, human capital, structural factors, and innovation diffusion. The table describes the indicators, and provides various sources for data on these indicators.

Table B.2: Indicators Related to Science, Technology, and Innovation Performance

Indicator	*Measure/description*	*Source*
	Scientific performance	
Patent applications, nonresidents	Worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention. Provides protection for the invention patent to the owner of the patent for a limited period, generally 20 years.	World Intellectual Property Organization (WIPO), WIPO Patent Report: Statistics on Worldwide Patent Activity
	Patent applications, residents	
Patents in United States	Number of patents filed in the U.S. by residents of a country.	U.S. Patent and Trademark Office
Patents in Europe	Number of patents filed in the European Union by residents of a country.	European Patent Office
Royalty and license fees, receipts (Balance of payments [BoP], current US$)	Royalty and license fees are payments and receipts between residents and nonresidents for the authorized use of intangible, nonproduced, nonfinancial assets and proprietary rights (such as patents, copyrights, trademarks, industrial processes, and franchises) and for the use, through licensing agreements, of produced originals of prototypes (such as films and manuscripts). Data are in current U.S. dollars	International Monetary Fund, Balance of Payments Statistics Yearbook and data files.
Licenses	Share of establishments (in percent) in the country/sector that have purchased either a foreign or local license	World Bank Enterprise Surveys
Researchers in research and development (R&D) (per million people)	Researchers in R&D are professionals engaged in the conception or creation of new knowledge, products, processes, methods, or systems and in the management of the projects concerned. Postgraduate PhD students (ISCED97 level 6) engaged in R&D are included.	World Development Indicators
Research and development expenditure (% of GDP)	Expenditures for research and development are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development.	
Scientific and technical journal articles	Scientific and technical journal articles refer to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.	National Science Foundation, Science and Engineering Indicators

Table B.2 (continued)		
Indicator	***Measure/description***	***Source***
Trademark applications, direct resident **Trademark applications, direct nonresident**	Trademark applications filed are applications to register a trademark with a national or regional intellectual property (IP) office. A trademark is a distinctive sign that identifies certain goods or services as those produced or provided by a specific person or enterprise. A trademark provides protection to the owner by ensuring the exclusive right to use it to identify goods.	World Intellectual Property Organization (WIPO)
	Human capital	
Technicians in R&D (per million people)	Technicians in R&D and equivalent staff are people whose main tasks require technical knowledge and experience in engineering, physical and life sciences (technicians), or social sciences and humanities (equivalent staff). They participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers.	World Development Indicators
Availability of scientists and engineers	To what extent do you agree that scientists and engineers in your country are widely available? 1: Disagree strongly, 5: Agree strongly	Executive Opinion Survey, World Economic Forum
Enrollment in STEM disciplines	Registered students in science, technology, engineering, or mathematics (STEM).	Country's own statistics
School enrollment, tertiary (% gross)	The gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Tertiary education, whether or not to an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level.	United Nations Educational, Scientific, and Cultural Organization (UNESCO), Institute for Statistics (UIS)
Share of population speaking English		Economic Growth Center at Yale University
% of tertiary-educated individuals in OECD countries		Docquier and Marfouk 2004
	Structural factors	
State of cluster development	In your country, how extensive is collaboration among firms, suppliers, partners, and associated institutions within clusters? 1 = Collaboration is non-existent, 7 = Collaboration is extensive	Executive Opinion Survey, World Economic Forum
Local availability of specialized research and training services	In your country, to what extent are high-quality specialized training services available? 1= not available, 7= widely available	
University-industry collaboration	To what extent do business and universities collaborate on research and development (R&D) in your country? 1 = Do not collaborate at all, 7 = Collaborate extensively	
Quality of scientific research institutions	To what extent do you agree that your country has adequate scientific research institutions available? 1: Disagree strongly, 5: Agree strongly	
Intellectual property protection	How would you rate intellectual property protection, including anti-counterfeiting measures, in your country? 1 = Very weak, 7 = Very strong	

Table B.2 (continued)		
Indicator	***Measure/description***	***Source***
	Non R&D innovation and technology adoption	
Business expenditures in non-R&D innovation	Firm turnover (%). Sum of total innovation expenditure for enterprises, in national currency and current prices excluding intramural and extramural R&D expenditures. (Community Innovation Survey: European Commission (2008) question 5.2, sum of variables RMACX and ROEKX).	Community Innovation Survey (CIS)
FDI net inflows	% of GDP	World Development Indicators
FDI in manufacturing	% of total FDI	Country's own investment statistics
FDI and technology transfer	To what extent does foreign direct investment (FDI) bring new technology into your country? 1 = Not at all, 7 = FDI is a key source of new technology	Executive Opinion Survey, World Economic Forum
Royalty and license fees, payments	BoP (current US$)	International Monetary Fund, Balance of Payments Statistics Yearbook, and data files
Imports of high-tech goods	% of GDP	CEPII BACI database
Imports of high tech capital goods	% of GDP	
Imports of intermediary goods	% of GDP	
Foreign intermediate inputs	% all inputs that are foreign by country/sector	World Bank Enterprise Surveys
International certifications	% of establishments in the country/sector that have an International Organization for Standardization (ISO) certification	
	Technology diffusion	
Electrical power consumption	kilowatt-hours/capita	World Development Indicators
International outgoing telephone traffic	minutes	
Air transport, registered carrier departures worldwide	Domestic takeoffs and takeoffs abroad of air carriers registered in the country	
Agricultural machinery: tractors	per 100 hectares of arable land	
Main lines	per 100 inhabitants	
Internet users	per 1,000 inhabitants	World Development Indicators
Personal computers	per 1,000 inhabitants	
Cellular subscribers	per 100 inhabitants	
Percentage of digital mainlines	per 100 inhabitants	

APPENDIX C

INFORMATION ON COUNTRY PERFORMANCE AND INNOVATION BENCHMARKS

The World Bank's World Development Indicators is a comprehensive source of data on country's economic and social performance. It compiles a host of indicators on science and technology. UNCTAD's trade database and United Nations Industrial Development Organization (UNIDO) industry database are potentially useful sources for data on country economic performance. The World Bank's Enterprise Surveys provides firm-level data on a broad range of firm performance and investment climate variables.

A growing number of organizations produce worldwide reports on competitiveness and innovation based on a composite index. The World Economic Forum is one commonly used source for competitiveness. The World Bank has developed a Knowledge Assessment Methodology (KAM) to generate the Knowledge Economy and Knowledge Indexes. The World Intellectual Property Organization (WIPO), Institut privé d'enseignement supérieur (INSEAD), and Cornell University jointly publish the Global Innovation Index. Eurostat produces an innovation index called the Innovation Union Scoreboard. The OECD Science, Technology and Industry database (http://stats.oecd.org/Index.aspx?DataSetCode=IPM_STIO) provides data for a comparative performance of national science and innovation systems with a focus on its member economies.

THE GLOBAL COMPETITIVENESS INDEX

The World Economic Forum's Global Competitiveness Index (GCI) provides a detailed assessment for analyzing a country's overall long-term economic competitiveness. It ranks countries according to three types of attribute. Basic requirements encompass institutions, infrastructure, macro-economic stability, health, and primary education. Efficiency enhancers include higher education; and training, labor efficiency, financial market sophistication, market size, and technological readiness. Innovation and sophistication factors include business sophistication and innovation.

The GCI comprises 12 pillars, including, among other considerations, institutions and the rule of law. The results for public institutions have a strong bearing on competitiveness and include measures on: (i) ethics and corruption, (ii) burden of government regulation, (iii) efficiency of legal framework, and (iv) transparency of government policy making. Excessive bureaucracy, red tape, overregulation, corruption, dishonesty in dealing with public contracts, and a lack of transparency and trustworthiness impose significant costs to businesses and have negative impacts on economic development.

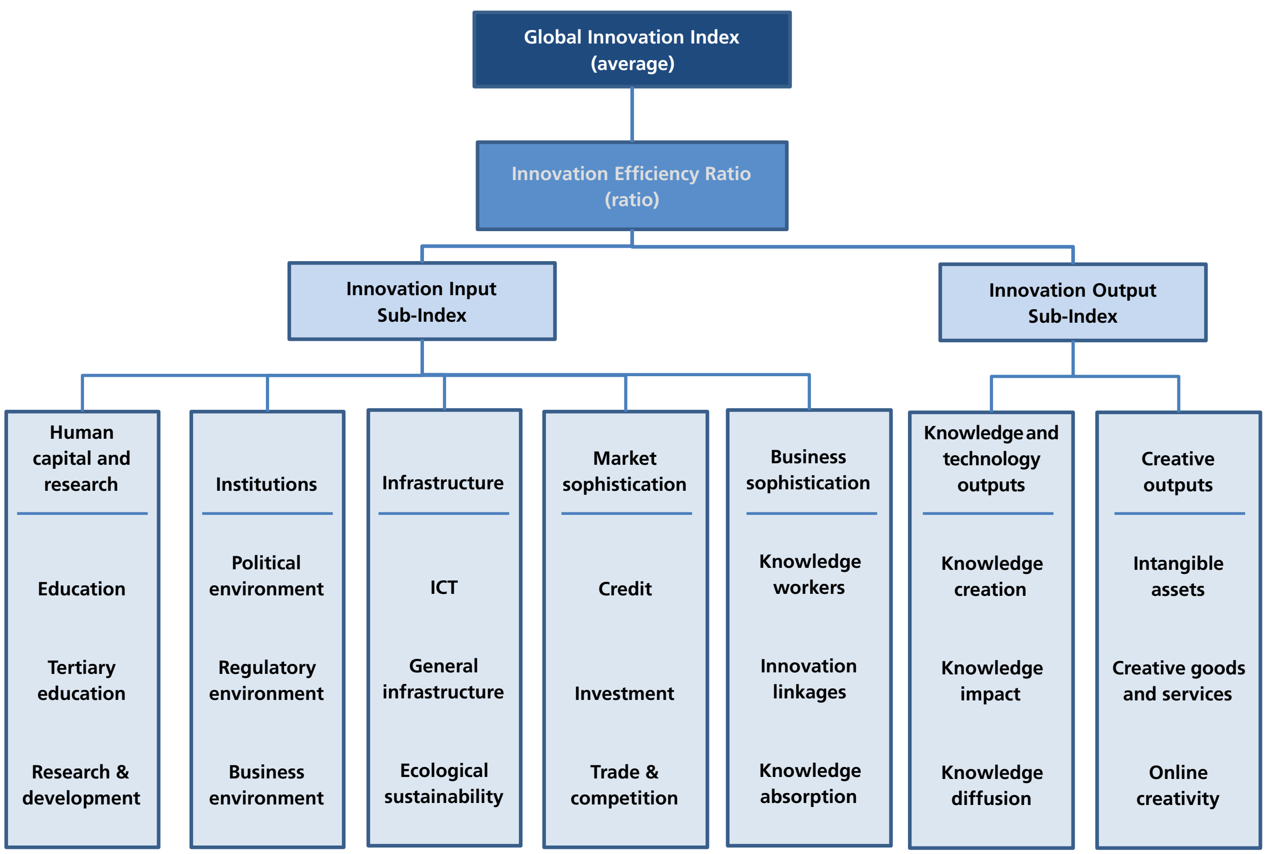
The GCI model for evaluating competitiveness has gone through several evolutions in recent years. Most recently, a "New Global Competitiveness Index" (WEF 2008) was published that took a more comprehensive approach to determining both microeconomic and macroeconomic factors influencing productivity in a country. The new index also models the relative impact of micro and macro factors on economies in different states of economic development.

Sources: WEF (2010) and World Bank (www.worldbank.org/kam), and Dutto and Lanvin (2013) and Innovation Union Scorecard (http://ec.europa.eu/enterprise/policies/innovation/policy/innovation-scoreboard/index_en.htm).

THE GLOBAL INNOVATION INDEX (GII)

The GII is depicted in figure C.1. The index relies on two sub-indices, the Innovation Input Sub-Index and the Innovation Output Sub-Index, each built around pillars. Five input pillars capture elements of the national economy that enable innovative activities: (1) Institutions, (2) Human capital and research, (3) Infrastructure, (4) Market sophistication, and (5) Business sophistication. Two output pillars capture actual evidence of innovation outputs: (6) Knowledge and technology outputs and (7) Creative outputs. Each pillar is divided into sub-pillars and each sub-pillar is composed of individual indicators (84 in total). Sub-pillar scores are calculated as the

Figure C.1: The Global Innovation Index—Summary Structure



Source: Dutto and Lanvin (2013): www.globalinnovationindex.org.

weighted average of individual indicators; pillar scores are calculated as the weighted average of sub-pillar scores (figure C.1). In 2013, the ranking covered 142 economies, accounting for 94.9 percent of the world's population and 98.7 percent of the world's GDP (in U.S. dollars). The report has been published once a year since 2007. Annual methodological adjustments in the structure of the index limit comparisons within long period of time.

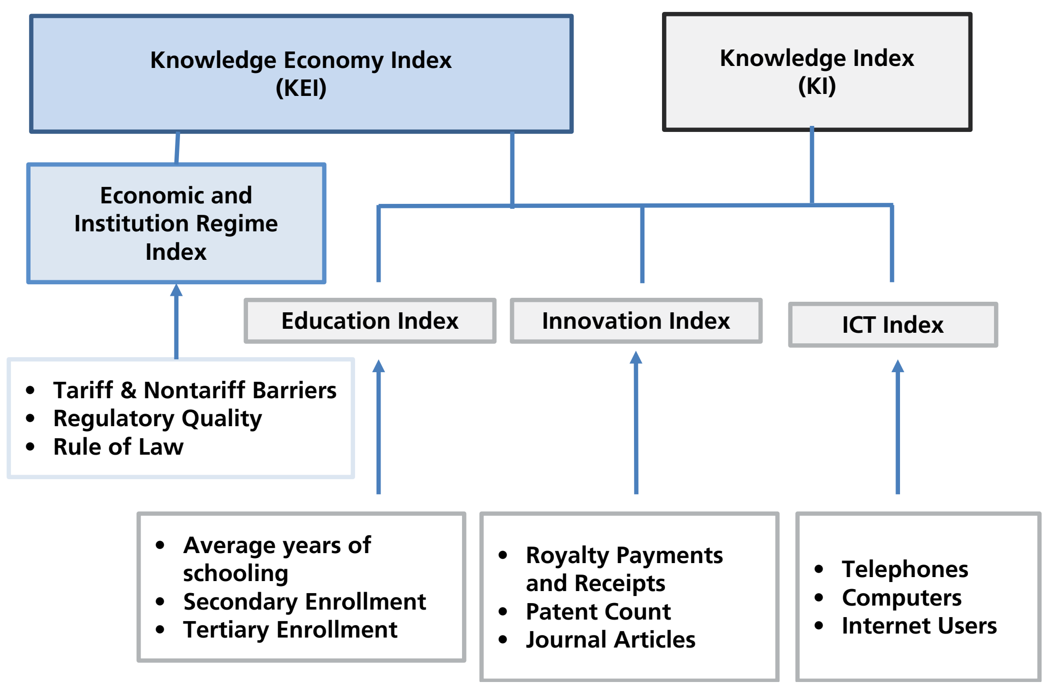
THE WORLD BANK'S KNOWLEDGE ASSESSMENT METHODOLOGY (KAM)

The KAM (see figure C.2) is an interactive benchmarking tool help countries identify the challenges and opportunities they face in making the transition to a knowledge-based economy. It consists of 148 structural and qualitative variables for 146 countries to measure their performance on the four Knowledge Economy (KE) pillars: (1) Economic Incentive and Institutional Regime, (2) Education, (3) Innovation, and (4) Information and Communications Technologies. Variables are normalized on a scale of 0 to 10 relative to other countries in the comparison group. The KAM also derives a country's overall Knowledge Economy Index (KEI) and Knowledge Index (KI).

The indicator is available in six different display modes:

- Basic Scorecard uses 12 key variables as proxies to benchmark countries on the aforementioned four KE pillars and derive their overall KEI and KI indexes. The scorecard allows comparisons for up to three countries for 1995, 2000, and 2012.
- Custom Scorecards allow any combination of the 148 variables and to compare up to three countries or regions for 2000 and the most recent available year.

Figure C.2: The Knowledge Assessment Methodology



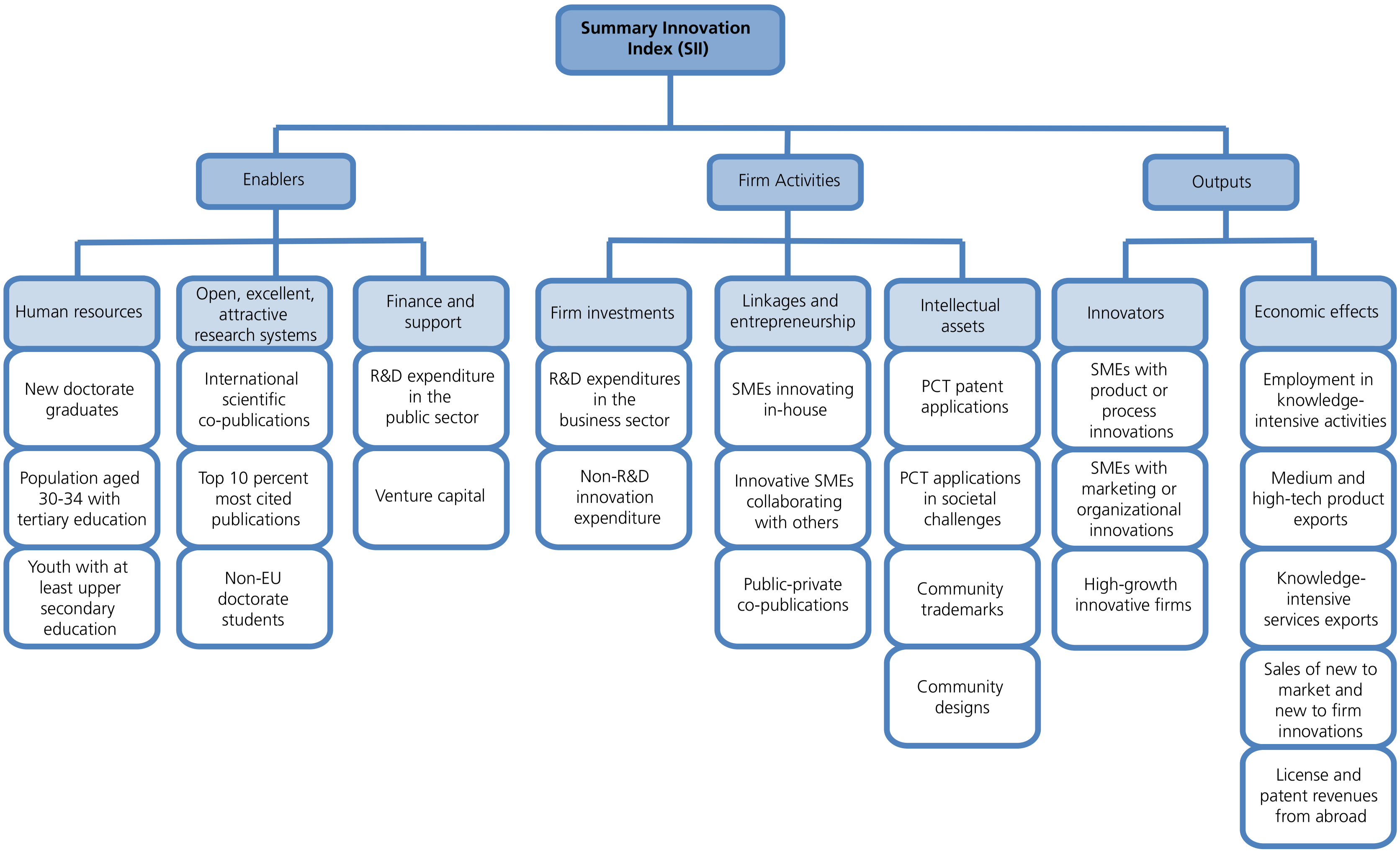
Source: KI and KEI Indexes website: http://go.worldbank.org/SDDP3I1T40.

- KEI and KI Indexes present performance scores of all countries on the KEI and KI indexes, as well as on the four KE pillars, in a sortable table format.
- Over Time Comparison demonstrates countries' progress on Knowledge Economy pillars and indexes from 1995, 2000, and the most recent year.
- Cross-Country Comparison allows bar-chart comparison of up to 20 countries on their KEI and KI indexes while demonstrating the relative contribution of different KE pillars to the countries' overall knowledge readiness.
- World Map provides a color-coded map for the global view of the world's KE readiness for 1995, 2000, and the most recent year.

EUROSTAT'S INNOVATION UNION SCOREBOARD (IUS)

The IUS provides a comparative assessment of the research and innovation performance of countries and the relative strengths and weaknesses of their research and innovation systems (figure C.3). The Scoreboard covers innovation indicators and trend analyses for the EU-28 member states, as well as for Serbia, the former Yugoslav Republic of Macedonia, Turkey, Iceland, Norway, and Switzerland. On a more limited number of indicators available internationally, it also covers Australia, Brazil, Canada, China, India, Japan, the Russian Federation, South Africa, the Republic of Korea, and the United States. The IUS replaces the European Innovation Scoreboard, which was published from 2001 to 2009. The IUS distinguishes between three main types of indicators and eight innovation dimensions, capturing in total 25 different indicators (see figure C.3).

Figure C.3: The Innovation Union Index—Summary Structure



Source: EC 2012.

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The purpose of this Guidance Note is to help countries to assess the quality of public spending on STI. It adopts a results-oriented framework, combining the consolidation of STI expenditures with the analysis of their main outputs, intermediate outcomes, and developmental impact. The framework proposes **the analysis of three main sources of deficiencies: (i) program design/ implementation; (ii) institutional conditions; and the (iii) composition and level** of public expenditure. The main product of this exercise is an integrated set of actionable measures combining institutional reforms with changes in the policy **mix (the composition and level of public spending) and strategic investments.**

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